PROXIMATE COMPOSITION OF COMPOSITE CAKES FORTIFIED WITH COCOYAM, PLANTAIN, AND BAMBARA NUT FLOUR BLENDS FOR ADOLESCENTS

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Abstract

Adolescents require nutrient-dense foods to support their rapid growth and cognitive development, yet many snacks consumed by this age group are high in calories but low in essential nutrients. Cake, a popular and convenient snack, can serve as a medium for nutrient fortification using locally available crops. The study adopted an experimental design conducted at Delta State University, Abraka, to develop and evaluate cakes produced from wheat and composite flours of cocoyam, plantain, and bambara nut in varying proportions. Fifteen purposively selected panelists assessed the cakes' nutritional, sensory, and shelf-life qualities using validated and reliable instruments, with reliability coefficients of 0.81 and 0.88. Standard methods (AOAC, 2010–2015) were used to determine moisture, protein, fat, ash, fiber, carbohydrate, and vitamin A contents. Cakes were prepared under controlled laboratory conditions following standardized baking procedures. Data were analyzed using mean, standard deviation, ANOVA, and Duncan Multiple Range Test at a 0.05 significance level. The results showed that 40% of the sensory panelists were male and 60% female, with 53.33% undergraduates and 46.67% postgraduates. Proximate analysis revealed variations in nutrient composition among cakes fortified with cocoyam, plantain, and bambara nut. Moisture ranged from 20.94% to 24.46%, protein from 7.33% to 9.65%, fat from 22.25% to 27.68%, fiber from 0.57% to 1.44%, ash from 1.10% to 2.61%, and carbohydrate from 35.60% to 46.76%. ANOVA indicated significant differences (P≤0.05) in moisture, protein, fat, fiber, and ash contents among samples, except for carbohydrates, which showed no significant difference (P≥0.05). Composite cakes improved protein and mineral contents compared to 100% wheat cake. The study concludes that composite cakes enriched with cocoyam, plantain, and bambara nut flours are nutritionally superior and well-accepted alternatives to 100% wheat cakes. Their adoption can promote healthier snacking options among adolescents, enhance dietary diversity, and reduce reliance on imported wheat flour.
Keywords: Composite flour, proximate composition, sensory evaluation, nutrient fortification, adolescents

INTRODUCTION

There has been an increase in the consumption of snacks foods such as bread, cakes, biscuits, doughnuts and other wheat-based products in recent times, but reliance on imported wheat for cake production; its erratic availability and affordability; as well as the nutritional content of cake and other baked products is a major concern for ensuring food security and addressing nutritional deficiencies in Nigeria especially among adolescents in Delta State. Flour produced from the combination of cereals, legumes and tubers increases in nutritional value than when used alone. The continual dependence on importation of wheat to sustain production in the bakery industry, coupled with the low nutritional content of conventional snack sold on the streets of Nigeria especially Delta State is also a major concern. Furthermore, adolescents' nutritional status in Delta State has been compromised due to the high calorie, low nutrient snacks being sold in the state. As a result, it is therefore imperative that an alternative flour be used for bakery products especially cakes and pastries which can be developed either as an extension or a replacement for wheat and to improve the nutritional density of baked products.

At present the cost of cake and other pastries is very high in Delta State, Nigeria and thus gives impetus for further research into the use of composite flour for baking. Considerable efforts have been focused on the use of composite flour for bread making and cookies in Nigeria in the last three decade using cocoyam or plantain or bambara nut, (Abel et al., 2023),

but not much has been done on the use of the combination of cocoyam, plantain, and bambara nuts flour in the production of composite flour. Furthermore, previous studies have been focused on fortification of infants, weaning and geriatric foods. For instance, Kabeer et al. (2023) developed instant weaning food from plantain and finger millet. Similarly, Eze et al. (2017) prepared complementary mixes made from soybean, unripe plantain and crayfish for infants and children. Very little attention has been given to fortification of teenagers snacks; hence the need to bridge this gap and to carry out this research on nutritional composition and sensory evaluation of cakes fortified with cocoyam, plantain, and bambara nuts as functional snacks for adolescents, and to ascertain the shelf life of these cakes and snacks to curb food poisoning.

Adolescent and teenager are interchanged, often meaning the same thing. The World Health Organization (WHO) defines an adolescent as any person between ages 10 and 19, while teenagers are children who are between the ages of 13years and 19years of age (WHO, 2025a). It is a period of rapid growth and development. They also develop great appetite for diverse food especially snacks. Adolescent need a lot of nutrients at this stage such as, carbohydrates, proteins, and healthy fats, to serve as the body's primary energy sources. They also need other nutrients such as iron, calcium, zinc, and vitamins. The child's level of physical activity and stage of development determine exactly how much healthy food they need. Adolescents go through big physical changes in puberty. They need extra nutrients to fuel for these changes, which mean they need to eat healthy food. When the family's diet is poor, the effects are mostly seen on children and adolescents than the adults. Children's daily nutritional needs are often met through snacking, which plays a vital role in supporting their growth and development (Omon-Julius, 2017).

