



Production, organoleptic evaluation, and overall acceptability of bread made from wheat enriched with finger millet and Bambara nut for sustainable health

Klara O. Elkanah

Department of Vocational Education (Home Economics Unit), Delta State University, Abraka, Nigeria

Juliana Ego Azonuche*

Department of Vocational Education (Home Economics Unit), Delta State University, Abraka, Nigeria

*Corresponding Authors: azonuchejulianaego@gmail.com

Abstract

This study is on Production, Organoleptic Evaluation and Overall Acceptability of Bread Made from Wheat Enriched with Finger Millet and Bambara Nut for Sustainable Health. Two research questions and Two hypotheses were formulated for the study, the study is an experimental study; it adopted experimental research design. The population was 18 judges who assessed the organoleptic attributes of the bread. Mean and Standard deviation was used to analyze the research questions, the hypothesis was tested with ANOVA analysis. The findings show that bread made with wheat, finger millet and bambara nut has better organoleptic content in terms of appearance, aroma and mouth feel to bread made from whole wheat, it also finds out that bread made from wheat enriched with finger millet and bambara nut was generally accepted to bread made with 100% wheat bread. In conclusion, sample A of wheat, millet and bambara nut in ratio (80:10:10) had the best appearance while sample D in ratio (50:25:25) had the best aroma. The study therefore recommends that optimum blend for composite bread production and Finger millet-bambara nut enriched bread be promoted as a healthier alternative to conventional wheat bread, as they promote sustainable health and generally accepted.

Keywords: Bread, Organoleptic Evaluation, Overall Acceptability and Sustainable Health



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Introduction

Bread is an important and widely consumed staple cereal-based food in many parts of the world including Nigeria. Bread is traditionally produced from wheat flour and the ingredients includes flour, water, yeast, and other ingredients. Bread making involves various processes, including mixing, kneading, proofing, and baking. The main ingredient primarily used in baking bread is Flour and it is derived from grinding cereal grains such as wheat, rye, barley. The type of flour used usually impacts the flavour, texture and nutritive content of the bread. Bread is one of the foods taken by humans, Food and its products are crucial for the survival of man, Food is any substance consumed by organism for nutritional support, and bread produced from wheat flour is an example of food, the organoleptic content of bread determine the preferences when been produced.

Organoleptic Evaluation refers to the assessment of food products using human senses. Sense of sight, smell, taste, touch, and hearing to determine a food products' overall quality and acceptability. Organoleptic evaluation plays a crucial role in food product development, quality control, and consumer preference studies (Meilgaard et al., 2015). Attribute sense involves description of Appearance- sight, color, shape, surface texture and uniformity. Aroma -smell, fragrance, off-odors intensity and flavor. Taste- sweetness, saltiness, bitterness, sourness and umami. Texture- touch, mouth feel, crispness, chewiness, smoothness and viscosity. Sound hearing- crunchiness and crackling during consumption. Organoleptic senses are varied perception to everyone based on their appearance, flavour, and mouth feel. This is as result of varieties of social

and psychological factors lead to different taste from one person to another. Humans have always used their senses to evaluate food safety and quality as they can tell when a food or beverage is good or bad by sight, smell, taste, and touch (Drake et al., 2023). Consumer product acceptability is usually determined by their preferences.

Acceptability of product, in the food aspect refers to the degree to which a food product is deemed suitable and pleasing to consumers. Bolha et al (2020) states that acceptability of food in sensory terms is influenced by the intrinsic property a product possess, that is appearance, aroma, flavour, texture, aftertaste, and auditory attributes of the food. The interaction between these variables is also an important consideration, and the manifestation of sensory attributes can be affected by factors such as temperature, and portion size. The appearance of a food provides cues regarding products acceptability such as the freshness of the product, the ripeness and skill in preparation. When bread is produced with the appropriate nutrients and when consumed, it helps to promote sustainable health.

The concept of sustainable health is centered on promoting health and well-being in a way that ensures the long-term existence and well-being of individuals, communities, and the planet. Sustainable health focuses on addressing the root causes of health issues and developing strategies that prevent the onset of diseases and promote overall health, rather than solely focusing on treating illnesses after they occur. This involves adopting a holistic approach that encompasses physical, mental, and social well-being, and considers the interconnectedness of individuals and their environments. In order to achieve sustainable health, various factors need to be considered according to Maceira et al.(2024), these include environmental sustainability, social equity, prevention and early intervention, collaboration and participation, education and empowerment. Some of the foods consumed are baked product mostly produced from wheat or other grains.

