

Physicochemical and Sensory Characterization of Retted Cassava (*Manihot esculenta* Crantz) Tubers Processing in Congo, Brazzaville

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Article History

Received: 12 August, 2026

Revised: 28 September, 2026

Accepted: 20 October, 2026

Published: 27 October, 2026

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Abstract

This study aimed to characterize the physicochemical properties of fermented *Manihot esculenta* Crantz tubers processed in the Republic of the Congo and to assess their quality using sensory evaluation. In 2025, boiled cassava tubers aged 12, 14, 16, 18, and 20 months were investigated. A total of 15 samples were analyzed in the laboratory for pH, titratable acidity, moisture content, and ash content using the required raw materials, reagents, and laboratory equipment. Sensory evaluation was conducted by a panel of 10 assessors using three samples (A, B, and C), with color and fermented odor as the evaluated attributes. The physicochemical analysis showed pH values ranging from 4.2 to 5.4, while titratable acidity ranged from 1.33 to 2.98 g/L, expressed as H₂SO₄. The ash content varied from 0.74% to 2.73%. For the sensory evaluation, mean color scores ranged from 2.2 to 2.3, whereas mean fermented-odor scores ranged from 3.1 to 3.3 on a five-point scale. The relatively narrow range of odor scores suggests that the samples exhibited similar sensory characteristics with respect to fermented odor. These findings provide preliminary information on the physicochemical and sensory characteristics of fermented cassava tubers processed in the Republic of the Congo.

Keywords: Characterization, Physico-chemical, sensory, *Manihot esculenta* Crantz, roui.

1. Introduction

Retted cassava is a cassava tuber that has undergone traditional fermentation by soaking in water for approximately 3–5 days. This process softens the roots and contributes to the reduction of cyanogenic compounds. In the Republic of the Congo, cassava is considered a staple food and plays an important role in the local food system. Retting is the first stage of many traditional cassava-processing methods and generally takes place shortly after harvesting (Trèche, 1993). This treatment facilitates subsequent processing operations by softening the cassava roots (Trèche, 1995). However, the retting process is difficult to control, which may result in variations in the physicochemical composition and organoleptic properties of the resulting product. Cassava fermentation has been reported to contribute to the removal of more than 70% of cyanogenic glycosides (Louembé, 2003), (Mokemiabeka D. S. C., 2011), (Dhellt J. R., 2016). The rate of soaking is influenced by the conditions of the soaking medium, with fermentation generally proceeding more rapidly in stagnant water. Variations in water temperature during soaking may also contribute to nutrient losses, particularly vitamins and minerals and, to a lesser extent, soluble proteins (Scriban, 1999), (Adrian, 1995). Therefore, determining an appropriate soaking duration is important for minimizing nutritional losses associated with water soaking. Environmental conditions and retting methods can significantly influence the nutritional composition, total acidity, and cyanide content of processed cassava (Trèche, 1991a). Retted cassava is characterized by a high moisture content, approximately 60–65%, and a high carbohydrate content, reported to be approximately 78%. It also contains nutrients and other compounds, including vitamin A, calcium, phosphorus, and volatile compounds sensory (Workshop Proceedings, 2007), (Sylvestre, 1983). Sensory evaluation is an important tool for assessing the quality and acceptability of food products. All food samples presented to sensory panelists must be safe for consumption and appropriate for (Sauvageot, 2001). During sensory evaluation, color variations may influence panelists' perception of other

attributes. Therefore, when evaluating characteristics such as odor, taste, or texture, it may be necessary to control or mask differences in color to minimize their potential influence on the assessment. The objective of this study was to characterize the physicochemical properties of retted *Manihot esculenta* Crantz tubers subjected to processing and to assess their sensory quality using a panel-based evaluation. Particular attention was given to physicochemical parameters and sensory attributes, including color and fermented odor, in order to provide information on the quality characteristics of traditionally processed cassava in the Republic of the Congo.

2. Materials and Methods

2.1. Materials

The biological material used is soaked bitter cassava (fermented tubers of *Manihot esculenta* Crantz) aged 12, 14, and 16 months (planting age) with a soaking time of 3 days, and 18 and 20 months with a soaking time of 4 days. In the laboratory, we used: a pH meter, beakers, Erlenmeyer flasks, and a spatula for pH determination. For titratable acidity, we used flasks, Erlenmeyer flasks, a magnetic stirrer, a wash bottle, a burette, a spatula, beakers, and a magnetic bar; distilled water, solutions, buffer, phenolphthalein, and soda (NaOH) as chemicals. Additionally, we used an incubator, a precision balance, and an electric heating oven, and finally, a scale for the hedonic test.