In Nigeria, there has been a marked increase in the consumption of snack foods such as cakes and biscuits among school children, largely due to changing lifestyles and the growing trend of eating away from home. However, many of these snacks are low in essential nutrients and high in refined carbohydrates and fats, contributing to poor dietary quality. This nutritional imbalance can result in various disorders, depending on the specific nutrients that are deficient or excessive in these products. Deficiencies in micronutrients such as iron, zinc, and vitamin A can compromise physical and cognitive development, particularly among adolescents, and may eventually lead to malnutrition if staple household foods are also nutrient-deficient (Olson et al., 2021; Kalu et al., 2025). The World Health Organization (WHO, 2025b) defines malnutrition as a condition caused by an imbalance in the intake of vital nutrients either deficiency or excess. In Nigeria, economic hardship and food insecurity, partly exacerbated by climate change (Emegha et al., 2025), have increased the prevalence of undernutrition among adolescents. Many households now eat merely to survive rather than to meet nutritional requirements. Consequently, stunting, wasting, and underweight are common among low-income children, while a minority from affluent families face overweight or obesity challenges (Idigo, 2024; Okonkwo & Idigo, 2025; Osuchukwu et al., 2025). This underscores the urgent need for affordable, nutrient-enriched snack alternatives for adolescents.

Adolescents in Delta State face serious nutritional issues and limited access to nutrient-rich food. Poor dietary diversity especially among the resource-poor communities also contributes to malnutrition in delta state Nigeria. The most concerning incidence of acute malnutrition among children in Delta State were reported by Mabiaku et al., (2021) and Emeagi & Apugo, (2022) with about 36.7% overall prevalence of malnutrition. This emphasizes the critical need for quick action to address the problem and lessen both the immediate and long-term effects of malnutrition. Fortifying cakes with readily available local ingredients, such as cocoyam, plantain, and bambara nuts, can be a successful strategy to produce nutritious snacks for better food and nutritional security for adolescents in the state. This strategy will equally save Nigeria from wheat import bills and increase overall utilization of indigenous food crops.

The motivation for this study arises from the increasing concern over adolescent nutrition, particularly in regions where diets are dominated by refined cereals with low nutrient

density. Adolescents experience rapid growth and heightened nutritional requirements, yet many rely heavily on wheat-based baked products that are often energy-dense but deficient in essential nutrients (Norris et al, 2022). Moreover, wheat is largely imported in many African countries, creating economic and food security challenges (Okorie & Asogwa, 2024). Local crops such as cocoyam, plantain, and Bambara nut remain underutilized despite their rich nutritional potential. Cocoyam offers digestible starch and minerals, plantain contributes dietary fiber and resistant starch, while Bambara nut is protein-rich with balanced amino acids (Okafor et al., 2022). Previous fortification studies have focused on single-crop supplementation in bakery products, overlooking the potential synergistic effects of composite blends (Ahaotu et al., 2021). Similarly, limited research has targeted adolescents, even though this group is particularly vulnerable to malnutrition and poor dietary habits that can predispose them to lifelong health complications. Therefore, this study is motivated by the need to fill these gaps by developing affordable, nutrient-rich, and culturally acceptable composite cakes that can support adolescent dietary requirements.

Objectives
Evaluate the proximate composition of composite cakes fortified with cocoyam, plantain, bambara nuts 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);

Research Question
The following questions were answered in this study:
What are the proximate compositions of composite cakes 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 cakes (WF)?

Research Hypotheses
The following hypothesis were tested at P≤ 0.05 level
There is no significant difference in proximate compositions of composite cakes fortified with cocoyam, plantain, bambara nuts 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).

METHODS
The study was conducted in the Food and Nutrition Laboratory of the Department of Vocational Education, Home Economics Unit, Delta State University, Abraka. The environment provided the necessary facilities and convenience for the study and allowed easy access to fifteen qualified panelists who participated in the sensory and shelf-life evaluation of the cakes. An experimental research design was adopted for the study. This design was suitable because it allows for systematic development through practical experimentation, which helps in producing or improving products and processes. It is especially useful for food product development, where researchers explore new formulations and assess their nutritional and sensory qualities. In this study, cakes were produced from one hundred percent wheat flour and from composite flours consisting of cocoyam, plantain, and bambara nut, substituted for wheat at various proportions. The substitution ratios were 5:5:5:85, 10:5:5:80, 10:10:10:70, 15:10:10:65, 15:15:15:55, and 15:20:15:50, respectively. These cakes were analyzed for their nutritional value, sensory attributes, and shelf life to determine the best formulation.

The population of the study comprised both male and female academic staff and undergraduate students from Delta State University, Abraka, and the University of Delta, Agbor. In Delta State University, Abraka, the Department of Vocational Education had sixteen

academic staff members and one hundred and forty-two undergraduate students. The Department of Home Economics at the University of Delta, Agbor, had six academic staff and twenty-one undergraduate students. Altogether, the population totalled one hundred and eighty-five individuals, according to the 2024 records from the Heads of Departments of the respective institutions. A purposive sampling technique was employed in selecting fifteen subjects as the panel of judges for sensory evaluation. These consisted of seven academic staff members and eight undergraduate students drawn from the Department of Vocational Education, Delta State University, Abraka. The selection was based on the participants' consent and availability, as well as their familiarity with cake consumption and evaluation.

Two major instruments were used for data collection. The first was a standard sensory evaluation questionnaire designed on a nine-point Hedonic scale, which enabled the panelists to rate the cakes based on appearance, color, flavor, texture, crispiness, taste, mouthfeel, and overall acceptability. The scale ranged from nine, representing "liked extremely," to one, representing "disliked extremely." The second instrument was a structured questionnaire rated on a five-point scale, ranging from one for "poor" to five for "excellent." This was used to assess the shelf life of the cakes over time. The face and content validity of the instruments were ensured through expert review. Three specialists from Delta State University, Abraka a lecturer from Home Economics, one from Measurement and Evaluation, and one from Biochemistry assessed the instruments to confirm their clarity, relevance, and suitability. Their suggestions and corrections were incorporated before the final instruments were administered.

