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(Research Article)

Physicochemical and phytochemical parameters and rottenness rate of cassava roots stored in box after blanching

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Abstract

Cassava (*Manihot esculenta* CRANTZ) plays an important role in the human diet. The processing and marketing of this foodstuff are hampered by its high perishability due to enzymatic browning of the roots. The aim of this study is to contribute to the reduction of post-harvest losses of cassava. This study concerned the cassava varieties Bocou 2, Bonoua 2, TMS4(2)1425 and Yacé. This study evaluated the effect of bleaching on the rotting rate and biochemical parameters of cassava roots during storage in box containing moistened sawdust. Analysis of the results showed that blanching (65°C for 30 seconds) cassava roots of the different varieties studied prior to burial in box increased the shelf life of fresh cassava to six (6) weeks and reduced the rot rate to 26.67% and 0%. The L*(white to black) parameter decreased significantly during storage (89.96±0.80 and 86.3±0.91). On the other hand, parameters a* (red to green) and b* (yellow to blue) increased significantly ($p < 0.05$) over the six weeks of storage in crates for the four cassava varieties studied. Variation in L*, a* and b* parameters is most pronounced in unbleached cassava roots exposed to the open air. Dry matter, ash, fiber, fat, reducing sugars, protein and starch content increased significantly with storage time in fresh cassava roots. On the other hand, hydrocyanic acid content fell significantly. The storage of fresh cassava roots in box after blanching extended their shelf life to six (6) weeks and preserved their nutritional characteristics.

Key words: Cassava; Bleaching; Box; Preservation

1. Introduction

Cassava (*Manihot esculenta* CRANTZ) is a perennial shrub belonging to the Euphorbiaceae family and is native to Latin America [1]. In Côte d'Ivoire, this plant was introduced in the 19th century by Akan immigrants (Abouré and Aladjan) from southern Ghana [2]. In sub-Saharan Africa, this inexpensive root is mainly used for human consumption [3]. Today, cassava is one of the most important food crops and one of the main starchy root and tuber crops grown worldwide [4]. It is the second most consumed foodstuff in the west and center of the country [5]. In Côte d'Ivoire, the area under cultivation is 350,000 hectares, with a production of 2,450,000 tons [6]. It is produced throughout the country, mainly in the southern, western, and central regions of Côte d'Ivoire [7]. People have developed a whole range of treatments to stabilize cassava and its derivatives, which are highly perishable commodities [8]. These treatments are mainly aimed at stabilizing the products and reducing or completely eliminating their toxicity. The highly perishable nature and presence of cyanogenic compounds in cassava roots require them to be processed immediately after harvest [9]. Despite all this potential, the processing, marketing, and use of this foodstuff faces a real problem in that its shelf life is only 2 to 3 days after harvest. There are many methods of preserving cassava. Among them, the method of storing cassava roots in crates after blanching allows the shelf life to be extended to six (6) weeks. This preservation method can have

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consequences on the biochemical characteristics of cassava roots. The objective of this study is to contribute to reducing post-harvest losses of cassava by evaluating the impact of the box storage method after blanching on the biochemical characteristics of cassava roots.

2. Materials and methods

The biological material used in this study consisted of cassava roots (*Manihot esculenta* CRANTZ) of the varieties Bocou 2, Bonoua 2, TMS4(2)1425, and Yacé (Photo 1). The cassava roots were harvested at physiological maturity from the Bonoua experimental plot in the locality of Soumalèkro (a village located in the southeast of Côte d'Ivoire, 60 kilometers from the city of Abidjan, latitude North: 05°14'36.0'', longitude west: 03°28'32.9''). They were then transported in coolers to the experimental site for storage tests and then to the laboratory for analysis.

