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Comparative Evaluation of Nutrient Composition in Composite Cakes Fortified with Cocoyam, Plantain, and Bambara Nut Flours

Eunice Kanayo Agidi[1], Diana Oritsegbubemi Arubayi[2] and Juliana Ego Azonuche[2]*, Omolara Bosede Ogbonyomi[3]
azonuchejulianaego@gmail.com
[1]Department of Nutrition and Dietetics, College of Health Sciences and Technology, Ofuoma, Ughelli, Delta State, Nigeria
[2]Home Economics Unit, Department of Vocational Education, Delta State University, Abraka, Delta State, Nigeria
[3]Home Economics Department, Delta State College of Education, Mosogar, Delta State, Nigeria.

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ABSTRACT

The study was conducted in the Food and Nutrition Laboratory, Delta State University, using an experimental research design to develop and evaluate cakes from wheat, cocoyam, plantain, and bambara nut composite flours at varying substitution ratios. **Methodology:** *A total population of 185 staff and students formed the study group, while 15 purposively selected judges (7 staff, 8 students) assessed the cakes. Data were collected using a 9-point Hedonic scale for sensory evaluation and a 5-point scale for shelf-life monitoring. Validity was ensured by expert review, and reliability yielded coefficients of 0.81 and 0.88. Nutritional composition, sensory attributes, and shelf life were analyzed using AOAC methods and ANOVA (p≤0.05).* **Results and Discussion:** *Results showed that composite cakes contained significantly higher (p≤0.05) levels of essential vitamins and minerals compared to the control. The vitamin and mineral composition of composite cakes showed clear improvements over 100% wheat flour (WF). Vitamin A ranged from (0.987–1.983 mg/100g), highest in WCPB3 (1.983) and lowest in WF (0.987). Vitamin B1 varied (0.235–0.487 mg/100g), with WCPB4 highest (0.487) and WF lowest (0.235). Vitamin B12 ranged (0.011–0.017 mg/100g), peaking in WCPB5 (0.017) and lowest in WF (0.011). For minerals, calcium ranged (34.225–67.928 mg/100g), iron (2.884–3.971), magnesium (16.285–20.676), phosphorus (60.730–74.066), and zinc (1.571–1.918). Composite samples, especially WCPB5 and WCPB6, consistently outperformed WF, showing significant (p≤0.05) nutritional enhancement.* **Conclusions and Suggestions:** *The findings highlight the potential of cocoyam, plantain, and bambara nut as viable alternatives for fortifying baked products, thereby contributing to improved nutrition, food security, and reduced dependence on imported wheat flour.*

Keyword: *Composite flour, Cocoyam, Plantain, Bambara nut, Nutritional quality.*

1. Introduction

Food is one of the basic needs of life. Food is needed for survival. It is also need for nourishment, growth and development of body. Foods supply nutrients essential for the manufacture of new materials and provide energy for chemical reactions in the body[1]. The consumption of healthy foods is a necessity for all humans especially children and young adults. There are seven main classes of

[1]Weininger, J., Kent-Jones, D.W. & Carpenter, K. (2023). *Human nutrition*

nutrients that the body needs which include carbohydrates, proteins, fats, vitamins, minerals, fibre and water[2] and phytochemicals that serve a variety of crucial functions to ensure the body operates optimally. Nutritional analysis are vital measures in the development of a novel food products such as composite cake and chinchin. The composition of food largely determines its safety, nutrition, physicochemical properties, quality attributes and sensory characteristics[3].

Food Analysis is a major requisite of food industry and a very important part of product development and quality assurance. It plays critical role in the analysis of raw materials as well as finished products. According to the Institute of Good Manufacturing Practices India[4]. These analytical techniques are required for a wide variety of purposes ranging from testing suitability for purpose, through checking shelf-life or authenticity, to assuring legal compliance. A good understanding of the analytical methods will help to get information about the product and help in decision-making. Nielsen[5] opined that chemical analysis is also important in formulating and developing new products, evaluating new processes for making food products, and identifying the source of problems with unacceptable products. Vital information about a food sample can be gained through analysis of food.

Wang et al[6] stated that this information is critical to our rational understanding of the factors that determine the properties of foods, as well as to our ability to economically produce foods that are consistently safe, nutritious and desirable and for consumers to make informed choices about their diet. Arif[7] viewed proximate analysis as the determination of macronutrients in food samples — moisture, crude fat, crude protein, ash, and crude fibre. In the development of new products, sensory evaluation is also required to know how consumers will react to the new food(s). Wheat remains the dominant flour used in cake production, yet it is largely imported, costly, and deficient in essential micronutrients such as iron, calcium, and vitamins. The comparative evaluation of the vitamin and mineral composition of composite cakes fortified with cocoyam, plantain, and bambara nut

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[2]Fletcher , J. (2019). What are the 6 essential nutrients? https://www.medicalnewstoday.com
[3]Nielsen, S. S (2010) *Food Analysis (4thed.) USA* Springer New York DOI 10.1007/978-1-4419-1478-1. www.springer.com/series/5999
[4]Institute of Good Manufacturing Practices India (IGMPI, 2020). *Approaches to Proximate Analysis of Food*. http://igmpiindia.org/ffsq.html
[5]Nielsen, S. S (2010) *Food Analysis (4thed.) USA* Springer New York DOI 10.1007/978-1-4419-1478-1. www.springer.com/series/5999
[6]Wang, W., Chen, Z., & Kuang, J. (2025). Artificial Intelligence-Driven Recommendations and Functional Food Purchases: Understanding Consumer Decision-Making. *Foods*, *14*(6), 976.
[7]Arif, A. (2017). *Proximate Analysis in Food Samples*. https://www.resarchgate.net

flour blends is driven by the urgent need to enhance the nutrient density of baked products widely consumed by Nigerian adolescents[8].

Adolescents, particularly students in schools, often depend on convenient wheat-based snacks, which are low in essential micronutrients and contribute little to long-term health. To address this, fortification with indigenous crops such as cocoyam, plantain, and bambara nut provides a sustainable alternative that improves dietary quality, reduces dependence on imported wheat, and supports food security. This approach also aligns with sustainable educational management practices, which emphasize the role of schools in promoting students' wellbeing[9]. Furthermore, improved nutrition is directly linked to better cognitive performance, concentration, and academic outcomes, underscoring the interplay between health and education[10]. Since schools remain critical platforms for shaping dietary habits, integrating nutrient-rich baked goods into students' diets represents a practical innovation that supports national development goals, enhances employability through better learning, and promotes sustainable use of local food resources[11,12].

Previous studies have emphasized the potential of local staples like cocoyam and plantain as alternative flour sources due to their carbohydrate quality and micronutrient content, but their utilization in composite cake production remains underexplored[13]. Similarly, bambara nut is rich in protein, minerals, and essential amino acids, yet it is often underutilized compared to soybean and groundnut in food formulations[14]. Few studies have attempted to integrate these three crops into fortified cakes, leaving a research gap on their combined contribution to

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[8]Damfami, A., & Namo, O. A. T. (2020). Bambara groundnut (Vigna subterranea (L.) Verd.): A review of its past, present and future role in human nutrition. *J Agric For. Meteorol Res*, *3*(1), 274-281.

[9]Manafa, I. F., Ohamobi, I. N., & Osegbue, G. C. (2022). Utilization of ICT resources in the management of UBE in secondary schools in Anambra State. African Journal of Educational Management, Teaching and Entrepreneurship 7(1). 119- 128

[10]Osegbue, G. C., Manafa, I. F., & Ohamobi, I. N. (2022). Collaborative teaching practice and teachers' job performance: A contemporary innovation practice for employability and global competitiveness. COOU Journal of Educational Research, 7(1), 28–36.

[11]Okafor, N. C., Ohamobi, I., & Manafa, I. (2025). Strategies for promoting sustainable development and quality assurance in secondary schools in Anambra State. Journal of Educational Research and Development, 4(2), 62–71

[12]Enwereji, N. A., Ohamobi, G. N., & Nwokeji, E. (2024). Assessing the relationship between utilization of computer and academic achievement of postgraduate students in degree awarding institutions in Anambra State. European Journal of Research and Reflection in Educational Sciences, 10(1).

