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Sensory and Microstructural Properties of Cakes Made with Flour from Low Postharvest Physiologically Deteriorated Cassava

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Abstract

The pertinent information generated from studying quality characteristics such as the structure and crumb properties of baked food products such as bread, cake etc. is very critical as it enhances product quality and inevitably help improve consumer acceptability. This research was carried out to assess the sensory qualities and investigate the microstructural properties of cakes made with high quality cassava flour (HQCF) from selected varieties of low postharvest physiologically deteriorated (PPD) cassava. Wholesome four varieties of yellow-fleshed Low PPD cassava and one variety of high PPD cassava were processed into high quality cassava flour following unit operations such peeling, washing, grating, pressing, pulverization and eventual drying using flash dryer operated at 120 °C for 10 minutes followed by milling with cyclone hammer mill fitted with a screen of 250 µm aperture size; the HQCF was allowed to cool, sieved and then packed into high density polyethylene bag. The cakes were analyzed for sensory and microstructural properties. Analysis of variance was performed on the data generated while significant means were separated applying Duncan Multiple Range Test using Statistical Package for Social Sciences (SPSS version 25.0). Generally, there was no significant difference ($p \geq 0.05$) in the sensory qualities (Color, texture, aroma, taste, flavor and overall acceptability) of the cakes made. The cake samples had sensory scores with ranges: color (2.20 – 3.40), texture (2.60 – 4.10), aroma (2.90 – 4.20), taste (3.10 – 3.80) favor (2.90 – 3.80) and overall acceptability (2.90 – 3.70). The most preferred cake sample was C-070593 (cake sample baked with HQCF from IITA-TMS-IBA070593 cassava. Microstructural properties of cake baked with wheat flour was significantly different from cakes baked with HQCF from low PPD cassava owing to water absorption capacity, starch gelatinization characteristics and dough composition such as gluten quality. Cakes of acceptable sensorial and microstructural characteristics similar to that made with 100% wheat flour were produced with HQCF from selected varieties of low PPD cassava.

Keywords: microstructural properties, Sensory properties, porosity, fluffiness, overall acceptability

1. Introduction

The people in the tropical areas eat cassava and array of food products prepared from cassava (Alimi et al., 2022a). The short postharvest life of cassava (Manihot esculenta Crantz) as a result of an occurrence termed ‘postharvest physiological deterioration (PPD)’ which restricts its market prospect and discourages stakeholders in its value chain with an attendant effect requiring the immediate processing of the roots into value added food products and this necessitate the screening of available cassava varieties. Screening of some varieties of cassava known for high PPD to have delayed PPD or low PPD with the view to increasing the storage life of cassava root from two days (48 hrs) to 5 days (120 hrs), improvement in the yield and nutritional profile especially with pro-vitamin A with its functional properties in enhancing the human health immune response and reduction in the risk of degenerative diseases (Alimi et al., 2022b).

Dependence on importation of wheat by countries in regions of the world where soil and climatic conditions are less favorable for the production of wheat is inevitable and this is critical issue when considering economic and national development of such a country. In view of the aforementioned point, flours produced from cassava, cowpea etc. had been researched into and prospected for application at domestic and industrial level in replacing wheat flour up to 30% with the view to reducing the over-dependence on wheat importation for use as food and industrial application to the barest minimum (Shittu et al., 2008; Alimi et al., 2016; Alimi et al., 2021). Interestingly, replacement of wheat flour with HQCF and flours from other food crops such as cowpea, potato etc. had been found beneficial both in terms of functional properties and nutritional composition. The Federal Government of Nigeria supported the use of HQCF to replace wheat flour to 10% for baking purposes and equally stipulate that flour mills should adhere to the 10% substitution injunction (Alimi et al., 2016).

The incidence of celiac diseases has necessitated prospecting gluten-free flour such as high quality cassava flour for baking purposes. High quality cassava flour has been widely known in the manufacture of baked product such as composite bread but now prospected for cookies, biscuits and cake (Alimi et al., 2022b). There is an increasing interest in the use of high quality cassava flour (gluten-free) for food and industrial purposes especially in the baking industry in Nigeria.

One of the conventional snacks consumed world-wide is cake which is basically produced with wheat flour and in addition with other ingredients. Cake is bread-like in appearance and texture. Cake is characteristically a sweet baked dessert which could be circular, disk and rectangular in shape depending on the preference of the consumers.

