

CONSUMER PERCEPTION AND ACCEPTABILITY OF GLUTEN-FREE COOKIES FROM BAMBARA NUT AND CASSAVA FLOURS

*Akintola, A.¹, Anifowose, M.T.², Akintola, T.M.³, Oyeniyi, A.O.⁴, Ogunsola, F.O.⁴ and Rasah, U.A.⁴

¹Department of Agricultural and Bio-Environmental Engineering, Oyo State College of Agriculture and Technology, Igboora; ²Department of Post-Harvest Technology, Oyo State College of Agriculture and Technology, Igboora; ³Department of Food Technology, University of Ibadan, Ibadan; ⁴Department of Food Technology, Oyo State College of Agriculture and Technology, Igboora.

* E-mail: akintunde.akintola@yahoo.com

Abstract

The growing demand for gluten-free baked products has necessitated the exploration of nutrient-rich, indigenous alternatives to wheat flour. This study evaluated the sensory attributes and overall consumer acceptability of cookies produced from varying blends of Bambara nut (*Vigna subterranea*) and cassava (*Manihot esculenta*) flours. Seven cookie formulations were prepared, including 100% cassava (negative control), 100% wheat (positive control), and five Bambara nut:cassava blends (70:30 to 30:70). Sensory evaluation was conducted by 30 untrained panelists using a 9-point hedonic scale to assess taste, aroma, texture, colour, and overall acceptability. Results indicated that cookies made with moderate levels of Bambara nut flour (especially the 40:60 and 30:70 blends) achieved high scores in taste, colour, and overall acceptability, comparable to or exceeding those of the wheat-based control. While cookies with higher Bambara nut content were denser, their nutty flavor and golden appearance were positively received. The 100% cassava cookie was the least preferred, primarily due to its bland taste and fragile structure. Statistical analysis confirmed significant differences ($p < 0.05$) among treatments, highlighting the role of flour composition in sensory quality. This study demonstrates that Bambara nut–cassava blends can be used to formulate nutritionally beneficial and sensory-acceptable gluten-free cookies. The findings support the utilization of underexploited local crops in functional food development and promote food diversification in regions facing wheat import dependency.

Keywords: *Bambara nut, Cassava flour, Gluten-free Cookies, Consumer acceptability, Underutilized legumes*

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Introduction

The increasing consumer knowledge of coeliac disease, gluten sensitivity, and a general interest in health-conscious diets have led to an increase in the demand for gluten-free

products in recent years. Alternative baked goods made with non-wheat flours that have both functional and nutritional advantages have been developed in response to this trend. Two native crops that are extensively grown in

sub-Saharan Africa are cassava (*Manihot esculenta*) and Bambara nut (*Vigna subterranea*), they have a great potential for use in the creation of gluten-free baked goods (Olatunde *et al.*, 2021). The Bambara nut is noteworthy for its high protein content and necessary amino acids, whilst cassava is a significant source of carbohydrates. (Adeola and Aworh, 2020; Onwuka *et al.*, 2022). However, Bambara nut consumption remains notably low in many developing nations (Akintola and Anifowose, 2025).

By using these flours in cookie production, poorer nations might lessen their dependency on imported wheat while also addressing nutritional shortages (Uchenna *et al.*, 2023). However, evaluating how consumers view these products and its sensory qualities is crucial if they are to become widely accepted. Food products' overall acceptability and marketability are greatly influenced by sensory qualities as flavour, aroma, texture, and appearance (Obadina *et al.*, 2021). Critical information on consumer preferences is obtained through sensory evaluation, which also aids in formulation refinement for increased acceptability. Due to differences in the starch and protein composition, cookies manufactured using composite flours frequently exhibit modifications in their physical and organoleptic characteristics. While cassava flour contributes crispiness and light texture, it may cause structural fragility. Bambara nut flour tends to introduce a beany flavour and darker colouration (Adebayo *et al.*, 2023; Uvere *et al.*, 2021). Because of the potential for both good and negative effects on consumer perception, comprehensive sensory evaluation is an essential component of product development.

With an emphasis on striking a balance between nutritional enhancement and sensory acceptability, a number of recent researches have examined the use of legume and root crop combinations in gluten-free baked goods. To find preferences for qualities including colour, texture, and taste, hedonic testing with

consumer panels are frequently used (Ikuomola *et al.*, 2022). These assessments provide as a roadmap for improving product desirability among target customers and optimizing ingredient ratios.

The sensory qualities and general consumer acceptance of cookies made with different combinations of cassava and Bambara nut flours are examined in this study. Finding gluten-free cookie recipes that are both aesthetically pleasing and nutritiously sound is the aim in order to promote the creation of locally based, sustainable snack options.