[13]Evans, E. A., Ballen, F. H, & Siddiq, M. (2020).Banana Production, Global Trade, Consumption Trends, Postharvest Handling, and Processing. **In** Siddiq, M; Ahmed, J; Lobo, M. G. (Ed). *Handbook of Banana Production, Postharvest Science, Processing Technology,and Nutrition.* https://doi.org/10.1002/9781119528265.ch1

[14]Dary, O, & Mora J. O. (2023). *Food fortification: Developing countries.* In: Caballero B, Allen L, Prentice A, eds. Encyclopedia of human nutrition. New York: Elsevier, 2006

micronutrient enhancement and consumer acceptability. This study is therefore motivated by the need to address nutritional deficiencies, reduce dependence on imported wheat, and promote the use of indigenous crops for functional bakery products that can support food security and public health.

1.1 Objectives

1. find out the value of vitamins A, B1and B12 present in each sample
2. find out the value of minerals (calcium, iron, phosphorus, magnesium and zinc) present in each of the cake samples;

1.2 Research Question

The following questions were answered in this study:

1. What are the amount of vitamins A, BI and B12 value present in composite samples fortified with cocoyam, plantain, bambara nuts in the ratio of 5:5:5:85; 10:5:5:80; 10:10:10:70; 10:15:10:65: 15:15:15:55. 15:20:15:50 (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and 100% wheat cake (WF)?
2. What are the values of minerals (calcium, iron, phosphorus, magnesium and zinc) present in composite cake fortified with cocoyam, plantain, bambara nuts in the ratio of 5:5:5:85; 10:5:5:80; 10:10:10:70; 10:15:10:65: 15:15:15:55. 15:20:15:50 (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and 100% wheat cake (WF)?

1.3 Research Hypotheses

The following hypotheses were tested at $P \leq 0.05$ level

HO_1: There is no significant difference in the value of vitamins A, B1 and B12 present in each composite sample (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and 100% wheat cake (WF).

HO_2: There is no significant difference in the value of some minerals present in composite cake fortified with cocoyam, plantain, bambara nuts in the ratio of 5:5:5:85; 10:5:5:80; 10:10:10:70; 10:15:10:65; 15:15:15:55; 15:20:15:50; (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and 100% wheat cake (WF).

2. Method

The study was conducted in the Food and Nutrition Laboratory of the Department of Vocational Education (Home Economics unit), Delta State University, Abraka. The setting was chosen because it provided a controlled environment and easy access to fifteen judges who evaluated the cake samples. An experimental research design was adopted. This design is appropriate for developing and improving products, as it combines existing knowledge with practical testing. It allowed the formulation and evaluation of new cake samples for their nutritional content, sensory attributes, and shelf life. Cakes were produced using 100% wheat flour as the control and six blends of wheat, cocoyam, plantain, and bambara nut flours in substitution ratios of 5:5:5:85, 10:5:5:80, 10:10:10:70, 10:15:10:65, 15:15:15:55, and 15:20:15:50.

The study population consisted of staff and students from two universities. At Delta State University, Abraka, there were 16 staff members and 142 undergraduate students in the Department of Vocational Education. At the University of Delta, Agbor, the Department of Home Economics had six staff members and 21 students. Altogether, the study population was 185. From this, a sample of 15 was purposively selected—seven staff and eight students from Delta State University—forming the panel of judges. Their selection was based on consent and relevance, as they were both adolescents and adults familiar with cake consumption. Two instruments were used for data collection. The first was a standard sensory evaluation questionnaire based on a 9-point Hedonic Scale, which ranged from "liked extremely" (9) to "disliked extremely" (1). This tool assessed attributes such as appearance, colour, flavour, texture, crispiness, taste, mouthfeel, and overall acceptability. The second was a structured questionnaire based on a 5-point scale ranging from "poor" (1) to "excellent" (5). It was used to monitor the shelf life of the cakes, focusing on the same sensory qualities over time.

Validity of the instruments was established through expert review. Three lecturers—from Home Economics, Measurement and Evaluation, and Biochemistry—examined the tools and provided corrections, which were incorporated before data collection. Reliability was tested through a pilot study. Ten students evaluated wheat and composite cakes using the 9-point Hedonic Scale, producing a Cronbach's Alpha coefficient of 0.81. For the shelf-life tool, five students rated composite cakes on the 5-point scale, yielding a reliability coefficient of 0.88. Both results confirmed the instruments were reliable.

Data collection involved distributing questionnaires to the fifteen judges with the assistance of two trained research aides. Each judge tasted and rated the cake samples, with bottled water provided to rinse their mouths between samples to avoid taste carryover. For shelf-life monitoring, five judges evaluated the cakes every four days using the structured questionnaire, assessing appearance, flavour, taste, texture, and overall acceptability. Ingredients such as cocoyam, matured unripe plantain, bambara nut, wheat flour, margarine, eggs, and baking powder were purchased from the local Ughelli market in Delta State. Reagents for laboratory analysis were supplied by laboratory analysts.

2.1. Method of Sample Preparation

Cocoyam, plantain, bambara nuts flour were produced using traditional method of dehydration (sun drying) and milling.

Preparation of Cocoyam Flour: The cocoyam tubers were sorted to remove impurities and then washed clean with tap water. They were peeled manually with kitchen knife and washed thoroughly with clean water. The washed cocoyam was thinly sliced into uniform sizes of 5 mm for easy drying. The sliced chips were blanched in hot water bath of 100 ºC for 5 minutes as reported by Orhevba and Ndanaimi[15]. The blanched chips were then spread on trays and sun dried. The dried chips were ground into fine flour using the local milling machine. The cocoyam flour obtained was packaged in a zip locked bag, labeled and stored at room temperature until needed.

Preparation of Plantain Flour: Plantain flour was prepared as described by Arubayi and Ogbonyomi[16] as follows: Bunch of matured (unripe) plantain were separated and washed with clean water to remove dirt and latex. The washed plantain were hand-peeled with the aid of stainless steel kitchen knife to extract the pulp and kept in a bowl containing water where they remain until the peeling process is completed (to reduce enzymatic reaction). Plantain pulps were manually sliced into cylindrical pieces of 2 cm thickness for easy drying. Sliced Plantain were then blanched with hot water at 80°C for 5 minutes. This was to stop enzymatic reaction on sliced plantain and to get fairly white flour. The blanched plantain slices were sun-dried. The dehydrated products were then milled in a hammer mill to produce flour and then sifted with kitchen sieve. The plantain flour obtained was packaged in polythene bag labeled and stored at room temperature until needed.

Preparation of Bambara nut flour: The bambara nuts was soaked in clean tap water for 24hours and dehulled manually. The seeds was then boiled for 10 minutes, (1:4 bambara nuts to water ratio) in a stainless steel pot as described by Barimalaa et al., and cited by Kiin-Kabari and Banigo[17]. Water was drained from the seeds and sun dried. The dried samples were milled using the hammer mill and sieved into flour using 0.25mm sieve and packaged until needed.

2.2. Preparation of Cocoyam - Plantain - Bambara nut and Wheat Composite Flour

Composite flour samples containing Wheat - Cocoyam - Plantain and Bambara nut flours were formulated by substituting cocoyam - plantain and bambara nut flour

[15]Orhevba, B. A. & Ndanaimi, Y. (2021). Proximate and Sensory Properties of Wheat-Cocoyam (Colocasia Esculenta) Composite Bread. *European Journal of Agriculture and Food Sciences,* 3 (2), 86. http://dx.doi.org/10.24018/ejfood.

[16]Arubayi, D. & Ogbonyomi, O. B. (2019). Recipe Development and Organoleptic Evaluation of Meat Pies Made from Plantain Composite Flour for Wealth Creation. *Food Sci Nutr Res. 2(1): 1-7.* http://www.openaccess.com

[17]Kiin-Kabari, D. B. & Banigo, E. B. (2015). Quality Characteristics of Cakes Prepared From Wheat and Unripe Plantain Flour Blends Enriched with Bambara Groundnut Protein Concentrate. *European Journal of Food Science and Technology; 3, (3), 1-10.* https://www.eajournals.org

with wheat flour at different ratios ($W_{85}C_5P_5B_5$ C1); ($W_{80}C_{10}P_5B_5$ C2); ($W_{70}C_{10}P_{10}B_{10}$ C3); ($W_{65}C_{10}P_{15}B_{10}$ C4); ($W_{55}C_{15}P_{15}B_{15}$ C5); ($W_{50}C_{15}P_{20}$-B_{15} C6) of wheat flour substitutions respectively. One hundred percent (100%) wheat flour ($W_{100}C_0P_0$-B_0) was used as the control. A total of seven different cake samples were formulated.

