Faculty of Natural and Applied Sciences Journal of Applied Biological Sciences
Print ISSN: 3027-0685, e-ISSN: 3043-6494
www.fnasjournals.com
Volume 2; Issue 4; December 2025; Page No. 83-94.
DOI: https://doi.org/10.63561/jabs.v2i4.1012

Phytochemical Analysis and Functional Properties of Composite Cereal Blends Used as Weaning Foods for Infants

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Abstract
This study investigated the phytochemical analysis and functional properties of five composite cereal blends formulated as weaning foods for infants. The study examined the proximate compositions of the blends and assessed their functional properties to determine their suitability for infant feeding. The Research and Development approach adapted from Gall et al. guided the formulation, evaluation, and improvement of the blends. Standard laboratory procedures were used to process raw materials into flour, develop recipes, and analyse nutrient composition, as well as functional characteristics. Proximate analysis covered protein, moisture, ash, crude fat, carbohydrate, and fibre, while functional properties assessed included loose bulk density, water absorption, pack bulk density, gelation time, gelation temperature, wettability, and sinkability. Data were collected in phases using laboratory analysis, organoleptic evaluation by nursing mothers, and growth performance assessment with infant albino rats. Mean and standard deviation were used to answer the research questions, and ANOVA tested the hypotheses at a 0.05 level of significance. The findings showed clear differences in the proximate compositions of the blends. Some blends contained higher protein and fat levels, while others provided greater carbohydrate content, indicating that each blend can support different nutritional needs. The functional properties also varied, reflecting how each blend behaves when prepared as food. Only loose bulk density did not differ significantly among the blends. The study concludes that the cereal blends vary in their nutritional and functional qualities, and these variations can guide their use in infant weaning. Based on the findings of the study, it was recommended that food processors should adjust drying methods for blends with high moisture to reduce the risk of spoilage and improve shelf life, and manufacturers should adjust milling and blending processes to achieve consistent bulk density across products.

Keywords: Phytochemical Analysis, Functional Properties, Cereal Blends, Weaning Foods, Infants

Introduction

Understanding the nutritional and practical qualities of food mixtures prepared for young children is important for supporting healthy growth and safe feeding practices. Phytochemical analysis involves the examination of plant-derived compounds in food materials, which can include both beneficial substances like antioxidants and potentially harmful anti-nutrients such as phytates, oxalates, tannins, and saponins, to evaluate their effects on nutrition and health (Abimbola, 2024; Agugo et al., 2024; Bamba & Gbogouri, 2022; Ezeanolue et al., 2025; Uche, 2020). In the context of cereal blends, this analysis helps identify levels of these compounds, for example, phytate ranging from 0.02% to 0.03%, oxalate from 0.13% to 1.23%, and tannins from 0.51% to 0.86%, which are often reduced through processing methods like fermentation, germination, and soaking to improve nutrient bioavailability (Agugo et al., 2024; Ezeanolue et al., 2025; Uche, 2020). Such analysis also covers flavonoids and total phenolics, with contents like 0.10% to 2.33% for flavonoids and 52.27 mg/100g for phenolics, noting their roles in antioxidant properties while ensuring levels stay within safe limits to avoid issues like mineral chelation (Bamba & Gbogouri, 2022; Ezeanolue et al., 2025). Methods for this analysis typically follow standard protocols, including alkaline precipitation for alkaloids, double extraction for saponins, and specific assays for phytates and oxalates, to quantify these compounds accurately in blends (Uche, 2020). Phytochemical analysis relates to the proximate composition of cereal blends used as weaning food for infants, reflecting their nutritional quality.

Proximate compositions of cereal blends as weaning food for infants refer to the basic nutritional makeup of these foods, including percentages of moisture, ash, protein, fat, fibre, and carbohydrates, determined through

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standard laboratory methods to assess their suitability for infant nutrition (Abimbola, 2024; Agugo et al., 2024; Bamba & Gbogouri, 2022; Ezeanolue et al., 2025; Maimuna Sani et al., 2020; Uche, 2020). For instance, moisture content in such blends ranges from 1.40% to 9.333%, kept low to enhance shelf stability and prevent microbial growth, while protein levels vary from 6.32% to 27.05%, often boosted by adding legumes like soybean or pigeon pea to meet infant requirements of 11% to 21% (Abimbola, 2024; Bamba & Gbogouri, 2022; Maimuna Sani et al., 2020; Uche, 2020). Ash content, indicating mineral levels, spans 0.49% to 4.10%, fat from 4.25% to 15.63%, and carbohydrates from 52.63% to 79.87%, with calculations like carbohydrate as 100 minus the sum of other components, ensuring energy values of 381.25 to 444.99 kcal/100g for growth needs (Abimbola, 2024; Bamba & Gbogouri, 2022; Ezeanolue et al., 2025; Maimuna Sani et al., 2020). Fibre content, typically 0.590% to 6.55%, supports digestion but is controlled to avoid nutrient absorption interference in infants (Abimbola, 2024; Maimuna Sani et al., 2020; Uche, 2020). The proximate composition of cereal blends as weaning food for infants influences their functional properties in infant feeding.

Functional properties of cereal blends as weaning food for infants describe the physical and chemical traits that influence how these foods behave during preparation, storage, and digestion, such as viscosity, water absorption capacity, and pasting characteristics, which affect their ease of use and nutritional delivery (Agugo et al., 2024; Bamba & Gbogouri, 2022; Ezeanolue et al., 2025; Maimuna Sani et al., 2020; Uche, 2020). Viscosity in gruels from these blends ranges from 201.25 to 3360.00 cps, often lowered by processing to create thinner, energy-dense foods suitable for infants, while water hydration capacity varies from 0.415 to 1.305 ml/g, improving at higher temperatures due to gelatinisation (Agugo et al., 2024; Maimuna Sani et al., 2020). Pasting properties include peak viscosity of 164 to 889 RVU and pasting temperatures of 82 to 92.6°C, contributing to stability during cooking and cooling, enhanced by fibre and processing techniques like germination (Agugo et al., 2024; Uche, 2020). These properties also encompass nutrient ratios like Ca/P above 1 for bone health and low anti-nutrient to mineral ratios to ensure bioavailability, making the blends digestible and acceptable for infant feeding (Bamba & Gbogouri, 2022; Ezeanolue et al., 2025; Uche, 2020). The functional properties of cereal blends as weaning food for infants relate to the functional properties of composite cereal blends used for infant feeding.

