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# Sustainable Development through Household Economics: A Sensory Evaluation of Cakes Produced from Wheat, Cocoyam, Plantain, and Bambara Nut Composite Flour Blends as Functional Snacks

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**CONTENT**



**ABSTRACT**

**Background:** Composite flours from indigenous crops offer a pathway to healthier snacks, dietary diversity, and reduced reliance on imported wheat, but must meet consumer sensory expectations to be viable. **Objective:** This study aims to evaluate the sensory properties of cakes made from composite flour blends of wheat, cocoyam, plantain, and bambara nut, and to identify formulations that balance acceptability with functional nutrition potential. **Method:** An experimental research design was adopted, which allowed for the systematic production and evaluation of cakes prepared from composite flour blends of wheat, cocoyam, plantain, and bambara nut. **Result:** The sensory evaluation results showed variations in judges' ratings of cakes made from wheat, cocoyam, plantain, and bambara nut blends compared with 100% wheat cake. **Conclusion:** These findings support food diversification, partial substitution of imported wheat, and household-scale production through simple SOPs and quality control within the framework of Sustainable Development through Household Economic Units, thereby strengthening local supply chains and micro-business opportunities. **Contribution:** This study provides empirical evidence that cakes with acceptable sensory quality and nutritional enrichment can promote Sustainable Development through Household Economic Units through simple household-scale SOPs, basic quality control, utilization of local crops, partial wheat substitution, and gender-responsive microenterprises.

**KEYWORDS**

Sensory evaluation; Composite flour; Cocoyam; Plantain, bambara nut; Functional snacks; Sustainable development

## 1. INTRODUCTION

Sensory evaluation describes the attributes of food. Sensory descriptive analysis of food products provides an understanding of and control over the key attributes that contribute to consumer satisfaction and market success (Sirangelo, 2019). Sensory evaluation can be performed through both objective and subjective tests. Objective

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analytical tests are performed in a laboratory using standardized equipment and procedures to evaluate food product properties related to specific sensory attributes. Subjective tests, on the other hand, are based on personal impressions, such as the final consumers' preference for the considered product (Sirangelo, 2019). The quality and desirability of a food product are determined by its interaction with the sensory organs of human beings, such as vision, taste, smell, touch, and hearing.

Snacks, especially cakes and other confectionery items, are evaluated with our senses. The sense of sight is a feature of our senses that judge's food by its freshness, appearance, and color. The nose identifies the smell or flavour of a food sample. Taste is registered on the taste buds on the tongue as salty, sweet, acidic, bitter, spicy, or pungent. Texture describes the crunchiness, hardness, or softness of a food sample. In light of this, Sensory properties of new or improved foods are usually tested by human beings to ensure that they are acceptable and desirable (Schmidt & Oliveira, 2023). Nti (2009) opined that nutrition, health, sensory information, and the source of this information have the potential to influence the acceptance of food products by communicating the health benefits of such products. The nutritional value of bakery products, such as cakes, must meet both dietary requirements and sensory acceptability. This is because sensory attributes play a significant role in the acceptance of novel food products.

Cake is a bakery product in the form of a sweet dessert that is typically baked (Oledimma, 2021). Cake is typically made from a combination of refined flour, shortening, sweeteners, eggs, milk, leavening agents, and flavorings, and is usually baked. Cake is also often eaten as a dessert in many homes and is particularly loved by children and teenagers. Cakes constitute a significant snack in the fast-food industry (Kiin-Kabari & Banigo, 2015). The demand for cakes in Nigeria is extremely high, as they are a highlight of many celebrations, including birthday parties, end-of-year gatherings, weddings, traditional marriages, anniversaries, baby dedications, and Christmas celebrations. This makes cake a perfect food item for fortification. Conventional cakes are often high in sugar, carbohydrates, and fat, while being deficient in vital nutrients such as protein, minerals, and vitamins (Emeagi & Apugo, 2022; UNICEF, 2020). However, the nutritional profile of cake and other snacks can be improved by fortifying them with nutrient-dense foods

Food fortification is defined as the practice of adding vitamins and minerals to commonly consumed foods during processing to increase their nutritional value (Olson et al., 2021). Food fortification is the addition of a nutrient to a food above the level that is usually present. Food fortification is defined as the addition of one or more vitamins and minerals to commonly consumed foods (Bhutta et al., 2013). It can also be viewed as the practice of deliberately adding essential micronutrients to food to provide a public health benefit by reducing essential nutrient deficiency diseases. Mbuya & Neufeld (2018) explained that food fortification is a cost-effective strategy for addressing nutrient deficiencies in contexts characterized by a combination of marginal diets, vulnerable population segments, and other factors that contribute to deficiency. According to Dwyer et al. (2014), fortification can be used as a tool to correct or prevent widespread nutrient inadequacies. Hence, the need arises to correct associated micronutrient deficiencies, balance the total nutrient profile of diets, restore nutrients lost during food processing, or make products more appealing to consumers. Mejia (2020) opined that it is desirable for the fortification process not to increase the total cost of the final product significantly. The use of indigenous crops, such as cocoyam, plantain, and bambara nuts, to fortify wheat flour will significantly reduce production costs while also enhancing the nutritional value of the finished product.

Wheat is the primary ingredient used in the production of most bakery products, including other ingredients such as fat, eggs, and sugar. Wheat had to be imported to meet the demand of the bakery industry in Nigeria and other developing countries. The importation has resulted in a significant loss of foreign exchange that could have been used for the development of the agricultural sector (Odifa, 2023). To reduce the imports of large quantities of wheat in Nigeria, researchers have proposed using composite flours, where a portion of the wheat component is substituted with an abundant domestic alternative in bread and other baked products (Kokoh et al., 2022). This is to decrease the demand for imported wheat and stimulate the production and use of locally grown non-wheat agricultural products. Arubayi & Ogbonyomi (2019) observed that composite flour technology refers to the process of mixing wheat flour with legumes or cereals, or utilizing locally available raw materials to produce high-quality food products economically. The production of bakery products using composite flour formulated from indigenous food materials will significantly increase the trend of consuming locally grown food. The production of snacks, especially cakes, using locally available food ingredients such as cocoyam, plantain, and bambara nuts will increase their dietary fiber, vitamins, minerals, and protein, all of which are important for teenagers' overall health and well-being, and also help prevent malnutrition.

Cocoyam (*Xanthosoma sagittifolium*) is a staple food in developing countries especially Nigeria, Cocoyam is one of the major five tuber crops produced in Nigeria for local consumption alongside yam, cassava, Irish potato and sweet potato (Otekunrin et al., 2018) Cocoyam ranks third in importance, after cassava and yam, among the classes of root and tuber crops cultivated and consumed in most African countries (Onyeka, 2014). However, the utilization options for cocoyam are mainly limited to direct consumption as a whole, boiled tuber, or pounded into fufu and used as a soup thickener, thus making it an underutilized food (Kabuo et al., 2018). Nutritionally, cocoyam provides a high amount of digestible carbohydrates, serving as a significant calorie source for its consumers. They contain high levels of essential amino acids, digestible starch, and vitamins as compared to other root crops (Woldemariyam et al., 2022). They are rich in essential amino acids (Otekunrin et al., 2018). The protein content of cocoyam is higher than that of other root crops in leaves and tubers. They are also rich in minerals such as calcium, phosphorus, iron, copper, sodium, and magnesium, as well as a fair amount of vitamin C, thiamine, riboflavin, and niacin (Ahmed et al., 2020). The high levels of dietary fiber in cocoyam are also beneficial due to their active role in regulating intestinal metabolism, which helps increase dietary weight and promote bowel movement by absorbing water (Muñoz-Cuervo et al., 2016). These features thus make it an excellent candidate for fortification, especially when combined with other food items such as plantain and bambara nut.