Methodology

Production of Bambara Nut Flour

Foreign particles and defective Bambara nut seeds were removed during sorting. The sorted seeds were then soaked in tap water at room temperature for 12 hours (Adetokunboh *et al.*, 2022), manually dehulled, and oven-dried till the weight remained constant. The seeds were grinded into fine flour with the help of a burr mill. Figure 1 illustrates the process flow for producing Bambara nut flour.

Cassava Flour Processing

After being harvested, the cassava roots were peeled, cleaned and crushed. The mash obtained was placed in a bag and pressed using a hydraulic press to remove excess moisture. The pressed cake was dried in a thermo-regulated oven (Galen, BS model 0v-160) at 60°C for 3–4 hours (Tiencheu *et al.*, 2021). The dried product was sieved and ground to obtain flour with a particle size of 250 µm. Figure 2 displays the flow chart used to produce cassava flour.

Production of Cookies

The flour used for cookies was from blends of Bambara nut flour and cassava flour. The flour was obtained by mixing in the ratio of (70:30, 60:40, 50:50, 40:60 and 30:70 cassava flour: Bambara nut flour). 100% cassava flour and 100% wheat flour cookies were used as

negative and positive controls, respectively. Powdered sugar and shortening were blended at low speed for 10 minutes using a dough mixer, after which a solution of sodium and ammonium bicarbonate in 50 ml of water was added. While mixing continued slowly, vanilla, sodium metabisulfite, and fructose syrup were incorporated. Skimmed milk, flour in designated ratios, and remaining ingredients were then added and mixed at low speed for another 10 minutes. Additional water was introduced, and mixing proceeded at high speed for 20 minutes until the dough was fully developed.

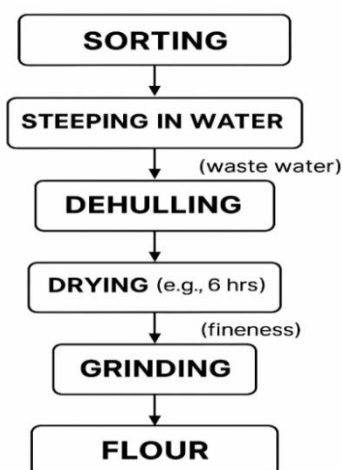


Figure 1: Flow diagram for the preparation of Bambara nut flour (Akintola and Anifowose, 2025)

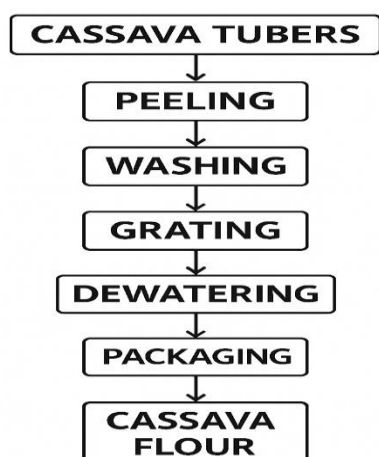


Figure 2: Flow chart for Cassava flour Production

Sensory Evaluation

Sensory evaluation was carried out using a 9-point hedonic scale (1 = dislike extremely; 9 = like extremely) to assess the appearance, aroma, texture, taste, and overall acceptability of each cookie sample. A total of 30 untrained panelists consisting of researchers at a conference were recruited for the evaluation following informed consent. Evaluations were conducted in well-lit sensory booths following ISO guidelines (ISO 8589:2007). Each panelist was provided with coded samples in randomized order, potable water to cleanse their palate between samples (Adebayo *et al.*, 2023; Ikuomola *et al.*, 2022).

Taste Evaluation

A 9-point hedonic scale was used to measure taste, with 1 denoting "extremely dislike" and 9 denoting "extremely like." To prevent taste transfer, the panelists were told to rinse their lips with water in between samples. Equation 1, which is shown below, was used to get the average taste score:

$$\text{Taste Score} = \frac{(\text{Sum of Panelist Scores})}{(\text{Number of Panelists})}$$

1

Aroma Evaluation

The same 9-point hedonic scale was used to evaluate aroma. Each sample was sniffed by the panelists, who then scored the aroma's intensity and pleasantness. To avoid bias, the test area was devoid of distracting smells.

Texture Evaluation

Sensory perception was used to define texture. On a 9-point rating system, panelists evaluated mouthfeel and sharpness.

Colour Evaluation

Colour was assessed under uniform lighting conditions using both sensory and instrumental methods. Panelists visually inspected the cookies and rated their colour. A Colorimeter (Model: Konica Minolta CR-400, Japan) was used to objectively measure colour attributes, including L* (lightness), a* (red-green), and b* (yellow-blue) values.