Functional properties of composite cereal blends used as weaning foods for infants pertain to the combined characteristics of mixed grains and legumes, such as sorghum with soybean or maize with pigeon pea, focusing on aspects like digestibility, sensory appeal, and microbial stability to support infant development (Abimbola, 2024; Agugo et al., 2024; Bamba & Gbogouri, 2022; Ezeanolue et al., 2025; Maimuna Sani et al., 2020; Uche, 2020). In these composites, germination and fermentation enhance predigestion, reducing anti-nutrients and improving nutrient absorption, with sensory scores on a 9-point scale reaching 7.40 for taste in 50:50 maize-pigeon pea blends (Uche, 2020; Ezeanolue et al., 2025). Microbial counts remain low, from 7.2 x 10^4 to 2.0 x 10^5 cfu/g for bacteria, due to processing, ensuring safety, while organoleptic traits like texture and flavour score above 5.0, often improved by additions like dates or banana pulp (Agugo et al., 2024; Ezeanolue et al., 2025). Ratios such as Na/K below 1 and low phytate/zinc support mineral uptake, with overall properties aligning with standards for complementary foods to prevent malnutrition (Abimbola, 2024; Bamba & Gbogouri, 2022; Maimuna Sani et al., 2020).

Statement of the Problem

The quality of weaning foods is important for supporting healthy growth in infants, yet many infants are introduced to cereal blends whose nutritional value and functional properties are not clearly known. In some cases, these foods may not provide adequate nutrients, or their functional properties may not support proper digestion and utilisation by infants. This raises concerns about whether the cereal blends commonly used for weaning truly meet the nutritional needs of infants during this sensitive stage of development. Although composite cereal blends are often promoted as affordable and accessible weaning options, there is limited information on their proximate compositions and how their functional properties may influence their suitability for infant feeding. Without clear scientific evidence, parents and caregivers may rely on products that do not fully support infant health. This study therefore, seeks to investigate the phytochemical composition and functional properties of selected cereal blends used as weaning foods, with the aim of providing clearer understanding of their nutritional adequacy and overall suitability for infant feeding.

Aim and Objectives of the Study

The aim of the study was to investigate phytochemical analysis and functional properties of composite cereal blends used as weaning foods for infants. Specifically, the study sought to:

1. Examine the proximate compositions of five cereal blends as weaning food for infants.
2. Ascertain the functional properties of five cereal blends as weaning food for infants.

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Research Questions

The following research questions guided the study:

1. What are the proximate compositions of the five cereal blends as weaning food for infants?
2. What are the functional properties of the five cereal blends as weaning food for infants?

Hypotheses

The following hypotheses were tested in the study at .05 level of significance:

$H0_1$: There are no significant differences in the proximate compositions of the five cereal blends as weaning food for infants.

$H0_2$: There are no significant differences in the functional properties of the five cereal blends as weaning food for infants.

Materials and Methods

The study employed the research and development (R&D) framework introduced by (Gall et al., 2003). This R&D approach utilizes research findings to create novel products and processes. Subsequently, it involves the application of research methods to field-test, assess, and enhance these products and procedures until they conform to predetermined criteria of effectiveness, quality, or similar benchmarks. The choice of this Research and Development approach was deemed appropriate for this study because it aligns with the study's objective of enhancing education through the creation and improvement of educational products. In this study, standardized procedures were employed to formulate new recipes for innovative products. The educational research and development model, as outlined by Gall et al. (2003), consists of ten sequential steps referred to as the cycle.

The ten steps comprised:

Step 1: Defining goals. This includes a needs assessment.
Step 2: Review of literature necessary for product development.
Step 3: Stating specific objectives and criteria for product development.
Step 4: Development of a prototype based on scientific evidence available for pertinent research findings.
Step 5: Field testing the prototype in the setting where it was finally used.
Step 6: Revision of the prototype to correct deficiencies found in the field testing stage.
Step 7: Conduct a main field test of the revised product.
Step 8: Design and conduct formative evaluation of the product.
Step 9: Revision of the prototype.
Step 10: Designing and conducting of summative evaluation.

Gall et al. (2003) noted that the entire ten steps may not all be used for a study, but could be modified. The current research adapted the R and D cycle using seven steps because many steps of the research design were in line with the purpose of the current study. The ten steps were modified to 7 steps to suit this study. The modified steps adapted are:

1. Determination of nutrient content of selected grains and nuts.
2. Processing of selected grains, nuts, and enrichments into flour.
3. Development of recipes.

In this seven-step design process used for the study, the objectives were carried out in five phases, and different methods were used for each phase. The phases and methods used are as follows:

Phase I: Determination of the proximate compositions of five composite cereal blends (Corn, millet, sorghum, rice, groundnuts, tigernuts, soy beans, and date)). This comprised steps 1, 2, and 3 of the R and D process.

Phase II: Determination of the functional properties of five composite cereal blends. This study was carried out in Rivers State, Nigeria. Rivers State is located in the Niger Delta region of Nigeria. The State has three senatorial zones, viz Rivers South East, Central, and West. There are twenty-three local government areas in the state with two Government Teaching Hospitals (University of Port Harcourt Teaching Hospital and Rivers State University Teaching Hospital). The population for this study was based on different phases. Two sets of population were used in the study. Judges Population. The population for this phase consisted of all nursing mothers attending immunization at the Health Centre of Ignatius Ajuru University of Education, Port Harcourt. There are 50 registered nursing mothers at the Health Centre of Ignatius Ajuru University of Education, Port Harcourt. The population used in phase determined that the efficacy of the cereal was the same in the previous phase of the study.

