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Sensory and Microbiological Qualities of Tidbits Produced with Flour from Cassava and Bambara Nut

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Abstract

Sensory properties of a food product depict its consumer acceptability, while the microbiological quality critically determines the safety, as this relates directly to public health. This study evaluated the sensory and microbiological qualities of tidbits produced with blends of flour from cassava and Bambara nuts. Cassava roots were processed into high-quality cassava flour via unit operations such as harvesting, peeling, washing, grating, pressing, pulverizing, and drying using a flash dryer at 120 °C for 8 min. The flour was milled using a cyclone hammer mill with a 250 µm screen, then cooled and stored in high-density polyethylene bags. Wholesome bambara nut seeds were processed into flour (BNF) through unit operations such as sorting, soaking, dehulling, sprouting, malting, draining, drying, milling, sieving, and packaging. A total of eight (8) samples/runs were generated as depicted by a simplex lattice mixture design, using Design Expert software. Each flour blend and proportionate ingredients were mixed thoroughly in 200 ml of water. Each sample was extruded into groundnut hot oil, to which sliced onion was added for additional flavor. It was then fried in deep, hot vegetable oil until golden brown at 190 °C for 12 minutes using a deep fryer. The cooled tidbits produced were evaluated for sensory and microbiological qualities. Results showed that the range of values for sensory score for appearance, colour, aroma, texture, taste, texture crunchiness and overall acceptability of the tidbits samples were 4.48-7.52%, 4.92-7.56%, 4.92-7.16%, 3.64-7.08%, 3.04-6.96%, 2.40-7.80%, 3.88-7.40%, respectively. According to the Standards Organization of Nigeria (SON), aerobic plate counts ranging from 10^4 to 10^6 CFU/ml in foods are acceptable. The sensory and microbiological qualities were significantly affected by fortifying high-quality cassava flour with bambara nut flour; the microbial counts in this study remained within safe limits for consumption.

Keywords: Antimicrobial Properties, Crispiness, Extrusion, Malnutrition, Tidbits

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INTRODUCTION

The development of new food products geared at improving human health with the view to tackling malnutrition, thereby addressing the third Sustainable Development Goal (SDG-3), is very important. Flour from promising crops such as cassava and Bambara nut is instrumental in achieving this goal. In 2024, cassava production in Nigeria was projected to reach 66.6 million metric tons (MT), representing a 6% increase from 2023. Cassava remains a vital crop for food security and economic growth in Nigeria, thanks to its adaptability and wide-ranging applications, which contribute to its importance. High quality cassava flour (HQCF) has diverse industrial applications due to its gluten-free nature and high starch content. It is widely used in the food industry for making bread, cakes, and other baked goods, often as a partial substitute for wheat flour (Alimi *et al*., 2024).

The Bambara nut (*Vigna subterranea*) is a leguminous crop, versatile in its application, such as being boiled, roasted, or processed into flour for various dishes. Studies also emphasize its potential in addressing food security, malnutrition, among others (Alimi *et al*., 2024b). Bambara nuts (*Vigna subterranea*) offer numerous health benefits owing to their richness in essential nutrients, including proteins, carbohydrates, dietary fiber, and minerals like iron, calcium, and potassium. The aforementioned nutritional value contributes to improved digestion, enhanced energy levels, and overall health maintenance.

The nuts also contain phytochemicals such as tannins, flavonoids, and phytic acids, which exhibit antioxidant properties (Alimi *et al*., 2024b). These antioxidants help combat oxidative stress, reducing the risk of chronic diseases like diabetes, cardiovascular issues, and certain types of cancer. It is of interest to know that Bambara nuts have antimicrobial properties that can inhibit microbial growth, further supporting health and food preservation (Alimi *et al*., 2024a) Their nutritional profile makes them a valuable food source for addressing malnutrition (SDG-3) and promoting sustainable diets, especially in regions with limited access to diverse food options.