Figure 1 Cassava roots Manihot esculenta CRANTZ; A: Bonoua 2 variety; B: Bocou 2 variety; C: TMS4(2)1425 variety; D: Yacé variety

2.1. Method of storage cassava roots in a fresh state after blanching

The harvested cassava roots (Bocou 2, Bonoua 2, TMS4(2)1425, and Yacé varieties) were sorted, and those that were undamaged were selected and placed in a perforated basket. They were then immersed in hot water at 65°C for 30 seconds (blanching) and left to cool to room temperature (28°C) before being placed in box (20 cassava roots). The roots were covered with wood sawdust moistened to 45%. Samples were taken after 3 days, 2 weeks, 4 weeks, and 6 weeks, and the root rot rate was calculated using the formula shown opposite:

$$Tp = \frac{Nme - Nnb}{Nme} \times 100$$

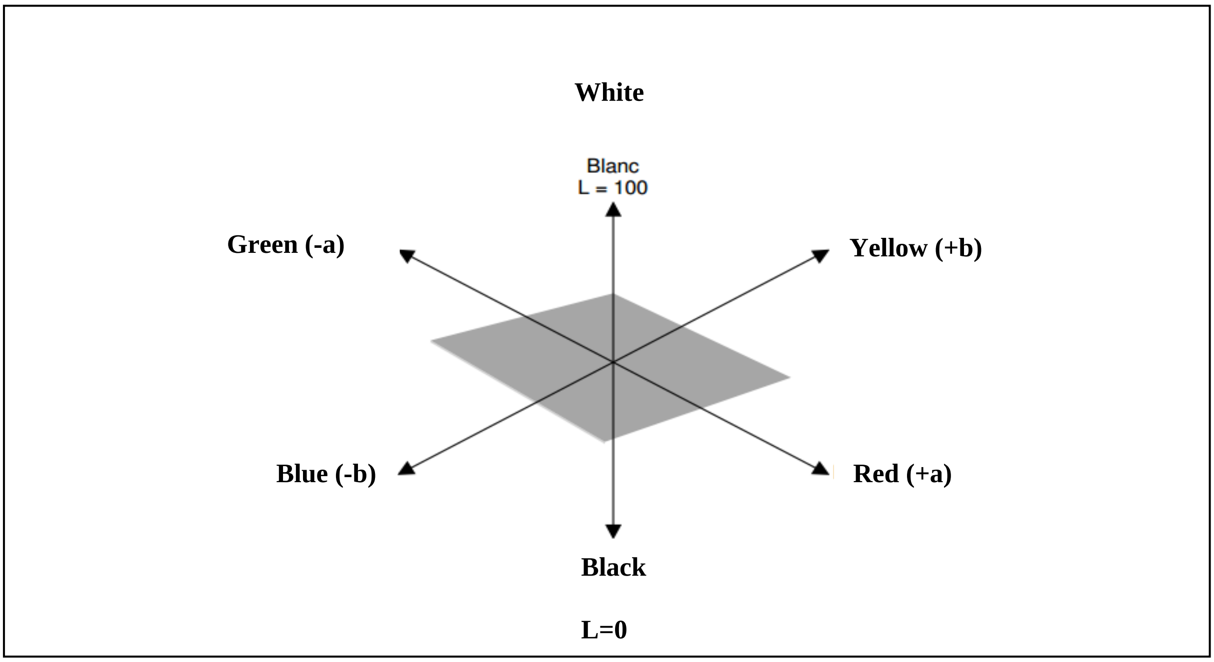
- Tp: Cassava root rot rate (%)
- Nme: Number of cassava roots buried
- Nnb: Number of cassava roots not browned

The samples collected were used for various analyses of color and physicochemical parameters.

2.2. Analysis of color and physicochemical parameters

The luminance (L*), red-green balance (a*) and yellow-blue balance (b*)) of the cassava pulp during storage was measured using a Color Reader CR-10 chromameter [10] (Figure 1).

The fiber, protein, fat, starch, and hydrocyanic acid contents, as well as the dry matter and ash levels, were determined during storage in box after blanching. Using STATISTICA 7.1 and MATLAB R2014a software, comparisons between dependent variables were determined using analysis of variance (ANOVA), Duncan's test, and the Chi-square test to evaluate the rate of cassava root rot during storage.



Source : CIE (1976)

Figure 2 Chromatic space

2.3. Determination of total polyphenols

The total polyphenol content was determined according to the method of [11] using the Folin-Ciocalteu reagent. One (1) g of cassava flour was homogenized in 10 ml of methanol (70%, v/v) by manual stirring for 10 min at room temperature (28°C). One (1) ml of this methanolic extract was placed in a test tube. One (1) ml of Folin-Ciocalteu reagent was added to the contents of the tube. The tube was shaken manually for 2 min at room temperature (28 °C) and left to stand for 3 min, then one (1) ml of sodium carbonate solution (20%, w/v) was added. The contents of the tube were made up to 10 ml with distilled water. The tube was placed in the dark for 30 minutes and the optical density was read at 745 nm against a blank containing no phenolic compounds. A standard curve established from a stock solution of gallic acid (1 mg/mL) under the same conditions as the assay was used to determine the amount of phenols in the sample.