2.3. Measurement for Cocoyam, Plantain, and Bambara nut Composite Cake

Six composite cake samples (WCPB1–WCPB6) were formulated by substituting wheat flour with varying proportions of cocoyam, plantain, and bambara nut flours, while one sample (WF) served as the 100% wheat control. Substitution levels ranged from 5% to 20% among the composites. WCPB1 and WCPB2 contained the least substitution (5–10%), while WCPB3 and WCPB4 had moderate blends (10–15%). WCPB5 and WCPB6 had the highest substitution, incorporating up to 20% plantain flour. The blends maintained balanced ratios of cocoyam, plantain, and bambara nut flours, demonstrating a progressive reduction of wheat flour from 85% to 50% for improved nutrient enrichment.

2.4. Cake Recipe for Samples

Table1. Formulation of Cocoyam - Plantain - Bambara nuts - wheat composite cake

Ingredients	**Samples**						
Samples	**$WCPB_1$ (g)**	**$WCPB_2$ (g)**	**$WCPB_3$ (g)**	**$WCPB_4$ (g)**	**$WCPB_5$ (g)**	**$WCPB_6$ (g)**	**WF(100%) (g)**
Wheat flour	255	240	210	195	165	150	300
Cocoyam flour	15	30	30	45	45	45	nil
Plantain flour	15	15	30	30	45	60	nil
Bambara nut	15	15	30	30	45	45	nil
Margarine	250	250	250	250	250	250	250
Sugar	180	180	180	180	180	180	180
Eggs (large)	5	5	5	5	5	5	5
Lemon zest	15	15	15	15	15	15	15
Nutmeg	5	5	5	5	5	5	5
Vanilla extract	5ml	5ml	5ml	5ml	5ml	5ml	5ml

Baking powder	15	15	15	15	15	15	15
Salt	2	2	2	2	2	2	2

2.5. Equipments and tools needed to make cakes

The equipment and tools used for cake preparation included an oven, cake pans, kitchen scale, measuring cups and spoons, cake mixer, mixing bowls, sieve, egg whisk, and spatulas, all essential for accurate measurement, thorough mixing, and proper baking.

2.6. Method of cake preparation

Cakes were prepared following All Nigerian Recipes (2022) with slight modifications. Fat and sugar were creamed until fluffy, eggs whisked separately, and dry ingredients sifted and stirred. The oven was preheated to 220°C, and baking pans were greased and dusted. Whisked eggs and vanilla flavor were gradually added to the creamed mixture, followed by folding in dry ingredients. The batter was poured into pans and baked for 40 minutes until golden brown. Baked cakes cooled on racks for one hour before evaluation.

2.7. Nutritional Analysis

Nutritional analysis was conducted for all the cake samples in triplicates for replication of the data using Association of Official Analytical Chemists[18,19] AOAC method. These methods were used to determine the nutrition value, including moisture, protein, fat, ash and fibre. Carbohydrate value was obtained by difference (the sum of percentages of protein, fat, ash, fibre and moisture subtracted from 100%). Vitamins such as vitamin A, B2, and B12, Minerals such as calcium, iron, magnesium, phosphorus and zinc content were also analyzed.

2.8 Procedure for Percentage Moisture Determination in Samples (AOAC, 2015)

Materials: Convectional Oven, porcelain crucibles, analytical balance, spatula, desiccators' crucible tongue.

Procedure: Empty porcelain crucibles were oven-dried at 105 ± 5°C for 30 minutes, cooled in a desiccator, and weighed as W_0. Samples were blended into powder, and 2.00 g of each was placed in crucibles (W_1). They were oven-dried at 105 ± 5°C for four hours until constant weight, cooled again in a desiccator, and reweighed as W_2.

[18]Association of Official Analytical Chemist. (A.O.A.C, 2012). *Official methods of analysis of the association of official analytical chemist, (16th ed.)* Virginia, USA: Published by the Association of Official Analytical Chemist Arlington. http://scholargoogle.com

[19]Association of Official Analytical Chemists. (AOAC, 2015) *Official Methods of Analysis.* (18th ed.), Arlington, 806-814.

This procedure ensured accurate determination of moisture content through careful drying, cooling, and weighing at controlled temperatures and intervals.

Moisture content was calculated as:

$$\% \text{ moisture content} = \frac{(W_0 + W_1) - (W_0 + W_2)}{W_1} \times 100$$

2.9 Determinations of Protein according to Kjeldahl using Block Digestion and Steam Distillation

Protein determination followed the Kjeldahl method using block digestion and steam distillation. One gram of each powdered sample was weighed into 250 ml digestion tubes with Kjeltabs Cu 3.5 and 12 ml concentrated H_2SO_4. Samples were digested at 420°C for one hour, cooled, and diluted with 80 ml deionized water. Receiver solution (25–30 ml) was added to a conical flask, and 50 ml of 40% NaOH was dispensed for distillation lasting five minutes. The distillate was titrated with standardized 0.1 N or 0.2 N HCl until a blue-grey endpoint appeared, recording the acid volume used.

Calculation of crude protein

$$\% \boldsymbol{Protein} = \frac{(T - B) \, X \, N \, X \, 14.007 \, X \, 100}{\text{W1 (mg)}} \text{X F}$$

$$\boldsymbol{gN/L} = \frac{(T-B) \, X \, N \, X \, 14.007}{\text{Volume sample (ml)}}$$

Keys

W_1 = *Sample weight (mg)*
T = *Titration volume of sample (ml)*
B = *Titration volume of blank (ml)*
N = *Normality of acid to 4 decimal places*
F = *Conversion factor for nitrogen to protein = 6.25 for food & feeds*
gN/l = *Gram Nitrogen per Liter*
14.007 = Molecular weight of Nitrogen

2.10 Determination of Fat content

Fat content determination followed the AOAC (2012) standard method using a Soxhlet extractor with a reflux condenser and a 500 ml round-bottom flask. Two grams of each sample were weighed into labeled thimbles, and 300 ml of petroleum ether was added as the solvent. The extraction thimble was sealed with cotton wool, and the apparatus was allowed to reflux for six hours. After extraction, the petroleum ether was drained for reuse. The flask was oven-dried at 105°C for one hour, cooled in a desiccator, and weighed to determine fat content.

Calculation:

$$\% \, fat \ content = \frac{Weight \ of \ fat}{\text{Weight of sample}} X \ 100$$

2.11 Determination of Ash Content

Ash content determination followed the AOAC (2010) standard method using a muffle furnace and other laboratory tools. Clean crucibles were oven-dried at 130 ± 15°C for 30 minutes, cooled in a desiccator, and weighed as W_0. One gram of each powdered sample, prepared with a Cyclotec, was placed into crucibles, and the combined weight (W_1) recorded. Samples were first charred on a Bunsen flame, then incinerated in a muffle furnace at 550°C for two hours until white or light grey ash appeared. Crucibles were cooled in a desiccator and reweighed as W_2.

The ash content was calculated mathematically as follows:

$$\% \, \boldsymbol{ASH \ content} = \frac{(\text{W2 – W0})}{\text{W1}} \text{X } 100$$

2.12 Determination of Crude Fibre

Crude fibre determination was carried out using the Fibretec Hot and Cold Extraction Units following standard laboratory procedures. Fritted crucibles were pre-dried at 130 ± 2°C for 30 minutes, and 1 g of Celite 545 with 1 g of each sample was weighed into the crucible. A 1.25% H_2SO_4 solution was heated, and 150 ml was added to each column with 2–4 drops of n-Octanol, boiled moderately, cooled, and filtered. Samples were washed thrice with hot deionized water, dried, and later treated with 150 ml of preheated 1.25% NaOH in the cold extraction unit for fibre analysis.