Statement of the Problem

Bread is a staple food consumed widely by different age groups and bread produced with wheat flour is high in gluten which some people usually react to due to health concerns, hence, many consumers are looking for bread that contain adequate nutrient with less gluten. Thus, the initiative of producing bread using finger millet and Bambara nut which have the potential to reduce the amount of gluten when combined to produce the bread. The lack of commercially available bread products that utilize these ingredients have been observed in bread making. Finger millet and bambara nuts are highly nutritious crops that have potential as alternative ingredients that can be used for enrichment in bread production. However, they are not widely used in conventional bread recipes, due to lack of knowledge of the value of the nutrients embedded in finger millet and Bambara nut. While several studies have researched on the use of composite flour from wheat and individual underutilized crops, there is scarcity of data on the combined use of finger millet and Bambara nuts in bread production, particularly in respect to sensory, acceptability and optimal formulation. This gap the study intends to cover.

Purpose of the Study.

The main purpose of the study is the production, organoleptic evaluation and overall acceptability of Bread made from Wheat enriched with Finger Millet and Bambara Nut for Sustainable health. Specific objectives include to:

1. Produce composite flour blends from wheat, finger millet and Bambara nuts in the ratio 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1- WFB4) and 100% wheat flour.
2. Prepare bread from the composite flour blend from (wheat, finger millet and Bambara nuts) and 100% wheat flour.
3. Determine the organoleptic evaluation (appearance, texture, taste, and aroma, colour, mouthfeel) of bread produced with composite flour (wheat, finger millet and Bambara nuts) in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1- WFB4) and 100% wheat bread. determine the overall acceptability of the bread produced in the different ratios.

4. Determine how the product (bread) produced from composite flour blends contributes to sustainable health

Research Questions

1. What are the mean rating of the judges on the organoleptic evaluation of bread made from wheat enriched with finger millet and Bambara nuts in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1- WFB4) and 100% wheat bread?
2. What are the mean rating of judges on the overall acceptability of bread made from wheat enriched with finger millet and Bambara nuts in the ratio 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1- WFB4) and 100% wheat bread?

Hypotheses

1. There is no significant difference in the mean rating of judges on the organoleptic evaluation of (appearances, texture, colour, taste, mouthfeel and aroma) bread made from wheat enriched with finger millet and Bambara nuts in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1- WFB4) and 100% wheat bread.
2. There is no significant difference in the mean rating of judges on the overall acceptability of bread produced from wheat enriched with finger millet and Bambara nuts in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1- WFB4) and 100% wheat bread.

Method

The study an experimental study and adopted experimental research design. Experimental design is where the researcher manipulates the independent variable or variables to observe its impact on a behavior or cognitive process (the dependent variables), while using random assignment of participation to groups to control external factors from influencing the results (Anyakora & Odimegwu, 2021). Generally the purpose is to establish the effect that a factor or independent variable has on dependent variable. The design consists of two treatments (Finger Millet and Bambara Nut) and one control (wheat). The population size was all the 18 lecturers in the Department of Vocational Education, Delta State University, Abraka. The entire population was used as Panelists, there was no sample due to the small population size. The instrument used to collect data was International Standard Organization (ISO) TC 34 12 (Sensory analysis), rated on a 9 point hedonic scale rated; liked extremely=9, liked very much=8, liked moderately=7, liked slightly=6, neither like nor dislike=5, disliked slightly=4, disliked moderately=3, very much disliked=2, disliked extremely=1, which were employed to all the samples. The data collected was analyzed with mean and standard deviation while the formulated hypotheses were tested with Analysis of Variance (ANOVA) analysis at 0.05 level of significance.

Preparation of finger millet and Bambara nut flour: The finger millet and bambara nut flour was produced by sun-drying (traditional method of dehydration) then it will be milled and sieved.

(a) Processing of finger millet Flour: Finger millet (*eleusinecoracana*) grain was sorted manually to remove stones, particles of dirt, and other extraneous materials, and then it was weighed, after weighing it was washed with clean tap water, spread on wide rubber sheet and sundried. The dried grain was then milled into flour using the local grinding machine and then it was sieved to obtain fine smooth flour. The finger millet flour that was obtained was then packaged in an airtight container, labeled and stored.

(b) Processing of Bambara nut Flour: Bambara nut (*Vigna subterranean*) grain was sorted manually to remove stones, particles of dirt and other extraneous materials, and then it was weighed, after weighing it was washed with clean tap water, spread on wide rubber sheet and sundried. The dried grain was then milled into flour using the local grinding machine and then it was sieved to obtain fine smooth flour. The bambara nut flour that was obtained was then packaged in an air-tight container, labeled and stored.

Preparation of Finger Millet, Bambara nut and Wheat Composite Flour: Composite flour samples consisting of finger millet, Bambara nut and Wheat was formulated by combining Finger millet, Bambara nut and Wheat flour at different ratios W (wheat 100%), WFB1 (W80, F10, B10), WFB2 (W60, F20, B20), WFB3 (W50,F25, B25), WFB4 (W40,F30,B30). Five different samples were formulated.

