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Proximate Composition and Microbiological Qualities of Cakes Made with High-Quality Cassava Flour

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Abstract

Proximate properties depict the nutritional value that food can provide while microbiological quality critically determine the food safety as this relate directly with the public health. This study evaluated the proximate composition and microbiological qualities of cakes made with high-quality cassava flour (HQCF) derived from selected cassava varieties. The unit operations involved in processing cassava roots include harvesting, peeling, washing, grating, pressing, pulverizing, and flash drying at 120 °C for 8 minutes. The flash-dried grits were milled using a cyclone hammer mill with a 250 µm screen. The fine flour produced was then allowed to cool, packaged in high-density polyethylene bags, and stored at ambient temperature. Cakes prepared with HQCF from these cassava varieties, along with wheat flour as a control, were analyzed for proximate composition and microbiological properties. Data analysis was conducted using ANOVA via SPSS (version 25.0), with significant differences

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determined by Duncan's Multiple Range Test. The results obtained indicated that there were significant difference (p≤0.05) in the nutritional composition of the cake samples, which are moisture (15.13±0.04% to 23.70±0.07%), protein (3.11±0.01% to 5.71±0.36%), fat (14.93±0.80% to 17.43±0.11%), ash (1.28±0.11% to 2.10±0.07%), fiber (0.35±0.00% to 0.58±0.04%), and carbohydrate content (51.32±0.04% to 63.38±0.13%). Microbiological analysis indicated an acceptable quality level, as the mold and yeast counts were minimal, likely due to the lethal effects of the baking temperature. Cakes made with HQCF demonstrated nutritional and microbiological properties comparable to those made with 100% wheat flour.

Keywords: Lethal effect, microbiological quality, nutritional composition, physiological deterioration, porosity,

INTRODUCTION

People in tropical areas eat a variety of food products prepared from cassava (Alimi *et al*., 2023b). The cassava root has a limited shelf life after harvest, caused by a phenomenon called postharvest physiological deterioration (PPD). This issue hampers its marketability and discourages participation from stakeholders in its supply chain. The aforementioned challenge in cassava value chain led to research efforts to screen some cassava varieties for delayed or low postharvest physiological deterioration which increased the storage life of cassava roots from two days (48 hrs) to 5 days (120 hrs), improved the food value (dry matter) and nutritional profile especially with pro-vitamin A with its unique functional properties in enhancing the human health immune response and reduction in the risk of degenerative diseases (Alimi *et al*., 2024c).

Consideration based on economic standpoint, dependence on the importation of wheat for domestic and industrial application in food industry by countries in regions of the world owing to less favourable soil and climatic conditions necessary for wheat production in such country is not supportive to national growth and economic development of a nation, therefore, effort geared at prospecting flours from crops having requisite functional properties that resembles and could complement that of wheat with the view to replacing wheat partially should be explored and strengthened (Alimi *et al*., 2024b). Researchers had made an effort to substitute wheat flour with HQCF in making baked food products (Ahemen *et al*., 2021; Shittu *et al*., 2007; Akintayo *et al*., 2020; Eje, 2020). Alimi *et al*. (2024c) substituted wheat flour with high-quality cassava flour and Bambara nut flour and reported improvement in some functional properties and nutritional composition. The need to save hard currency as a nation by reducing overdependence on importation of wheat and explore the potentials inherent in under-utilized or neglected crops informed the decision of the Federal Government of Nigeria to mandate the flour mills to include 10% of HQCF into the wheat flour meant for baking purpose (Ahemen *et al*., 2021).

The rising prevalence of celiac disease has led to the exploration of gluten-free flours, like high-quality cassava flour, for use in the baking industry. High-quality cassava flour is commonly used in producing baked goods like composite bread, cakes, and chinchin. Acceptable bread (Alimi *et al*., 2024b), cakes (Alimi *et al*., 2024a) were produced with high-quality cassava flour from selected varieties of low postharvest physiologically deteriorated cassava. The interest in the use of gluten-free flour such as HQCF for baking purposes is on the increase, and that may not be unconnected with the fact that consumers want variety in food consumption, coupled with the reduced risk of celiac disease when gluten-free flours are used in producing baked food products.