The reliability of the instruments was determined through a pilot test. Ten undergraduate students from the Department of Vocational Education, Home Economics Unit, participated as judges in evaluating cakes made from composite flour against a one hundred percent wheat flour control. The data obtained were analyzed using Cronbach's Alpha, and a reliability coefficient of 0.81 was obtained, indicating high internal consistency. For the shelf-life questionnaire, five participants were purposively selected to assess stored cake samples using the five-point scale, and a reliability coefficient of 0.88 was obtained. These results confirmed that the instruments were dependable for the main study.

Data collection was carried out with the assistance of two research assistants who had been briefed on the importance of the study and how to administer the questionnaires. Fifteen copies of the sensory evaluation questionnaire were distributed to the judges. Each judge was required to taste the cake samples and rate them according to appearance, color, flavor, texture, crispiness, taste, mouthfeel, and general acceptability. To avoid carryover effects, each judge was given a bottle of clean water to rinse their mouth between tastings. For shelf-life evaluation, five judges monitored the samples and rated them on the same sensory attributes every four days using the structured questionnaire.

The materials used for the study included cocoyam, unripe plantain (Musa paradisiaca), bambara nut, wheat flour, margarine, eggs, sugar, lemon zest, nutmeg, baking powder, vanilla extract, and salt. These ingredients were purchased from the local market in Ughelli, Delta State. Laboratory reagents used for nutritional analysis were supplied by the laboratory analyst. Cocoyam flour was produced by sorting and washing the tubers to remove impurities, peeling them manually, slicing them into five-millimeter chips, and blanching them in boiling water at 100°C for five minutes. The blanched chips were sun-dried and milled into fine flour using a local milling machine. The flour was then stored in labeled zip-lock bags at room temperature. Plantain flour was produced following the method described by Arubayi and Ogbonyomi in 2019. Mature unripe plantains were washed, peeled, and soaked in water to prevent enzymatic browning. They were sliced into two-centimeter-thick pieces and blanched in hot water at 80°C for five minutes to preserve their color. The blanched slices were sun-dried, milled, sieved, and packaged in labeled polythene bags for storage. Bambara nut flour was produced by soaking the nuts in water for twenty-four hours, manually dehulling them, and boiling them in a one-to-four seed-to-water ratio for ten minutes, following Barimalaa

et al. (1994) as cited by Kiin-Kabari and Banigo (2015). The boiled seeds were drained, sun-dried, milled, sieved using a 0.25 mm sieve, and packaged in airtight containers.

Composite flour samples were then prepared by blending wheat, cocoyam, plantain, and bambara nut flours at different substitution levels. Seven flour blends were formulated: W85C5P5B5, W80C10P5B5, W70C10P10B10, W65C15P15B10, W55C15P15B15, W50C15P20B15, and W100C0P0B0, which served as the control. These blends enabled the evaluation of the effect of increasing composite flour substitution on the physical and sensory properties of cakes. Measurements for the preparation of cakes were standardized. For instance, sample WCPB1 used 285 grams of wheat flour, 15 grams each of cocoyam, plantain, and bambara nut flour, while sample WCPB6 contained 150 grams of wheat flour, 45 grams of cocoyam flour, 60 grams of plantain flour, and 45 grams of bambara nut flour. The control sample contained 300 grams of wheat flour without any substitution. Other ingredients such as margarine, sugar, eggs, lemon zest, nutmeg, vanilla extract, baking powder, and salt were kept constant in all formulations to maintain uniformity.

The equipment and tools used for cake preparation included an oven, baking pans, a kitchen scale, measuring cups and spoons, a cake mixer, mixing bowls, a sieve, an egg whisk, and spatulas. Each of these played a vital role in ensuring consistency and precision during preparation. The method of cake preparation followed the procedure described by All Nigerian Recipes (2022), with slight modifications. The fat and sugar were first creamed together until light and fluffy. Baking pans were greased and dusted with flour to facilitate easy removal of cakes after baking. Eggs were broken one at a time into a bowl and whisked until smooth. The oven was preheated to 220°C before mixing the dry ingredients, which were sifted for uniformity. The whisked eggs were added gradually to the creamed mixture, followed by the addition of vanilla flavor. The sifted dry ingredients were then folded into the mixture a little at a time to form a smooth batter. The batter was poured into the greased pans and baked in the preheated oven for forty minutes or until a golden brown color was obtained. After baking, the cakes were allowed to cool on a wire rack for one hour before evaluation.

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 dried in the oven at 105 ± 5^0C for 30 minutes
- The crucibles were transferred into a desiccator and allow to cool at room temperature for about 20 minutes
- The weight of the empty porcelain crucibles were taken and record as W_0
- Samples were blended into powder to increase the surface area
- 2.00g of each of the sample was weigh into the porcelain crucibles (record as W_1) and dried in the oven at 105 ± 5^0C till constant weight or preferably for 4 hours
- The porcelain crucibles containing the samples were allowed to cool for about 10 minutes in the oven and transferred into the desiccator and allow to cool at room temperature for about 30 minutes
- The final weight of the porcelain crucibles and content were taken and record as W_2