Alimi *et al.* (2024b) beamed a search light into an array of food products that can be developed with flour from bambara nut and cassava. Flour from bambara nut, when blended with high-quality cassava flour, has been applied in the production of cakes, chin-chin, and bread with optimized quality. In recent years, the demand for convenient and nutritious snack options has surged, driven by increasingly fast-paced lifestyles and greater health awareness among consumers. Tidbit, a modern snack food, responds to this demand by offering a balanced blend of taste, texture, and nutritional value. Snack foods that are portion-controlled and made from whole or minimally processed ingredients have been shown to support healthier eating habits and aid in weight management (Hess *et al*., 2016). Furthermore, consumer preference is shifting toward snacks that offer functional benefits, such as high protein, fiber, or micronutrient content (Aschemann-Witzel *et al*., 2020). Tidbit is crafted with these principles in mind, providing a satisfying snacking experience while aligning with current scientific insights into health-conscious eating behaviors.

Food safety refers to the assurance that consuming food will not result in harm or injury to the consumer (Feed the Future, 2020). Food serves as a fundamental necessity for all living organisms, including microorganisms, as it is rich in nutrients like proteins, fats, carbohydrates, minerals, and vitamins. These nutrients, however, make food susceptible to contamination by microorganisms (Moushumi *et al*., 2019). The microbiological quality of food products being developed is a key consideration as it relates to the public health of the

consumers (Alimi *et al*., 2025a). This study assessed the sensory and microbiological qualities of tidbits produced with blends of flour from cassava and Bambara nuts.

MATERIALS AND METHODS

Cassava roots IITA-TMS-0700593 (Sunshine) were obtained from International Institute of Tropical Agriculture (IITA) Ibadan and Bambara groundnut from a local farm at Mokwa, Niger State. Other ingredients such as vegetable oil, crayfish, spice, and salt were procured from Mandate market, Ilorin, Kwara State.

Preparation of high-quality cassava flour (HQCF)

The high-quality cassava flour (HQCF) used for the study was produced from four varieties of low PPD and one variety of high PPD cassava as described by Alimi *et al*. (2022). The flow chart for the production of HQCF is presented in Figure 1.