One of the conventional snacks consumed worldwide is cake, which is produced with wheat flour and, in addition, with other ingredients. Cake is a popular global snack typically made from wheat flour along with other ingredients. Cake resembles bread in both appearance and texture. It is typically a sweet baked dessert available in various shapes, such as circular, disk-like, or rectangular, based on consumer preferences. Commonly, bread and cakes could be contaminated at post-baking stages of bakery manufacturing, i.e., during cooling, slicing, packaging, and storage, from the mold spores present in the atmosphere surrounding the loaves and cakes (Shovon *et al*., 2018). The aforementioned point underscored the need to ensure good manufacturing practices are adhered to in the production of baked food products such as bread, cake etc. This study, therefore, examined the proximate composition and microbiological quality of cakes made with high-quality cassava flours from selected varieties of cassava.

MATERIALS AND METHODS

Materials

"The project utilized cassava flours sourced from five (5) distinct varieties, which include IITA-TMS-IBA011368, IITA-TMS-IBA070593, IITA-TMS-IBA011412, and IITA-TMS-IBA011371. All cassava varieties were obtained from the International Institute of Tropical Agriculture (IITA), Ibadan. Additional materials included refined wheat flour from Honeywell Flour Mills, granulated sugar from Dangote Nigeria Plc, Lagos, and other ingredients such as DSM bakery ingredient baking powder (Dordrecht-Holland), Simas margarine (PT Intiboga Sejahtera, Jakarta, Indonesia), medium-sized eggs, evaporated milk, and vanilla essence. The varieties of cassava used in this study were selected based on flour yield (FY) and dry matter (DM) content. The Physical, proximate, and pasting properties of high-quality cassava flour from selected varieties of low postharvest physiologically deteriorated cassava are as presented in Alimi *et al*. (2021), as shown in Tables 1, 2 and 3.

Table 1: Physical properties of high-quality cassava flour

Cassava Variety	*L**	*a**	*b**	Hue	Chroma
IITA-1368	98.73±014^{a}	-0.71±0.01^{c}	9.70±0.45^{b}	94.35±0.04^{c}	9.72±0.45^{b}
IITA-0593	97.97±0.30^{a}	-1.05±0.01^{a}	10.08±0.09^{b}	95.93±0.02^{d}	10.13±0.13^{b}
IITA-1412	98.30±1.11^{a}	-1.05±0.04^{a}	15.28±0.21^{d}	93.92±0.20^{b}	15.32±0.21^{d}
IITA-1371	97.96±0.44^{a}	-1.00±0.01^{b}	13.88±0.62^{c}	94.11±0.14^{b}	13.78±0.80^{c}
TMEB419	99.01±0.12^{a}	-0.07±0.01^{d}	6.42±0.14^{a}	90.62±0.18^{a}	6.43±0.15^{a}

Data are presented as mean ± standard deviation from three replicates. Within each column, mean values with distinct superscript letters indicate significant differences ($p \leq 0.05$).

*L**: flour lightness; *a**: redness-greenness; *b**: yellowness-blueness; IITA-011368: IITA-TMS-IBA-011368; IITA-070593: IITA-TMS-IBA-070593; IITA-011412: IITA-TMS-IBA-011412; IITA-011371: IITA-TMS-IBA-011371

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).

Preparation of cake

The cakes were prepared with the recipe presented in Table 4. Sugar and butter were mixed according to the method as described by Alimi *et al*. (2024c), as illustrated in Figure 1. The homogenous mixture of baking fat and granulated sugar was made using a mixer for 20 minutes. The eggs were homogenized for 5 minutes. Cassava flours from IITA-TMS-IBA011368, IITA-TMS-IBA070596, IITA-TMS-IBA011412, IITA-TMS-IBA011371, TMEB419,

and wheat flour were each measured to be 300 g, thoroughly mixed for 10 minutes to form a uniform cream, with additional ingredients incorporated during the process.

Table 2: Proximate composition of HQCF from selected varieties of low PPD cassava

Cassava Variety	Moisture (%)	Protein (%)	Ash (%)	Fat (%)	CHO (%)	Dry matter (%)	Energy value (KJ/kg)
IITA-1368	6.84±0.01^{a}	0.17±0.00	0.58±0.09^{b}	0.27±0.03^{a}	92.14±0.07^{d}	93.16±0.01^{c}	1555.07±0.54^{b}
IITA-0593	7.35±0.01^{b}	0.17±0.00	0.23±0.02^{a}	0.58±0.09^{b}	91.69±0.08^{c}	92.66±0.01^{b}	1558.96±0.52^{b}
IITA-1412	8.73±0.33^{c}	0.34±0.00	0.63±0.18^{b}	0.23±0.02^{a}	90.08±0.16^{a}	91.27±0.33^{a}	1521.68±0.46^{a}
IITA-1371	7.63±0.01^{b}	0.17±0.00	0.27±0.03^{a}	0.58±0.09^{b}	91.36±0.05^{b}	92.36±0.01^{b}	1553.60±0.57^{b}
TMEB419	7.46±0.10^{b}	0.17±0.00	0.58±0.09^{b}	0.63±0.18^{b}	91.17±0.18^{b}	92.54±0.10^{b}	1543.94±3.78^{b}