The pertinent information generated from studying quality characteristics such as the structure and crumb properties of baked food products such as bread, cake etc. is very critical as it enhances product quality and inevitably help improve consumer acceptability (Alimi et al., 2016). This research therefore assessed the sensorial qualities and microstructural properties of cakes made with HQCFs prepared from selected varieties of low postharvest physiologically deteriorated (PPD) cassava.

2. Materials and Methods

2.1 Materials

The materials used for this study includes high quality cassava flours from five cassava root varieties. Cassava roots which are yellow fleshed used for this research were four viz: low PPD (IITA-TMS-IBA011368, IITA-TMS-IBA070596, IITA-TMS-IBA011412, IITA-TMS-IBA011371) while one white fleshed, high PPD namely TMEB419; all cassava roots were provided by International Institute of Tropical Agriculture (IITA). Refined wheat flour was provided by Nigerian Eagle Flour Mills of Nigeria, Ibadan. Other materials used include granulated sugar (Dangote Nigeria Plc., Lagos, Nigeria), baking powder (DSM

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bakery ingredient, Dordrecht-Holland), margarine, (PT Intiboga Sejahtera, Jakarta, Indonesia), eggs (medium sizes), evaporated milk and vanilla essence.

2.2 Preparation of High Quality Cassava Flour (HQCF)

Five varieties of cassava roots were processed into high quality cassava flour as described by Alimi et al. (2021).

2.3 Production of Cake

The recipe for the cake production with HQCF from selected varieties of low PPD cassava is presented in Table 1.

Butter was mixed with sugar while baking fat and granulated sugar were admixed together with the mixer for 20 mins to achieve complete mixing (Bennion & Bamford, 1983). The eggs were made homogenous mixture through whipping with homogenizer which lasted for 5mins. Six different flours were used for the baking experiment; refined wheat flour (control), four were HQCF from low PPD while one was of high PPD cassava variety.

300g of each flour sample was weighed and made over a period of 10mins with good creaming between the ingredient additions. 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. The pans were moved into the oven and baked at temperature of 190 °C for 15 mins. The cakes were cooled and removed from the pan after 1hr. The cooled cakes were then packaged in aluminum foils and kept in shelf until required for sensory evaluation.

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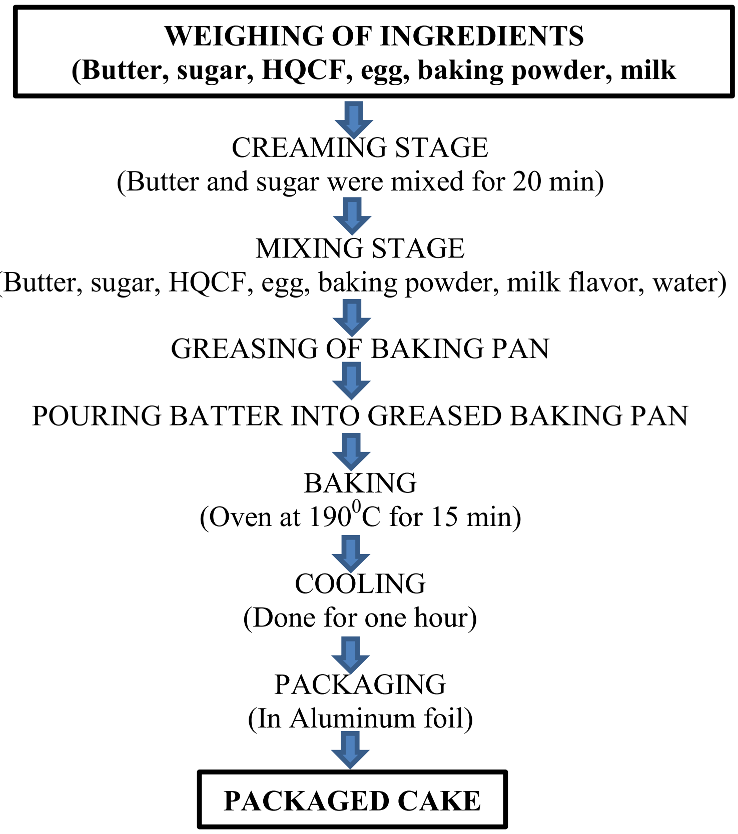

Figure 1. Process flow diagram for production of Cake (Adapted from Bennion and Bamford, 1983)

2.4 Sensory Analysis of the Cakes

The sensory Panel was basically twenty-person(s) trained; 12 were males and 8 females. Students (interns) and staff in the food laboratory, International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State, Nigeria assessed the baked product (cake). The assessors had age ranging from 20 to 45 year of which 70% of them were undergoing tertiary educational training. The cake samples were packaged in aluminum foils, assigned code, was subsequently presented to the assessors three (3) hours after baking exercise. The panelists scored the cake samples using sensory descriptive terms such as color, texture, aroma, taste, flavor and overall acceptability using a 9-point hedonic scale based on their degree of likeness, where 1= like extremely; 5= neither like nor dislike; 9= dislike extremely (Iwe, 2000).