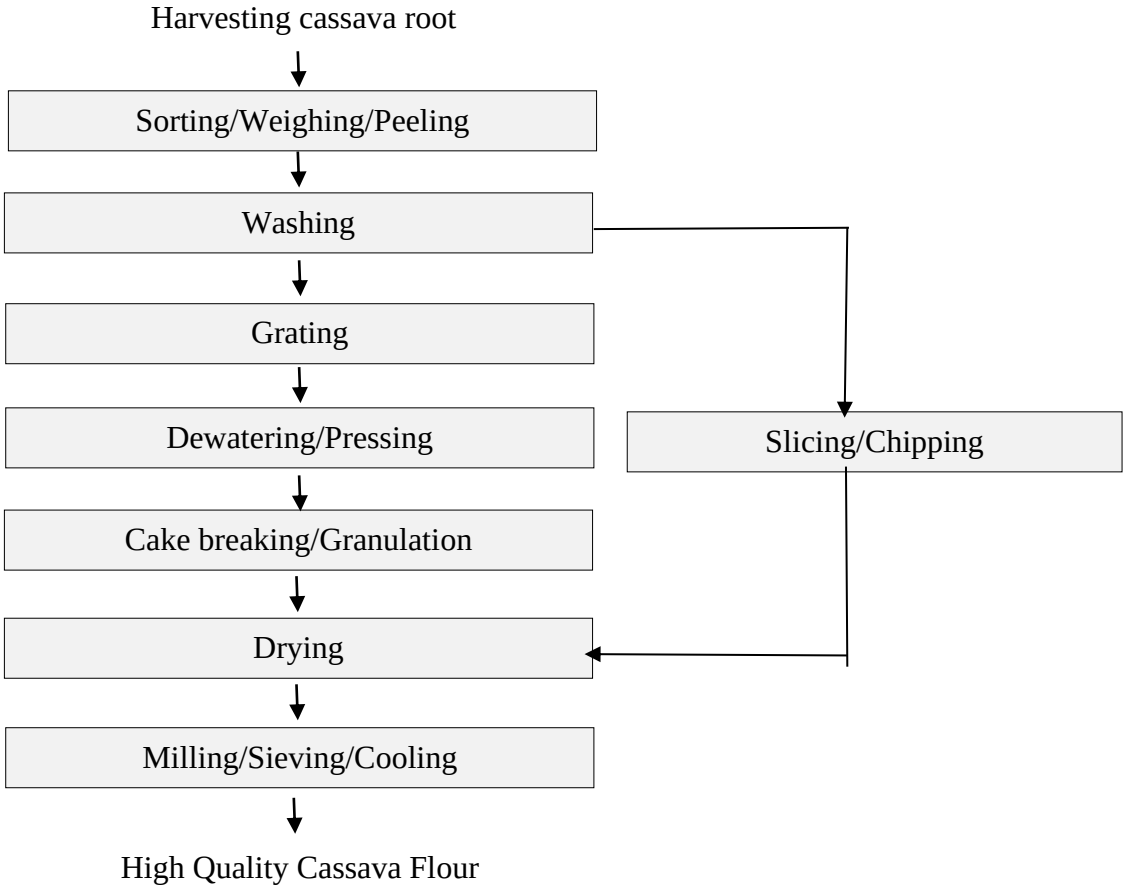

Figure 1. Flow chart for the production of high-quality cassava flour

Production of Bambara nut flour

The bambara nut seeds underwent a meticulous selection process to eliminate defective, insect-damaged seeds and extraneous materials. The variety under investigation is SAMNUT 21, which was subjected to a controlled hydration phase for 24 hours, followed by dehydration at 70 ^{o}C for 14 hours to achieve a targeted moisture level of 12%. The soaking medium was refreshed every 6 hours to optimize dehulling efficiency, minimize nutrient depletion, and facilitate the leaching of anti-nutritional factors into the liquid phase. Subsequently, the hydrated seeds were subjected to a germination cycle lasting 72 hours (James *et al*., 2018),

strategically implemented to diminish carbohydrate and lipid concentrations while simultaneously augmenting protein content and amino acid composition (Lyimo *et al*., 2004). The malted seeds were systematically drained, arranged on drying trays, and exposed to controlled dehydration using the dryer developed by the Nigerian Stored Products Research Institute (NSPRI) parabolic-shaped solar dryer (PSSD) at 60 ^{o}C for 24 hours. Once dried, the Bambara groundnuts were stabilized, finely milled, and sifted through a 250-micron mesh to attain uniform particle size. The resultant flour was securely packaged in high-density polyethylene bags to preserve its integrity for subsequent analytical procedures.

Flour blending

The high-quality cassava flour and Bambara nut flour were blended as depicted by Design Expert (Version 12). The mixed flour was used for the production of the tidbits, as indicated in the formulation and recipe.

Table 1. Recipe for the Production of Tidbits

Sample	Cray fish (g)	Onion and pepper mix (g)	Salt (g)	Maggi (g)
$HQCF_{80}BNF_{20}$	4	136	4	4
$HQCF_{65}BNF_{35}$	4	136	4	4
$HQCF_{70}BNF_{30}$	4	136	4	4
$HQCF_{60}BNF_{40}$	4	136	4	4
$HQCF_{75}BNF_{25}$	4	136	4	4
$HQCF_{80}BNF_{20}$	4	136	4	4
$HQCF_{60}BNF_{40}$	4	136	4	4
$HQCF_{70}BNF_{30}$	4	136	4	4
$WF_{60}BNF_{40}$	4	136	4	4
$HQCF_{60.00}CF_{40.00}$	4	136	4	4

Production of Tidbits

The recipe and formulation used for the production of the tidbits are presented in Table 1. A total of eight (8) samples/runs were generated as depicted by a simplex lattice mixture design using Design Expert software (Version 12.0), two (2) control samples: (WF+BNF and market sample HQCF+CF). Each flour blend and proportionate ingredients were mixed thoroughly in 200 ml of water. Each sample was extruded into groundnut hot oil, to which sliced onion was added for additional flavor. It was then fried in deep, hot vegetable oil until golden brown at 190 °C for 12 minutes using a deep fryer (Model: Moulimex). The fried Titbits were allowed to cool and then subsequently packed into high-density polyethylene for airtightness to prevent moisture absorption.

Sensory evaluation of the Tidbits

Twenty-five Panelists were trained for the assessment of the tidbits; 16 were females and 9 males. Students (interns) and staff at the Nigerian Stored Products Research Institute, Ilorin, Kwara State, Nigeria, assessed the tidbits samples. The assessors had an age ranging from 20 to 40 years, of which 70% were undergoing tertiary educational training. The tidbits samples were packaged in aluminum foils, assigned a code, and were subsequently presented to the assessors three (3) hours after the frying exercise. The panelists scored the tidbits samples using sensory descriptive terms such as appearance, color, crunchiness, aroma, taste, flavor and overall acceptability using a 9 points hedonic scale based on their degree of likeness, where 1= Dislike extremely; 5= neither like nor dislike; 9= like extremely (Iwe, 2002; Alimi *et al*., 2024a).