Data are presented as mean ± standard deviation from three replicates. Within each column, mean values with distinct superscript letters indicate significant differences (p≤0.05).

CHO: Carbohydrate; IITA-011368: IITA-TMS-IBA-011368; IITA-070593: IITA-TMS-IBA-070593; IITA-011412: IITA-TMS-IBA-011412; IITA-011371: IITA-TMS-IBA-011371

Table 3: Pasting properties of high-quality cassava flour

Cassava Variety	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback viscosity (RVU)	Peak time (min)	Pasting temperature (°C)
011368	585.67±3.54^{a}	68.29±9.96^{a}	517.38±13.50^{b}	333.50±3.54^{c}	265.21± 6.42^{d}	3.90± 0.04^{b}	73.50± 1.20^{b}
070593	552.25±11.67^{a}	164.96±46.37^{b}	387.29±58.04^{a}	315.29±0.76^{b}	150.34± 47.14^{bc}	4.07± 0.00^{c}	73.55± 0.07^{b}
011412	716.79±29.05^{b}	234.67±6.36^{c}	482.13±22.69^{c}	328.30±12.20^{bc}	93.63± 5.83^{ab}	3.80± 0.10^{b}	73.18± 0.53^{ab}
011371	694.58±0.71^{b}	193.75±22.27^{bc}	500.83±21.57^{b}	380.09±3.06^{d}	186.34± 19.21^{c}	3.53± 0.00^{a}	71.93± 0.04^{a}
419	566.54±0.41^{a}	205.42±0.47^{bc}	361.13±0.88^{a}	291.09±2.95^{a}	85.67± 2.48^{a}	4.13± 0.00^{c}	73.55± 0.00^{b}

Data are presented as mean ± standard deviation from three replicates. Within each column, mean values with distinct superscript letters indicate significant differences (p≤0.05).

This was done to prevent the curdling of the batter. After batter development of a soft velvety feel, the vanilla essence (flavoring) was added. The resulting batter was mixed with milk and water to proportion and poured into greased cake pans. These were put into the electric oven (Macadams, UK, model: Convecta B) and baked at a temperature of 190°C for 15mins. The cakes were cooled and removed from the pan after 1 hour. The cooled cake was then packaged in aluminum foil and kept on the shelf until required for subsequent analyses.

Table 4: Recipe for the cake production

Ingredient	Quantity
Cassava flours	300g
Sugar	100g
Margarine	200g
Baking powder	7.5g
Eggs (4 medium-sized)	180g
Evaporated milk	62mls
Vanilla essence	5 ml
Mixed fruits	100g

(Source: Alimi et al., 2023)