Composite Bread flour (finger Millet, Bambara nut and Wheat) Measurement

Sample W (100%)

500g wheat flour (100%)

0g finger millet (0%)

0g Bambara nut (0%)

Sample WFB1(80:10:10)

400g wheat flour (80%)

50g finger millet (10%)

50g Bambara nut (10%)

Sample WFB2(60:20:20)

300g wheat flour (60%)

100g finger millet (20%)

100g Bambara nut (20%)

Sample WFB3(50:25:25)

250g wheat flour (50%)

125g finger millet (25%)

125g Bambara nut (25%)

Sample WFB4(40:30:30)

200g wheat flour (40%)

150g finger millet (30%)

150g Bambara nut (30%)

Recipe measurement used for wheat, finger millet and Bambara nut bread: Different proportion of wheat, finger millet and Bambara nut were used in the production of the composite bread. Wheat being the control sample was used at 500g without substituting with finger millet or Bambara nut. For WFB1 composite bread, 50g of finger millet and 50g of Bambara nut was combined with 400g wheat. WFB2 have increased finger millet 100g and Bambara nut 100g, while wheat reduced to 300g. WFB3, finger millet was 150g, Bambara nut 150g and wheat 200g. the fourth variation had finger millet at 125g and Bambara nut at 125g, wheat 250, this gradual substitution allowing for varying of organoleptic attributes and acceptability.

Equipment used for the production of composite Bread: Oven for baking, Bread pan for baking desired shape of bread, mixing bowl for mixing and ensuring uniform blending of dough, Kitchen scale, Measurement spoons and cups for accurate measurement of ingredients, Sieve for removing unwanted grit and particles in flour and Wooden spoon for smooth mixing. For uniformity and to ensure that the outcome of the bread is based on the different substitution and not difference in ingredients, all other ingredients were kept constant in the formulation, margarine was measured at 30g, yeast 2^{1/2} tsp, sugar 100g, powdered milk 4tbsp, salt 1/2tsp, lukewarm water 250ml, little vegetable oil

Procedure used for Bread Production (finger millet, bambara nut and wheat composite):

Combine dry ingredients (flour, powdered milk and salt) in a bowl, mix and set aside. Proof yeast by dissolving yeast and sugar in luke warm water, cover and let it proof for about 5-8 minutes. Gradually stir in the proofed yeast into the mixed dried ingredients, mixed until the dough is formed, add margarine to the dough and knead for at least 15 minutes until smooth and elastic, Cover the dough in a bowl, placed the bowl in a warm place, leave it to rise for about 30 minutes to an hour until it doubles in size, Press to remove gas, Knead again slightly on a floured board, Flatten the dough, Roll up the dough, Place it in a greased pan and leave to rise for 40 minutes to 1 hour, Place pan with dough in preheated oven, bake it at 350°F for 30 minutes, When ready remove from pan to rack to cool.

Results

Data gotten from the mean rating of judges on the organoleptic and overall acceptability response for the research questions were answered using mean (\bar{X}) and standard deviation (SD). Hypotheses were tested with Analysis for variance (ANOVA) using SPSS (statistical package for the social sciences) version 23. least significant difference of mean was at $p < 0.05$.

Results

Research Question 1: What are the mean rating of the judges on the organoleptic evaluation of bread made from wheat enriched with finger millet and Bambara nuts in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1- WFB4) and 100% wheat bread?

Table 1: Mean and Standard Deviation analysis of the organoleptic evaluation of bread made from wheat enriched with finger millet and Bambara nuts

Samples and Proportion

Sample	WFB1	WFB2	WFB3	WFB4	WC
Parameters	50g,50g,400g	100g,100g,300g	150g,150g, 200g	125g,125g,250g	500g
Appearance	6.51	6.39	6.22	6.21	6.46
	2.414	2.576	2.232	2.615	2.479
Aroma	5.77	5.87	6.01	6.21	5.28
	2.519	2.525	2.434	2.26	2.331
Taste	5.92	6.24	6.02	5.91	5.01
	2.362	2.522	2.283	2.461	2.251
Texture	6.01	6.44	6.14	6.14	6.34
	1.763	1.761	1.720	1.720	1.789
Colour	6.67	6.48	6.31	6.31	6.51
	2.278	2.295	2.212	2.212	2.226
Mouthfeel	5.10	5.21	5.35	5.50	5.12
	2.369	2.294	2.237	2.469	2.131
Acceptability	6.04	6.23	6.15	6.18	6.11
	2.654	2.583	2.519	2.506	2.110

Key: A = Finger Millet/Bambara nut/Wheat 10:10:80%, B = Finger Millet/Bambara nut/Wheat 20:20:60 %, C = Finger Millet/Bambara nut/Wheat 25:25:50%, D = Finger Millet/Bambara nut/Wheat 30:30:40%, E = Wheat 100%.