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Two sets of samples (I and II) were used in the study. The sample size for phase IV of the study was A total of 20 nursing mothers who were randomly selected from the 50 registered nursing mothers attending immunization at the Health Centre of Ignatius Ajuru University of Education, Port Harcourt. These subjects were used for the study because they are the most appropriate sample capable of determining the acceptability of the weaning food. In phase IV of the study. A total of 25 albino rats participated in their postnatal day 28 (PND 28) participated in the study. A total of five (5) infant albino rats were assigned to each group to achieve statistically significant results. The rats were randomly assigned to each group to eliminate bias and ensure that each group is representative of the population.

Instrument for Data Collection

Three sets of instruments were used for data collection in phases.

1. Raw Materials (corn, millet, rice, sorghum, soybean, groundnut, date and tiger nut).
2. Proximate Composition: This were used to determine the nutrient compositions of the weening food prepared from the developed blends. The proximate analysis involving, protein, moisture content (%), ash content (%), crude fat (fats & oil%), carbohydrate, and fibre.
3. Functional properties: The functional properties such as Loose Bulk Density (g/ml),

H_20 Absorption (ml/g), Pack Bulk Density (g/ml), Gelation Time (minutes), Gelation Tempt (^{0}C), Wettability (Sec), and Sinkability (Sec).

In order to ensure the face and content validity of the instrument, a draft of the instrument was given to three experts in the Department. The researcher provided the experts with clear guidelines on what to do in a letter that accompanied the instrument. The purpose of the study, as well as the research questions and hypotheses that were stated, were included. This helped the experts to determine which items actually elicited the information they were intended to elicit. In addition to this, there were specific instructions to the experts to review the items in terms of their clarity, the appropriateness of the language and expression to the respondents, including the appropriateness of the instructions to the respondents. At the end of each instrument, a space was provided for any comments the experts may wish to make regarding the overall adequacy of the instrument. Thereafter, the items were modified along the lines suggested by the comments of these experts.

The content validity of the instrument was established in two phases. During the first phase, some copies of the instrument were given to three experts in the department to make their inputs. They were requested to aid the researcher in improving the content coverage of the instruments by including additional appropriate items (questions) in the instrument. The topic of the study, statement of the problem, purpose of the study with specific objectives, research questions, and hypotheses were attached to the copies of the instruments given to the experts. This is done to guide the experts in the inputs to make. In the second phase, improved copies of the instrument were given to two other experts in the department to indicate the degree of relevance of the items of the instrument. The scores obtained were analysed using mean and standard deviation based on a criterial mean cut-off of 2.5. The irrelevant items of the instrument were replaced. Other corrections were made at the final construction of the instrument. The Kendull coefficient of concordance was used to establish the reliability of the Phytochemical Analysis and Functional Properties of Composite Cereal Blends Used as Weaning Foods for Infants (PAFPCCBUWFI). The different cereal blends were administered to 20 nursing mothers who were not included in the study and were selected using a simple random sampling method from the Rumuolumeni Community Health Centre. After rating, the scores obtained from the different cereal blends were retrieved, coded, and analysed using the Cronbach Alpha (r_a) method to establish the reliability or the internal consistency of the instrument (r_a=0.82).

Method of Data Collection

The data for this study was collected in four phase

Phase I: Determination of nutrient content of enriched grains grains (maize, millet, sorghum rice, and date).

In phase one of the study, two food laboratory analysts assisted the researcher determined the cereal content of selected grains using the Association of Analytical Chemistry AOAC (2005). The AOAC is a standard instrument. The values of the analysis obtained were recorded as data collection.

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Phase II: Development of nutrients using the selected grains and the production of cereal using the developed blends.
Phase III: Determination of the nutrient composition of the cereal produced from the developed blend.
Phase IV: Organoleptic evaluation of the cereal produced
3.1.5 Phase V: Determining the efficacy in the nutritional impact of different cereal blends on the development (weight in grams and height in cm) of infant albino rats.

Sourcing of Raw Materials: The raw materials which were used in this study (Corn, Soybean, Groundnut, Date, Mille, Groundnut, Tiger nut and Rice) were purchased from the popular Mile 3 Market Diobu, Port Harcourt.
Processing of Raw Materials: The raw materials (Corn, Soybean, Groundnut, Date, Millet, Groundnut, Tiger nut and Rice) were thoroughly cleaned before processing.

Preparation of Sorghum, Maize, Rice, Millet Flours:
One hundred grammes each of sorghum, maize, rice, millet grains, 15 grams tiger nut, groundnut, date, and 20grames soybeans were carefully separated from stones and sand by hand-picking.

1. The sorghum, maize, rice, millet, date, tiger nut were properly washed and sun-dried for a minimum of 3 day.
2. The groundnut was warm water, salted and fried on low heat.
3. The Soybean were carefully selected, washed and parboiled for about 25 minutes, then drain and oven-dried for about 2 hours in a low heat of about 40^0C.
4. The dates were washed, deseeded and sun-dried for 3 days.
5. The five cereal blends were grounded separately in a blender to obtain a smooth texture.
6. The cereal blends were sieved and then stored in a dry and air-tight container with cover.

Experimental Methods
Chemical analysis
The samples of the four cereal blends underwent proximate analysis, vitamins, and anti-nutrients.

Protein: The protein content of raw food materials was determined by a number of methods. These methods vary in terms of their accuracy, precision, cost, and ease of use, so the choice of method will depend on the specific requirements of the analysis. They include Kjeldahl method, Biuret test, Duma's method, UV-Vi's spectrophotometry, and Infrared spectroscopy. The protein content of raw food materials was determined using **Kjeldahl method**: The most commonly used formula was the conversion of total nitrogen content to protein content using the factor of 6.25.
The formula is as follows:
Protein content (g/100g sample) = Total nitrogen content (g/100g sample) x 6.25.
The total nitrogen content of a sample must first be determined by a method such as the Kjeldahl method. This conversion factor of 6.25 assumes that all of the nitrogen in the sample is present as protein and that the average nitrogen-to-protein conversion factor is 0.16.