Microbiological assay on the Tidbits

After frying and packaging, 25 grams of each tidbits sample was immersed in 225 ml of sterile water for 1 hour, after which a fivefold serial dilution was performed. From the diluted samples, one milliliter (1 ml) of the 10^{-3} dilution was aseptically transferred in duplicates and plated using the pour plate technique. Specific media were prepared according to the manufacturers' instructions, and the pour plate technique was employed for the culture and enumeration of microbial counts. These included total heterotrophic counts (on Nutrient Agar incubated at 30°C for 24 hours), total coliform counts (on MacConkey Agar incubated at 37°C for 24 hours), and total yeast and mold counts (on Potato Dextrose Agar incubated at 28°C for 24-72 hours). After incubation, the average number of colony-forming units (CFU) per gram of the sample was determined by counting the microbial colonies on both plates and multiplying by the dilution factor (Alimi *et al*., 2025b; Medalcho *et al*., 2021; Onyemata and Ibrahim, 2018).

Statistical analysis

Statistical tools of the Statistical Package for Social Scientists (SPSS version 25) were employed in analyzing data generated, and separation of significant means was done with the application of Duncan Multiple Range Tests (DMRTs).

RESULTS AND DISCUSSION

Consumer acceptability of Tidbits made with blends of flour from cassava, and Bambara nut

The sensory score of the tidbits prepared with blends of flour from cassava and Bambara nut is presented in Table 2. The mean sensory score for appearance ranged from 4.48±2.02 to 7.52±1.42 with sample having 60% high quality cassava flour (HQCF) and 40% cowpea flour (CF) having the highest value while the sample with 60% wheat flour (WF) and 40% Bambara nut flour (BNF) had the lowest value. All the samples with blends of flour from HQCF and BNF were rated higher than the control sample with blend containing WF and BNF as adjudged by panelists; this observed preference by the assessors could be attributed to the characteristic aesthetic creamy color of the HQCF used in the blend formulation which has the propensity to create sensory appeal to the consumer.

The trend observed for colour of the tidbits is similar to that of the appearance, the tidbits samples have values ranging from 4.92±2.08 to 7.56±1.26, with sample having 60% HQCF and 40% CF having the highest value while the sample with 60% WF and 40% BNF had the lowest value; there was no significant difference ($p > 0.05$) in the tidbits produced with the blends of flour, except in the sample with 60% HQCF and 40% BNF.

In terms of aroma, there were no significant ($p > 0.05$) differences in the tidbits produced with blends of flour from cassava, Bambara nut, and wheat. The tidbits samples had values that ranged from 4.92±1.98 to 7.16±1.72, with the sample made up of 80% HQCF and 20% BNF having the highest value, while the sample with 60% WF and 40% BNF had the lowest value. The tidbits samples formulated with 60% HQCF and 40% BNF and 60% WF and 40% BNF (i.e., $HQCF_{60.00}BNF_{40.00}$ and $WF_{60.00}BNF_{40.00}$) were not significantly different ($p > 0.05$).

The tidbits samples were not significantly ($p > 0.05$) different in terms of taste, except in samples prepared with blends of flour in ratios 60% HQCF and 40% BNF, 60% HQCF and 40% BNF, and 60% WF and 40% BNF. The taste of the tidbit samples ranged from 3.64±1.87 to 7.08±1.80, with the tidbit sample with blend ratio 70% HQCF and 30% CF having the highest, while the sample with blend 60% WF and 40% BNF had the lowest.

The tidbit samples prepared with blends of flour from cassava and Bambara nut were not significantly ($p > 0.05$) different concerning texture, except the samples formulated using ratio 60% HQCF and 40% BNF, 60% HQCF and 40% BNF and 60% WF and 40% BNF (i.e. $HQCF_{60.00}BNF_{40.00}$, $HQCF_{60.00}BNF_{40.00}$ and $WF_{60.00}BNF_{40.00}$). The texture of the tidbit samples ranged from 3.04±1.54 to 6.96±1.57, with the tidbit sample prepared using a blend ratio of 80% HQCF and 20% BNF having the highest value, while the sample with a blend ratio of 60% WF and 40% BNF had the lowest value. Also, tidbit samples $HQCF_{60.00}BNF_{40.00}$ and $HQCF_{70.00}BNF_{30.00}$ were not significantly ($p > 0.05$) different.