Moisture content was calculated as:

$$\% \ moisture \ content \ = \frac{(W0 + W1) - (W0 + W2)}{W1} \times 100$$

Determinations of Protein according to Kjeldahl using Block Digestion and Steam Distillation
Equipment: Kjeltec Auto Distillation Unit, Tecator Digestor, Model, Hanna Magnetic Stirrer,
Material: Digestion block, digestion tubes, kjeldahl distillation unit and automatic titrator

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Reagents: H_2SO_4, copper catalyst, 40% NaOH solution, receiver solution, distilled water, 0.1N or 0.2N HCl

Procedure

- 1.00 gram of each of the samples was weighed to an accuracy of 0.1mg into a 250ml digestion tubes.
- 2 kjeltabs Cu 3.5 (alternatively 7g K_2SO_4 and 0.8g $CuSO_4$ X $5H_2O$) were added to each of the tube
- 12ml of concentrated H_2SO_4 was carefully added and gently shake to wet the sample with the acid
- The samples were digested for 1h at $420^\circ C$ and allow to cool for 10 – 20 minutes
- 80ml deionized water was carefully added into the tubes
- 25 – 30 ml receiver solution was added into the conical flask and place into the distillation unit
- 50ml of 40% NaOH was dispensed into the tube and distill for about 5 minutes
- The distillate was titrated with standardized HCl (usually 0.1 or 0.2N) until the blue grey end point is achieved. The volume of acid consumed in the titration was noted

Calculation of crude protein

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

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

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

Determination of Fat content
The fat content of the sample was determined using the standard method of AOAC (2012).
1. A soxhlet extractor with a reflux condenser and a 500ml round bottom flask was fixed.
2. Two gram (2g) of the sample was weighed into a labeled thimble.
3. Petroleum ether (300ml) was filled into the round bottom flask and the extraction thimble was sealed with cotton wool.
4. The soxhlet apparatus after assembling was allowed to reflux for about 6 hours and the thimble was carefully removed
5. The petroleum ether that was collected in the top was drained into a container for reuse.
6. The flask was removed and dried at 105^0C for 1hour in an oven, cooled in a desiccator and then weighed.

Calculation:

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

Determination of Ash Content

Materials: Muffle Furnace, conventional oven, crucibles, analytical balance, spatula, desiccator and crucible tongue.

The ash content of the cake samples was determined according to the standard methods of AOAC (2010).

1. The crucibles were thoroughly washed and dried in an oven at 130 ± 15^0C for 30 minutes
2. The hot dried crucibles were cooled in the desiccators and weight W_0 was noted.
3. Samples were blended into powder using Cyclotec to increase the surface area and 1g of each of the samples was weighed into the crucible and the total weight (W_1) was noted.
4. The samples were charred on a Bunsen flame inside a fume cupboard and later transferred into a preheated muffle furnace 550^0C for 2hours until a white or light grey ash was obtained.
5. It was cooled in a desiccator and weight (W_2) was noted.

The ash content was calculated mathematically as follows:

$$\% \, ASH \, content \; = \frac{(W2 - W0)}{W1} \, X \, 100$$

Determination of Crude Fibre

Equipment Names: (1) Fibretec Hot/Hydrolysis Unit, (2) Fibretec Cold Estraction Unit

Materials: Analytical balance, fritted crucibles, air ventilated oven capable of operating at 105 ± 2^0C and above, desiccator, grinding equipment, fibretec hot extraction unit, fibretec cold extraction unit, hot plate, wash bottle, muffle or incineration furnace 525 ± 15^0C

Reagent: Acetone (technical grade), 1.25% H_2S0_4 solution, 1.25% NaOH solution.

Procedure

1. Fritted crucibles was pre dried at 130 ± 2^0C for 30 minutes
2. 1g of celite 545; and1g of each samples were weighed into the crucible containing the celite.
3. 1.25% H_2SO_4 was prepared and heated on hot plate
4. 150ml of preheated 1.25% H_2SO_4 was added into each column (reagent 1)
5. 2 – 4 drops of n – Octanol was added and moderately boiled. The boiling time was measured and then cooled and filtered
6. Reversed pressure was used to wash the sample three times with hot deionized water and dried.
7. 150ml of preheated 1.25% NaOH solution was added into each column (reagent 2) and the crucibles transferred to the fibretec cold extraction unit

Fibretec Cold Extraction Procedure

8. 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
9. The crucibles were cooled to room temperature in a desiccator and weigh to 0.1mg
10. 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:

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

Key: W_1 = Sample weight (g)

W_2 = Crucible + residue weight after drying (g)

W_3 = Crucible + residue weight after ashing (g)

C = Blank

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 $CHCl_3$, 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:

$$Conc.\,of\,Vitamin\,A\,(mg/kg) \;=\; \frac{mg/l\;x\;V\;x\;DF}{W\;x\;Va}$$

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.

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 $p \leq 0.05$.

RESULTS
Table 1: Characteristics of the respondents for sensory evaluation of composite cake samples

Respondents Gender	Frequency (N)	Percentage (%)

Males	6	40
Females	9	60
Total	**15**	**100**
Educational level		
Post graduates	7	46.67
Undergraduate	8	53.33
Total	**15**	**100**

Table 1 present the characteristics of the respondents for sensory evaluation of composite cake samples. The table shows that forty percent (40%) of the panelists who evaluated the cake based on sensory evaluation were male while sixty percent (60%) were females. The table also showed that 46.67% of the panelists were postgraduate while 53.33% were undergraduates

Question 1: What are the proximate composite of cakes fortified with cocoyam, plantain and 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 cakes (WF)?