Table 1: shows the mean (\bar{X}) and standard deviation value of the organoleptic evaluation of all the ratio of bread samples produced from finger millet, bambara nut and wheat. From the table, sample A (50g,50g,400g) with a mean (\bar{X}) score of 6.51 has the best appearance Sample D (125g,125g, 250g) with a mean (\bar{X}) score of 6.21 has the best aroma, Sample B (100g,100g, 300g) with a mean (\bar{X}) score of 6.24 has the best taste, Sample B (100g,100g, 300g) with a mean (\bar{X}) score of 6.44 has the best texture, Sample B (100g,100g, 300g) with a mean (\bar{X}) score of 6.67 has the best colour. Sample C&D (150g,150g, 200g & 125,125,250) with a mean (\bar{X}) score of 5.35 has the best

mouthfeel, Sample B (100g,100g, 300g) with a mean (\bar{X}) score of 6.23 has the best overall acceptability. Indication is that, sample A has the best appearance, sample D has the best aroma, B has the best taste, texture, colour and overall acceptability while C and D has the best mouthfeel of the bread.

Table 2: Mean (\bar{X}) and Standard Deviation (SD) of Appearance of all bread sample made from wheat enriched with finger millet and bambara and 100% wheat.

Samples	Mean (\bar{X})	SD
WFB1	6.51	2.414
WFB2	6.39	2.576
WFB3	6.22	2.232
WFB4	6.21	2.615
WC	6.46	2.479

Table 2: shows the Mean (\bar{X}) and Standard Deviation (SD) rating of judges' preference of Appearance of all bread sample made from wheat enriched with finger millet and Bambara nut in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1 – WFB4) and 100% wheat bread. The table showed that WFB1 was rated best in appearance among all the bread samples, with a mean rating of 6.51 (2.414). Sample WC (control) was rated next with a mean rating of 6.46 (2.479), Sample WFB2 has a mean rating of 6.39 (2.576), Sample WFB3 has a mean rating of 6.22 (2.232), and Sample WFB4 6.21 (2.615). WFB1 had the highest mean appearance score (2.414) indicating that it was the most visually appealing among the samples as a result of an optimal level of substitution that did not alter the typical color and structure of wheat bread. WC also had a high mean score (2.479) indicating that the standard wheat bread maintained its familiar appearance, which is generally preferred by consumers. WFB2, WFB3, WFB4 recorded slightly lower mean scores (2.576, 2.232, 2.615), with Sample D having the lowest (6.21). The gradual decrease in appearance scores in these samples is attributed to increased levels of finger millet and Bambara nut flour, which can affect the color (darker appearance). The standard deviation value ranged from 2.232 to 2.615, indicating variability in the judges' responses. WFB3 had the lowest value (2.232) indicating more agreement among judges' ratings, while WFB4 had the highest (2.615) indicating greater variation in perception among the judges.

Table 3: Mean (\bar{X}) and Standard Deviation (SD) of Appearance of all bread sample made from wheat enriched with finger millet and bambara and 100% wheat.

Samples	Mean (\bar{X})	SD
WFB1	6.51	2.414
WFB2	6.39	2.576
WFB3	6.22	2.232
WFB4	6.21	2.615
WC	6.46	2.479

Table3: shows the Mean (\bar{X}) and Standard Deviation (SD) rating of judges' preference of Appearance of all bread sample made from wheat enriched with finger millet and Bambara nut in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1 – WFB4) and 100% wheat bread. The table showed that WFB1 was rated best in appearance among all the bread samples, with a mean rating of 6.51 (2.414). Sample WC (control) was rated next with a mean rating of 6.46 (2.479), Sample WFB2 has a mean rating of 6.39 (2.576), Sample WFB3 has a mean rating of 6.22 (2.232), and Sample WFB4 6.21 (2.615). WFB1 had the highest mean appearance score (2.414) indicating that it was the most visually appealing among the samples as a result of an optimal level of substitution that did not alter the typical color and structure of wheat bread. WC also had a high mean score (2.479) indicating that the standard wheat bread maintained its familiar appearance, which is generally preferred by consumers. WFB2, WFB3, WFB4 recorded slightly lower mean scores (2.576, 2.232, 2.615), with Sample D having the lowest (6.21). The gradual decrease in appearance scores in these samples is

attributed to increased levels of finger millet and Bambara nut flour, which can affect the color (darker appearance). The standard deviation value ranged from 2.232 to 2.615, indicating variability in the judges' responses. WFB3 had the lowest value (2.232) indicating more agreement among judges' ratings, while WFB4 had the highest (2.615) indicating greater variation in perception among the judges.

