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# Quality and taste of cookies made from high-quality cassava flour

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**Abstract**
Cassava (*Manihot esculenta Crantz*) has emerged as a crucial food resource in tropical and subtropical regions due to its resilience, nutritional benefits, and economic value. High-quality cassava flour (HQCF), produced from roots processed promptly to minimize postharvest physiological deterioration (PPD), has gained prominence as a gluten-free alternative to wheat flour, particularly in baked goods such as cookies. This review evaluates the physical and sensory attributes of cookies made with HQCF, exploring their nutritional composition, textural properties, consumer acceptability, and shelf stability. Additionally, the review highlights key factors influencing the quality of HQCF-based cookies, including cassava processing techniques, varietal selection, baking methodologies, and strategies for enhancing taste and texture. Future research opportunities are proposed to address existing challenges and to improve the adoption of HQCF-based products globally.

**Keywords:** Cassava (*Manihot esculenta* Crantz), high-quality cassava flour (HQCF), gluten-free flour, tropical and subtropical regions

## 1. Introductions
Cassava (*Manihot esculenta Crantz*), a staple root crop, is widely cultivated across sub-Saharan Africa, South America, and parts of Asia due to its ability to thrive in poor soil conditions and withstand prolonged drought periods (FAO, 2021) [1]. Traditionally, cassava roots are consumed boiled, fried, or processed into tapioca and starch. However, advancements in postharvest processing have led to the development of high-quality cassava flour (HQCF), a fine, gluten-free flour suitable for baking and food processing industries.
Why HQCF?: With the increasing prevalence of gluten intolerance (e.g., celiac disease) and rising consumer demand for gluten-free alternatives, HQCF has gained attention as a cost-effective and nutritional substitute for wheat flour. Unlike traditional cassava flour, HQCF is produced with strict postharvest controls to reduce physiological deterioration, resulting in superior quality, neutral flavor, and enhanced shelf life.

### This review aims to
1. Analyze the impact of HQCF on the quality and taste of cookies.
2. Discuss factors such as cassava variety, postharvest handling, and processing.
3. Summarize the nutritional value and health benefits of HQCF cookies.

## 2. High-Quality Cassava Flour (HQCF): Definition and Production
High-quality cassava flour (HQCF) is defined as cassava flour produced under controlled conditions to prevent postharvest deterioration. Unlike regular cassava flour, HQCF is processed within 24-48 hours of harvest to minimize cyanogenic glucosides and enzymatic browning. This ensures a flour product with whiter color, fine texture, and improved flavor neutrality (Adebayo *et al*., 2022) [7].

### Steps in HQCF Production
**A. Harvesting and Cleaning:** Fresh cassava roots are harvested and washed to remove soil contaminants. Timely processing (Within 24 hours) prevents postharvest deterioration.
**B. Peeling and Chipping:** The roots are peeled to eliminate toxins in the outer layers, then chipped or grated to reduce their size for faster drying.

**C. Drying:** Drying is a critical step. Options include:
- **Sun Drying:** Common in rural areas, but prone to contamination.
- **Mechanical Drying:** Ensures uniform moisture removal, reducing microbial activity.

**D. Milling and Sieving**: Dried cassava chips are finely milled and sieved to achieve a smooth texture.

The quality of HQCF depends heavily on drying methods and storage conditions. Okpala *et al*. (2020) [6] reported that improper drying can lead to mold growth, reducing flour quality and safety.

## 3. Quality Attributes of HQCF-Based Cookies

### 3.1 Physical and Textural Properties

The physical quality of cookies, including spread ratio, thickness, and hardness, is influenced by the particle size, moisture content, and starch composition of the flour.

- **Spread Ratio:** Cookies made with HQCF generally have a lower spread ratio compared to wheat flour cookies. This is attributed to the smaller particle size and high starch gelatinization in HQCF, which reduces cookie spread during baking (Adeyemi *et al*., 2021) [3].
- **Texture:** HQCF cookies often exhibit a firmer or harder texture due to the lower gluten content, which reduces dough elasticity. Adeola *et al.* (2021) [8] found that blending HQCF with rice flour or legume flours (e.g., soybean flour) can improve textural softness and create a desirable mouthfeel.
- **Color:** HQCF produces cookies with a lighter appearance due to the white color of the flour, which is appealing to consumers seeking clean-label products.

**Improvement Strategies**

Addition of hydrocolloids (e.g., xanthan gum) can enhance the structural integrity of HQCF-based cookies. Fat and sugar adjustments during dough preparation can compensate for the absence of gluten.