2.4. Determination of fiber content

The fiber content was determined using the [12]. method Two (2) g of flour were placed in a flask to which 50 ml of sulfuric acid (0.25 N) was added. The mixture obtained was homogenized and boiled for 30 min under reflux. After 30 min, fifty (50) ml of soda (0.31 N) were added to the contents and the mixture was boiled again under reflux for 30 min. The extract obtained was filtered through Whatman No. 4 filter paper and the residue was washed three times with hot water until the alkalis were completely removed. The residue was dried in an oven at 105°C for 8 hours. After cooling in a desiccator for 10 minutes, the residue was weighed and then incinerated in a muffle furnace (MEMMERT) at 550°C for 3 hours. After cooling to room temperature (28°C), the ashes obtained were weighed. The crude fiber content was calculated using the following equation:

$$\text{Crude fiber (\%)} = \frac{(m_1 - m_2) \times 100}{m_e}$$

2.5. Determination of starch content

The starch content of the flours was determined using the [13] method with anthrone. Starch extraction was performed by adding 3 ml of perchloric acid (66%, w/v) to 0.2 g of cassava root flour. After homogenization by manual stirring for 2 min at room temperature (28°C), the mixture was left to stand on the bench for 20 min at room temperature (28°C), then diluted in 100 ml of distilled water. Next, two (2) ml of this solution were diluted in 5 ml of anthrone reagent. They were then placed in a boiling water bath for 12 min. These tubes were left at room temperature (28°C) to cool for 10 min. The optical density was read at 630 nm against a starch-free control in a spectrophotometer (MS-V5100 visible spectrophotometer).

2.6. Determination of hydrocyanic acid content

The hydrocyanic acid content was determined using the silver nitrate titration method described by [14] and improved by [15]. Ten (10) g of cassava flour were mixed with 100 ml of distilled water in a flask. The mixture was stirred regularly and left to macerate for 3 hours at room temperature (28°C). The mixture was then distilled under refrigeration. The distillate was collected in a second flask containing 10 ml of soda (0.1 N). When the contents of the second flask reached 50 ml, distillation was stopped and, after cooling to room temperature (28°C) for 5 min, 4 ml of potassium iodide was added to the distillate. A solution of silver nitrate (0.02 N) contained in a burette was added drop by drop to the distillate until an opalescent color (whitish or yellowish cloudiness) appeared due to the formation of silver iodide (AgI). The hydrocyanic acid content was determined using the following mathematical relationship:

$$1 \text{ ml } AgNO_3 \text{ (0,02 N)} \longleftrightarrow 1{,}02 \text{ mg de HCN}$$

3. Results

The rates of cassava root (Bonoua 2, Bocou 2, TMS (2)1425 and Yacé) when fresh and stored in box after blanching indicate that rot rates vary significantly at the 5% threshold during storage in crates of fresh cassava roots after blanching at 65°C for 30 seconds. The rot rates obtained range from 0% to 26.67% for cassava roots that have been blanched and stored in box for 6 weeks. The Bocou 2 and Yacé varieties recorded a rot rate of 0% after 6 weeks of storage in crates following blanching at 65°C.