Plantain (*Musa paradisiaca*) is a low-fat source of starchy carbohydrates and fiber, especially hemicelluloses, as well as essential vitamins and minerals like vitamin C, B6, folates, niacin, riboflavin, thiamin, potassium, and magnesium (Adepoju et al., 2012*).* Ajayi et al. (2023) observed that, due to their high fiber content and low glycemic index, plantain may offer several potential health benefits, including supporting digestive health and reducing the risk of conditions such as heart disease, diabetes, and constipation. Their vitamin C content helps boost the immune system, while potassium may help regulate blood pressure (Baiyeri et al., 2011). The inclusion of plantain flour in the production of baked goods, especially cakes, would help to increase the nutrient value of baked products. One possible way to extend their utilization could be by blending them with wheat flour and other indigenous food products, such as cocoyam and bambara groundnut.

Bambara nut (*Vigna subterranean*) is an indigenous leguminous crop of African origin. Nutritionally, the bambara nut is considered a complete food due to its balanced macronutrient composition (Falade et al., 2015) Bambara nut is rich in protein, with a good balance of essential amino acids (Oyeyinka et al., 2018), and a relatively high proportion of lysine and methionine. They are high in carbohydrates and a good source of fiber, containing a low amount of fat, moisture, and a fair amount of crude ash. Bambara compares well with soybeans and groundnuts in terms of mineral composition, including calcium, iron, sodium, phosphorus, magnesium, manganese, and zinc. They contain vitamins such as thiamine, riboflavin, ascorbic acid, and niacin (Oyeyinka et al., 2018). Bambara nut has been reported to contain high levels of phytochemicals, including tannins and flavonoids, as well as antioxidant properties that may help prevent diabetes, stroke, heart disease, cancer, Alzheimer's disease, and cardiovascular disease (Ramatsetse et al., 2023). The high nutritional value of the bambara nut makes it a valuable functional food that can significantly enhance the nutritional profile of composite baked products. Recent studies have reported that bambara nut protein hydrolysate and peptide fractions may be potentially used as ingredients in the formulation of functional foods and nutraceuticals to combat high blood pressure and oxidative stress (Arise et al., 2017).

Functional foods are foods that have potentially beneficial effects on health when consumed regularly at specific levels (Klemm, 2019). These foods can have specific functional benefits on the body systems: digestive system, immune system, cardio-circulatory system and even cellular (Belkhodja et al., 2017). A functional food can be: a natural food; a food in which a component has been added; food in which a component has been replaced; a food whose bioavailability has been changed or any combinations of these (Morifuji, 2019). Functional foods promote children's growth and development, optimize metabolic processes and physiological activity of organs, and reduce the risk of chronic diseases with onset during childhood (Butnariu & Sarac, 2019). The nutritional content of cocoyam, plantain, and Bambara nuts, when combined with wheat flour, can be used to produce snacks such as cake. This can serve as a functional food for adolescents, providing a sustainable impact on their nutritional status by promoting increased intake of macronutrients and micronutrients.

Positioning fortified, composite-flour cakes within household economic units advances sustainable development on multiple fronts. First, substituting part of imported wheat with locally available crops such as cocoyam, plantain, and bambara nut supports resilient local supply chains, reduces foreign-exchange pressure, and stimulates smallholder demand (Odifa, 2023; Kokoh et al., 2022; Arubayi & Ogbonyomi, 2019). Second, home-based microenterprises can translate low-cost, nutrient-dense fortification into affordable snacks, thereby improving the quality of adolescent diets while maintaining sensory acceptability, a key factor in market uptake (Sirangelo, 2019; Dwyer et al., 2014; Mbuya & Neufeld, 2018; UNICEF, 2020). Third, household-scale processing leverages existing domestic assets and labor, enabling inclusive livelihood opportunities, particularly for women, through flexible production, local branding, and neighborhood distribution, while reinforcing food literacy and media-driven nutrition messaging. Fourth, integrating composite flours with functional food principles allows households to deliver products that couple desirable sensory profiles with enhanced macronutrients and micronutrients, aligning with prevention goals for micronutrient deficiencies and noncommunicable disease risk across the life course (Bhutta et al., 2013; Klemm, 2019; Belkhodja et al., 2017; Morifuji, 2019; Butnariu & Sarac, 2019). Ultimately, by incorporating quality control practices from sensory evaluation and standardizing simple fortification protocols, household producers can achieve consistent product specifications, minimize waste through local crop utilization, and contribute to community-level food security and circularity (Schmidt & Oliveira, 2023; Olson et al., 2021). In sum, the household unit becomes a practical node for a nutrition-sensitive enterprise that couples import substitution and rural development with sustained, culturally acceptable improvements in dietary intake.

1.1 Objectives

Conduct sensory evaluation (general appearance, colour, flavour, texture, crispiness, taste and mouth feel) of cakes made from different blends of wheat, cocoyam, plantain, and bambara nuts composite flours (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and 100% wheat cake (control) (WF);

1.2 Research Question

The following question were answered in this study: (1) What are the mean ($\bar{x}$) ratings of the judges in terms of sensory attributes (general appearance, colour, flavor, texture, crispiness, taste and mouth feel) of cakes made from different blends of wheat, cocoyam, plantain, and bambara nuts composite flours (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and 100% wheat cake (WF)?

1.3 Research Hypothesis

The following hypothesis were tested at $P \leq 0.05$ level. There is no significant difference in mean ($\bar{x}$) ratings of the judges in terms of sensory attributes (general appearance, colour, flavour, texture, crispiness, taste and mouth feel) of cakes made from different blends of wheat, cocoyam, plantain, and bambara nuts composite flours (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and 100% wheat cake (WF)

This study addresses gaps in composite-flour research where the specific blend of wheat, sweet potato, banana, and bambara bean has seldom been evaluated with an integrated lens that links sensory quality to functional nutrition, cost, and sustainability at the household economic unit level; prior work rarely maps trade-offs among liking, nutrient density, and unit costs or provides adoption metrics such as simple SOPs, basic quality control, shelf life under home conditions, and willingness to pay. Accordingly, the research aims to compare multiple composite ratios against a wheat-only control on appearance, color, flavor, taste, texture, mouthfeel, and overall acceptability; relate sensory outcomes to practical proxies of functional nutrition (e.g., fiber and protein targets); assess household-scale feasibility including ingredient availability, unit costs, SOPs, and quality checks; evaluate basic shelf life and early market acceptance; and quantify sustainability contributions through partial wheat substitution, strengthened local sourcing, and potential micro-economic gains for household producers.

## 2. METHOD

### *2.1 Research Design*

The study was carried out in the Food and Nutrition Laboratory of the Department of Vocational Education (Home Economics Unit), Delta State University, Abraka. The choice of this location was strategic, as it provided access to a panel of fifteen judges who participated in the sensory evaluation. An experimental research design was adopted, which allowed for the systematic production and evaluation of cakes prepared from composite flour blends of wheat, cocoyam, plantain, and bambara nut. The flour ratios examined included 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. These samples were subjected to nutritional analysis, sensory evaluation, and shelf-life studies.

The study population consisted of male and female academic staff and undergraduate students from Delta State University, Abraka, and the University of Delta, Agbor. Altogether, 185 subjects constituted the population, comprising 16 staff members and 142 students from Abraka, and six staff members and 21 students from Agbor. From this population, 15 participants (seven staff and eight students) were purposively selected as the panel of judges. They were chosen because of their willingness to participate, as well as because cake consumption is common among both adolescents and adults.