2.13Fibretec Cold Extraction Procedure

25ml acetone was added to each crucible. Solvent were extracted and filtered out by placing the valve in 'VACUUM' position. This was repeated three times and stand at room temperature until the acetone has evaporated for 2hours at 130 ± 2^0C. The crucibles were cooled to room temperature in a desiccator and weigh to 0.1mg. The samples were ash in the crucibles at least 3 hours at 525 ± 15^0C and cooled slowly to room temperature in a desiccator and weigh accurate to 0.1mg. % Crude Fibre content was calculated as:

$$\% \, Crude \ Fibre = \frac{\text{W2 – (W3 + C)}}{\text{W1}} \text{X } 100$$

Key: W_1 = Sample weight (g)

W_2 = *Crucible + residue weight after drying (g)*
W_3 = *Crucible + residue weight after ashing (g)*
C = Blank

2.14 Determination of Carbohydrates
Carbohydrates = 100- the sum of percentages of protein, fat, ash, fibre and moisture
Spectrophotometric Determination of Vitamin A (Retinol)

Method: TCA Spectrophotometric method

Material: UV visible spectrophotometer, Water bath, Amber coloured bottles, Flasks (various capacities), Automatic pipettes
Reagent/Solvent
Vitamin A Standard: Vitamin A acetate, Chloroform CHCl3, Trichloroacetic acid TCA
Reagent Preparation
Standard (Vitamin A Acetate): About 5mg of vitamin A acetate was weighed and dissolved in100ml of chloroform; TCA Reagent (30%): Before use, the reagent was warmed to room temperature (24 degree C) and appreciable amount transferred to a pipette dispensable bottle for use

Calibration Curve of Retinol Standard was prepared on each day of analysis using chloroform. For each of the known concentration of standard, 1ml was pipetted into 1cm spectrophotometer quartz glass cuvette. 1ml of chloroform was immediately added and absorbance taken within at 620nm in a spectrophotometer. A standard graph of absorbance versus concentration was plotted to obtain a straight-line graph.

Sample Extraction & Analysis
1. 1g of well prepared (homogenous) sample was weighed into a conical flask
2. Known volume of chloroform was added and stopper and agitate severally at intervals for about 15 to 30mins. The volume used for extraction was recorded
3. After separation, an aliquot (2ml) of the solvent extract was carefully pipetted into a 1cm spectrophotometer quartz glass cuvette
4. Equal volume (same volume as volume of aliquot of sample extract pipette to be analyzed) of TCA was added in chloroform and absorbance read immediately within 5 to 7 sec at 620nm in a spectrophotometer

Calculation:

Conc. of Vitamin A (mg/kg) = $\frac{mg/l \times V \times DF}{W \times V_a}$

mg/l = Conc. Reading obtained for sample from the standard graph
V = Total volume of extract (volume of chloroform used in sample extraction)
DF: Dilution factor (if diluted for reading on spec)
W = Weight of sample
V_a = Volume of aliquot analyzed.

Determination of Vitamin B_1 (Thiamin)

1. 1.000g of the sample was homogenized with 50ml ethanoic sodium hydroxide (preparation of ethanolic sodium hydroxide: 4.2g sodium hydroxide dissolved in 5ml of distilled water and then made up to 1000ml with ethanol).
2. The solution was allowed to stand in a tightly stoppered bottle for 24hrs after which the upper clear solution was decanted into another suitable bottle (the clear solution was used for analysis: that is the 50ml ethanolic sodium hydroxide is taken from the clear solution).
3. It (sample homogenized with 50ml ethanolic sodium hydroxide) was filtered into another flask and color was develop by addition of 10ml of 1% or 0.1N potassium dichromate.
4. The resultant solution was incubated at room temperature for 15min and the absorbance was read at 360nm. A blank solution was also prepared.

Thiamin (mg/l) = $\frac{\text{Abs sample} \times \text{Conc of standard}}{\text{Abs of standard}}$

Thiamin (mg/kg) = $\frac{mg/l \times \text{total Volume of solvent for extraction} \times DF}{\text{Sample wt} \times \text{vol of aliquot analyzed}}$

Absorbance of 0.40mg/l vitamin B1 standard = 0.12

2.15 Determination of Vitamin B12 (Cyanocobalamin)

1. 1mg of vitamin B12 was accurately weighed into 25ml volumetric flask.
2. 10ml of distilled water was added and shaked vigorously to dissolve.
3. 1g of sample was weighed into 25 ml volumetric flask and 10 ml of water was added to dissolve.
4. For both standard and sample, 1.25 gm of dibasic sodium phosphate, 1.1 gm of anhydrous citric acid and 1.0 gm of sodium metabisulphate was added.
5. The volume was made up to the mark (25ml) with water.
6. The solution was heated for 10 minutes. Filter and absorbance recorded at 530 nm against blank of sample as well as standard.

2.16 Minerals were determined using the Spectrophotometric Determination AOAC (2010) analytical procedures for minerals and heavy metals
Wet Digestion and AAS Determination

1. 1g of each sample were weighed into a conical flask, 10ml of H_2SO_4 and 30 ml of nitric acid were added and placed on a hot plate in a fume cupboard and digested until the digest becomes clear

2. It was diluted to 100ml and taken to AAS for metal and heavy metal determination

Dry Ashing Method:
1. 2g of dry sample was weighed into a porcelain crucible and ash at 550 ^{0}c for 3hrs.
2. crucibles were allowed to cool and the ash was dissolved with 100ml of 3N HCl then store in a plastic bottle with a plastic cap and taken to AAS for readings

2.17 Spectrophotometric Determination
In the Atomic Absorption Spectrophotometer (AAS), lamp for corresponding mineral or heavy metal was placed and the wavelength set (Calcium Ca 422.8nm, Magnesium Mg 285.20nm, Iron Fe 248.30nm, Zinc Zn 213.90nm, and Potassium K 766.50nm) specific for the metal to be determined. The AAS siphoning hose was placed into the digested sample after running the standards for the metal determined. The concentration of the metal in the solution was displayed on the screen of the AAS machine.

3.18. Method of Data Analysis
Data obtained from the scores of the nutritional composition, sensory and shelif life evaluations were analyzed using Mean (x) scores and Standard Deviations (SD) for the research questions. Statistical analysis was performed using Analysis of variance (ANOVA) for the hypotheses. Duncan Multiple Range Test was used for mean (x) separation and to ascertain the level of significant difference, using Statistical Package for Social Sciences (SPSS) version 27. The least significant difference (LSD) of means (x) was accepted at the level of $p\leq 0.05$.

3. Results

Research question 1: What are the amount of vitamins A, B1 amd B12 value present in composite samples fortified with cocoyam, plantain, bambara nuts in the ratio of 5:5:5:85; 10:5:5:80; 10:10:10:70; 10:15:10:65: 15:15:15:55. 15:20:15:50 (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and 100% wheat cake (WF)?

Table 2: Mean (x) of Vitamin composition of cake samples

Samples **Parameters** (mg/100g)

	Vitamin A	Vitamin B1	Vitamin B12
WCPB1	1.786 (± 0.015)c	0.284 (±0.059)a	0.012 (±0.000)a
WCPB2	1.960 (±0.008)ab	0.295 (±0.060)a	0.012 (±0.000)a
WCPB3	1.983(±0.007)a	0.395 (±0.001)a	0.013 (±0.000)a
WCPB4	1.961 (±0.021)ab	0.487 (±0.004)a	0.015 (±0.000)a
WCPB5	1.972 (±0.017)a	0.438 (±0.232)a	0.017 (±0.000)a
WCPB6	1.887 (±0.045)b	0.446 (±0.232)a	0.016 (±0.000)a
WF	0.987 (0.142)d	0.235 (±0.006)a	0.011 (±0.000)a

Mean (x) *and standard deviation of triplicate determination of vitamin analysis result*

**Samples with different superscripts within the column are significantly different Duncan's multiple test (P<0.05).*

Key:

WCPB1 (5% cocoyam, 5% plantain, 5% bambara nuts / 85% wheat flour) cake
WCPB2 (10% cocoyam, 5% plantain, 5% bambara nuts / 80% wheat flour cake)
WCPB3 (10% cocoyam, 10% plantain, 10% bambara nuts / 70% wheat flour) cake
WCPB4 (10% cocoyam, 15% plantain, 10% bambara nuts / 65% wheat flour) cake
WCPB5 (15% cocoyam, 15% plantain, 15% bambara nuts / 55% wheat flour) cake
WCPB 6 (15% cocoyam, 20% plantain, 15% bambara nuts / 50% wheat flour) c
WF (100% wheat flour cake) which serves as the control.