2.2. Methods

The principle was as follows: in a beaker, we mix 5g of cooked cassava with 20ml of distilled water, then we stir to homogenize; we prepare a buffer solution at pH 4 at a temperature of 25°C with 40 ml of distilled water; we immerse the digital pH meter in the buffer solution (the pH values range from 3.7 to 4); the pH meter is then placed in the filter, and we wait a few seconds to see the number that will appear prominently on the pH meter. We then repeat the same Sodium hydroxide solution contained in the burette is added to the Erlenmeyer flask while stirring, until a purple color appears, and then the volume at the endpoint is read on the burette. Formula: Titrable acidity = Number of moles of sodium hydroxide (NaOH) $\times$ 0.4g. Total acidity is expressed in g/L of H₂SO. The ash content allows you to judge purity and evaluate the mineral content of a product. We weigh 5 g of raw material and put it in an electric oven for 8 hours at a temperature of 550°C, and we get a residue after incineration. This content is determined according to NF.T76.110 standards from September 1981.

Ashes (%) = $(M2 - M0) / (M1 - M0) \times 100$. Where: M0: Mass of the empty crucible M1: Mass of the raw material before drying; M2: Mass of the sample after drying. Sensory Analysis

We put together a group of panelists or tasters able to detect the organoleptic characteristics in roasted cassava (bitter cassava tubers that have been roasted). We conducted a hedonic test using a 5-point category scale with a panel of 10 assessors (undergraduate students). The goal was to measure product appreciation (Robert, 1994). The panelists chose for each sample the category that matched their appreciation after identifying the organoleptic characteristics in the fermented cassava, focusing on color and fermented smell.

2.3. Sensory Analysis

A panel of assessors was selected to evaluate the organoleptic characteristics of retted cassava (retted bitter cassava tubers). A hedonic test was performed using a 5-point category scale with a panel of 10 student assessors (undergraduate level) to measure product acceptability (Robert, 1994). After evaluating the organoleptic attributes of the fermented cassava, specifically color and fermented odor, the panelists selected the category that best corresponded to their appreciation for each sample.

2.4. Data Analysis

Data from the hedonic test were analyzed by converting the sensory categories into numerical scores using a scale ranging from 1 ("dislike extremely") to 5 ("like extremely"). Score distributions for each sample were tabulated. Treatment means were compared using Duncan's multiple range test to determine statistically significant differences in the mean acceptability scores among samples at a significance level of $P \leq 0.05$.

3. Results

The physico-chemical characterization of roasted cassava in terms of pH, titratable acidity, ash content, and sensory properties is shown in the following tables:

Table-1. pH of roasted cassava (fermented tubers of *Manihot esculenta* Crantz)

PH				
Sample	1^{er} Test	2^e Test	3^e Test	Average
Sample ₁	4,2	4,6	4,4	4,4
Sample ₂	4,7	4,1	4,4	4,4
Sample ₃	4,3	4,5	4,1	4,3
Sample ₄	4,4	4,4	4,2	4,3
Sample ₅	4,2	4,2	4,2	4,2
Sample ₆	4,3	4,3	4,3	4,3
Sample ₇	4,2	4,6	4,4	4,4
Sample ₈	4,3	4,4	4,4	4,3
Sample ₉	4,5	4,8	4,2	4,5
Sample ₁₀	4,4	4,2	4,6	4,4
Sample ₁₁	5,2	5,3	5,4	5,3
Sample ₁₂	5,3	5,3	5,3	5,3
Sample ₁₃	4,9	4,9	4,9	5,4
Sample ₁₄	4,9	4,9	4,9	4,9
Sample ₁₅	5,6	5,6	5,2	5,4

The highest average pH of roasted cassava is 5.4, with samples 13 and 15 according to Table 1

Table-2. Titratable acidity and ash content of boiled cassava (fermented *Manihot esculenta* Crantz tubers)

Sample	Settings	Ash content (%)	Titratable acidity (g/L H₂SO₄)
Sample ₁		0,84	1,33
Sample ₂		1,31	1,63
Sample ₃		1,32	1,63
Sample ₄		0,83	1,33
Sample ₅		0,74	1,33
Sample ₆		1,61	1,33
Sample ₇		0,74	1,63
Sample ₈		1,53	1,63
Sample ₉		0,74	2,30
Sample ₁₀		2,73	2,30
Sample ₁₁		2,52	2,90
Sample ₁₂		2,73	2,88
Sample ₁₃		0,84	2,98
Sample ₁₄		1,62	2,90
Sample ₁₅		1,44	2,88

According to Table 2, the highest titratable acidity is 2.98 g/L H₂SO₄, found in sample 13, and the highest ash content was found in samples 10 and 12 with a value of 2.73%.