Data were collected using two research instruments: a standard sensory evaluation questionnaire and a structured questionnaire. The sensory evaluation questionnaire employed a 9-point Hedonic scale, ranging from “like extremely” (9) to “dislike extremely” (1), and was used to assess appearance, colour, flavour, texture, crispiness, taste, and general acceptability. The structured questionnaire, on the other hand, was a 5-point scale ranging from “poor” (1) to “excellent” (5) and was used to monitor shelf life. The instruments were subjected to face and content validation by three experts in Home Economics, Measurement and Evaluation, and Biochemistry. Following their suggestions, corrections were made, and a pilot test was then conducted. Reliability was tested using Cronbach’s Alpha, and the coefficient indices of 0.81 for the 9-point scale and 0.88 for the 5-point scale demonstrated high reliability.

For data collection, research assistants administered the questionnaires to the judges, who evaluated the cake samples under controlled conditions. Clean water was provided to rinse their mouths between tastings. Shelf-life evaluation was conducted by five judges every four days, assessing similar attributes as in the sensory Analysis. Materials used included cocoyam, unripe Plantain, bambara nut, wheat flour, margarine, eggs, and baking powder, all sourced from the local market in Ughelli, Delta State. Laboratory analysts provided laboratory reagents required for nutritional Analysis. This structured methodology ensured the validity, reliability, and accuracy of the data collected for the study.

### *2.2 Method of Sample Preparation*

Cocoyam, Plantain, and Bambara nuts flour were produced using the traditional method of dehydration (sun drying) and milling.

a) Preparation of Cocoyam Flour

The cocoyam tubers were sorted to remove impurities and then washed clean with tap water. They were peeled manually with a 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 a hot water bath of 100 ºC for 5 minutes as reported by Orhevba & Ndanaimi (2021). The blanched chips were then spread on trays and dried in the sun. The dried chips were ground into fine flour using the local milling machine. The cocoyam flour obtained was packaged in a zip-lock bag, labeled, and stored at room temperature until needed.

b) Preparation of Plantain Flour

Plantain flour was prepared as described by Arubayi & Ogbonyomi (2019) as follows: A Bunch of matured (unripe) Plantain was separated and washed with clean water to remove dirt and latex. The washed plantains were hand-peeled with the aid of a stainless-steel kitchen knife to extract the pulp and kept in a bowl containing water, where they remained until the peeling process was completed (to reduce enzymatic reaction). Plantain pulps were manually sliced into cylindrical pieces of 2 cm thickness for easy drying. The sliced Plantain was then blanched in hot water at 80°C for 5 minutes. This was to stop the 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 subsequently sifted using a kitchen sieve. The plantain flour obtained was packaged in a polythene bag, labeled, and stored at room temperature until needed.

c) Preparation of Bambara nut flour

The Bambara nuts were soaked in clean tap water for 24 hours and then manually dehulled. The seeds were then boiled for 10 minutes (1:4 ratio of bambara nuts to water) in a stainless-steel pot, as described by Barimalaa et al. (1994) and cited by Kiin-Kabari & Banigo (2015). The seeds were drained of water and sun-dried. The dried samples were milled using a hammer mill and then sieved into flour using a 0.25mm sieve. Afterward, they were packaged for use as needed.

### *2.4 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 flours with wheat flour at different ratios (W85C5P5B5 C1); (W80C10P5B5 C2); (W70C10P10B10 C3); (W65C10P15B10 C4); (W55C15P15B15 C5); (W50C15P20-B15 C6) of wheat flour substitutions, respectively. One hundred percent (100%) wheat flour (W100C0P0-B0) was used as the control. A total of seven different cake samples were formulated.

### *2.5 Measurement for Cocoyam, Plantain, and Bambara Nut Composite Cake*

The cakes were formulated using different proportions of wheat flour blended with cocoyam, plantain, and bambara nut flours to create six composite samples alongside a 100% wheat flour control. The control sample (WF) was prepared with 300 g of wheat flour alone, without any substitution. In the first composite formulation, WCPB1, 285 g of wheat flour (85%) was combined with 15 g each of cocoyam, Plantain, and bambara nut flours (5% each). For WCPB2, wheat flour was reduced to 240 g (80%), while cocoyam was increased to 30 g (10%); plantain and bambara nut flours were maintained at 15 g each (5%). In WCPB3, the blend consisted of 210 g of wheat flour (70%), and 30 g each of cocoyam, Plantain, and bambara nut flours (10% each). WCPB4 further reduced wheat flour to 195 g (65%), with 45 g of cocoyam (15%), 30 g of Plantain (10%), and 30 g of bambara nut flour (10%). In WCPB5, 165 g wheat flour (55%) was mixed with equal quantities of 45 g each of cocoyam, Plantain, and bambara nut flours (15% each). The final composite, WCPB6, contained 150 g wheat flour (50%), 45 g cocoyam flour (15%), 60 g plantain flour (20%), and 45 g bambara nut flour (15%). This gradation allowed systematic substitution of wheat with nutrient-rich alternatives.

### *2.6 Cake Recipe for Samples*

In the formulation of the cakes, different proportions of wheat flour, cocoyam flour, plantain flour, and bambara nut flour were used while keeping the other ingredients constant. In the control sample, only wheat flour was used at 300 g without the inclusion of cocoyam, Plantain, or bambara nut. For the first composite cake, 255 g of wheat flour was combined with 15 g each of cocoyam, Plantain, and bambara nut. In the second variation, wheat flour was reduced to 240 g, with 30 g of cocoyam, 15 g of Plantain, and 15 g of bambara nut added. The third variation further reduced the wheat flour to 210 g, with 30 g each of cocoyam, Plantain, and bambara nut included. In the fourth formulation, 195 g of wheat flour was used along with 45 g of cocoyam, 30 g of Plantain, and 30 g of bambara nut. In the fifth formulation, wheat flour was reduced to 165 g, while cocoyam, Plantain, and bambara nut were each increased to 45 g. The final formulation contained the least amount of wheat flour, 150 g, and the highest proportion of substitutes, with 45 g of cocoyam, 60 g of Plantain, and 45 g of bambara nut. Across all formulations, the other ingredients were kept constant to ensure uniformity. Margarine was measured at 250 g, and sugar at 180 g; five large eggs were also included. Flavoring and leavening agents were also consistent, consisting of 15 g of lemon zest, 5 g of nutmeg, 5 mL of vanilla extract, 15 g of baking powder, and 2 g of salt. These controlled measures ensured that any variation in the outcome of the cakes was attributed to the different proportions of the composite flours rather than differences in the other ingredients.

### *2.7 Equipment and Tools Needed to make Cakes*

The preparation of the cakes required several essential equipment and tools to ensure accuracy and efficiency. An oven was used for baking the cakes, while cake pans provided the containers for shaping them. A kitchen scale, along with measuring cups and spoons, ensured precise measurement of ingredients. A cake mixer and mixing bowls were employed to achieve uniform blending of the batter, while a sieve was used to sift the composite flour for consistency. Eggs were whisked using an egg whisk, and spatulas were utilized for folding, scraping, and smooth mixing. Together, these tools facilitated the preparation and baking of cakes adequately.

### *2.8 Method of Cake Preparation*

Cakes were prepared from the composite flour samples following the procedure outlined by All Nigerian Recipes (2022), with slight modifications in measurements and formulations. The fat and sugar were first creamed together until light and fluffy. Afterward, baking pans were greased and dusted with flour to aid in the easy removal of the cakes. Eggs were broken one at a time, whisked until smooth, and the oven was preheated to 220°C. All dried ingredients were sifted and stirred before the whisked eggs were gradually added to the fat and sugar mixture. Vanilla extract was incorporated, and the sifted dry ingredients were folded in small portions. The batter was poured into prepared pans, baked for 40 minutes until golden brown, cooled on a rack, and later evaluated.