Moisture content
There are several methods to determine the moisture content in a raw food material, including: Oven drying method, Karl Fischer titration, Loss-on-ignition, Halogen moisture analyzer, and microwave moisture analyzer. The formula to calculate moisture content in raw food materials.
The formula is as follows:

Moisture content (w/w) = (Wet weight - Dry weight) / Wet weight x 100%

Where "Wet weight" is the weight of the sample before drying and "Dry weight" is the weight of the sample after drying. The moisture content is expressed as a percentage of the wet weight of the sample.

Ash content
Ash content in a raw food material was dry ashing and wet ashing procedures. The ash content was expressed as a percentage of the dry weight of the sample and can provide information about the mineral content of the food material. To obtain accurate results, it is recommended to use a calibrated balance and to follow the procedure

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carefully to ensure that all organic matter is completely burned away and the ash is accurately weighed. The formula to calculate ash content in raw food materials. The formula is as follows:
Ash content (w/w) = (Ash weight) / (Dry weight) x 100%

Where "Ash weight" is the weight of the ash after ashing, and "Dry weight" is the weight of the sample before ashing. The ash content is expressed as a percentage of the dry weight of the sample.

Crude fat (fats & oil%)
Crude fat in a raw food material was a variety of methods, including: Soxhlet extraction, Gravimetric method, Chemical methods and Infrared spectrophotometry.
Crude fat content (w/w) = (Fat weight) / (Dry weight) x 100%

Where "Fat weight" is the weight of the fat after extraction or measurement, and "Dry weight" is the weight of the sample before extraction or measurement. The crude fat content is expressed as a percentage of the dry weight of the sample.

Carbohydrates
Crude carbohydrates in a raw food was a variety of methods, including: Enzymatic-gravimetric methods, Anthrone method, Phenol-sulfuric acid method and
Gas chromatography. The formula to calculate carbohydrates in raw food materials is as follows:

Carbohydrates content (w/w) = (Carbohydrates weight) / (Dry weight) x 100%

Where "Carbohydrates weight" is the weight of the carbohydrates after measurement, and "Dry weight" is the weight of the sample before measurement. The carbohydrates content is expressed as a percentage of the dry weight of the sample.

Fiber
Fiber content in a raw food material was a variety of methods, including:
Enzymatic-gravimetric methods, Gravimetric methods, Total Dietary Fiber (TDF) methods, and
Specific fiber analysis. The formula to calculate fiber content in raw food materials is as follows:
Fiber content (w/w) = (Fiber weight) / (Dry weight) x 100%
Where "Fiber weight" is the weight of the fiber after measurement, and "Dry weight" is the weight of the sample before measurement. The fiber content is expressed as a percentage of the dry weight of the sample.

Vitamins
The determination of vitamins in a raw food was a variety of analytical techniques, including: High Performance Liquid Chromatography (HPLC), EnzymeLinked Immunosorbent Assay (ELISA), Spectrophotometry and Fluorometry. There is no general formula that can be used to calculate the amount of any vitamin in a raw food material. The actual number of vitamins in a food depends on many factors, including the variety of the food, growing conditions, storage conditions, and processing methods. The most accurate way to determine the vitamin content of a food is to analyze it using a validated analytical method, such as those mentioned above. These methods can provide a quantitative measurement of the vitamins in a food sample, which can then be used to determine the vitamin content per serving or per 100 g of food. It is also important to note that the number of vitamins in a food can vary greatly from one sample to another, even within the same batch or crop. Therefore, it is essential to use representative samples and to average the results over several samples to obtain a reliable estimate of the vitamin content in a food.

Anti-nutrients
Antinutrients are naturally occurring or added substances in food that interfere with the absorption of essential nutrients. While some antinutrients are harmful in large amounts, they are also known to have some health benefits, such as reducing the risk of certain diseases, such as cancer and cardiovascular disease. It is important to have a balanced diet and to consume antinutrients in moderation. They are commonly found in plant-based foods, such as grains, legumes, nuts, and seeds, and can impact the bioavailability of nutrients such as vitamins, minerals, and proteins. Some common antinutrients include:

1) Phytates: These are found in whole grains, legumes, nuts, and seeds, and inhibit the absorption of minerals, such as iron, zinc, and calcium.

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2) Lectins: These are found in legumes, grains, and some vegetables and fruits, and can interfere with the absorption of vitamins and minerals.
3) Protease inhibitors: These are found in legumes, nuts, and seeds, and inhibit the digestion of proteins.
4) Tannins: These are found in tea, wine, and some fruits and vegetables, and can bind to proteins and minerals, making them unavailable for absorption.
5) Oxalates: These are found in some vegetables and fruits, such as spinach and rhubarb, and can bind to minerals, such as calcium, making them unavailable for absorption.

Antinutrients in raw food materials can be determined using several analytical techniques, including: High Performance Liquid Chromatography (HPLC), Enzyme Inhibition Assays, Enzyme-Linked Immunosorbent Assay (ELISA) and Spectrophotometry. There is no general formula that can be used to calculate the amount of antinutrients in a raw food material. The actual amount of antinutrients in a food depends on many factors, including the variety of the food, growing conditions, storage conditions, and processing methods. The most accurate way to determine the antinutrient content of a food is to analyze it using a validated analytical method, such as those mentioned above. These methods can provide a quantitative measurement of the antinutrients in a food sample, which can then be used to determine the antinutrient content per serving or per 100 g of food.

The data generated from the research involving proximate compositions and organoleptic evaluations was analysed using the Statistical Package for Social Sciences (SPSS). The research questions were answered using mean, standard deviation, percentages and graphs, whereas the hypotheses were tested using the Analysis of Variance (ANOVA) at a 0.05 level of significance.

Results

Research Question 1: What are the proximate compositions of the five composite cereal blends?

Table 1: Proximate compositions of the five different composite cereal blends.