2.5 Statistical Analyses

Analysis of variance was performed on the data generated while significant means were separated applying Duncan Multiple Range Test using Statistical Package for Social Sciences (SPSS version 25.0).

Table 1. Recipe for the cake production

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

Adapted from Akubor et al. (2000).

3. Results and Discussion

The sensory properties of caked produced with high quality cassava flour from low postharvest physiologically deteriorated (PPD) cassava are presented in Table 2. Generally, there was no significant difference ($p \geq 0.05$) in all the sensory attributes of the cake samples as adjudged by the panelists.

There was no significant difference ($p \geq 0.05$) in the cakes with regards to color with range of value (2.20 – 3.40); the color sensory score of 2.20±1.03 correspond to 'like very much' for sample C-B419 while cake sample C-011371 had 3.40±2.32 corresponding to 'like moderately'. When considering the texture and aroma of all the cake samples, there was no significant difference ($p \geq 0.05$). The sensory scores for texture of the cake was (2.60 – 4.10); the score 2.60±1.17 for cake sample C-011412 correspond to 'like very much' while the value 4.10±2.03 for C-011371 correspond to 'like slightly'. The range of value for aroma of the cakes was (2.90 – 4.20); the sensory score 2.90±1.91 for cake sample C-B419 correspond to 'like very much' while the value 4.20±1.79 for cake sample C-011371 corresponds to 'like slightly'. The range of values for taste was (3.10 – 3.80); the sensory score 3.10±2.19 for cake sample C-B419 correspond to 'like moderately' while the value 3.80±1.75 for cake sample C-070593 correspond to 'like moderately'. The range of values for flavor (sensory attributes) of the cakes was (2.90 – 3.80); the sensory score 2.90±1.60 for cake sample C-B419 correspond to 'like very much' while the value 3.80±1.55 for cake sample C-070593 which correspond to 'like moderately'. This implies that cake produced with the HQCF from selected varieties of low postharvest physiologically deteriorated (PPD) cassava compared favorably with the one produced with refined wheat flour knowing fully well that the same proportion of ingredient was added to all the cake samples as indicated in Table 1.

Considering the overall acceptability, there was no significant difference ($p \geq 0.05$) statistically between the cake samples. The range of sensory scores for the overall acceptability was (2.90 – 3.70). The sensory score 2.90±1.45 for cake sample C-070593 correspond to 'like very much' while the value 3.70±1.42 for cake sample C-011368 corresponds to 'like moderately'. The most preferred cake sample was C-070593 (cake sample baked with HQCF from IITA-TMS-IBA070593 cassava).

The varietal effect of the cassava roots from which the flours were prepared on the quality characteristics of cake produced is presented in Figure 2. The variation in the porosity of the cake crumb of the cake samples are presented in Figure 3. Talking about porosity, the cake sample produced with refined wheat flour was the most porous of all the cake samples owing to fact that its pores were uniformly distributed within the crumb structure when compared with the cake samples baked with high quality cassava flours from selected varieties of low PPD cassava which were densely packed. Presented in Figure 4 are the gray images of crumb cells obtained from cake baked with high quality cassava flours from selected varieties of low PPD cassava and refined wheat flour. The differences observed were majorly due to the varietal differences of the cassava and flour type (HQCF and wheat flour); the pasting behavior of HQCF is quite different from that of wheat flour.

Noteworthy is the fact that cake baked with refined wheat flour had uniformly distributed crumb cells and exhibited open structure that allows moisture migration from within the crumb structure to the crust surface. Compact crumb structure tends to retain moisture, this is desired qualitatively in that it maintains freshness and reduces retrogradation tendencies especially bread (Alimi et al., 2016; Brennan et al., 2004). This phenomenon explains why staling of cake produced with wheat flour could occur at a rate that is comparatively higher than that of cakes made with high quality cassava flours.