The crunchiness of the tidbit samples ranged from 2.40±1.47 to 7.80±1.32, with tidbit samples prepared with a blend ratio of 80% HQCF and 20% BNF having the highest value, while samples with a blend ratio of 60% WF and 40% BNF had the lowest value. There was a significant difference ($p < 0.05$) in the tidbit samples, except in the sample with blend ratio 80% HQCF and 20% BNF, 70% HQCF and 30% BNF, 75% HQCF and 25% BNF, and 70% HQCF and 30% CF, with respect to crunchiness.

The overall acceptability of the tidbit's samples revealed that the samples prepared using a blend ratio of 60% HQCF and 40% CF were the most acceptable, as adjudged by the assessors, followed by the tidbit made with a blend ratio of 80% HQCF and 20% BNF. The judgment of the panelists could have been influenced by the sample's appearance, color, and taste. The sample prepared using a blend ratio of 60% WF and 40% BNF had the lowest value. Tidbit samples $HQCF_{80.00}BNF_{20.00,}$ $HQCF_{70.00}BNF_{30.00,\ and}$ $HQCF_{70.00}BNF_{30.00}$ were not significantly ($p > 0.05$) different.

Assessing the sensory attributes of food plays a crucial role in both product innovation and maintaining quality standards. This process allows for a detailed examination of the sensory characteristics of food items, aids in distinguishing variations among products that share similar traits, highlights perceptible differences within a specific item, and gauges the consumer reactions regarding their overall preference and acceptance (Gonzalez-Casado *et al*., 2019).

Table 2: Sensory Attributes of Tidbit produced with blends of flour from cassava and Bambara Nut

Sample	Appearance	Colour	Aroma	Taste	Texture	Crunchiness	Overall acceptability
$HQCF_{80.00}BNF_{20.00}$	6.92±1.08^{bc}	7.04±1.14^{bc}	7.16±1.72^{c}	6.80±1.76^{d}	6.84±1.65^{d}	7.24±1.92^{d}	7.20±1.35^{de}
$HQCF_{65.00}BNF_{35.00}$	7.04±1.43^{bc}	6.96±1.10^{bc}	6.64±1.47^{bc}	6.08±1.58^{cd}	5.96±1.79^{cd}	5.72±1.79^{c}	6.32±1.46^{cd}
$HQCF_{70.00}BNF_{30.00}$	7.16±1.07^{bc}	6.80±0.96^{bc}	6.72±1.54^{bc}	6.96±1.40 ^{d}	6.60±1.47^{d}	7.32±1.54^{d}	7.16±1.18^{de}
$HQCF_{60.00}BNF_{40.00}$	6.92±1.12^{bc}	6.48±1.23^{b}	6.00±1.56^{b}	5.28±1.84^{bc}	5.24±1.45^{bc}	5.04±1.24^{c}	5.80±1.23^{bc}
$HQCF_{75.00}BNF_{25.00}$	7.00±1.35^{bc}	6.88±0.93^{bc}	6.76±1.51^{bc}	6.40±1.53^{d}	6.28±1.57^{d}	6.76±1.88^{d}	6.60±1.35^{cde}
$HQCF_{80.00}BNF_{20.00}$	6.72±1.31^{bc}	6.84±1.28^{bc}	6.68±1.73^{bc}	6.60±1.89^{d}	6.96±1.57^{d}	7.80±1.32^{d}	7.08±1.41^{de}
$HQCF_{60.00}BNF_{40.00}$	6.36±1.47^{b}	6.32±1.07^{b}	5.80±1.56^{ab}	4.84±1.84^{b}	4.96±1.79^{b}	3.72±1.75^{b}	5.32±1.68^{b}
$HQCF_{70.00}BNF_{30.00}$	7.12±1.33^{bc}	6.80±1.12^{bc}	6.24±1.45^{bc}	6.40±1.50^{d}	6.88±1.54^{d}	7.28±1.82^{d}	6.92±1.38^{de}
$WF_{60.00}BNF_{40.00}$	4.48±2.02^{a}	4.92±2.08^{a}	4.92±1.98^{a}	3.64±1.87^{a}	3.04±1.54^{a}	2.40±1.47^{a}	3.88±1.72^{a}
$HQCF_{60.00}CF_{40.00}$	7.52±1.42^{c}	7.56±1.26^{c}	7.04±1.59^{c}	7.08±1.80^{d}	6.80±2.07^{d}	7.60±1.73^{d}	7.40±1.92^{e}

Values are mean ± standard deviation. Mean values with different superscripts within the same column are significantly different at the 5% level; HQCF: High quality cassava flour; BNF: Bambara nut flour; WF: Wheat Flour; CF: Cowpea flour.