Table 4: ANOVA Analysis of the mean rating of judges on the organoleptic evaluation for appearance of bread made from different ratios.

Appearance	Sum of Square	df	Mean (\bar{X}) Square	F	Sig	Decision
Between Groups	920.938	3	102.326	39.821	0.000	Rejected
Within Groups	925.086	366	2.570			
Total	1846.024	369				

Table 4 above shows the general ANOVA result of the organoleptic evaluation appearance of bread made from wheat enriched with finger millet and bambara nut in different ratios. The result show that $F\text{-value} = 39.821 > 0.05$, $P < 0.05$. indicating that there is a significant difference in the mean rating of judges on the organoleptic evaluation for appearance of bread as a result of varying proportion of wheat enriched with finger millet and bambara nut in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1: WFB4), this indicates that bread made with varying proportion of wheat, finger millet and bambara nut visual quality (appearance) is significantly affected by the substitution.

Table 5: Mean (\bar{X}) and Standard Deviation (SD) of Aroma of all bread sample made from wheat enriched with finger millet and bambara with 100% wheat.

Samples	Mean (\bar{X})	SD
WFB1	5.77	2.519
WFB2	5.87	2.525
WFB3	6.01	2.434
WFB4	6.21	2.226
WC	5.28	2.331

Table 5: shows the Mean (\bar{X}) and Standard Deviation (SD) rating of judges' preference of Aroma of all bread sample made from wheat enriched with finger millet and Bambara nut in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1 – WFB4) and 100% wheat bread. The table showed that WFB4 was rated best in aroma among all the bread samples, with a mean rating of 6.21 (2.226). Sample WFB3 was rated next with a mean rating of 6.01 (2.434), Sample WFB2 has a mean rating of 5.87 (2.525), Sample WFB1 has a mean rating of 5.77 (2.519), and Sample WC (control) 5.28 (2.331). Sample WFB4 had the highest mean aroma score (6.21) indicating that it had the most preferred aroma among the samples, which can be attributed to an optimal blend of finger millet and Bambara nut flour, which contributed positively to the characteristic smell of the bread. WFB3 and WFB2 also showed relatively high aroma scores (6.01, 5.87) followed by WFB1 (5.77) The results indicate that enrichment can enhance the aroma profile of bread, WC recorded the lowest mean aroma score (5.28) indicating that the enriched samples were generally more preferred in terms of aroma compared to wheat bread.

Table 6: ANOVA Analysis of the mean rating of judges on the organoleptic evaluation for aroma of bread made from different ratios.

Aroma	Sum of Square	Df	Mean (\bar{X}) Square	F	Sig	Decision
Between Groups	808.894	3	89.877	31.197	0.000	Rejected
Within Groups	1037.130	366	2.881			
Total	1846.024	369				

Table 6: above shows the general ANOVA result of the organoleptic evaluation aroma of bread made from wheat enriched with finger millet and bambara nut in different ratios. The result show that $F(3,366) = 31,197$ $P < 0.05$. Therefore, means that there is a significant difference in the

mean rating of judges on the organoleptic evaluation for aroma of bread made from wheat enriched with finger millet and bambara nut in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1: WFB4), this indicated that the substitution of wheat flour with finger millet and bambara nut flour had a significant effect on the aroma quality of the bread.

Table 7: Mean (X) and Standard Deviation (SD) of Mouth feel of all bread sample made from wheat enriched with finger millet and bambara with 100% wheat.

Samples	Mean (\bar{X})	SD
WFB1	5.10	2.369
WFB2	5.21	2.294
WFB3	5.35	2.237
WFB4	5.50	2.469
WC	5.12	2.131

Table 7: shows the Mean (\bar{X}) rating of judges' preference of mouthfeel of all bread sample made from wheat enriched with finger millet and Bambara nut in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1 – WFB4) and 100% wheat bread and Standard Deviation (SD). The table showed that WFB4 was rated best in mouthfeel among all the bread samples, with a mean rating of 5.50 (2.469). Sample WFB3 was rated next with a mean rating of 5.35 (2.237), Sample WFB1 has a mean rating of 5.10 (2.369), Sample WFB2 has a mean rating of 5.21 (2.284), and Sample WC (control) 5.12 (2.131). The mean mouthfeel scores indicate that all samples were moderately acceptable in terms of mouthfeel. However WFB4 (5.50) recorded the highest mean score, indicating that it was the most preferred formulation for mouthfeel, WC had a score value similar to WFB1 and slightly lower than other enriched samples. WFB (5.35) and WFB2 (5.21) also showed improved acceptability compared to the control, indicating that enrichment with finger millet and Bambara nut do not adversely affect mouthfeel.

Table 8: ANOVA Analysis of the mean rating of judges on the organoleptic evaluation for mouthfeel of bread made from different ratios.