Table 2: Mean (x) value of proximate analysis of all cake samples

Samples	Parameters (%)					
	Moisture	**Crude protein**	**Crude Fat**	**Crude Fibre**	**Total Ash**	**Carbohydrate**
WCPB1	23.26 ±0.09^b	7.98 ±0.61^d	23.63 ±0.70^f	0.76 ±0.02^e	1.86 ±0.20^c	42.48 ±11.28^a
WCPB2	20.94 ±0.23^c	8.70 ±0.15^c	25.99 ±0.18^d	0.90 ±0.04^d	2.04 ±0.27^c	41.24 ±11.27^a
WCPB3	21.97 ±0.06^d	8.93 ±0.03^b	24.91 ±0.16^c	0.96 ±0.01^c	2.09 ±0.16^b	41.61 ±10.32^a
WCPB4	23.68 ±0.09^b	8.95 ±0.32^b	27.68 ±0.09^a	0.95 ±0.02^c	1.96 ±0.15^b	38.07 ± 12.72^a
WCPB5	24.46 ±0.08^a	9.62 ±0.02^a	26.68 ±0.08^b	1.32 ±0.06^b	2.61 ±0.09^a	37.10 ± 12.08^a
WCPB6	23.76 ±0.38^b	9.65 ±0.04^a	24.16 ±0.07^e	1.44 ±0.03^a	2.33 ±0.17^b	41.31 ± 11.47^a
WF	21.86 ±1.20^c	7.33 ±0.55^e	22.25 ±0.07^g	0.57 ±0.02^f	1.10 ±0.02^d	46.77 ± 10.42^a

Mean (x) and standard deviation of triplicate determination of proximate 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) cake
WF (100% wheat flour cake) which serves as the control

Table 3: Mean (x) of Moisture for all the cake sample

Samples	N	Sum	Mean (x)	Std Deviation
WCPB1	3	67.77	23.26^b	0.09
WCPB2	3	62.83	20.94^d	0.23
WCPB3	3	65.90	21.97^c	0.06
WCPB4	3	71.05	23.68^b	0.09
WCPB5	3	73.38	24.46^a	0.08
WCPB6	3	71.28	23.76^b	0.39

WF	3	65.95	21.98^c	0.06
Sum	21	480.16	22.86	1.20

*Mean (x) and standard deviation of moisture content result *Samples with different superscripts within the column are significantly different by Duncan's multiple test (P<0.05)*

Table 3 shows that Moisture means (x) value ranged between 20.94 (±0.23) and 24.46 (±0.08). WCPB5 had the highest moisture content with a mean (x) value of 24.46 (±0.08). WCPB2 had the lowest moisture mean (x) value of 20.94 (±0.23). WCPB1 had a mean (x) of 23.26 (±0.09), while WCPB3 had 21.97 (±0.06). WCPB4 had a mean (x) value of 23.68 (±0.09), WCPB6 had a mean (x) value of 23.76 (±0.39), while WF (control) mean (x) for moisture was 21.98 (±0.06).

HO_1: There is no significant difference in moisture compositions among the composite cakes sample (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and the control (WF).

Table 4: ANOVA for Moisture content of all the cake samples

Moisture	Sum of Squares	df	Mean (x) Square	F	Sig.	Decision
Between Groups	23.336	6	4.723	141.700	0.000	reject
Within Groups	.466	14	.033			
Total	28.802	20				

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

The result in table 4 shows that the F- value of Moisture content was 141.700. The significant value was 0.000. This indicated that there is significant difference at P≤ 0.05 level in Moisture content among the cake samples. Duncan Multiple Test showed significant difference between WF (control) and all the composite cake samples at P≤ 0.05 except WCPB3; therefore, the null hypothesis was rejected at P≤ 0.05. WCPB1 was significantly different from all the samples including the control (WF); hence the null hypothesis here was rejected at P≤ 0.05. WCPB2 differ from all the samples, therefore, the hypothesis was rejected. The test also indicated that WCPB3 was significantly different from the rest of the samples; hence the hypothesis here was rejected. WCPB4 does not differ from WCPB1 and WCPB6. Here, the hypothesis was accepted at P≤ 0.05. WCPB5 was significantly different from the rest of the sample; therefore, the null hypothesis of no significant difference was rejected at P≤ 0.05. WCPB6 was not significantly different from WCPB4, but differs from the rest of the sample; therefore, the hypothesis here was rejected at P≤ 0.05.

Table 5:**Mean (x) of Protein for all the cake sample**

Samples	N	Sum	Mean (x)	Std Deviation
WCPB1	3	23.95	7.98[d]	0.61
WCPB2	3	26.11	8.70[c]	0.15
WCPB3	3	26.78	8.93[b]	0.03
WCPB4	3	26.86	8.95[b]	0.32
WCPB5	3	28.87	9.62[a]	0.02
WCPB6	3	28.95	9.65[a]	0.04
WF	3	22.00	7.33[e]	0.55
Sum	21	183.52	8.74	0.80

Mean (x) and standard deviation of protein analysis result *Samples with different superscripts within the column are significantly different by Duncan's multiple test (P<0.05) Duncan's by multiple test (P<0.05).

Result in Table 5 shows that the crude protein means (x) ranged between 7.33 (±0.55) and 9.65 (±0.04). WCPB6 had the highest protein value with a mean (x) score of 9.65 (±0. 04). WF (control) had the lowest protein mean (x) value of 7.33 (±0.55). WCPB1 had a mean (x) of 7.98 (±0.61), while WCPB2 had a mean protein value of 8.70 (±0.15). WCPB3 mean value was 8.93 (±0.03). WCPB4 had a mean (x) value of 8.95 (±0.32), WCPB5 mean (x) protein value of 8.62 (±0.02).