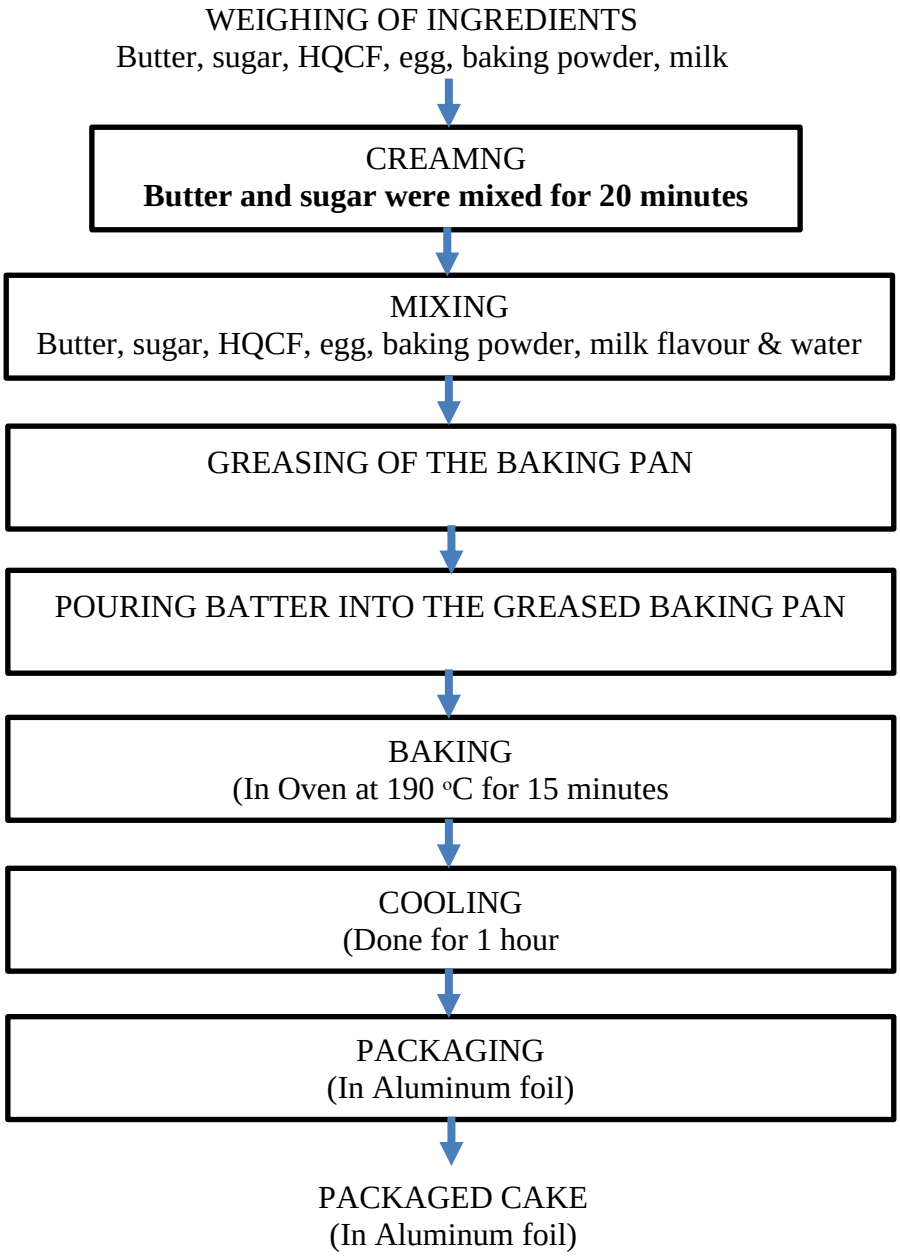


Figure 1. Flow chart for the production of cake
Source: Alimi et al., 2023

Determination of the proximate composition of cake
The composition of cakes made with HQCF from low PPD cassava, including moisture, protein, fat, ash, fiber, and total carbohydrate contents, was analyzed using the official AOAC (2005) standard methods.

Microbiological analysis of the cakes
To isolate fungal colonies in the cake samples, a 10-fold serial dilution was performed. First, 1 gram of the cake sample was mixed with 9 mL of peptone water. From this mixture, 1 mL was transferred into another 9 mL of peptone water, and this process was repeated six times to achieve multiple dilutions. Next, 1 mL from the 10^{-1}, $10^{-3,}$ and 10^{-5} dilutions was plated onto Potato Dextrose Agar (PDA) using the pour plate method. The plates were incubated at 27°C

for 3–5 days, with 25 µg of chloramphenicol added to the agar medium before autoclaving to suppress bacterial growth. After four days of incubation, a plate count was conducted to quantify moulds and yeasts. Distinct fungal colonies were then isolated by transferring them with a flamed inoculating needle onto freshly prepared agar medium, followed by an additional incubation at 27°C for four days (ICMSF, 1988).

Statistical analysis
The nutritional composition and microbiological data of the cakes were analyzed using analysis of variance (ANOVA) with SPSS version 25.0 (SPSS Inc., USA). Differences between significant means were determined using Duncan's Multiple Range Tests (DMRTs).