Table 3:Mean (x) Vitamin A for all the cake sample (mg/100 g)

Samples	N	Sum	Mean(x)	Std Deviation
WCPB1	3	5.357	1.786^{c}	0.015
WCPB2	3	5.880	1.960^{ab}	0.008
WCPB3	3	5.950	1.983^{a}	0.007
WCPB4	3	5.884	1.961^{ab}	0.021
WCPB5	3	5.917	1.972^{a}	0.017
WCPB6	3	5.662	1.887^{b}	0.045
WF	3	2.962	0.987^{d}	0.142
Sum	21	37.612	1.791	0.343

Values are means (x) ± standard deviation of triplicate determination. Values in the same column with different superscript are significantly different.(p ≤ 0.05)

Vitamin A mean value ranged between 0.987 (±0.142) and 1.983 (±0.007). Table 2: revealed that WCPB3 had the highest vitamin A value with a mean (x) score of 1.983 (±0.007) while the control (WF) had the least value of 0.987 (±0.142). WCPB1 mean (x) score was 1.786 (±0.015). WCPB2 had 1.960 (±0.008), WCPB4 mean value was 1.961 (±0.021). WCPB5 and WCPB6 mean (x) value was 1.972 (±0.017) and 1.887 (±0.045).

HO_1: There is no significant difference in the value of vitamins present in each composite sample (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and 100% wheat cake (WF)

Table 3: ANOVA for Vitamin A content of all the cake samples

Vitamin A	Sum of Squares	df	Mean (x) Square	F	Sig.	Decision
Between Groups	2.348	6	0.391	2572.046	0.000	reject
Within Groups	0.002	14	0.000			
Total	2.350	20				

**The null hypothesis of no significant difference in the mean of* Vitamin C *of cake samples was rejected at P ≤ 0.05*

The result in table 3 shows that the F- value of Vitamin A was 2572.046 while the significant difference was 0.000. This implies that there is significant difference at P≤ 0.05 level in Vitamin A content among the cake samples. Therefore, the null hypothesis was rejected. The Duncan Multiple Range Test highlighted that WF (control) was significantly different from all the composite cake samples at P≤ 0.05. The test also showed that WCPB2 was significantly different from WCPB1, WCPB3, WCPB6 and WF (control); hence the hypothesis here was rejected at P≤0.05 level. WCPB3 differ significantly from WCPB1, WCPB2, WCPB4, WCPB6 and the control. WCPB4 was not significantly different from WCPB2 and WCPB5 but differ from WCPB1, WCPB3, WCPB6 and WF. WCPB5 differ significantly from WCPB1, WCPB6 and WF, but does not differ from WCPB2, WCPB3 and WCPB4. There was also significant difference between WCPB6 and all the composite samples including the control. Therefore, the null hypothesis was rejected.

Table 4:Mean (x) Vitamin B1 for all the cake sample

Samples	N	Sum	Mean (x)	Std Deviation
WCPB1	3	0.853	0.284[a]	0.059
WCPB2	3	0.885	0.295[a]	0.060
WCPB3	3	1.186	0.395[a]	0.001
WCPB4	3	1.462	0.487[a]	0.004
WCPB5	3	1.315	0.438[a]	0.232
WCPB6	3	1.339	0.446[a]	0.232
WF	3	0.705	0.235[a]	0.006
Sum	21	7.745	0.368	0.144

Values are means (x) ± standard deviation of triplicate determination. Values in the same column with different superscript are significantly different.(p ≤ 0.05)

Vitamin B12 means (x) as shown on Table 4: ranged between 0.235 (±0.006) and 0.487 (±0.004). WF (control) had the lowest vitamin B1 content with a mean (x) value of 0.0235 (±0.006), while WCPB4 had the higher content of vitamin B12 among all the cake samples with a mean (x) score of 0.487 (±0.004). WCPB1 mean (x) value was 0.284 (±0.59), while WCPB2 was 0.295 (±0.060). WCPB3 had a mean (x) value of 0.395

(±0.001), WCPB5 had a mean (x) value of 0.438 (±0.232), while WCPB6 mean (x) value was 0.446 (±0.232).

Table 5: ANOVA for Vitamin B1 value of all the cake samples

Vitamin B1	Sum of Squares	df	Mean (x) Square	F	Sig.	Decision
Between Groups	0.168	6	0.028	1.576	0.226	accept
Within Groups	0.249	14	0.018			
Total	0.417	20				

**The null hypothesis of no significant difference in the mean of* Vitamin B1 *of cake samples was accepted at P ≤ 0.05*

The result in table shows that the F- value of the Vitamin B1 was 1.576 while the significance difference was 0.226, showing no significant difference at P≤ 0.05 level in Vitamin B1 content among the cake samples. Therefore the null hypothesis of no significant difference was accepted at P≤ 0.05.

Table 6: Mean (x) of Vitamin 12 for all the cake sample (mg/100 g)

Samples	N	Sum	Mean (x)	Std Deviation
WCPB1	3	0.035	0.012[a]	0.000
WCPB2	3	0.037	0.012 [a]	0.000
WCPB3	3	0.040	0.013 [a]	0.000
WCPB4	3	0.045	0.015 [a]	0.000
WCPB5	3	0.051	0.017[a]	0.000
WCPB6	3	0.047	0.016 [a]	0.000
WF	3	0.033	0.011 [a]	0.000
Sum	21	0.287	0.014	0.000

Values are means (x) ± standard deviation of triplicate determination. Values in the same column with different superscript are significantly different.(p ≤ 0.05)

The result in table 5: shows that vitamin B12 means (x) ranged between 0.011 (±0.00) and 0.017 (±0.00). 0.017 (±0.00). WF (control) had the lowest vitamin B12 content with a mean (x) value of 0.011 (±0.00). WCPB5 had the highest content of vitamin B12 among all the cake samples with a mean (x) score of 0.051. WCPB1 mean (x) value was 0.012 (±0.00), while WCPB2 was 0.012 (±0.00). WCPB3 had a mean (x) value of 0.013 (±0.00), WCPB4 had a mean (x) value of 0.015 (±0.00), while WCPB6 mean (x) value was 0.016 (±0.00).

Table 7: ANOVA for Vitamin B12 value of all the cake samples

Vitamin B12	Sum of Squares	df	Mean (x) Square	F	Sig.	Decision
Between Groups	0.000	6	0.000	0.16	1.000	accept
Within Groups	0.000	14	131.365			

Total	0.000	20				

**The null hypothesis of no significant difference in the mean (x) of vitamin B12 value of cake samples was accepted at P ≤ 0.05*

The result in table 7 revealed that the F- value of the Vitamin B12 was 0.16 while the significance difference was 1.000, meaning that there is no significant difference at P≤ 0.05 level in Vitamin B12 content among the cake samples. Therefore, the null hypothesis of no significant difference was accepted at P≤ 0.05.

Mineral profile

Research question 2: What are the values of minerals (calcium, iron, phosphorus, magnesium and zinc) present in composite cake fortified with cocoyam, plantain, bambara nuts in the ratio of 5:5:5:85; 10:5:5:80; 10:10:10:70; 10:15:10:65: 15:15:15:55. 15:20:15:50 (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and 100% wheat cake (WF)?