Proximate composition	SBGD	MBGT	RBGT	CBGD	CRLC
Moisture content	1.79±0.14	2.40±0.84	9.49±0.58	3.73±0.25	2.19±0.21
Ash content	2.22±0.03	1.99±0.00	1.44±0.21	1.89±0.07	3.09±0.14
Crude fat(Fats/Oils)	16.42±1.44	15.06±0.73	12.71±1.15	12.68±1.68	2.58±0.28
Crude Protein	21.13±0.06	20.86±0.00	15.75±0.00	14.38±0.62	14.01±0.06
Crude fibre	14.90±0.59	12.39±0.86	8.41±1.34	12.73±0.04	10.24±0.67
Carbohydrate	43.56±1.97	47.32±2.43	52.20±0.17	54.61±2.50	67.91±0.81

Key: SBGD = Sorghum 50%, Soybean 20%. Groundnut 20%, Date 10%; MBGT=Millet 50%, Soybean 20%, Groundnut 20%, Tigernut 10%; RBGT=Rice 50%, Soybean 20%, Groundnut 20%, Tigernut 10%; CBGD=Corn 50%, Soybean 20%. Groundnut 20%, Date 10%; and CRLC=Cerelac, Moisture (%), Ash (%), Fat (%), Crude Protein (%), Crud Fibre (%), & Carbohydrate (%).

The results from Table 1 shows the proximate compositions of the five different composite cereal blends. The results showed the mean and standard deviation for each of the proximate such as moisture, ash, fats/oils, crude protein, crude fibre, and carbohydrate across the five cereal blends. The presented below are the major findings: The blend RBGT had the highest content of moisture (9.49±0.58, %), this was followed by CBGD (3.73±0.25%), MBGT (2.40±0.84%), CRLC (2.19±0.21 %) and the least was SBGD (1.79±0.14%). The highest moisture content was found in the RBGT and this results is likely to be due to the presence of rice in the composite cereal blend.

This represents the mineral content in the composite cereal blends. The composite blend, CRLC (cerelac) had the highest ash content (3.09±0.14 %), this was followed by SBGD (2.22±0.03%), MBGT (1.99±0.00%), CBGD (1.89±0.07%) and the least was RBGT (1.44±0.21%). In comparison to other cereal blends, CRLC and SBGD had relatively higher ash content than other blends.

The crude fat differs across the composite blends. The highest crude fat was found in SBGD (16.42±1.44%), this was followed by the blend MBGT(15.06±0.73%), RBGT(12.71±1.15%), CBGD (12.68±1.68%) and the least was CRLC (2.58±0.28%). A closer look at the table revealed that SBGD and MBGT respectively had relatively higher crude fat content when compared to other composite cereal blends.

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The protein content information were provided by the crude protein content in the cereal blends. The highest protein content was found in the SBGD blend (21.13±0.06%), this was closely followed by MBGT (20.86±0.00%), then RBGT (15.75±0.00%), CBGD (14.38±0.62%), and the least was CRLC (14.01±0.06%). SBGD and MBGT contain higher protein content in comparison to other blends.

The dietary fibre content in the cereal blends were provided by the crude fibre content in the cereal blends. The highest crude fibre content was found in SBGD (14.90±0.59%), this was followed by CBGD (12.73±0.04%), MBGT (12.39±0.86%), CRLC (10.24±0.67%) and the least was RBGT (8.41±1.34%). The results showed that SBGT had the highest level of crude fibre among the blend and this suggests a relatively higher fibre content.

The major source of energy in the composite blends is represented by carbohydrate content. The results showed that CRLC (67.91±0.81%) had the highest carbohydrate content. This was followed by CBGD (54.61±2.50%), RBGT (52.20±0.17%), MBGT (47.32±2.43%) and the least was SBGD (43.56±1.97%). The result indicated that cerelac (CRLC) had the highest source energy (carbohydrate content) among other composite blends compared.

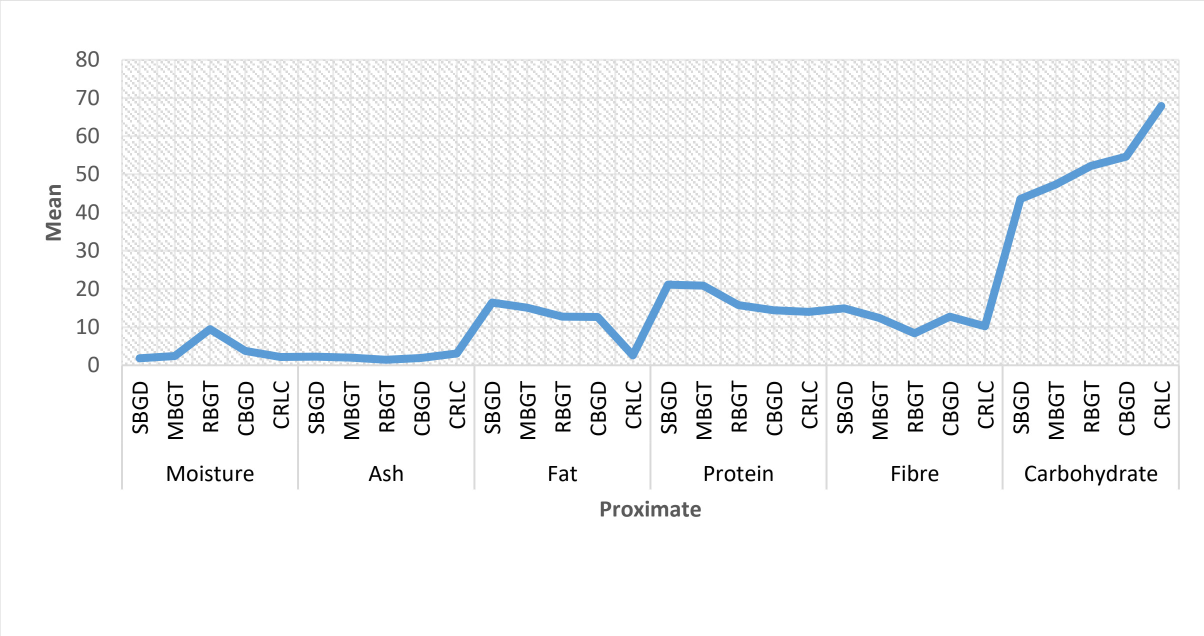

Fig. 1: Composite bar chart on proximate analysis of five cereal blends.