Mouthfeel	Sum of Squares	df	Mean (X) Square	F	Sig	Decision
Between Groups	18.012	3	205.114	15.513	0.000	Rejected
Within Groups	46.120	366	6.321			
Total	64.132	369				

Table 8 above shows the general ANOVA result of the organoleptic evaluation mouthfeel of bread made from wheat enriched with finger millet and bambaranutin different ratios shows that there is significant difference in the mouthfeel of bread samples produced from composite flour at varying ratio, indicated by the p-value (0.000) which is less than the level of significant 0.05 ($p < 0.05$). This indicates that the null hypotheses that there is no significant difference among the samples is rejected. The result show that $F(3,366) = 15.513$ $P < 0.05$. Therefore, means that there is a significant difference in the mean rating of judges on the organoleptic evaluation for mouthfeel of bread made from wheat enriched with finger millet and bambara nut in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1: WFB4), this indicate that bread made from different substitution ratios of wheat enriched with finger millet and bambara nut flour greatly influence the mouthfeel of the bread.

Table 9: Mean (X) and Standard Deviation (SD) of Taste of all bread sample made from wheat enriched with finger millet and bambara with 100% wheat.

Samples	Mean (\bar{X})	SD
WFB1	5.92	2.365
WFB2	6.24	2.522
WFB3	6.02	2.283
WFB4	5.91	2.461
WC	5.01	2.251

Table 9: shows the Mean (\bar{X}) and Standard Deviation (SD) rating of judges on preference of Taste of all bread sample made from wheat enriched with finger millet and Bambara nut in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1 – WFB4) and 100% wheat bread. The table showed that WFB2 was rated best in taste among all the bread samples, with a mean rating of 6.242 (.522). Sample WFB3 was rated next with a mean rating of 6.01 (2.283), Sample WFB1 has a mean rating of 5.92 (2.362), Sample WFB4 has a mean rating of 5.91 (2.461), and Sample WC (control) 5.01 (2.251). WFB2 has the highest taste score (2.522), indicating that this formulation was the most preferred in terms of taste. this was followed by WFB3 (2.283) WFB1 (2.362) and WFB4 (2.461) which had similar taste score levels. WC (2.251) had the lowest taste mean, indicating that enrichment with finger millet and Bambara nut improves taste of bread.

Table 10: ANOVA Analysis of the mean rating of judges on the organoleptic evaluation for taste of bread made from different ratios.

Taste	Sum of Square	Df	Mean (\bar{X})Square	F	Sig	Decision
Between Groups	1271.847	3	158.981	99.955	0.000	Rejected
Within Groups	574.177	366	1.591			
Total	1846.024	369				

Table 10 above shows the general ANOVA result of the organoleptic evaluation taste of bread made from wheat enriched with finger millet and bambara nut in different ratios shows that there is significant difference in the taste of bread samples produced from composite flour at varying ratio, indicated by the p-value (0.000) which is less than the level of significant 0.05 ($p < 0.05$). This indicates that the null hypotheses that there is no significant difference among the samples is rejected. The result show that $F(3,366) = 99.955$ $P < 0.05$. Therefore, means that there is a significant difference in the mean rating of judges on the organoleptic evaluation for taste of bread made from wheat enriched with finger millet and bambara nut in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1: WFB4), this indicated that bread made from different substitution ratios of wheat enriched with finger millet and bambara nut flour greatly influence the texture of the bread,

Table 11: Mean (\bar{X}) and Standard Deviation (SD) of Texture of all bread sample made from wheat enriched with finger millet and bambara with 100% wheat.

Samples	Mean (\bar{X})	SD
WFB1	6.01	1.763
WFB2	6.44	1.761
WFB3	6.14	1.720
WFB4	6.14	1.720
WC	6.34	1.789

Table 11: shows the Mean (\bar{X})and Standard Deviation (SD) rating of judges' preference of Texture of all bread sample made from wheat enriched with finger millet and bambara nut in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1 – WFB4) and 100% wheat bread. The table showed that WFB2 was rated best in texture among all the bread samples, with a mean rating of 6.44 (1.761). Sample WC (control) was rated next with a mean rating of 6.34 (1.789), Sample WFB1 has a mean rating of 6.01 (1.763), Sample WFB3 has a mean rating of 6.14 (1.720), and Sample WFB4 6.14 (1.720). The mean texture scores from WFB1 (6.01) to WFB2 (6.44) indicate that the bread samples were generally rated as good in texture by judges. WFB2 had the highest texture score indicating that it was the most preferred formulation in terms of texture. WC (6.34) had a slightly lower score than WFB2 but higher than WFB1, showing that the enrichment did not negatively affect bread texture, WFB3 and WFB4 had identical mean scores (6.14) indicating comparable texture acceptability.