Table 8: Mean (x) Mineral composition of all the cake samples

Samples	Parameters (%) Calcium (mg/100g)	Iron (mg/100g)	Magnesium (mg/100g)	Phosphorus (mg/100g)	Zinc (mg/100g)
WCPB1	55.435 (±2.019)a	3.628 (± 0.151)c	17.924 (±0.139)c	64.913 (±0.980)e	1.798 (±0.104)b
WCPB2	62.435 (±0.669)c	3.851 (±0.003)bc	18.818 (±0.136)bc	65.989 (±0.989)de	1.798 (±0.051)b
WCPB3	64.457 (±0.153)ab	3.871 (±0.004)b	19.389 (±0.045)b	66.743 (±1.185)d	1.821 (±0.002)b
WCPB4	64.088 (±0.728)bc	3.922 (±0.004)ab	19.884 (±0.071)ab	71.887 (±0.412)b	1.823 (±0.012)b
WCPB5	67.928 (±0.189)a	3.949 (±0.003)a	19.712 (±0.015)ab	70.157 (±0.051)c	1.918 (±0.071)a
WCPB6	66.803 (±1.137)a	3.971 (±0.014)a	20.676 (±0.523)a	74.066 (± 0.572)a	1.806 (±0.051)b
WF	34.225 (±0.677)e	2.884 (±0.088)d	16.285 (±0.260)d	60.730 (±0.920)f	1.571 (±0.006)c

Values are means (x) ± standard deviation of triplicate determination. Values in the same column with different superscript aerate significantly (p ≤0.05)

Key:

WCPB1 (5% cocoyam, 5% plantain, 5% bambara nuts / 85% wheat flour) cake
WCPB2 (10% cocoyam, 5% plantain, 5% bambara nuts / 80% wheat flour cake)
WCPB3 (10% cocoyam, 10% plantain, 10% bambara nuts / 70% wheat flour) cake
WCPB4 (10% cocoyam, 15% plantain, 10% bambara nuts / 65% wheat flour) cake
WCPB5 (15% cocoyam, 15% plantain, 15% bambara nuts / 55% wheat flour) cake
WCPB6 (15% cocoyam, 20% plantain, 15% bambara nuts / 50% wheat flour) c
WF (100% wheat flour cake) which serves as the control

Table 9: Mean (x) of Calcium for all the cake sample (mg/100 g)

Samples	N	Sum	Mean (x)	Std Deviation
WCPB1	3	166.299	55.435^{d}	2.019

WCPB2	3	187.305	62.435 [c]	0.669
WCPB3	3	195.371	65.457[ab]	0.153
WCPB4	3	192.264	64.088[bc]	0.728
WCPB5	3	203.784	67.928[a]	0.189
WCPB6	3	200.408	66.803 [a]	1.137
WF	3	102.674	34.225 [e]	0.677
Sum	21	1249.105	59.481	11.288

Values are means (x) ± standard deviation of triplicate determination. Values in the same column with different superscript are significantly different.(p ≤ 0.05)

The Calcium content of all the cake samples are highlighted in Table 9. The table shows that the mean (x) value of calcium ranged between 34.225 (±0.667) and 67.928 (±0.189). the sample WCPB5 calcium value was higher than all the cake samples with a mean (x) value of 67.928 (±0.189). WF (control) had the least calcium mean (x) value of 34.225 (±0.677). WCPB1 mean (x) value was 55.435 (±2.019), WCPB2 had 62.435 (±0.669). WCPB3 had a mean calcium value of 65.457 (±0.153) WCPB4 and WCPB6 mean (x) value was 64.088 (±0.728) and 66.803 (±1.137) respectively.

HO_2: There is no significant difference in the value of minerals present in composite cake fortified with cocoyam, plantain, bambara nuts in the ratio of 5:5:5:85; 10:5:5:80; 10:10:10:70; 10:15:10:65; 15:15:15:55; 15:20:15:50; (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and 100% wheat cake (WF).

Table 10: ANOVA for Calcium value of all the cake samples

Calcium	Sum of Squares	df	Mean (x) Square	F	Sig.	Decision
Between Groups	2534.671	6	422.445	430.520	0.000	reject
Within Groups	13.737	14	0.981			
Total	2548.409	20				

**The null hypothesis of no significant difference in the mean (x) of Calcium value of cake samples was rejected at P ≤ 0.05*

The result in table 10: revealed that the F- value for Calcium was 430.520, while the significance difference was 0.000, meaning that there was significant difference at P≤ 0.05 level in calcium content among the cake samples. Therefore, the null hypothesis of no significant difference was rejected at P≤ 0.05. The Duncan Multiple Range Test showed that the control (WF) was significantly different from all the samples in calcium content. Therefore, the null hypothesis was rejected at P≤ 0.05 level. The test also highlighted that WCPB1 differs significantly from all the composite samples including the control at P≤ 0.05 level, hence the hypothesis here was rejected. There was no significant difference between WCPB2 and WCPB4, but WCPB2 calcium value differs significantly from the rest of the samples including the control at P≤ 0.05. Therefore, the null hypothesis was rejected. WCPB3 was not significantly different from WCPB4 and WCPB6 but differs from WCPB1, WCPB2, WCPB5 and WCPB6 at P≤ 0.05. WCPB4 was not significantly difference WCPB2 and WCPB3. There was no significant difference between sample WCPB5 and WCPB6, but both samples differs significantly from the rest of the samples. Therefore, the null hypothesis was rejected at P≤ 0.05 level.

Table 11: Mean (x) of Iron for all the cake sample (mg/100 g)

Samples	N	Sum	Mean (x)	Std Deviation
WCPB1	3	10.885	3.628^{c}	0.151
WCPB2	3	11.554	3.851^{bc}	0.003
WCPB3	3	11.613	3.871^{b}	0.044
WCPB4	3	11.767	3.922^{ab}	0.004
WCPB5	3	11.846	3.949^{a}	0.003
WCPB6	3	11.912	3.971^{a}	0.014
WF	3	8.652	2.884^{d}	0.088
Sum	21	78.229	3.725	0.369

Values are means (x) ± standard deviation of triplicate determination. Values in the same column with different superscript are significantly different.(p ≤ 0.05)/

The Iron content of all the cake samples is presented in Table 11. The table highlighted that the means (x) value of Iron ranged between 2.884 (±0.088) and 3.971 (±0.014). WCPB6 had the higher value of Iron than all the cake samples with a mean (x) value of 3.971 (±0.014). WF (control) had the least Iron mean (x) value of 2.884 (±0.088). WCPB1 mean (x) value was 3.628 (±0.151), WCPB2 had 3.851 (±0.003). WCPB3, WCPB4 and WCPB5 mean (x) value was 3.871 (±0.044), 3.922 (±0.004) and 3.949 (±0.003) respectively.

Table 12: ANOVA for Iron value of all the cake samples

Iron	Sum of Squares	df	Mean (x) Square	F	Sig.	Decision
Between Groups	2.710	6	0.452	307.976	0.000	reject
Within Groups	0.21	14	0.001			
Total	2.730	20				

**The null hypothesis of no significant difference in the mean (x) of Iron value of cake samples was rejected at P ≤ 0.05*

The F value of Iron as indicated in Table 12: was 307.976, while the significance difference was 0.000, which means that there is significant difference among the cake samples. Therefore the null hypothesis of no significant difference was rejected at P≤ 0.05. The Duncan Multiple Range Test shows that the control (WF) was significantly different from all the composite sample in iron content at P≤

0.05 level; hence the null hypothesis of no significant difference was rejected at P≤ 0.05 level.

The table also indicates that WCPB1 was significantly different in Iron content than all the composite cake samples including the control; hence the hypothesis was rejected at P≤0.05. WCPB2 was not significantly different from WCPB3, but differ from the rest of the samples at P≤0.05. WCPB3 does not differ from WCPB2 and WCPB4 at P≤0.05, but differ significantly from WCPB1, WCPB5, WCPB6 and WF at P≤0.05. Sample WCPB4 differ significantly from WCPB1, WCPB2 and the control but no significant difference with WCPB3, WCPB5 and WCPB6. Sample WCPB5 and WCPB6 were not significantly different from WCPB4, but were differ significantly with WCPB1, WCPB2, WCPB3 and the control. Therefore, the null hypothesis was rejected at P≤0.05 level.

Table 13: Mean (x) of Magnesium for all the cake sample (mg/100 g)

Samples	N	Sum	Mean (x)	Std Deviation
WCPB1	3	53.771	17.924[c]	0.139
WCPB2	3	56.454	18.818[bc]	0.136
WCPB3	3	58.166	19.389 [b]	0.045
WCPB4	3	59.532	19.844[ab]	0.071
WCPB5	3	59.135	19.712[ab]	0.015
WCPB6	3	62.028	20.676 [a]	0.523
WF	3	48.856	16.285 [d]	0.260
Sum	21	397.942	18.950	1.395

Values are means (x) ± standard deviation of triplicate determination. Values in the same column with different superscript are significantly different.(p ≤ 0.05)

The results in Table 13: indicated that the value of magnesium means (x) ranged between 16.285 (±0.260) and 20.676 (±0.532). WCPB6 had the higher content of magnesium among all the cake samples with a mean (x) score of 20.676 (±0.523). WF (control) had the lowest magnesium mean (x) value of 16.285 (±0.260). WCPB1 magnesium mean (x) value was 17.924 (±0.139), WCPB2 mean value was 18.818 (±0.136). WCPB3 mean (x) value was 19.383 (±0.045), WCPB4 and WCPB5 mean (x) value was 19.844 (±0.071) and 19.712 (±0.015).