### *2.9 Sensory Evaluation of Cake Samples*

The cake samples, including the 100% wheat flour (controls) and those made from the different blends of cocoyam, Plantain, bambara nuts, and wheat composite flour, were evaluated for general appearance, taste, colour, flavour, texture, mouth feel, and overall acceptability using a preference method on a 9-point hedonic scale. Fifteen panelists, who gave their consent, were purposively selected from among the academic staff and students of the Department of Vocational Education at Delta State University, Abraka, for the study. The samples were evaluated on a 9-point hedonic scale (9 - liked immensely, 8 - liked very much, 7- liked moderately, 6 - liked slightly, 5 - neither like nor dislike, 4 - disliked slightly, 3 - disliked moderately, 2 - very much disliked, 1 - disliked immensely), scores from 9 to 5 point is like, below 5 is dislike. The cut-off mark was 5. Any sample with a mean score below 5.00 was regarded as disliked. Any sample with a mean score of 5.00 to 9.00 was viewed as liked.

### *2.10 Method of determination of shelf life of cake samples*

All the composite cake samples, including the 100% wheat flour (controls), were subjected to shelf-life evaluation using the sensory evaluation method. Six parameters (general appearance, colour, flavour, taste, texture, and overall acceptability) were monitored. Five semi-trained panelists, who gave their consent, were purposively selected from undergraduate students in the Home Economics Department and the Department of Vocational Education at Delta State University, Abraka, for the study. A 5-point scale structured questionnaire (5 – excellent, 4 – very good, 3 - good, 2 – poor, 1 - very poor) was used to collect data. The cut-off mark was 3. Any sample with a mean score between 5.00 and 3.00 was regarded as good, and those below three were viewed as bad.

### *2.11 Method of Data Analysis*

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

## 3. RESULT AND DISCUSSION

### *3.1 Result*

Research Question: What are the mean ratings of the judges in terms of sensory attributes (general appearance) of cakes made from different blends of wheat, cocoyam, Plantain, and bambara nuts composite flours (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5, and WCPB6) and 100% wheat cake (WF)?

Table 1. Mean Ratings of sensory evaluation of all the Cake Samples

| Parameters | WCPB1 | WCPB2 | WCPB3 | WCPB4 | WCPB5 | WCPB6 | WF |
|---|---|---|---|---|---|---|---|
| | 85:5:5:5 | 80:10:5:5 | 70:10:10:10 | 65:10:15:10 | 55:15:15:15 | 50:15:20:15 | 100% |
| Appearance | 8.07±0.59[a] | 8.20 ±0.41[a] | 7.80 ±0.56[b] | 8.13±0.52[a] | 7.60 ±0.51[c] | 7.40 ±0.51[c] | 8.27 ±0.46[a] |
| Colour | 8.00±0.65[a] | 8.07±0.46[a] | 7.80 ±0.56[a] | 7.53±0.64[b] | 7.47 ±0.64[b] | 7.47 ±0.64[a] | 8.13±0.64[a] |
| Flavour | 7.00±0.82[a] | 7.13±0.99[a] | 7.07±0.88[a] | 7.13±0.86[a] | 6.73 ±0.88[a] | 6.80 ±0.92[a] | 7.33±0.85[a] |
| Taste | 7.33±0.97[a] | 7.87±0.64[a] | 7.27±0.59[a] | 7.47 ±1.69[a] | 7.20 ±0.68[a] | 7.27 ±1.16[a] | 7.80±1.01[a] |
| Texture | 7.27±0.46[a] | 8.20±0.68[a] | 7.27±0.59[a] | 7.67±2.20[a] | 7.00±0.54[b] | 7.47 ±0.64[a] | 8.13±0.64[a] |
| Mouth feel | 7.20±0.86[a] | 8.13±0.52[a] | 7.20±0.86[a] | 8.07±0.70[a] | 7.13 ±0.83[a] | 7.07 ±0.88[a] | 8.20 ±0.68[a] |
| Overall Acceptability | 7.07±0.96[a] | 7.20±1.21[a] | 6.83±0.83[a] | 7.13±1.19[a] | 6.73 ±1.28[a] | 6.80 ±1.08[a] | 7.47±0.64[a] |

Research Question: What are the mean ($\bar{x}$) ratings of the judges in terms of sensory attributes (general appearance) of cakes made from different blends of wheat, cocoyam, plantain, and bambara nuts composite flours (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and 100% wheat cake (WF)?

Table 2. Mean ratings of appearance for all cake samples

| Sample | N | Sum | Mean (x̄) | Std. Deviation |
|---|---|---|---|---|
| WCPB1 | 15 | 121 | 8.07[a] | 0.594 |
| WCPB2 | 15 | 123 | 8.20[a] | 0.414 |
| WCPB3 | 15 | 117 | 7.80[b] | 0.561 |
| WCPB4 | 15 | 122 | 8.13[a] | 0.516 |
| WCPB5 | 15 | 114 | 7.60[c] | 0.507 |
| WCPB6 | 15 | 111 | 7.40[c] | 0.507 |
| WF | 15 | 127 | 8.27[a] | 0.458 |
| Total | 105 | 832 | 7.792 | 0.583 |

The result in Table 2: shows the mean rating of Judge's preference for Appearance of all the cake samples. The table indicated that all the cake samples have mean rating between 7.40 (±0.51) and 8.27 (±0.46). The table showed that WF (control) was rated best in appearance among all the cake samples with a mean rating of 8.27 (±0.46). WCPB2 was rated next with a mean rating of 8.20 (±0.41). sample WCPB1 had a mean ration of 8.07 (0.59). Sample WCPB3 had a mean rating of 7.80 (± 0.56), while WCPB4 had a mean rating of 8.13 (± 0.52), samples WCPB5 and WCPB6 had mean ratings of 7.60 (±0.51) and 7.40 (±0.51).

H0: There is no significant difference in the mean ratings of the judges in terms of sensory attributes (general appearance) of cakes made from different blends of wheat, cocoyam, plantain, and bambara nuts composite flours (WCPB1 - WCPB6) and 100% wheat cake

Table 3. ANOVA for General Appearance of cake samples

| Appearance | Sum of Squares | df | Mean (x̄) Square | F | Sig. | Decision |
|---|---|---|---|---|---|---|
| Between Groups | 9.790 | 6 | 1.632 | 6.247 | 0.000 | reject |
| Within Groups | 25.600 | 98 | 0.261 | | | |
| Total | 35.390 | 104 | | | | |

The result in Table 3 indicated that the F-value was 6.247 and the significant value was 0.000 at the $P \leq 0.05$ level. This shows that there was a significant difference in colour preference among all the cake samples and the cake made with 100% wheat flour at the $P>0.05$ level. Therefore, the null hypothesis was rejected. The Duncan Multiple Range Test revealed that there was no significant difference in the appearance mean ratings of WF (control) when compared to WCPB1, WCPB2, and WCPB4, hence the null hypothesis was accepted at the $P>0.05$ level. The test result also indicated that there was a significant difference when WF (control) was compared to WCPB3, WCPB5, and WCPB6; hence, the hypothesis was rejected. The Duncan Multiple Range Test showed that WCPB1 was significantly different from WCPB5 and WCPB6 but did not differ from WCPB2, WCPB3, WCPB4, and WF. Therefore, the null hypothesis was accepted.

The sample WCPB2 had no significant difference when compared with WCPB1, WCPB4, and WF, hence the hypothesis was accepted. However, there was a significant difference among WCPB2, WCPB3, WCPB5, and WCPB6. Thus, the null hypothesis was rejected. WCPB5 differs significantly when compared with WCPB1, WCPB2, WCPB4, and WF (control). There was no significant difference between WCPB6 and WCPB5, but WCPB6 differed significantly from WCPB1, WCPB2, WCPB3, WCPB4, and WF. Therefore, the null hypothesis was rejected.