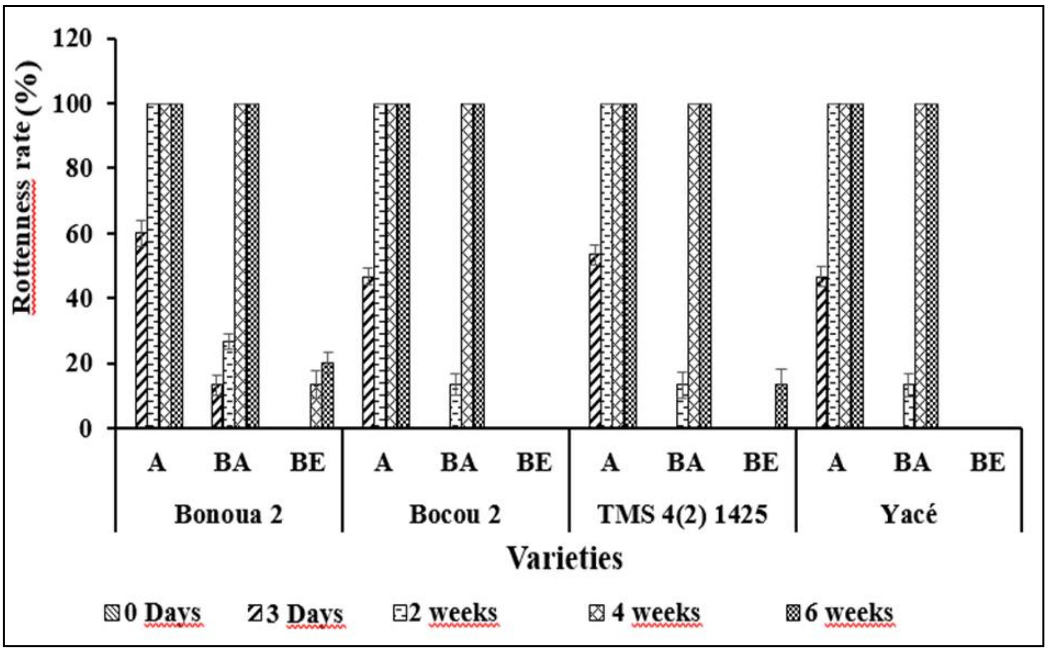


Figure 3 Changes in rot rates during storage in crates after blanching fresh cassava tubers. A: Open air; BA: Blanched and exposed to open air; BB: Blanched and then buried

With regard to color changes, the L* parameter (white to black), which reflects the whiteness of the pulp, generally decreases during storage. The values range from 89.96±0.80 to 86.13±0.15 for storage in crates after blanching at 65°C. The parameters a* (red to green) and b* (yellow to blue) increase sharply during the six weeks of storage in box.

Table 1 Color change in *Manihot esculenta* CRANTZ cassava pulp stored in box in a fresh state after blanching at 65°C

		Lieux et temps de conservation					
variétés de manioc	**Paramètres L*a*b***	**Reference (0 jour)**	**Air libre (3 jours)**	**Blanchie et exposée air libre (2S)**	**Blanchie et enfouie (2S)**	**Blanchie et enfouie (4S)**	**Blanchie et enfouie (6S)**
	L	86,4±0,2^{d}	76,3±1,3^{a}	85,88 ± 1,0^{c}	85,3 ± 1,0^{bc}	84,6 ± 0,45^{b}	84,17 ± 0,5^{b}
Bocou 2	a	4,4±0,2a	6,1± 0,55^{d}	4,85 ± 0,7^{b}	4,66 ± 0,7^{b}	5,11 ± 0,1^{c}	5,2 ± 0,55^{c}
	b	28,6±1,1^{b}	21,0±1,09^{a}	29,07± 0,85^{b}	29,9 ± 1,3^{b}	29,6 ± 1,4^{b}	30,8 ± 1,02^{b}
Bonoua2	L	89,40±0,98^{b}	78,93±0,51^{d}	89,23±0,40^{ab}	89,16±0,58^{ab}	88,04±0,82^{ac}	87,86±0,44^{c}
	a	2,23±0,45^{ab}	4,13±0,47^{c}	2,36±0,15^{a}	2,3±0,40^{ab}	2,73±0,37^{ab}	2,88±0,18^{b}
	b	15,66±1,10^{a}	21,03±0,68^{c}	15,83±0,83^{a}	16,13±0,80^{a}	16,83±0,05^{a}	18,80±0,37^{b}
TMS4 (2)1245	L	89,96±0,80^{d}	74,33±0,83^{c}	87,66±0,70^{b}	87,06±0,11^{ab}	87,03±0,15^{ab}	86,13±0,15^{a}
	a	2,2±0,10^{b}	3,73±0,40^{d}	2,3±0,5^{bc}	2,8±0,17^{a}	3,06±0,15^{a}	3,13±0,25^{a}
	b	18,56±0,80^{a}	22,23±0,95^{c}	18,53±0,55^{a}	19,71±0,30^{ab}	20,83±0,92^{b}	23,13±0,49^{b}
Yacé	L	89,73±0,47^{b}	80,4±0,45^{c}	89,53±0,58^{b}	88,33±0,64^{d}	87,1±0,52^{a}	86,53±0,49^{a}
	a	1,33±0,11^{a}	2,1±0,10^{cd}	1,53±0,15^{ab}	2±0,40^{bc}	2,56±0,32^{de}	2,86±0,41^{e}
	b	16,73±1,53^{a}	21,86±0,90^{d}	17,23±0,40^{ab}	18,6±0,51^{bc}	19,46±0,77^{c}	21,23±0,98^{c}