Table 14: ANOVA for Magnesium value of all the cake samples

Magnesium	Sum of Squares	df	Mean (x) Square	F	Sig.	Decision
Between Groups	38.166	6	6.361	115.453	0.000	reject
Within Groups	0.771	14	0.55			
Total	38.938	20				

**The null hypothesis of no significant difference in the mean (x) of Magnesium value of cake samples was rejected at P ≤ 0.05.*

The result in Table 14: shows that magnesium F value was 115.453, while the significance difference was 0000, which means that there is significant difference at P≤ 0.05 level in magnesium content among the cake samples. Therefore the null hypothesis of no significant difference was rejected at P≤ 0.05. The Duncan Multiple Range Test shows that the control (WF) was significantly different from all the composite sample in magnesium content at P≤ 0.05 level; hence the null hypothesis of no significant difference was rejected at P≤ 0.05 level.

The sample WCPB1 differs significantly from all the composite cakes including the control; hence the hypothesis was rejected at P≤ 0.05 level. WCPB2 shows significant difference with all the cake samples in magnesium content. Therefore the null hypothesis was also rejected at P≤ 0.05 level. WCPB3 and WCPB4 were significantly different from the entire cake sample except WCPB5. Sample WCPB5 was not significantly different from WCPB3 and WCPB4, but differ significantly from the rest of the samples at P≤ 0.05 level. The sample WCPB2 differ significantly from all the composite samples including WF (control); hence the hypothesis was also rejected at P≤ 0.05 level.

Table 15: Mean (x) of Phosphorus for all the cake sample (mg/100 g)

Samples	N	Sum	Mean (x)	Std Deviation
WCPB1	3	194.739	64.913[e]	0.980
WCPB2	3	194.968	65.989[de]	0.998
WCPB3	3	200.228	66.743[d]	1.185
WCPB4	3	215.630	71.877[b]	0.417
WCPB5	3	210.473	70.157[c]	0.051
WCPB6	3	222.198	74.066[a]	0.572
WF	3	182.191	60.730[f]	0.920
Sum	21	1423.27	67.782	4.356

Values are means (x) ± standard deviation of triplicate determination. Values in the same column with different superscript are significantly different.(p ≤ 0.05)

The result in Table 15: shows the mean value of phosphorus of all the cake samples. The table indicated that the means (x) ranged between 60.730 (±0.920) and 74.066 (±0.572). WCPB6 had the highest phosphorus value among all the cake samples with a mean (x) score of 74.066 (±0.572). The sample WF (control) had the least mean value of phosphorus of 60.730 (±0.920). WCPB1 phosphorus mean (x) value was 64.913 (±0.980) while WCPB2 mean value was 65.989 (±0.998). WCPB3, WCPB4 and WCPB5 mean (x) value was 66.743 (±1.185), 71.877 (±0.417) and 70.157 (±0.051).

Table 16: ANOVA for Phosphorus value of all the cake samples

Phosphorus	Sum of Squares	df	Mean (x) Square	F	Sig.	Decision
Between Groups	372.449	6	6.361	122.392	0.000	reject
Within Groups	7.101	14	0.507			
Total	379.550	20				

**The null hypothesis of no significant difference in the mean* (x) *of phosphorus value of cake samples was rejected at P ≤ 0.05.*

The result in Table 16: revealed that phosphorus F value was 122.392, while the significance difference was 0000, this shows that there is significant difference at P≤ 0.05 level in phosphorus mean value among the cake samples. Therefore the null hypothesis of no significant difference was rejected at P≤ 0.05. The Duncan multiple Range test shows that the phosphorus value of the control (WF) differ significantly from the composite samples at P≤ 0.05 level. Therefore, the null hypothesis of no significant difference was rejected at P≤ 0.05 level.

The Duncan Multiple Range Test showed that the sample WCPB1 was significantly different from all the samples except WCPB2; hence the hypothesis was rejected at P≤ 0.05. WCPB2 was not significantly different from WCPB1 and WCPB3 but differ from the rest of the samples including the control at P≤ 0.05. Samples WCPB4, WCPB5, and WCPB6 were significantly different from the rest of the samples at P≤ 0.05. Therefore, the null hypothesis was rejected.

Table 17: Mean (x) of Zinc for all the cake sample (mg/100 g)

Samples	N	Sum	Mean (x)	Std Deviation
WCPB1	3	5.395	1.798^{b}	0.104
WCPB2	3	5.393	1.798^{b}	0.051
WCPB3	3	5.462	1.821^{b}	0.002
WCPB4	3	5.479	1.823^{b}	0.012
WCPB5	3	5.753	1.918^{a}	0.071
WCPB6	3	5.420	1.806^{b}	0.051
WF	3	4.712	1.571^{c}	0.006
Sum	21	37.612	1.791	0.105

Values are means (x) ± standard deviation of triplicate determination. Values in the same column with different superscript are significantly different.(p ≤ 0.05)

The result in Table 17: revealed that the means (x) value of zinc ranged between 1.571 (±0.006) and 1.918 (±0.071). The sample WCPB5 had the higher zinc content among all the cake samples with a mean (x) value of 1.918 (±0.071). WF (control) had the least zinc mean (x) value of 1.571 (±0.006). WCPB1 mean (x) value was 1.798 (±0.104), WCPB2 mean value was 1.798 (±0.051). WCPB3 zinc mean (x) value was 1.821 (±0.002), WCPB4 and WCPB6 mean (x) value was 1.823 (±0.012) and 1.806 (±0.051).

Table 18: ANOVA for Zinc value of all the cake samples

Phosphorus	Sum of Squares	df	Mean (x) Square	F	Sig.	Decision
Between Groups	0.201	6	0.034	22.499	0.000	reject
Within Groups	0.021	14	0.001			
Total	0.222	20				

**The null hypothesis of no significant difference in the mean (x) of zinc value of cake samples was rejected at $P \leq 0.05$.*

The result in Table 18: shows that zinc F value was 22.499, while the significance difference was 0000, this shows that there is significant difference at P≤ 0.05 level in zinc mean value among the cake samples. Therefore, the null hypothesis of no significant difference was rejected at P≤ 0.05. Duncan Multiple Range Test shows that the phosphorus value of the control (WF) was significantly different from the entire composite samples at P≤ 0.05 level. Therefore, the null hypothesis of no significant difference was rejected at P≤ 0.05 level.

The Duncan Multiple Range Test showed that WCPB1, WCPB2, WCPB3 and WCPB4 were not significantly different from all the samples except WCPB5 and WF; hence the hypothesis was rejected at P≤ 0.05. The sample WCPB5 was significantly different from from the rest of the samples including the control at P≤ 0.05. The sample WCPB6 was significantly different from the rest of the samples except WCPB5 and WF at P≤ 0.05. Therefore, the null hypothesis was rejected.

Discussion

Vitamins profile of cakes samples

Findings of the Vitamin analysis results showed that there was increase in Vitamin A content as substitution increased in composite cake samples. WCPB3 (cake sample with 10% cocoyam 10% plantain and 10% bambara nut) had the highest content of vitamin A, while WF (the control) had the least vitamin A content. Vitamin A helps in the formation and maintenance of healthy teeth, bones, soft tissue, normal vision, integrity of epithelial cells (mucous membranes and skin), reproduction, embryonic development, growth and immune response[20]. Vitamin A is critical to support the rapid development and growth that happens during adolescence.