The general results established the differences in the proximate compositions among the varying composite cereal blends. The CRLC had the highest carbohydrate content whereas SBGD and MBGT had higher protein and fat contents. The nutritional profiles of the cereal blends created for infants weaning can be further analyzed and understood using the useful information from these findings.

Research Question 2: What are the functional properties of the five composite cereal blends?

Table 2: Functional properties of the five different composite cereal blends.

Functional Properties	SBGD	MBGT	RBGT	CBGD	CRLC
Loose Bulk Density(LBD)	0.38±0.01	0.41±0.02	0.37±0.02	0.42±0.02	0.42±0.01
H_2O Absorption	1.79±0.28	1.89±0.14	1.89±0.14	2.69±0.16	3.90±0.14
Pack Bulk Density (PBD)	0.79±0.00	0.74±0.01	0.60±0.00	0.74±0.02	0.57±0.00
Gelation Time	3.50±0.71	2.50±0.71	2.50±0.71	4.00±0.00	7.50±0.71
Gelation Temperature	96.00±1.41	93.00±1.41	82.00±1.41	91.50±0.71	100.00±0.00
Wettability	4.62±0.47	7.58±0.23	2.61±0.03	2.61±0.03	5.05±0.05
Sinkability	9.28±0.46	10.38±0.00	6.86±0.70	4.94±0.06	8.57±0.03

Key: SBGD = Sorghum 50%, Soybean 20%. Groundnut 20%, Date 10%; MBGT=Millet 50%, Soybean 20%, Groundnut 20%, Tigernut 10%; RBGT=Rice 50%, Soybean 20%, Groundnut 20%, Tigernut 10%; CBGD=Corn

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50%, Soybean 20%. Groundnut 20%, Date 10%; and CRLC=Cerelac. Loose Bulk Density (g/ml), H_20 Absorption (ml/g), Pack Bulk Density (g/ml), Gelation Time (mins), Gelation Tempt (^{0}C), Wettability (Sec) & Sinkability (Sec).

The results from Table 2 show the functional properties of the five different composite cereal blends. The results showed the mean and standard deviation for each of the functional properties such as Loose Bulk Density, H_2O Absorption, Pack Bulk Density, Gelation Time, Gelation Temperature, Wettability, and Sinkability across the five cereal blends. The presented below are the major findings:

Loose Bulk Density (LBD): The LBD showed no substantial variations in the composite cereal blends. The results showed that CBGD (0.42±0.02 g/ml) and CRLC(0.42±0.01 g/ml), had higher LBD compared to others. This was followed by MBGT (0.41±0.02 g/ml), SBGD (0.38±0.01 g/ml) and the least LBD was in RBGT (0.37±0.02 g/ml).

H_2O Absorption: The H_2O Absorption showed ample variations in the composite cereal blends. The results showed that CRLC (3.90±0.14 ml/g) had the highest H_2O absorption ability among others. This was followed by CBGD (2.69±0.16 ml/g), MBGT (1.89±0.14 ml/g), RBGT (1.89±0.14 ml/g) and the least H_2O absorption capacity was in SBGD (1.79±0.28 ml/g).

Pack Bulk Density (PBD): The PBD showed sizeable variations in the composite cereal blends. The results showed that SBGD (0.79±0.00 g/ml) had the highest PBD compared to others. This was followed by MBGT (0.74±0.01 g/ml), CBGD (0.74±0.02 g/ml), RBGT (0.60±0.00 g/ml) and the least PBD was in CRLC (00.57±0.00g/ml).

Gelation Time: The gelation time showed substantial variations in the composite cereal blends. The results showed that CRLC (7.50±0.71 minutes) had the highest gelation time compared to others. This was followed by CBGD (4.00±0.00 minutes), SBGD (3.50±0.71 minutes) and the least gelation time were in MBGT (2.50±0.71 minutes) and RBGT(2.50±0.71 minutes).

Gelation Temperature: The gelation temperature showed large variations in the composite cereal blends. The results showed that CRLC (100.00±0.00 ^{0}C) had the highest gelation temperature compared to others. This was followed by SBGD (96.00±1.41 ^{0}C), MBGT (93.00±1.41^{0}C), CBGD (91.50±0.71 ^{0}C), and the least gelation temperature was in RBGT (82.00±1.41^{0}C).

Wettability: The wettability showed enormous variations in the composite cereal blends. The results showed that MBGT (7.58±0.23 Sec) had the highest wettability compared to others. This was followed by CRLC (5.05±0.05 Sec), SBGD (4.62±0.47 Sec), and the least wettability were in RBGT (2.61±0.03 Sec) and CBGD (2.61±0.03 Sec).

Sinkability: The sinkability showed huge variations in the composite cereal blends. The results showed that MBGT (10.38±0.00 Sec) had the highest sinkability compared to others. This was followed by SBGD (9.28±0.46 Sec), CRLC (8.57±0.03Sec), RBGT (6.86±0.70 Sec), and the least sinkability was in CBGD (4.94±0.06Sec).

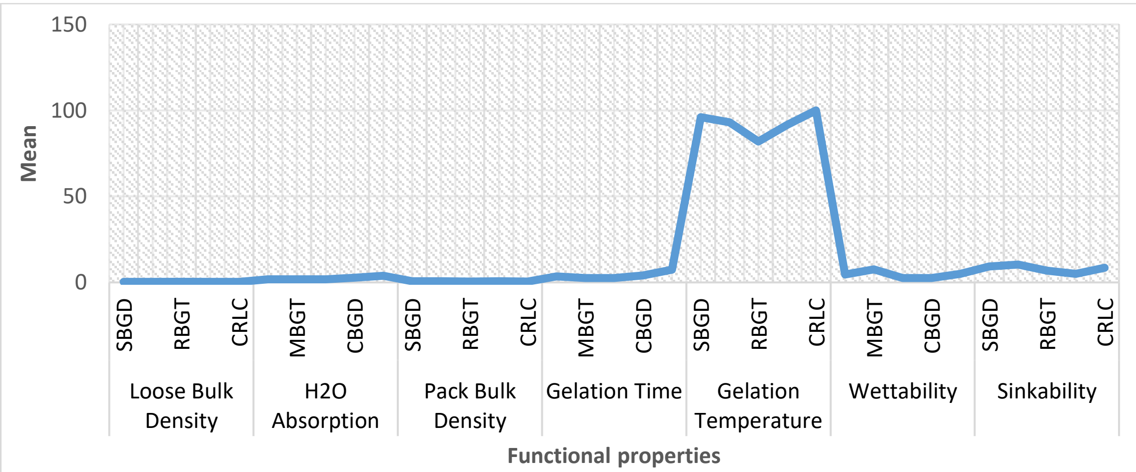

Fig. 2: This graph shows the mean variation of the functional properties based on the five cereal blend.