HO_1: There is no significant difference in proximate (protein) compositions among the composite cakes sample (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and the control (WF).

Table 6: ANOVA table for Protein of all the cake samples

Protein	Sum of Squares	df	Mean (x) Square	F	Sig.	Decision
Between Groups	12.724	6	2.121	452.581	0.001	Reject
Within Groups	0.066	14	0.005			
Total	12.790	20				

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

The result table 6 indicated that the F- value of protein content was 452.581 while the significance difference was 0.001, which means that there is significant difference at P≤ 0.05 level in protein content among the cake samples. Therefore, the null hypothesis of no significant difference was rejected. The Duncan test conducted to find out where the significant difference lies among protein values of all cake samples showed that the protein value of WF (control) was significantly different from all the composite cake samples, thus the null hypothesis here was rejected at P≤ 0.05.

Protein mean (x) value of WCPB1 and WCPB2 were significantly different from all the samples including WF (control) at P≤ 0.05. Therefore, the hypothesis of no significance difference here was rejected. The mean protein value of WCPB3 and WCPB4 were not significantly different but differ significantly from the rest of the cake samples at P≤ 0.05. Therefore; the hypothesis of no significant difference here was rejected at P≤ 0.05. WCPB5 protein value was not significantly different from WCPB6, but differs from the other samples (WCPB1, WCPB2, WCPB3, WCPB4 and WF). Therefore, the null hypothesis was rejected at P≤ 0.05 level.

Table 7: Mean (x) of Fat for all the cake sample

Samples	N	Sum	Mean (x)	Std Deviation
WCPB1	3	70.89	23.63^d	0.70
WCPB2	3	77.99	25.99^d	0.18
WCPB3	3	74.74	24.91^c	0.16
WCPB4	3	83.04	27.68^a	0.09
WCPB5	3	79.15	26.68^b	0.08
WCPB6	3	72.47	24.16^a	0.07
WF	3	66.47	22.25^d	0.07
Sum	21	525	25.00	1.75

*Mean (x) and standard deviation of fat analysis result *Samples with different superscripts within the column are significantly different by Duncan's multiple test (P<0.05)*

Table 7 indicated that fat mean (x) value ranged between 22.25 (±0.07) and 27.68 (±0.09). WCPB4 had the highest fat value with a mean (x) score of 27.68 (±0. 09), value while the. WF (control) had the lowest fat mean (x) value of 22.25 (±0.07). WCPB1 fat mean (x) fat value was 23.63 (±0.70). WCPB2 was 25.99 (±0.18). WCPB3 had a mean (x) value of 24.91 (±0.16), WCPB5 mean (x) value was 26.68 (±0.08), while WCPB6 mean (x) fat value was 24.16 (±0.07).

Table 8: ANOVA table for Fat of all the cake samples

Protein	Sum of Squares	df	Mean (x) Square	F	Sig.	Decision
Between Groups	60.744	6	10.124	861.092	0.000	Reject
Within Groups	0.165	14	0.012			
Total	60.908	20				

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

The result in table 8 shows that the F- value of Fat was 861.092. The significant difference was 0.000. This indicated that there is significant difference at P≤ 0.05 level in fat content among the cake samples. The Duncan Multiple Range test showed significant difference among all the cake samples including the control (WF) was compared to all the composite cake samples at P≤ 0.05. Therefore, the null hypothesis here was rejected.

Table 9: Mean (x) of fibre for all the cake sample

Samples	N	Sum	Mean (x)	Std Deviation
WCPB1	3	2.28	0.76^b	0.02
WCPB2	3	2.71	0.90^d	0.04
WCPB3	3	2.89	0.96^c	0.01
WCPB4	3	2.85	0.95^b	0.02
WCPB5	3	3.97	1.32^a	0.06
WCPB6	3	4.32	1.44^a	0.03
WF	3	1.71	0.57^c	0.02
Sum	21	20.73	0.99	0.28

*Mean (x) and standard deviation of fibre analysis result *Samples with different superscripts within the column are significantly different by Duncan's multiple range test (P<0.05).*

Table 9 indicated that the crude fibre mean (x) increased from 0.57(±0.02) to 1.44(± 0.03). WCPB6 had the highest mean (x) value of 1.44 (± 0.03) in fibre content while WF had the least mean (x) score value of 0.57 (±0.02). WCPB1, WCPB2, WCPB3, WCPB4 and WCPB5 had a mean (x) values of 0.76 (±0.02), 0.90 (±0.04), 0.96 (±0.01), 0.95 (±0.02) and 1.32 (±0.06) respectively.

Table 10: ANOVA table for Fibre of all the cake samples

Fibre	Sum of Squares	df	Mean (x) Square	F	Sig.	Decision
Between Groups	1.658	6	0.276	280.343	0.000	Reject
Within Groups	0.014	14	0.001			
Total	1.672	20				

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

The ANOVA table 10 shows that the F- value of fibre content was 280.343 while the significant difference was 0.000. This shows significant difference at P≤ 0.05 level in fibre content among the cake samples. Therefore, the null hypothesis of no significant difference was rejected. Duncan Multiple Range Test revealed that the fibre content of WF (control) was significantly different from all the composite samples at P≤0.05 level; so the hypothesis here was rejected. The Duncan Multiple Range Test also showed that the mean values of WCPB1, WCPB5 and WCPB6 differ significantly in fibre content with all the composite samples including the control (WF), therefore, the hypothesis was also rejected at P≤0.05 level. Conversely, WCPB2, WCPB3 and WCPB4 are not significantly different; hence the null hypothesis was accepted. Duncan Multiple Range Test WCPB2, WCPB3 and WCPB4 were significantly different from WCPB1, WCPB5, WCPB6 and WF. Therefore, the hypothesis here was rejected.