Table 12: ANOVA Analysis of the mean rating of judges on the organoleptic evaluation for texture of bread made from different ratios.

Texture	Sum of Square	Df	Mean (\bar{X})Square	F	Sig	Decision
Between Groups	728.224	3	104.032	33.691	0.000	Rejected
Within Groups	1117.800	366	3.088			
Total	1846.024	369				

Table 12 above shows the general ANOVA result of the organoleptic evaluation texture of bread made from wheat enriched with finger millet and bambara nut in different ratios shows that there is significant difference in the texture of bread samples produced from composite flour at varying ratio, indicated by the p-value (0.000) which is less than the level of significant 0.05 ($p < 0.05$). This indicates that the null hypotheses that there is no significant difference among the samples is rejected. The result show that $F(3,366) = 33.691$ $P < 0.05$. Therefore, means that there is a significant difference in the mean rating of judges on the organoleptic evaluation for texture of bread made from wheat enriched with finger millet and bambara nut in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1: WFB4), this indicated that bread made from different substitution ratios of wheat enriched with finger millet and bambara nut flour greatly influence the texture of the bread.

Table 13: Mean (\bar{X})and Standard Deviation (SD) of Colour of all bread sample made from wheat enriched with finger millet and bambara with 100% wheat.

Samples	Mean (\bar{X})	SD
WFB1	6.67	2.278
WFB2	6.48	2.295
WFB3	6.31	2.212
WFB4	6.31	2.212
WC	6.51	2.226

Table 13: shows the Mean (\bar{X})and Standard Deviation (SD) rating of judges preference of colour of all bread sample made from wheat enriched with finger millet and Bambara nut in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1 – WFB4) and 100% wheat bread. The table showed that WFB1 was rated best in colour among all the bread samples, with a mean rating of 6.67 (2.278). Sample WC (control) was rated next with a mean rating of 6.51 (2.226), Sample WFB2 has a mean rating of 6.48 (2.295), Sample WFB3 has a mean rating of 6.31 (2.212), and Sample WFB4 6.31 (2.226). The mean colour scores ranged from 6.31 to 6.67 indicating that all the samples were generally acceptable in appearance, however WFB1 (6.67) had the highest score, indicating it was the most preferred in terms of colour, the control sample WC had a slightly lower score than WFB1.

Table 14: ANOVA Analysis of the mean rating of judges on the organoleptic evaluation for colour of bread made from different ratios.

Colour	Sum of Squares	Df	Mean (\bar{X}) Square	F	Sig	Decision
Between Groups	756.456	3	84.051	27.771	0.000	Rejected
Within Groups	1089.568	366	3.027			
Total	1846.024	369				

Table 14 above shows the general ANOVA result of the organoleptic evaluation colour of bread made from wheat enriched with finger millet and bambara nut in different ratios shows that there is significant difference in the colour of bread samples produced from composite flour at varying ratio, indicated by the p-value (0.000) which is less than the level of significant 0.05 ($p < 0.05$). This indicates that the null hypotheses that there is no significant difference among the samples is rejected. $F(3,366) = 27.771$ is higher than the p-value ($P < 0.05$). indicating that there is a significant difference in the mean rating of judges on the organoleptic evaluation for colour of bread made from wheat enriched with finger millet and bambara nut in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25

(WFB1: WFB4), this indicating that bread made from different substitution ratios of wheat enriched with finger millet and bambara nut flour greatly influence the colour of the bread.

Research Question 2: What are the mean rating of the judges on the overall acceptability of bread made from wheat enriched with finger millet and bambara nut in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1 - WFB4) and 100% wheat bread?

Table 15: Mean and Standard Deviation analysis of the overall acceptability of bread made from wheat enriched with finger millet and Bambara nuts.

Samples	Mean (\bar{X})	SD
WFB1	6.04	2.654
WFB2	6.23	2.583
WFB3	6.15	2.519
WFB4	6.18	2.506
WC	6.11	2.110

Table 15: shows the mean (\bar{X})rating of judges' preference of overall acceptability of all bread sample made from wheat enriched with finger millet and Bambara nut in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1 – WFB4) and 100% wheat bread and Standard Deviation (SD). The table showed that WFB2 was rated best in overall acceptability among all the bread samples, with a mean rating of 6.23 (2.583). Sample WFB4 was rated next with a mean rating of 6.18 (2.506), Sample WFB1 has a mean rating of 6.04(2.654), Sample WFB3 has a mean rating of 6.15 (2.519), and Sample WC (control) 6.11 (2.110). The table shows that the overall acceptability of bread made from wheat enriched with finger millet and bambara nut in different ratios is above the cut off mark of 5.00. Therefore, this implies that the bread made from wheat enriched with finger millet and bambara nut were generally accepted by the judges.