Mean ± standard deviation; lines with the same letter do not differ significantly from each other (p > 0.05) according to Duncan's test. **2W** : Two weeks, **4W** : Four weeks, **6 W :** Six weeks

Table 2 Changes in the physicochemical and phytochemical characteristics of *Manihot esculenta* CRANTZ cassava roots stored in boxes in a fresh state, blanched at 65 °C

Cassava varieties	Storage time	Physicochemical and phytochemical characteristics								
		Fibers (%)	Proteins (%)	Fat (%)	Red sugars (%)	Ash (%)	DM (%)	Polyphenols Total (mg/100g)	Starch (%)	Hydrocyanic acid (mg/100g)
	0 day	1,39±0,01^{g}	1,76±0,01^{f}	0,72±0,02^{c}	0,38±0,00^{a}	1,27±0,06^{bc}	47,80±0,20^{g}	31,78±0,03^{b}	60,27±0,75^{h}	7,61±0,51^{mn}
	A 3days	1,41±0,09^{h}	1,81±0,02^{g}	0,83±0,00^{e}	0,43±0,01^{b}	1,45±0,01^{de}	47,96±0,59^{gh}	23,45±0,02^{a}	60,61±1,02^{hi}	7,52±0,53^{mn}
Bocou 2	BA 2W	1,58±0,01^{j}	2,55±0,01^{k}	1,02±0,02^{f}	0,69±0,01^{f}	1,63±0,03^{f}	49,53±1,17^{hij}	41,59±0,09^{d}	63,52±0,43^{n}	7,06±0,47^{l}
	BB 2W	1,68±0,01^{l}	2,77±0,02^{m}	0,83±0,01^{e}	0,67±0,01^{e}	1,71±0,01^{g}	48,41±0,08^{h}	56,68±0,13^{g}	62,07±0,68^{jk}	7,17±0,13^{l}
	BB 4W	1,80±0,01^{m}	2,86±0,01^{n}	1,27±0,05^{i}	0,74±0,00^{g}	1,85±0,02^{i}	49,82±0,67^{ij}	59,78±0,33^{i}	66,63±0,48^{m}	6,58±0,68^{hijkl}
	BB 6W	2,19±0,04^{n}	3,09±0,03^{o}	1,40±0,01^{l}	1,16±0,02^{i}	2,31±0,00^{k}	52,17±0,45^{k}	64,91±0,43^{l}	67,51±0,73^{n}	6,27±0.19^{h}
Bonoua2	0 day	0,81±0,02^{a}	1,22±0,01^{a}	0,65±0,02^{b}	0,49±0,04^{d}	1,57±0,10^{e}	36,94± 0,37^{a}	78,22±0,09^{r}	51,88± 0,11^{f}	6,74±0,01^{k}
	A 3days	0,98±0,02^{b}	1,26±0,01^{b}	0,66±0,00^{b}	0,47±0,01^{cd}	1,42±0,11^{cd}	37,75±0,7^{4ab}	66,4± 0,01^{m}	51,97±0,03^{f}	6,54±0,00^{j}
	BA 2W	1,27±0,08^{de}	1,77±0,13^{fg}	1,09±0,05^{g}	0,89±0,04^{h}	1,69±0,21^{efi}	42,06±1,08^{bc}	81,17±0,09^{t}	57,17±0,09^{g}	6,07±0,08^{g}
	BB 2W	1,30±0,02^{e}	2,17±0,00^{i}	0,80±0,02^{e}	0,75±0,01^{g}	1,03±0,01^{a}	39,89±0,53^{b}	80,56±0,02^{s}	60,63±0,35^{h}	6,22±0,10^{h}
	BB 4W	1,69±0,02^{l}	2,15±0,03^{hi}	1,17±0,00^{h}	1,08±0,02^{i}	1,27±0,05^{bc}	43,53±0,09^{c}	83,07±0,01^{u}	62,06±0,05^{j}	6,13±0,02^{g}