Research Question: What are the mean ratings of the judges in terms of sensory attributes (colour) of cakes made from different blends of wheat, cocoyam, plantain, and bambara nuts composite flours (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and 100% wheat cake (WF)?

Table 4. Mean Ratings of Color for all Cake Samples

| Sample | N | Sum | Mean (x̄) | Std. Deviation |
|---|---|---|---|---|
| WCPB1 | 15 | 120 | $8.00^{a}$ | 0.655 |
| WCPB2 | 15 | 121 | $8.07^{a}$ | 0.458 |
| WCPB3 | 15 | 117 | $7.80^{a}$ | 0.561 |
| WCPB4 | 15 | 113 | $7.53^{b}$ | 0.640 |
| WCPB5 | 15 | 112 | $7.47^{c}$ | 0.640 |
| WCPB6 | 15 | 112 | $7.47^{c}$ | 0.640 |
| WF | 15 | 122 | $8.13^{a}$ | 0.516 |
| Total | 105 | 817 | 7.78 | 0.635 |

The result in Table 4: shows the mean rating of Judge's preference for Colour of all the cake samples. The table indicated that all the cake samples had a mean rating between 8.13 (±0.52) and 7.47 (±0.64). The result from the table showed that WCPB2 was rated best in colour among all the cake samples with a mean rating of 8.13 (±0.52). Sample WCPB3 had a mean rating of 7.80 (±0.56), while WCPB4 had mean rating of 7.53 (±0.64). Samples WCPB5 and WCPB6 had the same mean ratings of 7.47 (±0.64). Sample WCPB7 (control) had a mean of 8.13 (±0.52).

$H_0$: There is no significant difference in mean ratings of the judges in terms of sensory attributes of colour of cakes made from different blends of wheat, cocoyam, plantain, and bambara nuts composite flours (WCPB1 - WCPB6) and 100% wheat cake.

Table 5. ANOVA for Colour of Cake Samples

| Colour | Sum of Squares | df | Mean ($\bar{x}$) Square | F | Sig. | Decision |
|---|---|---|---|---|---|---|
| Between Groups | 7.181 | 6 | 1.197 | 3.519 | 0.003 | Reject |
| Within Groups | 33.333 | 98 | 0.340 | | | |
| Total | 40.514 | 104 | | | | |

The result in Table 5 shows that the F-value was 3.519 and the significant value was 0.003 at P ≤ 0.05. This shows that there was a significant difference in colour preference among all the cake samples at the P>0.05 level. Therefore, the null hypothesis was rejected. Duncan Multiple Range Test showed that there was no significant difference in the mean colour ratings of WF (control) when compared to WCPB1, WCPB2, and WCPB3, hence the null was accepted at the P>0.05 level. The test result also showed that there was a significant difference when the WF (control) colour was compared to WCPB4, WCPB5, and WCPB6. This implies that the null hypothesis of no significant difference in colour was rejected.

The sample WCPB1 was not significantly different from WCPB2, WCPB3, and WF (control). Therefore, the null hypothesis was accepted at the P>0.05 level. The sample WCPB1 differs significantly from WCPB4, WCPB5, and WCPB6. Hence, the null hypothesis was rejected at the P>0.05 level. The test result also showed that WCPB2 had no significant difference in colour preference with WCPB1, WCPB3, and WF (control), but differed significantly with WCPB4, WCPB5, and WCPB6. The sample WCPB3 was not significantly different from the rest of the samples (WCPB1, WCPB2, WCPB4, WCPB5, WCPB6, and WF. Therefore, the null hypothesis was accepted.

Furthermore, the sample WCPB4 differs significantly from WCPB1 and WCPB2; hence, the hypothesis was rejected at the P>0.05 level. Conversely, the test result also showed that there was no significant difference in the colour ratings of WCPB3, WCPB5, and WCPB6. Therefore, the null hypothesis was accepted at the P>0.05 level. Also, the test showed that there was a significant difference when WCPB5 and WCPB6 were compared with WCPB1, WCPB2, and WF. Therefore, the null hypothesis was rejected at the P>0.05 level. The samples WCPB5 and WCPB6 were not significantly different from WCPB3, WCPB4, and WCPB6. Hence, the null hypothesis is accepted.

Research Question: What are the mean ratings of the judges in terms of sensory attributes (flavour) of cakes made from different blends of wheat, cocoyam, plantain, and bambara nuts composite flours (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and 100% wheat cake (WF)?

Table 6. Mean Ratings of Flavour for all Cake Samples

| Sample | N | Sum | Mean ($\bar{x}$) | Std. Deviation |
|---|---|---|---|---|
| WCPB1 | 15 | 105 | 7.00[a] | 0.816 |
| WCPB2 | 15 | 107 | 7.13[a] | 0.990 |
| WCPB3 | 15 | 106 | 7.07[a] | 0.884 |
| WCPB4 | 15 | 107 | 7.13[a] | 0.862 |
| WCPB5 | 15 | 101 | 6.73[a] | 0.884 |
| WCPB6 | 15 | 102 | 6.80[a] | 0.915 |
| WF | 15 | 110 | 7.33[a] | 0.845 |
| Total | 105 | 738 | 7.03 | 0.882 |

The mean flavour rating in Table 6 showed that the mean score rating of flavour of all the cakes varied between 7.33 (±0.85) and 6.73 (±0.88). The result on the table showed that WF (control) was rated higher in terms flavour than all the cake samples with a mean rating of 7.33 (±0.85), while cake sample WCPB5 had the lowest mean rating of 6.73 (±0.88). Sample WCPB1 had mean ratings of 7.00 (±0.82). Samples WCPB2 and WCPB4 had sane mean rating of 7.13 (±0.99) and (0.915). WCPB3 and WCPB6 had mean ratings of 7.07 (±0.884) and 6.80 ± 0.92) respectively.

$H_0$: There is no significant difference in the mean ratings of the judges in terms of sensory attributes (flavour) of cakes made from different blends of wheat, cocoyam, plantain, and bambara nuts composite flours (WCPB1 - WCPB6) and 100% wheat cake

Table 7. ANOVA for Favour of cake samples

| Flavour | Sum of Squares | df | Mean ($\bar{x}$) Square | F | Sig. | Decision |
|---|---|---|---|---|---|---|
| Between Groups | 3.848 | 6 | 0.641 | 0.815 | 0.560 | Accept |
| Within Groups | 77.067 | 98 | 0.786 | | | |
| Total | 80.914 | 104 | | | | |

The result in table 7 shows that the F- value was 0.815 and the significant value was 0.560 at P ≤ 0.05 level. This indicates that there is no significant difference among judges on flavour preference of all the cake samples at 5% (P>0.05) level. Therefore the null hypothesis was accepted.

Research Question: What are the mean ratings of the judges in terms of (taste) of cakes made from the different blends of wheat, cocoyam, plantain, and bambara nuts composite flours (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and 100% wheat cake (WF)?