Overall Acceptance

Overall acceptance was calculated as the mean score of all sensory attributes using Equation 2.

$$\text{Overall Acceptance} = \frac{(\text{Taste} + \text{Aroma} + \text{Texture} + \text{Colour})}{4}$$

Statistical Analysis

Data obtained from the sensory evaluation were subjected to analysis of variance

(ANOVA) using SPSS version 26.0. Mean differences were separated using Duncan's Multiple Range Test at a significance level of $p < 0.05$. Graphical representations of sensory scores were generated using Microsoft Excel 2021. This statistical approach has been widely adopted in sensory studies to ensure reliable inference of consumer preferences across multiple treatments (Obadina *et al.*, 2021; Onwuka *et al.*, 2022).

Results and Discussion

The consumer perception and acceptability of blends of bambara and cassava flour at various mixing ratios are shown in Table 1.

Table 1: Consumer perception and acceptability of Bambara-cassava flour blends

Treatment	Taste	Aroma	Texture	Colour	Overall Acceptability
BC 70:30	5.30±0.68 ^a	5.80±0.42 ^a	5.00±1.05 ^a	5.40±0.70 ^a	5.38±0.48 ^a
BC 60:40	5.50±1.08 ^b	5.60±0.84 ^a	5.37±0.82 ^a	5.90±1.29 ^a	5.59±0.83 ^b
BC 50:50	6.00±0.82 ^{ab}	5.70±0.82 ^a	5.80±0.92 ^a	6.10±0.88 ^a	5.90±0.63 ^{ab}
BC 40:60	6.30±0.82 ^a	6.30±0.95 ^a	5.60±0.70 ^a	6.20±0.79 ^a	6.10±0.52 ^a
BC 30:70	6.50±0.53 ^a	5.80±0.63 ^a	5.70±0.95 ^a	6.10±0.57 ^a	6.03±0.68 ^{ab}
100% Cassava	4.80±0.82 ^{ab}	5.00±0.64 ^a	5.20±1.04 ^b	6.00±0.48 ^b	5.25±0.68 ^a
100% Wheat	6.00±1.02 ^b	5.80±0.63 ^{ab}	5.60±0.74 ^a	6.00±0.54 ^c	5.85±0.62 ^{ab}

The taste, aroma, texture, colour, and general acceptability of cookies manufactured with different blends of Bambara nut and cassava flours (B:C) varied significantly, according to the results as shown in Table 1.

The range of taste ratings was 4.80 to 6.50. The 30:70 B:C blend had the highest grade (6.50 ± 0.53), indicating that flavour was enhanced by a moderate amount of Bambara nut inclusion. The 100% cassava sample had the lowest score (4.80 ± 0.82). The score for the wheat control was 6.00 ± 1.02. Adebayo *et al.* (2023) and Ikuomola *et al.* (2022), who noted enhanced flavour at modest levels of legume inclusion, corroborate these findings.

The range of aroma scores (5.00 to 6.30) was comparatively constant among treatments. With the highest scent rating (6.30 ± 0.95), the 40:60 B:C combination suggested a pleasing

interaction between cassava and Bambara nut. Obadina *et al.* (2021) observed similar patterns, suggesting that mild legume inclusion had no discernible effect on scent. The 50:50 B:C blend received the highest texture rating, with ratings ranging from 5.00 to 5.80. The wheat sample scored 5.60 ± 0.74, while the 100% cassava sample scored 5.20 ± 1.04. In line with research on legume-rich cookies by Adeola and Aworh (2020), cookies with a higher Bambara nut content were denser.

The 40:60 blend had the highest colour score, which ranged from 5.40 to 6.20. The golden-brown colour was enhanced with a moderate amount of Bambara nut addition without sacrificing aesthetic attractiveness. Additionally, Onwuka *et al.* (2022) observed that cookies made with Bambara nut flour looked better.

The range of overall acceptance was 5.25 to 6.10. Most people liked the 40:60 blend, which was followed by the 30:70 and 50:50 blends. The wheat control had a score of 5.85, while the 100% cassava sample received the lowest score of 5.25. These findings support excellent sensory appeal at moderate Bambara nut inclusion, which is consistent with Uvere *et al.* (2021) and Adebayo *et al.* (2023).

In summary, cookies containing 60–70% cassava flour and 30–40% Bambara nut flour offered superior sensory attributes. This confirms the potential of Bambara nut–cassava blends in developing acceptable gluten-free baked products.

Conclusion

The sensory qualities and general acceptability of cookies made with different combinations of Bambara nut and cassava flours, as well as formulations composed entirely of wheat (positive control) and cassava (negative control), were assessed in this study. The findings showed that, without sacrificing flavour or texture, a moderate amount of Bambara nut flour specifically, the 40:60 and 30:70 B:C blends significantly improved the cookies' overall acceptability, taste, and colour. The results support the possibility of utilizing cassava and Bambara nuts as workable gluten-free substitutes in baked goods, particularly in areas without access to locally cultivated wheat. The integration of underutilized legumes in product creation to fill nutritional shortages while preserving sensory appeal is supported by this research.

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