Results and Discussion

Proximate composition of cakes
The results for nutritional properties of cakes are presented in Table 5. The moisture content of a food is indicative of the dry matter in that food (Alimi *et al*., 2024c). The cakes produced were significantly ($p \leq 0.05$) different with regard to moisture content. The moisture content of the cakes ranged from 15.13 - 23.70%, cake sample C-011412 having the least moisture, while the highest value was recorded in sample C-WHEAT, respectively. The range (15.13 - 23.70%) of value for cakes' moisture content in this study falls within the range(14.85 – 19.64 %) reported by Ammar and Abd El-Razik (2013) but was higher than (14.00 – 14.40 %) that reported by Alozie *et al*. (2009) and this could be attributed to the high water absorption capacity of the high quality cassava flour prepared from low postharvest physiologically deteriorated cassava which correspond to higher product yield (i.e. increased loaf volume) in baked food products as noted by Alimi *et al*. (2024c) and Puhr and D' Appolonia (1992). The range (15.13 - 23.70%) of value for moisture content reported in this study is within the range for cake and lower than the range (26.70 - 30.90 %) for composite wheat-cowpea bread (Alimi *et al*., 2024c).

Protein has been reported to correlate with the texture and appearance of finished food product attributes and also forms the basic building block for cell and tissue repairs in the body (Alimi *et al*., 2023). The protein content of the cake samples varied significantly ($p \leq 0.05$), ranging from 3.11% to 5.71%. Sample C-011368 recorded the lowest protein level, while sample C-WHEAT showed the highest, as indicated in Table 5. The range (3.11 to 5.71 %) of protein content of the cake sample in this study was lower than the range (9.20 – 17.40 %) reported by Alozie *et al*. (2009) and (9.15 – 19.21 %) reported by Ammar and Abd El-Razik (2013); the differences observed in the range of protein value could be attributed to the fact that flour blends with which the cakes in the latter were prepared contained flours that are relatively rich in protein, which includes flours from wheat and African yam bean; wheat, pumpkin, potato blends, respectively, which consequently resulted into relatively high protein content than cake produced with HQCF only.

Fat supplies the body with energy and acts as a flavor enhancer in food (Alimi *et al*., 2024c). The fat content of the cake samples varied between 14.93% and 17.43%. Sample C-B419 had the lowest fat content, while the wheat flour-based cake (C-WHEAT) recorded the highest, as shown in Table 5. Cake samples C-011371 and C-WHEAT were significantly different ($p \leq 0.05$) in terms of fat content, while samples C-070593, C-011412, C-011371, and C-B419 were not significantly different ($p \geq 0.05$). The range of values for fat in this study is relatively higher than the range of values reported by Alozie *et al*. (2009).

The ash content of a food material or item serves as an indicator of its mineral composition. The ash contents of the cakes ranged from 1.28 - 2.10% in sample C-011368 and C-011412, respectively; The ash content of cake samples C-011371 and C-WHEAT showed no significant difference ($p \leq 0.05$). Similarly, samples C-070593, C-011412, C-011371, and C-B419 did not exhibit any significant difference ($p \geq 0.05$) (Table 5). The range (1.28 - 2.10%) of value for ash content in this study is within the range (0.65 – 2.52 %) reported by Ammar and Abd El-Razik (2013) but less than the range of value reported by Alozie *et al*. (2009), this could be attributed to the additive effect of the ash content of the constituent flours blended (wheat and African yam bean) when compared with HQCF only.

Except for sample C-011412, the fibre content of the cake samples showed no significant difference ($p \geq 0.05$). The fibre content ranged between 0.35% and 0.58%, with sample C-011412 exhibiting higher fibre content compared to sample C-WHEAT (Table 5). The range (0.35 – 0.58%) of value for crude fibre recorded in this study is close to the range (0.14 – 1.80 %) reported by Alozie *et al*. (2009) for cake made with a blend of wheat and African yam bean flour.

Table 5: Nutritional properties of cake produced with HQCF from cassava varieties

CAKE SAMPLE	Moisture content (%)	Protein content (%)	Fat content (%)	Fibre content (%)	Ash Content (%)	Total Carbohydrate (%)
C-011368	22.40±0.21^{e}	3.11±0.01^{a}	16.45±0.07^{b}	0.38±0.04^{a}	1.28±0.11^{a}	53.90±3.33^{a}
C-070593	16.13±0.11^{b}	3.22±0.12^{ab}	15.50±0.07^{a}	0.35±0.00^{a}	1.80±0.21^{b}	62.91±0.13^{c}
C-011412	15.13±0.04^{a}	3.77±0.27^{c}	15.10±0.70^{a}	0.58±0.04^{b}	2.10±0.07^{b}	63.38±0.13^{c}
C-011371	20.95±0.21^{d}	3.57±0.18^{abc}	15.15±0.07^{a}	0.35±0.00^{a}	2.05±0.14^{b}	57.97±0.32^{b}
C-B419	18.43±0.60^{c}	3.71±0.15^{bc}	14.93±0.80^{a}	0.38±0.04^{a}	1.90±0.07^{b}	60.90±0.06^{bc}
C-WHEAT	23.70±0.07^{f}	5.71±0.36^{d}	17.43±0.11^{c}	0.35±0.00^{a}	1.50±0.14^{a}	51.32±0.04^{a}