Table 8. Mean ratings of taste for all cake samples

| Sample | N | Sum | Mean ($\bar{x}$) | Std. Deviation |
|---|---|---|---|---|
| WCPB1 | 15 | 110 | 7.33[a] | 0.976 |
| WCPB2 | 15 | 118 | 7.87[a] | 0.640 |
| WCPB3 | 15 | 109 | 7.27[a] | 0.594 |
| WCPB4 | 15 | 112 | 7.47[a] | 1.685 |
| WCPB5 | 15 | 108 | 7.20[a] | 0.676 |
| WCPB6 | 15 | 109 | 7.27[a] | 1.163 |
| WF | 15 | 117 | 7.80[a] | 1.014 |
| Total | 105 | 783 | 7.46 | 1.029 |

Table 8: shows the mean rating of Judge's preference for taste among all the cake samples. The table indicated that all the cake samples have a mean rating between 7.87 (±0.64) and 7.20 (±0.68). The result from the table showed that WCPB2 has the highest mean rating among all the cake samples in terms of taste with a mean rating of 7.87 (±0.64). Sample WF (control) was rated next with a mean rating of 7.80 (±1.01). WCPB1 mean rating was 7.33 (± 0.98), while WCPB3 and WCPB4 had a mean rating of 7.27 (±0.59) and 7.47 (1.69). Sample WCPB5 and WCPB6 had mean ratings of 7.20 (± 0.68) and 7.27 (±1.16).

$H_0$: There is no significant difference in the mean ratings of the judges in terms of sensory attributes (taste) of cakes made from different blends of wheat, cocoyam, plantain, and bambara nuts composite flours (WCPB1 - WCPB6) and 100% wheat cake.

Table 9. ANOVA for Taste Preference of the Cake Samples

| Taste | Sum of Squares | df | Mean ($\bar{x}$) Square | F | Sig. | Decision |
|---|---|---|---|---|---|---|
| Between Groups | 6.590 | 6 | 1.098 | 1.040 | 0.404 | Accept |
| Within Groups | 103.467 | 98 | 1.056 | | | |
| Total | 110.057 | 104 | | | | |

The result in table 9 shows that the F- value was 1.040 and the significant value was 0.404 at P ≤ 0.05 level. This indicates that there is no significant difference among judges taste preference in among all the cake samples at 5% (P>0.05) level. Therefore, the null hypothesis was accepted.

Research Question: What are the mean ratings of the judges in terms of sensory attributes (texture) of cakes made from different blends of wheat, cocoyam, plantain, and bambara nuts composite flours (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and 100% wheat cake (WF)?.

Table 10. Mean Ratings of Texture for all Cake Samples

| Sample | N | Sum | Mean ($\bar{x}$) | Std. Deviation |
|---|---|---|---|---|
| WCPB1 | 15 | 109 | 7.27[b] | 0.458 |
| WCPB2 | 15 | 123 | 8.20[a] | 0.676 |
| WCPB3 | 15 | 109 | 7.27[b] | 0.594 |
| WCPB4 | 15 | 114 | 7.67[a] | 2.197 |
| WCPB5 | 15 | 105 | 7.00[b] | 0.535 |
| WCPB6 | 15 | 112 | 7.47[b] | 0.640 |
| WF | 15 | 122 | 8.13[a] | 0.640 |
| Total | 105 | 783 | 7.56 | 1.055 |

The result in Table 10: shows the mean rating of Judge's preference for texture among all the cake samples. Result from the table indicated that all the cake samples had a mean rating between 8.20 (±0.68) and 7.00 (±0.54). The result also showed that WCPB2 has the highest mean rating among all the cake samples in terms of texture with a mean rating of 8.20 (±0.68). Sample WCPB1 and WCPB3 had the same mean rating of 7.27 (±0.46) and (±0.59) respectively. Samples WCPB4 mean rating was 7.67 (± 2.20), while WCPB5 and WCPB6 mean ratings was 7.00 (± 0.54) and 7.47 (±0.64) While the control (WF) mean rating was 8.13 (±0.64)

$H_0$: There is no significant difference in the mean ratings of the judges in terms of sensory attributes (texture) of cakes made from different blends of wheat, cocoyam, plantain, and bambara nuts composite flours (WCPB1 - WCPB6) and 100% wheat cake.

Table 11. ANOVA for Texture Preference of the cake Samples

| Texture | Sum of Squares | df | Mean ($\bar{x}$) Square | F | Sig. | Decision |
|---|---|---|---|---|---|---|
| Between Groups | 18.514 | 6 | 3.086 | 3.107 | 0.008 | Reject |
| Within Groups | 97.333 | 98 | 0.993 | | | |
| Total | 115.848 | 104 | | | | |

The result in table 11 showed that the F- value for texture was 3.107 and the significant value was 0.008 at P ≤ 0.05 level. This indicates that there is significant difference among judge's texture preference among all the cake samples at P>0.05 level. Therefore the null hypothesis was rejected. The Duncan multiple comparison text showed that the control (WF) differs significantly with WCPB1, WCPB3 and WCPB5. Therefore, hence the null hypothesis here was rejected. Furthermore, the test result also showed that WF was not significantly different from WCPB2, WCPB4 and WCPB6.

Duncan test also showed that WCPB1 differ significantly in texture from WCPB2 and WF but not significantly different from significant WCPB3, WCPB4, WCPB5 and WCPB6. Therefore, the hypothesis was upheld. WCPB2 was significantly different from WCPB1, WCPB3, WCPB5 and WCPB6; thus, the null hypothesis here was also rejected. WCPB3 was significantly different from WCPB2 and WF.

Conversely, WCPB4 was not significantly different from all the samples including the control (WF); hence the hypothesis was accepted at P≤ 0.05 level. Sample WCPB5 was significantly different from WCPB1 and WF; also WCPB6 differ significantly from WCPB2. Therefore the null hypothesis was rejected at P≤ 0.05 level.

Research Question: What are the mean ratings of the judges in terms of sensory attributes (mouth feel) of cakes made from different blends of wheat, cocoyam, plantain, and bambara nuts composite flours (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and 100% wheat cake (WF)?.

Table 12. Mean Ratings of Mouthfeel for all Cake Samples

| Sample | N | Sum | Mean ($\bar{x}$) | Std. Deviation |
|---|---|---|---|---|
| WCPB1 | 15 | 108 | $7.20^{b}$ | 0.862 |
| WCPB2 | 15 | 117 | $8.13^{a}$ | 0.516 |
| WCPB3 | 15 | 108 | $7.20^{b}$ | 0.862 |
| WCPB4 | 15 | 121 | $8.07^{a}$ | 0.704 |
| WCPB5 | 15 | 107 | $7.13^{b}$ | 0.834 |
| WCPB6 | 15 | 106 | $7.07^{b}$ | 0.884 |
| WF | 15 | 123 | $8.20^{a}$ | 0.676 |
| Total | 105 | 795 | 7.57 | 0.897 |

The result in Table 12: shows the mean rating of Judge's preference for mouth feel among all the cake samples. The table revealed that all the cake samples have a mean rating between 8.20 (±0.68) and 7.07 (±0.88). The table showed that WF was rated best mean rating among all the cake samples in terms of feeing in the mouth with a mean rating of 8.20 (±0.68). WCPB1 mean rating was 7.20 (±0.86). WCPB2 mean rating was 8.13 (± 0.52), while WCPB3 had 7.20 (±0.86). WCPB4 mean rating was 8.07 (±0.70), while WCPB5 and WCPB6 had mean ratings of 7.13 (± 0.83) and 7.07 (±0.88).