In the same vein, the crumb cell structure of the cake samples produced with high quality cassava flours exhibit a closed structure that contains closely packed crumb cells that allow less moisture migration freely when compared with cake baked with refined wheat flour, consequently, staling or firming is expected to be delayed in cassava cakes (Alimi et al., 2016).

C-011368 C-011412 C-011371 C-B419 C-070596 C-WHEAT

Figure 2: Picture showing varietal effect of HQCF from selected varieties of low PPD cassava on cake quality

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

Table 2. Sensory properties of cake produced with HQCF from low postharvest physiologically deteriorated cassava

Cassava Variety	**Color**	**Texture**	**Aroma**	**Taste**	**Flavor**	**Overall Accept.**
C-011368	2.70 ± 1.16^a	3.50 ± 1.08^a	3.30 ± 0.95^a	3.30 ± 1.34^a	3.50 ± 1.08^a	3.70 ± 1.42^a
C-070593	3.10 ± 1.79^a	3.40 ± 1.78^a	3.70 ± 1.42^a	3.80 ± 1.75^a	3.80 ± 1.55^a	2.90 ± 1.45^a
C-011412	2.80 ± 1.14^a	2.60 ± 1.17^a	3.10 ± 1.45^a	3.60 ± 1.58^a	3.40 ± 1.26^a	3.40 ± 1.27^a
C-011371	3.40 ± 2.32^a	4.10 ± 2.03^a	4.20 ± 1.79^a	3.30 ± 1.16^a	3.70 ± 1.42^a	3.50 ± 1.08^a
C-B419	2.20 ± 1.03^a	3.10 ± 1.29^a	2.90 ± 1.91^a	3.10 ± 2.19^a	2.90 ± 1.60^a	3.50 ± 0.97^a
C-WHEAT	3.20 ± 1.48^a	3.30 ± 1.57^a	3.20 ± 1.14^a	3.20 ± 1.59^a	3.40 ± 1.51^a	3.20 ± 1.32^a

Results are expressed as mean + standard deviation of 3 replicate. Mean values followed by different superscript letter within a column are significantly different ($p\leq0.05$).

Overall Accept.: Overall acceptability

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

C-011368

C-070593

C-B419

C-011412

C-011371

C-WHEAT

Figure 3: Crumb porosity of cake produced with HQCF from selected varieties of low PPD cassava and wheat flour. Differences observed are due to varietal differences.

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

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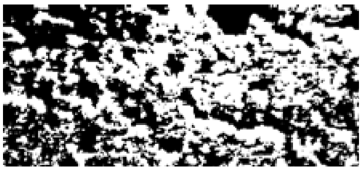
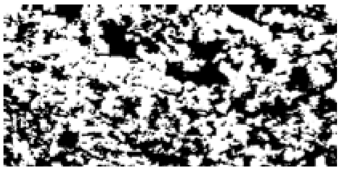
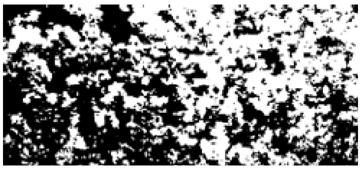


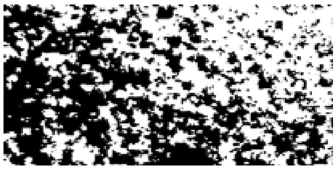
C-011368



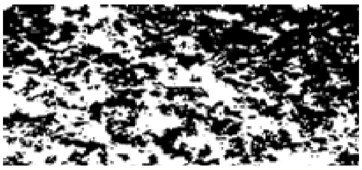
C-070593



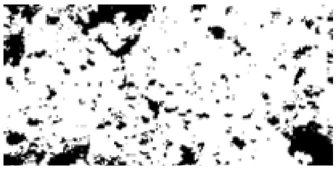
C-B419



C-011412



C-011371



C-WHEAT

Figure 4: Gray images of cake crumb cells obtained from cake baked with HQCF from selected varieties of low PPD cassava and wheat flour. Differences observed are due to varietal differences.