	BB 6W	1,82±0,00^{n}	2,38±0,01^{l}	1,12±0,03^{g}	1,10±0,01^{i}	1,33±0,02^{c}	45,07±1,07^{de}	83,03±0,02^{u}	62,75±0,17^{k}	5,78±0,06^{f}
TMS4 (2)1425	0 day	1,30±0,00^{e}	1,36±0,02^{dc}	0,62±0,02^{b}	0,38±0,00^{a}	1,47±0,06^{d}	45,80±0,04^{d}	41,78±0,03^{e}	60,63±0,75^{hi}	5,61±0,51^{efg}
	A 3days	1,33±0,02^{f}	1,39±0,01^{d}	0,73±0,01^{c}	0,44±0,01^{b}	1,65±0,04^{e}	46,57±0,47^{e}	40,27±0,02^{c}	60,86±0,01^{i}	5,24±0,07^{e}
	BA 2W	1,72±0,14^{e}	1,51±0,03^{e}	1,17±0,05^{h}	1,21±0,12^{ijk}	1,68±0,10^{efgh}	47,27±1,08^{defg}	45,25±0,03^{f}	63,55±0,03^{l}	4,34±0,02^{b}
	BB 2W	1,65±0,01^{j}	2,11±0,02^{h}	1,07±0,01^{g}	0,74±0,01^{d}	1,77±0,01^{h}	46,41±0,08^{e}	56,68±0,13^{g}	62,07±0,68^{hi}	4,87±0,03^{d}
	BB 4W	1,78±0,07^{m}	2,23±0,01^{j}	1,31±0,02^{j}	1,27±0,02^{j}	1,89±0,02^{i}	46,87±0,01^{ef}	56,77±0,01^{gh}	62,22±0,02^{hi}	4,53±0,02^{c}
	BB 6W	1,79±0,01^{m}	2,27±0,04^{k}	1,39±0,02^{k}	1,35±0,07^{k}	1,95±0,11^{gh}	48,28±0,11^{h}	61,37±0,02^{k}	62,66±0,02^{i}	4,08±0,07^{a}
	0 day	1,11±0,01^{c}	1,33±0,02^{c}	0,53±0,02^{a}	0,40±0,01^{b}	1,60±0,02^{e}	46,63±0,04^{e}	67,98±0,73^{n}	42,53±1,65^{ab}	8,75±0,05^{o}
	A 3days	1,27±0,08^{de}	1,39±0,02^{d}	0,55±0,05^{a}	0,43±0,01^{b}	1,62±0,02^{e}	46,95±0,02^{f}	60,31±0,02^{j}	42,76±0,09^{b}	8,04±0,02^{n}
Yacé	BA 2W	1,65±0,07^{k}	2,06±0,27^{ghij}	0,79±0,02^{d}	1,15±0,10^{ij}	1,87±0,21^{efgh}	49,52±0,11^{i}	69,08±0,03^{o}	44,52±0,02^{c}	7,67±0,02^{k}

	BB 2W	1,50±0,01^{i}	2,04±0,01^{g}	0,66±0,04^{bc}	0,71±0,02^{fg}	2,07±0,12^{hi}	47,71±0,03^{g}	73,26±0,10^{p}	47,23±1,10^{de}	6,77±0,06^{k}
	BB 4W	1,63±0,01^{j}	2,17±0,02^{i}	1,02±0,15^{fgh}	1,14±0,04^{i}	2,17±0,10^{i}	49,54±0,25^{i}	74,12±0,03^{q}	47,91±0,09^{d}	6,53±0,02^{j}
	BB 6W	1,67±0,01^{k}	2,22±0,01^{j}	1,14±0,05^{h}	1,24±0,03^{j}	2,21±0,09^{i}	49,64±0,02^{i}	74,35±0,02^{q}	48,88±0,11^{e}	6,45±0,03^{i}

Mean ± standard deviation; in the columns, means with the same letter are not significantly different from each other ($p > 0.05$) according to Duncan's test. Open Air (A); Blanched and exposed to open Air (BA), Blanched and buried (BB); Storage time (Storage Time); Fat (Fat); Dry matter (DM); Reducing sugars (Red Sugars); Weeks (W).