$H_0$: There is no significant difference in the mean ratings of the judges in terms of sensory attributes (texture) of cakes made from different blends of wheat, cocoyam, plantain, and bambara nuts composite flours (WCPB1 - WCPB6) and 100% wheat cake

Table 13. ANOVA for Mouth feel Preference of the Cake Samples

| Mouth feel | Sum of Squares | df | Mean ($\bar{x}$) Square | F | Sig. | Decision |
|---|---|---|---|---|---|---|
| Between Groups | 25.181 | 6 | 4.197 | 7.027 | 0.000 | Reject |
| Within Groups | 58.533 | 98 | 0.597 | | | |

| Mouth feel | Sum of Squares | df | Mean ($\bar{x}$) Square | F | Sig. | Decision |
|---|---|---|---|---|---|---|
| Total | 83.714 | 104 | | | | |

The result in table 13 showed that the F- value for mouth feel was 7.027 and the significant value was 0.000 at $P \leq 0.05$ level. This shows that there is significant difference among judges mouth feel preference from all the cake samples at P>0.05 level. Therefore the null hypothesis was rejected. The Duncan Multiple Range Test indicated that the control (WF) differ significantly in mouth feel with WCPB1, WCPB3, WCPB5 and WCPB6; hence the null hypothesis was rejected. Furthermore, the test result also showed that WF (control) was not significantly different with WCPB2 andWCPB4. Thus, the hypothesis was accepted.

Although, the cake sample WCPB1 differs significantly from WCPB2, WCPB4, and WF, but does not differ from WCPB3, WCPB5 and WCPB6. The test result also showed that WCPB2 was not significantly different from WCPB4 and the control (WF), but differs from WCPB1, WCPB3, WCPB5 and WCPB6. Therefore, the null hypothesis was rejected. Sample WCPB3 was not significantly different from WCPB1, WCPB5 and WCPB6, but showed significant difference with WCPB2, WCPB4 and the control.

Sample WCPB4 was significantly different from all the samples except WCPB2 and the control (WF); hence the hypothesis was also rejected. Similarly, WCPB5 and WCPB6 are significantly different from WCPB2, WCPB4 and WF. Therefore, the hypothesis was also rejected.

Research Question: What are the mean ratings of the judges in terms of sensory attributes (overall acceptability) of cakes made from different blends of wheat, cocoyam, plantain, and bambara nuts composite flours (WCPB1, WCPB2, WCPB3, WCPB4, WCPB5 and WCPB6) and 100% wheat cake (WF)?

Table 14. Descriptive statistics for overall acceptability

| Sample | N | Sum | Mean ($\bar{x}$) | Std. Deviation |
|---|---|---|---|---|
| WCPB1 | 15 | 106 | $7.07^a$ | 0.961 |
| WCPB2 | 15 | 108 | $7.20^a$ | 1.207 |
| WCPB3 | 15 | 103 | $6.83^a$ | 0.834 |
| WCPB4 | 15 | 107 | $7.13^a$ | 1.187 |
| WCPB5 | 15 | 101 | $6.73^a$ | 1.280 |
| WCPB6 | 15 | 102 | $6.80^a$ | 1.082 |
| WF | 15 | 112 | $7.47^a$ | 0.640 |
| Total | 105 | 739 | 7.04 | 1.046 |

The result in Table 14: shows the mean rating of Judge's preference for overall acceptability among all the cake samples. The table revealed that all the cake samples have a mean rating between 6.73 (±1.28) and 7.47 (±0.64). The table showed that sample WF was rated best among all the cake samples in terms of overall acceptability with a mean rating of 7.47 (±0.64). WCPB1 mean rating was 7.07 (±0.96). WCPB2 mean rating was 7.20 (± 1.21), while WCPB3 had 6.83 (±0.83). Sample WCPB4 mean rating was 7.13 (±1.19), while WCPB5 and WCPB6 had mean ratings of 6.73 (± 1.28) and 6.80 (±1.08).

Table 15. ANOVA for Overall Acceptability Preference of the Cake Samples

| Acceptability | Sum of Squares | df | Mean ($\bar{x}$) Square | F | Sig. | Decision |
|---|---|---|---|---|---|---|
| Between Groups | 5.981 | 6 | 0.997 | 0.906 | 0.494 | Accept |
| Within Groups | 107.867 | 98 | 1.101 | | | |
| Total | 113.848 | 104 | | | | |

The ANOVA table 15 revealed that the F- value for overall acceptability was 0.906 and the significant value was 0.494 at $P \leq 0.05$ level. This shows that there is no significant difference among judges overall acceptability preference of all the cake samples including the control at P>0.05 level. Therefore the null hypothesis was accepted

### 3.2. Discussion

The sensory evaluation of cakes formulated with composite flours from wheat, cocoyam, plantain, and bambara nut demonstrates that partial substitution can preserve key consumer-facing attributes while improving the product's nutritional profile. Across core dimensions of quality such as color, crumb structure, aroma, sweetness balance, and mouthfeel, the blends achieved acceptability comparable to wheat-only controls, indicating that texture and flavor integrity can be maintained alongside higher fiber and protein targets. This balance suggests that underutilized crops can be integrated without sacrificing overall liking, offering a practical pathway to develop functional snacks that align with taste expectations while nudging diets toward greater nutrient density and diversity.

Beyond product quality, the approach advances sustainability and inclusivity through household economic units (Krysovatyy et al., 2024). Leveraging locally available crops reduces reliance on imported wheat, buffers price volatility, and supports domestic value chains, while small-scale, home-based production enables flexible livelyhoods, often benefiting women as primary food entrepreneurs (Stephens et al., 2022). Simple standard operating procedures, basic quality control (consistent particle size, moisture targets, and baking parameters), and feasible shelf-life practices under typical home storage conditions can help ensure reproducibility and safety at the microenterprise scale. Together, these outcomes position composite-flour cakes as an affordable, acceptable, and nutrition-forward alternative to conventional snacks, with spillover benefits for food security, local agriculture, and community-level income generation.

Flavor is the primary driver of liking or disliking. A good cake should present a pleasant, natural flavor that appeals to adolescents; it ought to taste rich, sweet, and agreeable, with a satisfying natural aroma (Ogbonyomi et al., 2023). Sensory evaluation results showed that all cake samples scored high on taste preference and were moderately liked by the judges, with no significant differences between the composite formulations and the wheat-only control.

Texture should be light and fluffy rather than dense or overly crumbly. Panelists liked the textural quality of all composite cakes, indicating that the fortificants (cocoyam, plantain, and bambara nut flours) did not negatively affect texture; all were judged acceptable, and none was disliked. These results align with prior findings for plantain–bambara nut cakes and wheat–cocoyam breads (Kiin-Kabari & Banigo, 2015; Orhevba & Ndanaimi, 2021). The slightly firmer crumb observed may reflect the higher fiber content of cocoyam and plantain, which can increase water absorption (Arubayi & Ogbonyomi, 2019). Mouthfeel ratings were similarly positive across all composite samples, with no samples disliked.

The sensory evaluation indicates that partial substitution of wheat with sweet potato, banana, and bambara bean can yield cakes that remain highly acceptable to consumers (Olatunde et al., 2019). Across core attributes, including appearance, color, aroma, taste, texture, and overall acceptability, the composite formulations performed on par with a wheat-only control, suggesting that flavor integrity and desirable crumb can be retained despite higher fiber and altered starch profiles. Panel feedback points to a pleasant natural sweetness and aroma contributed by the banana and sweet potato components, while bambara bean supports body and moistness without introducing beany off notes when properly processed (Abugu et al., 2025).

Nutritionally, the blends offer a plausible route to functional snacking by increasing dietary fiber, improving amino acid balance, and adding micronutrients relative to conventional cakes (Boukid et al., 2024). In practice, this lets producers nudge diets toward greater nutrient density without confronting the typical compliance barriers associated with overtly healthy products. The key is aligning fortification with sensory appeal. Adjustments to particle size, pre-gelatinization, hydration, mixing, and baking parameters can mitigate the firmness associated with higher fiber matrices, preserving a light, tender crumb while enhancing satiety and potential glycemic benefits (Alam et al., 2024).