Table-3. Results by category of the hedonic test (the color)

Tasters	A	B	C	Total tasters	Average of the tasters
1	2	1	4	7	2,33
2	1	1	1	3	1,00
3	2	2	2	6	2,00
4	2	1	1	4	1,33
5	4	2	1	7	2,33
6	1	2	2	5	1,66
7	3	3	2	8	2,66
8	3	3	2	8	2,66
9	3	3	3	9	3,00
10	4	4	3	11	3,66
Total treatment	23	22	22	-	-
Big total	-	-	-	67	-
Average Treatment	2,3	2,2	2,2	-	-

According to Table 4, the highest average fermented smell, 3.3, was found in sample B

4. Discussion

The surveys carried out made it possible to have a sample of 25 chikwangue makers whose ages range from 25 to 60 years. The observation made by the chikwangue makers is that cassava aged 12 months (samples 1, 2, and 3), 14 months (samples 4, 5, and 6), and 16 months (samples 7, 8, and 9) is easy to soak, with 3 days of fermentation during the rainy season because it is very hot and 4 days during the dry season. On the other hand, cassava aged 18 months (samples 10, 11, and 12) and 20 months (samples 13, 14, and 15) takes 4 days to soak during the rainy season and 5 days during the dry season. The latter has fibers that are tougher and harder. They mentioned the point about the water used during soaking, which can also help soften the cassava tubers. Thus, the characteristic smell observed during this fermentation is an indicator of the good softening of the cassava.

The average pH ranges between 4.2 and 5.4 according to Table 1. All samples have a pH below 7; it was slightly acidic. The age of the cassava and the fermentation time did not greatly influence the pH variation. These results are close to those found by (Trèche, 1980); the pH of *Dioscorea dumetorum* tubers is 4.6 and that of *Dioscorea seriflora* cited by (Rakotoarimanana, 2004), is 4.6. The pH of yams mainly varies according to the state of the tuber (fresh, fermented, or processed into starch/flour) and its maturity. For the maturity indicator: the pH changes during underground growth. For some species, reaching a pH of 5.3 or higher is the biochemical signal of optimal tuber maturity for harvest. Regarding the extracted starch: the pH of purified starch strongly depends on the variety. The starch of *Dioscorea dumetorum* shows a very acidic pH of 4.61, while that of *Dioscorea rotundata* (white yam) is almost neutral at 6.49, higher than that of our results. Traditional fermentation to make yam flour or bread generally stabilizes the pH at a value close to neutrality (6.6 to 6.7), although some lactic fermentations can deliberately lower it to improve preservation.

The ash content of fermented cassava is between 0.62 and 2.73%. However, the results found by (were 3.1% for *Dioscorea dumetorum* and 2.3% for *Dioscorea rotundata*, and that of *Dioscorea seriflora* was 0.73% found by (Rakotoarimanana, 2004). According to Table 2, the highest average ash content of the soaked cassava is 2.73%, but according to (Actes Atelier, 2007), the ash content of the peeled root is 4%; so this ash content is higher than that of our results. Ash directly reflects the mineral richness of the tuber.

The titratable acidity ranged between 1.3 and 2.98 g/L (Table 2). (Scriban, 1993) mentioned that fermentation products have an acidity of 0.156%. We note that cassava fermented for 3 to 4 days shows an insignificant difference in titratable acidity. Thanks to its complex carbohydrates, cassava provides lasting energy and prolonged satiety. Cassava contains vitamin C, which is essential for collagen formation, iron binding in the blood and its storage in the liver, tyrosine metabolism, antibody synthesis, combating oxidants, and eliminating free radicals (Luis, 1987). Training of the panelists enabled them to carry out sensory evaluation based on the perception of color and odor or aroma. The color (off-white) and odor (fermented) present in the samples were evaluated on samples A, cassava aged 12 months, and B, cassava aged 14 months (fermentation duration 3 days) and C, 18-month-old cassava (soaking duration 4 days). The perceived color, from dirty white to light white, has an average between 2.2 or 20.20% (samples B and C) and 2.3 or 20.60% (sample A). So, these samples are not significantly different in terms of color according to the panelists' judgment. The average smell or aroma of the products ranges from 3.1, or 60.20% (samples A and C) to 3.3 or 60.60% (sample B) of the fermented smell released by the soaked cassava on a scale from 1 to 5.

Thus, (Magnusson M. K., 2002) highlighted the point about the effect of education level on food product consumption. (Muller, 2003) studied the influence of literacy level when performing descriptive sensory tests. They made the following observation: a high literacy level helps reduce training time. However, this factor does not affect the agreement level among panelists.

The second point to emphasize is training. Indeed, repeatability is better for tastes, aromas, and odors. Training also helps increase the level of repeatability according to (Robert A. K., 1994). However, (Pineau, 2006) pointed out that age, sex, experience level in sensory analysis, and education level are the four variables that characterize a panelist. We observe that almost all the panelists were able to judge on nearly the same wavelength.

5. Conclusion

This study aimed to characterize the physicochemical parameters of retted cassava (*Manihot esculenta* Crantz) during processing and to evaluate product quality through sensory analysis to determine its organoleptic characteristics. The physicochemical and sensory profiles were successfully established. The analytical results demonstrated that processors initiate the transformation of cassava with the tuber fermentation stage, which is crucial for eliminating the cyanogenic compounds naturally present in the crop. Furthermore, the sensory evaluation revealed that the different cassava varieties used did not exhibit significant differences regarding the two sensory attributes assessed by the panelists. These findings highlight the critical importance of implementing the water-retting technique by soaking tubers to ensure product safety and quality.

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