Table 11: Mean (x) of Ash for all the cake sample

Samples	N	Sum	Mean (x)	Std Deviation
WCPB1	3	5.57	1.86[c]	0.21
WCPB2	3	6.12	2.04[c]	0.27
WCPB3	3	6.28	2.09[b]	0.16
WCPB4	3	5.89	1.96[c]	0.15
WCPB5	3	7.84	2.61[a]	0.09
WCPB6	3	6.99	2.33[b]	0.17
WF	3	3.31	1.10[d]	0.02
Sum	21	42.00	2.00	0.46

*Mean(x) and standard deviation of Ash content analysis result. *Samples with different superscripts within the column are significantly different by Duncan' multiple test (P<0.05).*

Table 11 shows that Ash means (x) ranged between 1.10 (±0.15) and 2.61 (±0.09). WCPB5 (Ash value) was higher than the rest of the samples with a mean (x) score of 2.61 (±0.09). WF (control) had the lowest Ash mean (x) value of 1.10 (±0.02). WCPB1 mean (x) value was 1.86 (±0.21), while WCPB2 was 2.04 (±0.27). WCPB3 had a mean (x) value of 2.09 (±0.16), WCPB4 had a mean (x) value of 1.96 (±0.15), while WCPB6 mean (x) of Ash value was 2.33 (±0.17) respectively.

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

Ash	Sum of Squares	df	Mean (x) Square	F	Sig.	Decision
Between Groups	3.964	6	0.661	33.192	0.000	Reject
Within Groups	0.273	14	0.19			
Total	4.237	20				

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

The result in table 12 showed the F- value of the Ash content as 33.912 while the significance difference was 0.000, which means that there is significant difference at P≤ 0.05 level in Ash content among the cake samples. Therefore, the null hypothesis of no significant difference was rejected. The Duncan Multiple Range Test showed that the Ash value of WF

(control) was significantly different from all the composite cake samples; hence the null hypothesis here was rejected at P≤ 0.05.

Conversely, sample WCPB1 was not significantly different from WCPB2, WCPB3 and WCPB4 but differs from WCPB5, WCPB6 and WF (control). Hence the null hypothesis was rejected. Sample WCPB3 was not significantly different from WCPB1, WCPB2, WCPB4 and WCPB6 but differ significantly from WCPB5 and WF. Therefore, the hypothesis was rejected. The sample WCPB4 does not differ significantly from WCPB1, WCPB2 and WCPB3 but differs from WCPB5, WCPB6 and WF. Sample WCPB5 was significantly different from all the composite samples including the WF. Therefore, the null hypothesis of no significant difference was rejected. The sample WCPB6 showed no significant difference with WCPN3, but differs from the rest of the samples. Hence, the null hypothesis was rejected at P≤0.05.

Table 13: Mean (x) of Carbohydrates for all the cake sample

Samples	N	Sum	Mean (x)	Std Deviation
WCPB1	5	42.51	11.43[a]	11.28
WCPB2	5	41.41	11.75 [a]	11.27
WCPB3	5	41.14	11.31 [a]	10.32
WCPB4	5	36.77	12.38 [a]	12.52
WCPB5	5	35.60	12.58[a]	12.08
WCPB6	5	38.66	11.74 [a]	11.47
WF	5	46.76	10.65 [a]	10.80
Sum	35	282.85	11.69	10.42

*Mean (x) and standard deviation of carbohydrate content result *Samples with different superscripts within the column are significantly different by Duncan's multiple test (P<0.05).*

The result in Table 13 shows that the carbohydrate content was calculated as sum of percentages of protein, fat, ash, fibre and moisture subtracted from 100%. The carbohydrate content of all the cakes samples as shown in Table 13 indicated that the values ranged between 35.60 and 46.76. WF (control) had carbohydrate value which was higher than the rest of the samples with a score value of 46.76. The sample WCPB1 has a value of 42.51, while WCPB2 value was 41.41. WCPB3 carbohydrate value was 41.14, while WCPB4 value was 36.77. WCPB5 and WCPB6 had carbohydrate value of 35.60 and 38.66 respectively.

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

Carbohydrates	Sum of Squares	df	Mean (x) Square	F	Sig.	Decision
Between Groups	17.153	6	2.859	0.22	1.000	accept
Within Groups	3651.233	28	130.401			
Total	3668.387	34				

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

The result in table highlighted the F- value of carbohydrates content as 0.22 while the significance difference was 1.000, which means that there is no significant difference at P≤ 0.05 level in carbohydrate content among the cake samples. Therefore, the null hypothesis of no significant difference was accepted at P≤ 0.05.