The results indicated that varying parameters affect how composite cereal blends perform. Lower loose bulk densities for RBGT and SBGD point to less compact structures. The capacity to absorb water was higher in CBGD and CRLC. The capacity to pack densely was greater for CRLC, which had the lowest pack bulk density. In comparison to other mixes, CRLC had the longest gelation period and highest gelation temperature. While taking the longest to float in water, MBGT had the highest wettability. Based on the required qualities for certain

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applications, these variances in functional features can guide the choice and application of composite cereal blends.

Testing of hypotheses

H0$_1$: There are no significant differences in the proximate compositions of the five composite cereal blends.

Table 3: Summary of ANOVA on the differences in the proximate compositions of the five different composite cereal blends.

Proximate Composition	SBGD	MBGT	RBGT	CBGD	CRLC	F	p-value	Decision
Moisture content	1.79±0.14	2.40±0.84	9.49±0.58	3.73±0.25	2.19±0.21	87.40	0.00	Sig.
Ash content	2.22±0.03	1.99±0.00	1.44±0.21	1.89±0.07	3.09±0.14	52.36	0.00	Sig.
Crude fat(Fats/Oils)	16.42±1.44	15.06±0.73	12.71±1.15	12.68±1.68	2.58±0.28	43.66	0.00	Sig.
Crude Protein	21.13±0.06	20.86±0.00	15.75±0.00	14.38±0.62	14.01±0.06	317.49	0.00	Sig.
Crude fibre	14.90±0.59	12.39±0.86	8.41±1.34	12.73±0.04	10.24±0.67	18.52	0.00	Sig.
Carbohydrate	43.56±1.97	47.32±2.43	52.20±0.17	54.61±2.50	67.91±0.81	51.83	0.00	Sig.

Key: SBGD = Sorghum 50%, Soybean 20%. Groundnut 20%, Date 10%; MBGT=Millet 50%, Soybean 20%, Groundnut 20%, Tigernut 10%; RBGT=Rice 50%, Soybean 20%, Groundnut 20%, Tigernut 10%; CBGD=Corn 50%, Soybean 20%. Groundnut 20%, Date 10%; and CRLC=Cerelac, Moisture (%), Ash (%), Fat (%), Crude Protein (%), Crud Fibre (%), & Carbohydrate (%).

The results from Table 3 showed the summary of ANOVA on the difference in the proximate compositions of the five different composite cereal blends. It showed that there was significant difference in the proximate compositions of the five composite cereal blends. Specifically, moisture (F=87.40, p=0.00), ash content (F=52.36, p=0.00), crude fat (F=43.66, p=0.00), crude protein (F=317.49, p=0.00), crude fibre (F=18.52, p=0.00) and carbohydrate (F=51.83, p=0.00). The p-value was less than 0.05 level of significance. The above results show that there are significant differences in the proximate compositions of the five composite cereal blends. The null hypothesis one was rejected at a 0.05 level of significance.

H0$_2$: There are no significant differences in the functional properties of the five composite cereal blends.

Table 4: Summary of ANOVA on the difference in the functional properties of the five composite cereal blends.

Functional Properties	SBGD	MBGT	RBGT	CBGD	CRLC	F	p-value	Decision
Loose Bulk Density	0.38±0.01	0.41±0.02	0.37±0.02	0.42±0.02	0.42±0.01	3.37	0.11	Not Sig.
H_2O Absorption	1.79±0.28	1.89±0.14	1.89±0.14	2.69±0.16	3.90±0.14	50.35	0.00	Sig.
Pack Bulk Density	0.79±0.00	0.74±0.01	0.60±0.00	0.74±0.02	0.57±0.00	301.10	0.00	Sig.
Gelation Time	3.50±0.71	2.50±0.71	2.50±0.71	4.00±0.00	7.50±0.71	21.25	0.00	Sig.
Gelation Temperature	96.00±1.41	93.00±1.41	82.00±1.41	91.50±0.71	100.00±0.00	69.23	0.00	Sig.
Wettability	4.62±0.47	7.58±0.23	2.61±0.03	2.61±0.03	5.05±0.05	151.75	0.00	Sig.
Sinkability	9.28±0.46	10.38±0.00	6.86±0.70	4.94±0.06	8.57±0.03	64.83	0.00	Sig.

Key: SBGD = Sorghum 50%, Soybean 20%. Groundnut 20%, Date 10%; MBGT=Millet 50%, Soybean 20%, Groundnut 20%, Tigernut 10%; RBGT=Rice 50%, Soybean 20%, Groundnut 20%, Tigernut 10%; CBGD=Corn 50%, Soybean 20%. Groundnut 20%, Date 10%; and CRLC=Cerelac. Loose Bulk Density (g/ml), H_20 Absorption (ml/g), Pack Bulk Density (g/ml), Gelation Time (mins),Gelation Tempt (^{0}C), Wetability (Sec) & Sinkability (Sec).