### 3.2 Nutritional Value

HQCF cookies are rich in carbohydrates and dietary fiber but are relatively low in protein and fat.

| Nutrient Component | HQCF-Based Cookies | Wheat-Based Cookies |
|---|---|---|
| Carbohydrates (%) | 82.5 | 71.2 |
| Protein (%) | 1.2 | 11.0 |
| Fiber (%) | 3.5 | 2.0 |
| Fat (%) | 0.3 | 2.0 |

To address the low protein content, fortification with soy flour or pea protein is common. Studies by Oladele and Aina (2019) [3] showed that fortification increased protein content by up to 8%, enhancing the nutritional quality and reducing protein-energy malnutrition risks in target populations.

### 3.3 Shelf Life

HQCF-based cookies have an extended shelf life due to their low fat and moisture content, which minimizes rancidity and microbial spoilage. Research by Ogunlade *et al*. (2020) [4] reported that HQCF cookies stored in airtight containers maintained quality for up to 6 months without significant changes in texture or flavor. Proper storage methods, such as vacuum packaging and moisture-proof materials, further enhance shelf stability.

## 4. Sensory Evaluation of HQCF-Based Cookies

### 4.1 Taste and Flavor

HQCF has a neutral taste profile, which complements cookie formulations without overpowering other ingredients. Flavor enhancers such as vanilla, cocoa, or spices (e.g., cinnamon) can mask any subtle bitterness or earthy notes in cassava flour (Adeyemi *et al*., 2021) [3].

**Examples of Sensory Scores**: A study involving 100 participants evaluated cookies made with 100% HQCF:
- **Flavor:** 8.5/10
- **Aroma:** 8.2/10
- **Texture:** 7.5/10
- **Overall Acceptability:** 8.0/10

These findings indicate that HQCF-based cookies are well-accepted, particularly in gluten-free consumer markets.

## 5. Challenges and Future Directions

Despite the growing popularity and benefits of high-quality cassava flour (HQCF) in cookie production, several challenges persist that hinder its widespread adoption. One major challenge lies in the nutrient deficiency of HQCF, particularly its low protein and fat content compared to wheat flour. While HQCF is rich in carbohydrates and dietary fiber, its nutritional limitations restrict its use as a standalone flour in nutritionally balanced products. This necessitates the development of fortification strategies using protein-rich sources such as legumes, soy flour, or dairy powders to improve the protein content and overall nutritional quality of cookies. Another significant challenge is the lack of access to advanced processing infrastructure, particularly in rural cassava-producing regions. The production of high-quality cassava flour requires efficient peeling, drying, and milling systems to maintain its quality and safety. However, many small-scale farmers and processors still rely on traditional, labor-intensive methods that are inefficient and prone to contamination. Investments in affordable and modern cassava processing technologies, such as mechanical dryers and improved milling systems, are crucial for maintaining flour quality, minimizing postharvest losses, and scaling up production. Consumer perception and market awareness also present barriers to the widespread adoption of HQCF-based cookies. While gluten-free products are gaining traction globally, many consumers remain unfamiliar with cassava flour and its benefits as a functional, allergen-free ingredient. Effective marketing strategies, education campaigns, and product diversification are essential to create awareness and boost consumer confidence. Additionally, sensory preferences such as texture and flavor remain critical factors influencing acceptability, and further innovations in baking techniques, ingredient blends, and flavor enhancement can address these concerns. Future research should focus on optimizing HQCF formulations to improve sensory and nutritional attributes of cookies while ensuring cost-effectiveness for producers. Investigating innovative solutions such as the use of hydrocolloids, natural flavor additives, and fat substitutes can significantly enhance the texture, taste, and overall consumer appeal of HQCF-based cookies. Expanding studies on consumer acceptability across diverse

demographics and markets will provide valuable insights to refine product development and positioning. With advancements in cassava processing technologies and greater emphasis on nutritional fortification, HQCF has the potential to play a transformative role in the food industry by addressing gluten-free demands, improving food security, and promoting sustainable agricultural practices globally.

## 6. Conclusion

High-quality cassava flour (HQCF) has proven to be a valuable gluten-free alternative in cookie production, offering acceptable taste, improved shelf life, and sustainable solutions for food industries. While HQCF-based cookies exhibit minor differences in texture compared to wheat-based cookies, advances in flour blending and baking techniques can further improve quality. With continued research and investment, HQCF has the potential to revolutionize gluten-free baking and address nutritional needs worldwide.

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