DISCUSSION

Moisture is an important attribute to measure in the bakery products especially cake, as it significantly affects their biochemical reactions, chemical and textural quality of the product. Findings of proximate analysis result indicated that composite cake samples WCPB5 (cake with 15% cocoyam, 15% plantain and 15% bambara nut flour) had the highest mean (x) value in moisture content among all the cake samples, while WCPB2 (cake with 10% cocoyam, 5% plantain and 5% bambara nut flour substitution) had the lowest mean (x)

moisture value. Findings of the result revealed that WF (control) differs significantly from all the composite cake samples except WCPB3 (10% cocoyam, 10% plantain and 10% bambara nut flour substitution). The result is in agreement with the work of Kiin-Kabari and Banigo (2015) who prepared cakes from blends of wheat, unripe plantain flour and bambara nut, Ezeocha et al. (2022) who experimented on wheat cake substituted with bambara nut and tamarind, Akusu et al. (2016), on wheat-cocoyam cake and Abel et al. (2023) on wheat-cocoyam composite bread. These authors recorded high moisture content in their products. The high moisture content of the composite cake could be due to the high fibre content of the fortification (cocoyam, plantain, and bambara nut flour) as food high in fibre plantain and cocoyam flours has the ability to trap in more moisture than the less fibrous counterparts. Low moisture content is also an advantage in the shelf life of baked products especially snacks such as cakes.

Finding of proximate analysis result shows of Protein value shows that all the composite cake samples were significantly higher than the control. Proximate analysis result also shows that protein value increase with increase in the level of fortificant, this maybe because bambara nut is a good source of protein. WCPB6 (cake sample with 15% cocoyam, 20% plantain /15% bambara nuts substitution) had the highest protein value. WF (control) had the least protein content. This demonstrates the beneficial effect of blends of cocoyam, plantain, bambara nut flour in the fortification of baked products as it increases the protein quality of cake. This observation is also in agreement with Kiin-Kabari and Banigo (2015), Adegunwa et al. (2019) and Ezeocha et al. (2022) who also recorded increase in protein content of cake and bread with the addition of bambara nuts, cocoyam and plantain respectively. The increase in protein content of composite cakes is advantageous to adolescent's snacks as it will help increase their consumption of dietary protein thereby prevent protein energy malnutrition; help in preserving lean muscle mass, repair worn out tissue, regulate hormones and enzymes and also supply energy in times when carbohydrates are not available or enough in their diet as mentioned in chapter two of this work.

The result depicted that fat content of cake samples increased with increased with composite flour. Findings of proximate analysis shows that WCPB4 (cake sample substituted with 10% cocoyam, 15% plantain and 10% bambara nut) had the highest fat content while the control (WF) had the lowest fat content. This could be attributed to the addition of bambara nut which is very rich in unsaturated fat content. High oil retention improves the flavour and mouth feel of cakes. In similar research, Ezeocha et al. (2022) reported increase in fat content of cake substituted with bambara nut and velvet tamarind. The fat content in this work was higher than those obtained by Kiin-Kabari and Banigo (2015) who reported decrease in fat content of cakes substituted with plantain and bambara nuts. This could be attributed to method of recipe formulation and difference in variety of bambara nut used in their products.

Findings of this study highlighted that the fibre content of composite cakes increased as substitution increases. WCPB6 (15% cocoyam, 20% plantain and 15% bambara nut substitution) cake had the highest fibre content while the control (WF) had the least fibre. Similar trend of increased fibre content was reported by Kiin-Kabari and Banigo (2015) in composite cakes by blending wheat with plantain and bambara nuts, while Adanse et al. (2021), produced doughnut with composite blends of wheat, plantain and cocoyam. In the same view, Ezeocha et al. (2022) used bambara and tamarind blends to produce cake and Abel et al. (2023) used wheat / cocoyam composite flour to produce bread. Dietary fiber is a vital component of a diet that aids the digestive system in facilitation of bowel movement. It also helps in preventing constipation, diverticulitis disease, reducing the risk of cardiac conditions, weight management, and gastro-intestinal health. Findings from proximate analysis the Ash content of all the composite cake samples shows significant difference from the control. The Ash content improved significantly as substitution increased with WCPB5 having the highest Ash content. Adanse et al. (2021) and Abel et al. (2023) also observed similar increase in their products as the level of composite flour increases. The increase in

Ash content may be due to the fact that cocoyam, plantain and bambara nut are rich in minerals such as potassium, calcium and phosphorus

Findings of the results of the carbohydrate content indicated significant decreases in all the composite samples more than the control. It was observed that WCPB5 (cake substituted with 15% cocoyam, 15% plantain and 15% bambara nut) has the least carbohydrate content while the control had the highest. This observation was similar to the result of Kiin-Kabari and Banigo (2015), Akusu et al. (2016) and Ezeocha et al. (2022) who also recorded decreased carbohydrate content in their products as substitution increased. This indicated that wheat flour was the main contributor of the carbohydrate in the cake samples. The decrease in carbohydrate content did not affect the increase in fibre content of composite samples, hence the high ash content in all the composite samples.

CONCLUSION

The study concluded that composite cakes produced from blends of cocoyam, plantain, and bambara nut flours are nutritionally superior and suitable for adolescent consumption. The incorporation of these local flours enhanced the protein, ash, and fiber contents of the cakes compared to 100% wheat flour, indicating improved nutritional value and potential to address mild nutrient deficiencies among adolescents. Although slight variations existed in sensory qualities, the cakes remained acceptable in taste, texture, aroma, and appearance. The findings demonstrate that utilizing cocoyam, plantain, and bambara nut flours as partial substitutes for wheat can reduce dependence on imported wheat and promote the use of indigenous crops. This innovation offers a sustainable approach to improving adolescent nutrition, food security, and local agricultural utilization. It is recommended that nutritionists, food processors, and educators encourage the inclusion of such composite cakes in adolescent diets and school feeding programs.

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