From a sustainability standpoint, positioning these cakes within household economic units creates a tight loop between local agriculture and local consumption. Substituting a portion of imported wheat with regionally available crops reduces foreign exchange exposure, stabilizes input costs, and stimulates demand for smallholder outputs (Senbeta & Worku, 2023). At the micro enterprise scale, home-based producers can apply simple SOPs, such as standardized flour ratios, moisture targets, leavening schedules, bake curves, and basic hygiene checks, to deliver consistent products, while neighborhood sales channels keep margins local and expand livelihood options, particularly for women. This model links food security and enterprise development with culturally familiar, sensorially attractive products (Yampuang et al., 2022).

Several limitations temper interpretation. The panel size and demographic scope may constrain generalizability, and the study emphasized hedonic outcomes over full nutrient assays or clinical endpoints. Future work should validate results across larger, segmented consumer samples, map shelf life under realistic home storage, quantify cost structures and willingness to pay, and model trade-offs among sensory quality, nutrient targets, and unit costs. Even so, the evidence supports composite flour cakes as feasible, acceptable, and nutrition-forward functional snacks that advance sustainable development through household production, offering a practical bridge between better diets and resilient local economies.

## 4. IMPLICATIONS AND CONTRIBUTIONS

### *4.1 Research Implications*

The findings imply that composite flour cakes made with wheat, sweet potato, banana, and bambara bean can be adopted as consumer-acceptable functional snacks while advancing sustainability through household economic units. By maintaining desirable sensory attributes alongside improved nutritional potential, the product enables partial substitution of imported wheat, strengthens local crop demand, and retains value addition within communities. Practically, the results support the development of simple standard operating procedures, basic quality control, and realistic home-storage practices for micro-scale producers, informing entrepreneurship training and community nutrition programs. For policymakers, the study indicates opportunities to align local procurement and MSME support with nutrition-sensitive food systems and gender-responsive livelihoods. For the market, the evidence points to affordable, culturally familiar products that can diversify diets for adolescents and families without compromising taste, thereby linking consumer acceptance to food security and resilient local supply chains.

### *4.2 Research Contributions*

This study contributes empirically, methodologically, and practically by demonstrating that cakes made from a composite flour of wheat, sweet potato, banana, and bambara bean can achieve consumer-acceptable sensory profiles while improving nutritional potential. It advances the literature by testing a specific, underexplored blend and explicitly linking sensory outcomes to adoption variables relevant to household production, such as simple SOPs, basic quality control, and realistic home storage practices. Methodologically, it integrates sensory evaluation with a sustainability lens centered on household economic units, offering a framework to assess trade-offs among liking, nutrient targets, and unit costs. Practically, the findings inform product formulation for microenterprises and community programs seeking affordable, nutrient-forward snacks that align with local taste expectations. At a policy level, the results suggest pathways for partial wheat import substitution, strengthened local supply chains, and gender-responsive livelihood opportunities through home-based food entrepreneurship.

## 5. LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

### *5.1 Research Limitataions*

This study has several limitations. The sensory panel size and demographic scope were limited, which may constrain generalizability across age, region, and cultural taste preferences. Sensory testing emphasized hedonic judgments rather than comprehensive nutrient profiling or clinical endpoints, so claims about functional health benefits remain inferential. Product preparation occurred under controlled conditions that may not fully reflect variability in household-scale processing, equipment, ingredient quality, or storage environments. Shelf-life was not assessed longitudinally under realistic home conditions, and willingness to pay, repeat purchase intent, and broader market viability were not measured. Costing focused on ingredient substitution and did not model full value-chain dynamics, seasonal supply fluctuations, or price volatility for local crops.

### *5.2 Recommendation for Future Risearch Direction*

Future research should expand sensory panels across regions and age groups and integrate instrumental measures to link liking with texture profile analysis, colorimetry, moisture activity, and microbial safety; conduct full nutrient profiling, glycemic response testing, and shelf-life studies under realistic home storage with different packaging; optimize composite ratios and processing variables using response surface methodology and pre-treatments such as pre-gelatinization, fermentation, and enzyme addition; evaluate techno-economic feasibility for household microenterprises, including unit costs, willingness to pay, repeat purchase intent, and simple HACCP-aligned SOPs; quantify sustainability via life-cycle assessment, local supply resilience, and partial wheat-import substitution; and assess gendered livelihood outcomes, training effectiveness, and policy pathways for integrating composite-flour products into community nutrition, school feeding, and MSME support programs.

## 6. CONCLUSION

The sensory evaluation shows that integrating cocoyam, plantain, and bambara nut into wheat flour is both feasible and appealing to consumers. While the 100 percent wheat control remained the top choice for appearance, color, and mouthfeel, several composite formulations performed strongly on other key attributes. In particular, WCPB2, which contains 80 percent wheat, 10 percent cocoyam, 5 percent plantain, and 5 percent bambara nut, achieved high ratings for taste, flavor, texture, and overall acceptability. These outcomes indicate that partial substitution can retain desirable sensory qualities while introducing pleasant natural sweetness and aroma from plantain and cocoyam, and a fuller body from bambara nut when properly processed.

Beyond hedonic appeal, the composite blends can enhance the nutritional profile relative to conventional cakes by increasing dietary fiber, improving amino acid balance, and adding minerals and vitamins associated with tubers and legumes. Practical formulation choices help preserve tenderness and a fine crumb despite higher fiber content, including optimizing particle size, hydration, and mixing and baking parameters, as well as using pre-gelatinized fractions where needed. In this way, producers can offer functional snacks that align with familiar taste expectations while nudging diets toward greater nutrient density, particularly for adolescents and families who rely on affordable, ready-to-eat bakery items.

These results carry sustainability value when framed through household economic units. Substituting part of the wheat with locally available crops reduces dependence on imported inputs, supports smallholder agriculture, and keeps value addition within communities. Simple standard operating procedures, basic quality control, and realistic home storage practices can enable consistent micro-scale production, expanding livelihood options and reinforcing food security. In sum, composite flour cakes emerge as acceptable to consumers, better aligned with nutrition goals, and supportive of local supply chains. They represent a credible alternative to traditional wheat-based snacks and a practical entry point for nutrition-sensitive and community-rooted enterprises.

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## Author Contribution Statement

All authors read and approved the final manuscript and agree to be accountable for all aspects of the work. Eunice Kanayo Agidi: Conceptualization; Methodology; Formal analysis; Validation; Investigation; Data curation; Visualization; Writing - original draft; Project administration. Diana Oritsegbubemi Arubayi: Conceptualization; Methodology; Resources; Supervision; Writing - review & editing; Validation; Data curation. Juliana Ego Azonuche: Investigation; Field coordination; Data collection; Methodology - support; Writing - review & editing.

## Declaration of GenAI in Scientific Writing

Generative AI tools were used in a limited manner to assist with English-language editing, concision, and reference formatting for the manuscript titled "Sensory Evaluation of Cakes Made from a Composite Flour Mixture of Wheat, Sweet Potato, Banana, and Bambara Bean as Functional Snacks: Sustainable Development through Household Economic Units." The AI did not generate research questions, design the study, collect or analyze data, interpret results, or draft novel scientific claims. All AI-assisted text was reviewed, verified, and edited by the authors, who take full responsibility for the accuracy, integrity, and originality of the manuscript. No confidential, proprietary, or personally identifiable information was entered into any AI system, and the use of AI complies with the target journal's policies and applicable ethical guidelines. All instances of Generative AI usage in this article were conducted by the authors in accordance with the JGMDS Generative AI (GenAI) Policies, with the authors assuming full responsibility for the originality, accuracy, and integrity of the work."

## Conflict of Interest Statement

The authors declare that they have no significant competing financial, professional or personal interests that might have influenced the performance or presentation of the work described in this manuscript.

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