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

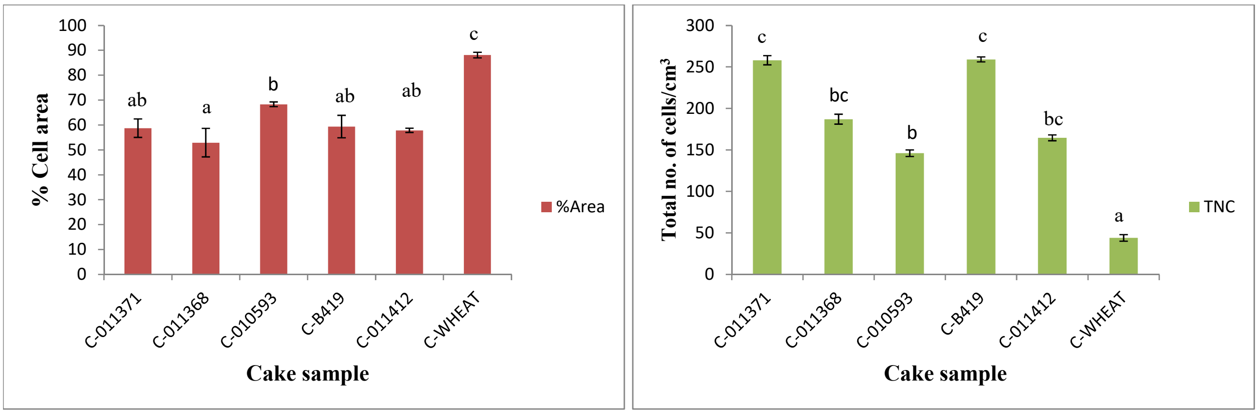


Figure 5: Effect of cassava variety on the crumb cell characteristics of cake produced with high quality cassava flour from low postharvest physiologically deteriorated cassava. Digital image was used to analyze the cakes (n=6).

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

Pertinent information generated from studying quality characteristics such as the structure and crumb properties of baked food products such as bread, cake etc. is very critical as it enhances product quality. The mean value of the frequency of gray color intensity in each crumb area (200 × 200 squared pixels) estimated while a measure of uniformity of crumb structure was noted as the coefficient of variation (CV) of GL intensity. This assumption was considered since there is a relationship between cellular structures of cake crumb and the intensity of light reflected during image acquisition.

The region with finer structure reflect more light (lower gray level intensity) while regions with coarser texture reflect less light (Figure 4). The higher the CV value the less uniform the crumb structure (Shittu et al., 2008). The crumb cell characteristics of the cakes baked with high quality cassava flours from selected varieties of low PPD cassava is presented in Figure 5. Notably, cake sample C-WHEAT (cake baked with refined wheat flour) had the highest cell area while the least was sample C-111368. The observed differences in the % cell area of the cake crumb cells could be attributed to the differences in water absorption capacity of flours (i.e. wheat flour and HQCF). Water absorption capacity of HQCF is relatively higher when compared with that of wheat flour as noted by Alimi et al. (2021). Similar observation was made by Shittu et al. (2008) who observed that 57% of the variation in the % cell area of bread slices was connected with the water absorption capacity of flour used in the baking experiment. Starch gelatinization characteristics could also be adduced as a reason for the observed difference in the % cell area of the cake crumb structures. Similar observation was noted by Eggleston et al. (1993) that starch gelatinization characteristics critically affected the crumb structure of wheatless bread. Also, gas production and retention due to viscoelastic nature of gluten present in wheat flour could possibly have resulted in the observed significantly higher % cell area in the cake baked with wheat flour when compared with cakes baked with HQCF. Conversely, it was noted that cake sample C-WHEAT (cake baked with refined wheat flour) had the least total number of cells while cake samples C-111371 and C-B419 which were not significantly different had the highest. Authors noted that differences in crumb cell microstructure of composite bread may not be unconnected with major factors such as dough composition such as flour gluten quality, starch pasting, dough formulation alpha amylase activity of flour, mixing and proofing process the dough was subjected to and heating mode (Shittu et al., 2008; Alimi et al., 2016; Ragaee & Abdel-Aal, 2006; Tohver et al., 2005).

4. Conclusion

Cakes of acceptable sensorial qualities and microstructural properties comparable to 100% wheat flour cakes have been produced with high quality cassava flours from selected varieties of low postharvest physiologically deteriorated (PPD) cassava. Cakes baked with wheat flour had relatively high cell area, low total number of cells and high porosity when compared with cakes made with HQCF from selected varieties of low PPD cassava. The use of HQCF from yellow fleshed low PPD cassava in cake making would greatly enhance the utilization of this crop in sub-Saharan African countries like Nigeria where the crop has not been optimally explored and utilized.

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Conflicts of Interest

The authors declared that there is no significant competing financial, professional, or personal interest that might have influenced the performance or presentation of the work described in this manuscript.

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