Analysis of the physicochemical characteristics of the flours of the four cassava varieties (Bocou 2, Bonoua 2, TMS4(2)1425, and Yacé) stored in box after blanching shows a significant variation at the 5% threshold for the parameters. The levels of fiber, protein, fat, ash, dry matter, total polyphenols, and starch increase significantly during storage in crates of fresh cassava roots after blanching. On the other hand, the hydrocyanic acid content of stored cassava root flour decreased significantly during storage in box, with hydrocyanic acid levels ranging from 7.61±0.51 to 6.33±0.11 mg/100g, from 6.74±0.01 to 5.78±0.06 mg/100g, from 5.61±0.51 to 4.08±0.07 mg/100g, and from 8.75±0.05 to 6.45±0.03 mg/100g, respectively, for the Bocou 2, Bonoua 2, TMS4(2)1425, and Yacé, respectively.

4. Discussion

The rates of cassava root rot were assessed during post-harvest storage after blanching. The results indicate that the rates of rot in roots that were blanched and then stored in box were significantly lower than those in roots that were not blanched and exposed to the open air. The decrease in the rate of decay of fresh cassava roots appears to be the result of heat treatment (blanching) applied to the roots before they are stored in crates. According to [16], blanching cassava roots at 54-56°C for 10-15 minutes reduces post-harvest physiological deterioration (enzymatic browning) by 22% in cassava roots stored at ambient conditions. Similarly, [17] showed that storing blanched cassava roots in a modified atmosphere reduced enzymatic browning by 78 %. Heat treatment at 50°C for 90 seconds reduces enzymatic browning in fresh-cut lettuce and celery [18]. Furthermore, the study of the thermodynamic parameters of polyphenoloxidase and peroxidase activities in the cassava varieties studied showed that the enzymes responsible for these activities are sensitive to increases in ambient temperature [19]. In addition, heat treatment can also reduce respiratory intensity. Respiration is generally stimulated by exposure to temperatures between 35 and 40°C for 1 to 2 days. However, it is reduced following exposure to high temperatures for shorter periods [20]. Color parameters (L*a*b*) vary during the six weeks of storage in crates of cassava roots (Bocou 2, Bonoua 2, TMS4(2)1425, and Yacé) after blanching. The decrease in luminance is thought to be due to the oxidation of phenolic compounds and the auto-oxidation of anthocyanin and β-carotene [21]. The variation in L*a*b* parameters observed during the storage of fresh cassava roots in box is identical to that reported by [22] in their work on the storage of cassava flour.

The fat, fiber, protein, and starch contents increase significantly during storage in box of blanched cassava roots. [23] observed an increase in the fat, fiber, reducing sugar, protein, and starch content of *Dioscorea rotundata and Dioscorea alata* yam tubers during eight (8) weeks of storage. According to these authors, the increase in biochemical parameters during storage is linked to water loss from the roots. Metabolic activities such as transpiration and respiration contribute to reducing the water content in the roots during storage and, as a result, to an increase in biochemical parameters.
However, the hydrocyanic acid content of cassava roots decreases significantly when stored in box after blanching. This decrease in hydrocyanic acid content could be linked to the treatment (blanching) applied to the roots. According to [24], blanching cassava roots for 5 to 10 minutes in boiling water reduces the cyanide content of the roots by 50%.

5. Conclusion

The technique of storing cassava roots in box after blanching has extended the shelf life of cassava roots (varieties Bocou 2, Bonoua 2, TMS4(2)1425, and Yacé) to six (6) weeks. This storage method also resulted in rot rates of between 0% and 26.67%. The study of color parameters (L*a*b*) showed variations over the storage period. The dry matter, ash, fat, fiber, protein, and starch content increased over the six weeks of storage. However, the hydrocyanic acid content of cassava roots decreased during storage. It would be useful to extend this study to other cassava varieties and damaged roots in order to evaluate the performance of the storage method developed.

Compliance with ethical standards

Disclosure of conflict of interest

There are no conflicts of interest to disclose.

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