Data are presented as mean ± standard deviation from three replicates. Within each column, the mean values with distinct superscript letters indicate significant differences ($p \leq 0.05$).

C-011371: Cake baked with HQCF from IITA-TMS-IBA011371 cassava
C-011368: Cake baked with HQCF from IITA-TMS-IBA011368 cassava
C-070593: Cake baked with HQCF from IITA-TMS-IBA070593 cassava
C-B419: Cake baked with HQCF from TMEB419 cassava
C-011412: Cake baked with HQCF from IITA-TMS-IBA011412 cassava
C-WHEAT: Cake baked with refined wheat flour

Carbohydrate food is essential as it provides the body with energy to do work and subsequently helps in the regulation of blood glucose (Alimi *et al*., 2024c). The carbohydrate contents ranged from 51.32 - 63.38% in cake samples C-WHEAT and C-011412, respectively. The total carbohydrate content of cake samples C-011368 and C-WHEAT showed no significant difference; likewise, samples C-070593 and C-011412. It is pertinent to note that cakes produced from HQCF had higher carbohydrate contents than cakes from wheat flour Table 5).

Microbiological quality of cakes

Table 6 provides salient information on the microbiological quality of the cake samples. The mold and yeast count for the cake samples C-011368, C-070593, C-011412, C-011371, C-B419 and C-WHEAT were 0, 4, 0, 6, 1 and 1 (x 10^3) cfu/g, while for yeast 0, 0, 1, 0, 0, 0 (x 10^3) cfu/g, respectively. Notably, cake sample C-011371 had a relatively high count (6 x 10^3) cfu/g.

The microbiological quality status of the cake samples was acceptable simply because the count for the molds and yeast was within 10^4 <10^6 cfu/g for dry and ready-to-eat foods as outlined by the International microbiological standards (HPA, 2009; ICMSF, 1996). The low mold load and yeast count observed can be attributed to the lethal impact of the baking

temperature and the effective hygiene practices (GHP) maintained by the food handlers (Alimi *et al*., 2025a; Alimi *et al*., 2025b). Without these measures, post-baking contamination of the cake samples could have occurred.

Table 6: Microbiological quality of cake produced with HQCF from low cassava varieties

Cassava Variety	Mould count ($x 10^3$) (Cfu/g)	Mould count ($x 10^6$) (Cfu/g)	Yeast count ($x 10^3$) (Cfu/g)	Yeast count ($x 10^6$) (Cfu/g)
C-011368	Nil	Nil	Nil	Nil
C-070593	4	Nil	Nil	Nil
C-011412	Nil	4	1	Nil
C-011371	6	3	Nil	Nil
C-B419	1	5	Nil	Nil
C-WHEAT	1	1	Nil	Nil

C-011371: Cake baked with HQCF from IITA-TMS-IBA011371 cassava
C-011368: Cake baked with HQCF from IITA-TMS-IBA011368 cassava
C-070593: Cake baked with HQCF from IITA-TMS-IBA070593 cassava
C-B419: Cake baked with HQCF from TMEB419 cassava
C-011412: Cake baked with HQCF from IITA-TMS-IBA011412 cassava
C-WHEAT: Cake baked with refined wheat flour

Conclusion

Cakes of desirable nutritional composition and microbiological qualities comparable to 100% wheat flour cakes have been produced from low postharvest physiologically deteriorated (PPD) cassava. The microbiological results indicated that the cakes are safe for consumption as the count for the molds and yeast was within 10^4 <10^6 cfu/g for dry and ready-to-eat foods as outlined by the International microbiological standards. High-quality cassava flour derived from these selected low-PPD cassava varieties (IITA-TMS-IBA011371, IITA-TMS-IBA011368, IITA-TMS-IBA070593, IITA-TMS-IBA011412) has potential applications in the confectionery industry.

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