Ho: There is no significant difference in the in the mean rating of judges on the overall acceptability of bread made from wheat enriched with finger millet and bambara nut in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1: WFB4) and 100% wheat bread.

Table 16: ANOVA Analysis of the mean rating of judges on the overall acceptability of bread made from different ratios.

Overall Acceptability	Sum of Squares	Df	Mean Square	F	Sig	Decision
Between Groups	20.191	3	6.73	0.955	0.004	Rejected
Within Groups	2578.201	366	7.044			
Total	2598.392	369				

Table 16 above shows the ANOVA result of the mean rating of judges on the overall acceptability of bread made from wheat enriched with finger millet and bambara nut in different ratios shows that there is significant difference in the overall acceptability of bread samples produced from composite flour at varying ratio, indicated by the p-value (0.004) which is less than the level of significant 0.05 ($p < 0.05$). This indicates that the null hypotheses that there is no significant difference among the samples is rejected. The $F(3,366) = 0.955$, result is low, showing the magnitude of variation between group mean which is small compared to the variability within groups, this indicate that there is a significant difference in the mean rating of judges on the overall acceptability of bread made from wheat enriched with finger millet and bambara nut in the ratio of 80:10:10, 60:20:20, 40:30:30, 50:25:25 (WFB1: WFB4) and 100% wheat bread, implying that bread made from different substitution ratios of wheat enriched with finger millet and bambara nut flour greatly influence the overall acceptability of the bread sample.

The judges rating on the organoleptic evaluation of bread made from composite flour from wheat, finger millet, and Bambara nuts showed that sample A has the best appearance, sample B with best taste, texture, colour, and overall acceptability while C and D best mouthfeel of the bread,

majority of the judges preferred composite bread produced with 20% finger millet, 20% Bambara nut and 60% wheat flour in terms of appearance, texture, colour, general acceptability and the aroma of bread made from wheat enriched with finger millet and bambara nut. This implies that partial substitution of wheat with finger millet and Bambara nut in the production of bread improve the sensory profile of bread. This finding supports the studies of Agidi, Arubayi and Azonuche, (2025) who carried out work on sensory evaluation of bread produced bambara nut flour, the result shows that the bread varied in Aroma, texture, taste and colour when there is additional bambara nut flour. The result shows that all the bread samples were generally acceptable but the least preferred was sample with 40% bambara nut substitution. The finding also showed that bread made in different ratios were generally accepted. Though, all the bread samples were generally accepted, composite bread made in the ratio of 20% finger millet, 20% bambara nut 60 % wheat flour has the most overall acceptability. This is in agreement with Agidi, Arubayi and Azonuche, (2026) who found that incorporating bambara nut into wheat flour can yield nutritionally enriched cakes with initial acceptable sensory qualities. Also Suresh, et al, (2015) reported that composite flour biscuit was awarded highest score in overall acceptability than whole wheat flour biscuit and Nyamayi et al (2022) stated that wheat/cassava composite bread was generally accepted by students and rated highest in consumer acceptability.

Contribution to knowledge

The evaluation of the organoleptic properties of the composite bread identified the optimal level that balances nutrition and consumer acceptability and preference of the enriched bread. The study provided empirical evidence that composite bread made from wheat flour, finger millet and Bambara nut can achieve a reasonable shelf life of four to five days at ambient temperature without the use of chemical preservatives. The study expands existing knowledge on underutilized crop, especially Bambara nut, thereby formulating and testing a new composite flour blend using wheat, finger millet and Bambara nut, supporting agricultural sustainability and local food system. The work provides baseline data for future academic and industrial studies.

Conclusion

Bread being a staple in the families' table contributes to the nutritional health of members of the family. Apart from wheat there other grains and legumes that can be used in production as well as in the fortification of bread for sustainable health, Findings showed that majority of the judges preferred composite bread produced with 20% finger millet, 20% Bambara nut, 60% wheat flour in terms of appearance, texture, colour, general acceptability and the aroma of bread made from wheat enriched with finger millet and bambara nut. Though all the bread products were accepted, sample B had the most preference. There is significant difference in the overall acceptability of bread made from wheat enriched with finger millet and Bambara nut produced with 20% finger millet, 20% Bambara nut and 60% wheat flour compared to that of 100% wheat bread. Also, the bread made with wheat flour enriched with finger millet can help to sustain health, the more the ratio of wheat flour, finger millet and bambara nut are added, the more the level of sustainability increase s when the bread is consumed. Based on the findings these recommendations are hereby made that:

1. Finger millet and bambara nut should be increased in ratio of 30% substitution in bread production to add value and diversity to local food products.
2. Bread made from Finger millet and bambara nut should be incorporated in other snacks formulation to help address malnutrition and micronutrient deficiencies based on its functional properties. .

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