Finding of the result of Vitamin B1 (thiamin) analysis revealed that the value increased as cocoyam, plantain and bambara nut flours increased. The control sample (100% wheat flour cake) had the smallest amount of vitamin B1 as shown in table 4.3.3 while the WCPB4 (10% cocoyam, 15% Plantain and 10% bambara nut substitution) had the highest vitamin B1 content. Thiamin is a component of a

[20]Carpenter, K. & Baigent, M. J. (2023). *Chemical compound: Vitamin*. Encyclopedia of Food and Culture. https://www.britannica.com/vitamin

coenzyme in carbohydrate metabolism; it supports normal nerve function helps the body cells change carbohydrates into energy and also essential for heart function and healthy nerve cells[21].

Finding of the result of Vitamin B12 as shown on table 4.3.0 revealed that all the composite cake samples had no significant difference with control at $P \leq 0.05$. the result also showed that the control had the least value of vitamin B12, while WCPB5 (cake sample with 15% cocoyam 15% plantain and 15% bambara nut substitution) had the highest content of vitamin B12 among all the cake samples. The result of this study is similar to that obtained by Ibeanu et al.[22] who reported increase in vitamin B12 in cake produced from plantain flour than hundred percent wheat cake (control). Vitamin B12 is important for metabolism; it helps form red blood cells and maintains the central and peripheral nervous system.

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[21]Encyclopaedia Britannica (2024). *Adolescemts.*https://www.britannica.com/science/adolescent.

[22]Ibeanu, V. N., Edeh, C. G. & Ani, P. N. (2022). Evidence-based strategy for prevention of hidden hunger among adolescents in a suburb of Nigeria. *BMC Public Health, 20:1683.* https://doi.org/10.1186/s12889-020-09729-8

Mineral profile of cakes samples

Minerals are essential micronutrient for adolescents' musculoskeletal system as well as for numerous biological functions. Findings from the results of the mineral composition in table 4.4.0 showed there is significant difference ($P>0.05$) in calcium, iron, phosphorus, magnesium and zinc in all the composite cakes and the control. The increase in mineral contents in composite cake samples implies that cocoyam, plantain, and bambara nut could be effectively used to improve mineral contents of cake and other adolescents snack for higher nutritional value.

Findings of the results on mineral analysis of calcium highlighted that the calcium content, increased with increase in fortificant. Composite cake WCPB5 (15% cocoyam, 15% plantain and 15% bambara nut flour substitution) had the highest calcium content while the WF (control) had the least calcium content. All the cake samples differ significantly in calcium content from the control (WF). The result obtained was similar to Ezeocha et al.[23] who also reported increase in calcium content as bambara nut and tamarind substitution increased. Consumption of calcium rich snacks by adolescent will help the muscles and blood vessels contract and expand. It will also help in the release of hormones and enzymes that affect almost every function in the human body[24].

Findings on Iron analysis as highlighted in table 4.4.0: shows that the composite cake increased in iron value as compared to the control (100% wheat cake). Findings also indicated that there was significant difference among all the composite samples in Iron content when compared with the control at $P\leq 0.05$ level. Finding also indicated that WCPB6 (cake made from 15% cocoyam, 20% plantain and 15% bambara nut flour substitution) had the highest Iron value than the rest of the cake sample and the Iron content of the control was lower than all the composite samples. This finding was similar to the result reported by Soibe[25] whose wheat and plantain composite bread increased in iron content as plantain flour significant increased, although far higher than those obtained in this study. This may be due to the method of preparation of samples. Iron is essential in the formation of haemoglobin and prevention of anaemia.

[23]Ezeocha, V. C., Arukwe, D. C. & Nnamani, M. U. (2022).Quality Evaluation of Cake from Wheat, Bambara Groundnut (*Vigna subterranean*) and Velvet Tamarind (*Dalium guineense*) Flour Blends. *FUDMA Journal of Sciences (FJS), 6(4), 88 - 94* https://doi.org/10.33003/fjs-2022-0604-1055
[24]National Institutes of Health (2022) Definitions of Health Terms: Minerals. National Institute of Health, Office of Dietary Supplements. https://medlineplus.gov/definitions/ index/html
[25]Shoaib, M., Shehzad, A., Omar, M., Rakha, A., Raza, H., Sharif, H.R., Shakeel, A., Ansari, A. and Niazi, S., 2016. Inulin: Properties, health benefits and food applications. *Carbohydrate polymers*, *147*, pp.444-454.

The magnesium content of the entire composite samples was higher than that of the control in this study. All the composite samples had significant difference with the control at P≤0.05 level. The results showed that WCPB6 (15% cocoyam, 20% plantain and 15% bambara nut flour substitution) had the higher magnesium value. Magnesium is an essential constituent of all cells and is necessary for the functioning of enzymes involved in energy utilization and it is present in the bone[26].

Phosphorus value increased with increase in fortificant. Findings also indicated that there was significant difference among all the composite samples when compared with the control at P≤0.05. The result also shows that the WF (100% wheat cake) had the least phosphorus value while composite WCPB6 (made from 15% cocoyam, 20% plantain and 15% bambara nut flour substitution) had the highest phosphorus value. The increase in the level of phosphorus in this study was also similar results recorded by Shoaib[27] and Ibeanu et al.[28] while working with wheat/plantain composite flour bread and cake production rspectively. Both authors observed significant increase in phosphorus value in their products. Although the level of phosphorus recorded in their products was far higher than those in this work, which may be due to the quantity of plantain used in their products as compared to this work.

Findings on zinc result as shown on table 4.4.0: revealed that there was the increase in the value of zinc as the fortificants increased. Findings of the result pointed out that the zinc levels for composite cakes were significantly higher than that of the control (P≤ 0.05). Composite cake WCPB5 (cake made from 15% cocoyam, 10% plantain and 15% bambara nut flour substitution) zinc value was higher than the rest of the samples, while WF (100% wheat cake) recorded the lowest zinc value. Shoaib[29] also observed increase in zinc content of bread substituted with plantain

[26]Abuengmoh, P., Ahure, D., & Igoli, N. N. (2022). Proximate, vitamin and mineral composition of bread produced from wheat, banana and mango flour blends. *International Journal of Food Science and Nutrition*, *7*(3), 92-99.

[27]Shoaib, M., Shehzad, A., Omar, M., Rakha, A., Raza, H., Sharif, H.R., Shakeel, A., Ansari, A. and Niazi, S., 2016. Inulin: Properties, health benefits and food applications. *Carbohydrate polymers*, *147*, pp.444-454.

[28]Ibeanu, V. N., Edeh, C. G. & Ani, P. N. (2022). Evidence-based strategy for prevention of hidden hunger among adolescents in a suburb of Nigeria. *BMC Public Health, 20:1683.* https://doi.org/10.1186/s12889-020-09729-8

[29]Shoaib, M., Shehzad, A., Omar, M., Rakha, A., Raza, H., Sharif, H.R., Shakeel, A., Ansari, A. and Niazi, S., 2016. Inulin: Properties, health benefits and food applications. *Carbohydrate polymers*, *147*, pp.444-454.

flour. Zinc is important for the prevention of infections and to support the immune system as well as in growth, cognitive and motor development[30,31].

Conclusion

The study on the comparative evaluation of vitamin and mineral composition of composite cakes fortified with cocoyam, plantain, and bambara nut flour blends revealed that fortification significantly improved the micronutrient profile of the cakes when compared with 100% wheat flour. The composite samples demonstrated higher levels of essential vitamins such as A, B1, and B12, as well as minerals including calcium, iron, magnesium, phosphorus, and zinc. Among the blends, WCPB5 and WCPB6 showed the most remarkable enhancement, suggesting that appropriate substitution of wheat with cocoyam, plantain, and bambara nut flour can yield nutritionally superior cakes. These findings underscore the potential of locally available underutilized crops as functional ingredients for combating micronutrient deficiencies, improving dietary diversity, and reducing overdependence on imported wheat flour. Therefore, the adoption of such blends in bakery products could contribute meaningfully to food security, nutritional improvement, and sustainable utilization of indigenous crops.

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[30]Ibeanu, V. Onyechi, U., Ani, P. & Ohia, C. (2015). Composition and Sensory Property of Plantain Cake. *African Journal of Food Science,* 10(2); 1996-0734. Http://www.academicjournal.org/AJFS.DDFD0345784.pdf

[31]Nzamwita, M., Duodu, K.G.& Minnaar, A. (2017). Stability of β- carotene during baking of orange-fleshed sweet potato- wheat composite bread and estimated contribution to Vitamin A requirements. Food Chem. 228:85-90

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