The results from Table 4 showed the summary of ANOVA on the difference in the functional properties of the five composite cereal blends. It showed that there were significant differences in the functional properties of the

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five composite cereal blends. Specifically, Loose Bulk Density (F=3.37, p=0.11), H_2O Absorption (F=50.35, p=0.00), Pack Bulk Density (F=301.10, p=0.00), Gelation Time (F=21.25, p=0.00), Gelation Temperature (F=69.23, p=0.00), Wettability (F=151.75, p=0.00), and Sinkability (F=64.83, p=0.00). The p-values were less than 0.05 level of significance. The above results show that there are significant differences in the functional properties of the five composite cereal blends, except in LBD. The null hypothesis four was rejected at a 0.05 level of significance

Discussion

The results from Table 1 highlight clear differences in the nutrient contents of the five composite cereal blends. For example, the moisture levels varied, with RBGT showing the highest value at 9.49±0.58 per cent, likely because of the rice included in that mix, while SBGD had the lowest at 1.79±0.14 per cent. This suggests that some blends might store better than others due to lower moisture. In terms of ash, which points to mineral levels, CRLC topped the list at 3.09±0.14 per cent, followed closely by SBGD, indicating these two could offer more minerals compared to the rest. Crude fat also differed, with SBGD reaching 16.42±1.44 per cent and MBGT not far behind at 15.06±0.73 per cent, meaning these blends provide more energy from fats than CRLC, which had the least at 2.58±0.28 per cent. Protein levels stood out as well, with SBGD at 21.13±0.06 per cent and MBGT at 20.86±0.00 per cent, higher than the others, which ranged down to 14.01±0.06 per cent in CRLC. This shows that certain mixes, like SBGD and MBGT, could support better growth in infants through increased protein. Crude fibre followed a similar pattern, peaking in SBGD at 14.90±0.59 per cent, which might help with digestion, while RBGT had the lowest at 8.41±1.34 per cent. Carbohydrates, as the main energy source, were highest in CRLC at 67.91±0.81 per cent, making it a strong option for quick energy, compared to SBGD at 43.56±1.97 per cent.

The ANOVA results from Table 3 confirm these differences are real, with significant p-values below 0.05 for all nutrients, including moisture (F=87.40), ash (F=52.36), crude fat (F=43.66), crude protein (F=317.49), crude fibre (F=18.52), and carbohydrates (F=51.83). This means the blends are not the same in their makeup, and we can reject the idea that they are similar at the 0.05 level. Overall, these findings give useful insights into how each blend might fit for infant weaning, with CRLC strong in carbs and minerals, but SBGD and MBGT better for protein, fat, and fibre. These results align with other studies on similar mixes. For instance, blends with legumes added to cereals often show higher protein, as seen in Oluwajoba et al. (2021), where protein ranged from 17.41 per cent to 21.31 per cent in their weaning formulas, much like the elevated levels in SBGD and MBGT here. In the same way, Olusesi et al. (2025) found that combining legumes with cereals boosted overall nutrient quality, including protein and fibre, which matches the high fibre and protein in SBGD compared to the other blends.

The results from Table 2 point to clear differences in how the five composite cereal blends behave in terms of their functional properties. For instance, loose bulk density stayed fairly similar across the blends, with CBGD and CRLC both at 0.42 g/ml, just ahead of MBGT at 0.41 g/ml, while RBGT had the lowest at 0.37 g/ml. This suggests the blends pack loosely in a comparable way, which might affect storage or handling. Water absorption showed more variation, with CRLC leading at 3.90 ml/g, meaning it soaks up water well, followed by CBGD at 2.69 ml/g, and SBGD coming in last at 1.79 ml/g. Such differences could influence how the blends mix with liquids during preparation. Packed bulk density also varied, peaking at 0.79 g/ml in SBGD, which indicates a denser pack, and dropping to 0.57 g/ml in CRLC. This might make some blends better for packaging or portion control. Gelation time was longest in CRLC at 7.50 minutes, compared to the shortest times of 2.50 minutes in both MBGT and RBGT, showing that some blends form gels faster, which could suit quick cooking. Gelation temperature followed a similar trend, with CRLC at 100°C and RBGT at the low end of 82°C, pointing to different heat needs for processing. Wettability was highest in MBGT at 7.58 seconds, meaning it takes longer to wet, while RBGT and CBGD were quickest at 2.61 seconds each. Sinkability mirrored this somewhat, with MBGT at 10.38 seconds and CBGD at 4.94 seconds, suggesting variations in how the blends disperse in water.

The ANOVA results from Table 4 back this up, showing significant differences in most properties at p less than 0.05, such as water absorption (F=50.35), packed bulk density (F=301.10), gelation time (F=21.25), gelation temperature (F=69.23), wettability (F=151.75), and sinkability (F=64.83). However, loose bulk density had no significant difference (F=3.37, p=0.11). This means the blends truly differ in key ways, and we can reject the null hypothesis for those properties at the 0.05 level. In general, these findings offer helpful details on how each blend might work for infant weaning, like choosing one with good water absorption for easier mixing or higher gelation for texture. These results line up with other work on similar blends. For example, adding legumes to cereal often leads to higher packed bulk density, as noted in Ikujenlola et al. (2020), where legume-rich mixes reached 0.70 to 0.82 g/ml, close to the high value in SBGD here. Likewise, Ayo-Omogie et al. (2023) reported

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that composite weaning blends had water absorption from 1.8 to 3.5 ml/g, with cereal-heavy ones higher, much like the pattern seen in CRLC and CBGD compared to the others.

Conclusion

The study assessed the proximate and functional properties of five composite cereal blends prepared for infant feeding. The findings showed that the blends differed in their nutritional composition. CRLC provided the highest carbohydrate content, while SBGD and MBGT offered higher levels of protein and fat. These variations suggest that each blend may support different nutritional needs based on energy, growth, and fibre requirements. The results also showed clear differences in the functional properties of the blends. Differences were recorded in water absorption, pack bulk density, gelation time, gelation temperature, wettability, and sinkability. These properties influence how each blend behaves during preparation and use, and they provide useful guidance for selecting blends that suit specific feeding or processing needs. Only loose bulk density did not differ significantly among the blends. The study established that both the proximate and functional properties of the blends vary in meaningful ways. These results help to explain how the blends can be used, how they may meet different nutritional demands, and how they can support infant weaning. The information from the study can guide food developers, caregivers, and health professionals in choosing or improving cereal blends for young children.

Recommendations

Based on the findings of the study, the following recommendations are made:

1. Food processors should adjust drying methods for blends with high moisture to reduce the risk of spoilage and improve shelf life.
2. Manufacturers should adjust milling and blending processes to achieve consistent bulk density across products.

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