The integration of sensory analysis plays a key role in enhancing aspects such as product alignment, classification, modification, and consumer preference assessment in both quality assurance and the development of novel food products (Carpenter *et al*., 2000). Findings from this study indicate that participants are open to adjustments in the sensory attributes of tidbits, moving away from the conventional version fortified with Cowpea flour toward a preference

for those enriched with Bambara groundnut flour. Combining high-quality cassava flour with Bambara nut flour may enhance the tidbit's sensory aromatic appeal, while incorporating Bambara nut flour, even at a 20% level, can improve its texture and desirable crispness, ultimately making the snack more enjoyable (Sharanagat *et al*., 2022). These modifications contribute to a more gratifying snacking experience, leading to increased overall acceptance among sensory panels.

Microbiological qualities of the Tidbits

The initial mean total viable counts of microbial load in Tidbits produced from HQCF and Bambara nuts are presented in Table 3. The total heterotrophic bacterial count ranged from 6 x 10^3 to 3.3 x 10^4 CFU/g across samples 80% high quality cassava flour 20% Bambara nut flour,65% high quality cassava flour 35% Bambara nut flour,70% high quality cassava flour 30% Bambara nut flour and 70% high quality cassava flour 30% Cowpea flour with sample 70% high quality cassava flour 30% Bambara nut flour recording the highest count, potentially due to normal microflora. These counts are within the permissible limit of 5.30 $\log_{10}$ CFU/ml, as stipulated by the ICMSF. No microbial growth was detected on MacConkey agar or Potato Dextrose Agar, indicating the absence of coliforms and fungal counts. According to the Standards Organization of Nigeria (SON), aerobic plate counts ranging from 10^4 to 10^6 cells per milliliter or gram in foods are acceptable. Therefore, the microbial counts in this study remain within safe limits for consumption and storage. Several factors likely contributed to the reduced microbial load, including the effects of pH, lower water activity (a_x), the intensity and duration of heat during frying, as well as hygienic handling practices, particularly during packaging by food handlers. (Alimi *et al*., 2025b).

Table 3: Mean viable counts from Tidbits produced with blends of flour from cassava and Bambara Nut (CFU/g)

SAMPLES	TOTAL HETEROTROPHIC COUNTS	TOTAL COLIFORM COUNTS	TOTAL FUNGAL COUNTS
$HQCF_{80.00}$ $BNF_{20.00}$	2.4 x 10^4	0	0
$HQCF_{65.00}$ $BNF_{35.00}$	7 x 10^3	0	0
$HQCF_{70.00}$ $BNF_{30.00}$	6 x 10^3	0	0
$HQCF_{60.00}$ $BNF_{40.00}$	0	0	0
$HQCF_{75.00}$ $BNF_{25.00}$	0	0	0
$HQCF_{80.00}$ $BNF_{20.00}$	0	0	0
$HQCF_{60.00}$ $BNF_{40.00}$	0	0	0
$HQCF_{70.00}$ $BNF_{30.00}$	3.3 x 10^4	0	0
$WF_{60.00}$ BNF 40.00	0	0	0
$HQCF_{60.00}$ $CF_{40.00}$	3.2 x 10^4	0	0
Control	0	0	0

CONCLUSION

This research successfully demonstrated that fortifying high quality cassava flour with Bambara nut flour significantly altered the consumer acceptability and microbiological quality of tidbits. Acceptable and added-value tidbits of comparable quality with those produced with high quality cassava fortified with cowpea were produced with flour blends from high quality cassava and Bambara groundnut. The tidbits produced with the flour blends were acceptable to the sensory panels. The microbial analysis of all tidbit samples revealed no presence of coliform or fungal growth. The microbial counts observed in this study remain well within the safety threshold for both consumption and storage.

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