

Study of Varietal Influence Post Conservation on Biochemical and Sensory Qualities of Attiéké and Boiled Cassava (*Manihot esculenta* Crantz)

Pierre Martial Thierry Akely^{1,2*}, Yves Djina³, Brou Roger Konan¹, Kady Irie¹, Lucien Patrice Kouame³, N'guessan Georges Amani¹

¹Laboratoire de Biochimie Alimentaire Technologie de Produits Tropicaux, UFR STA, UNA, Abidjan, Cote d'Ivoire

²Section Sciences de la vie et de la Terre, Sciences et Technologie, ENS, Abidjan, Cote d'Ivoire

³Laboratoire d'Enzymologie et Catalyse Enzymatique, UFR STA, UNA, Abidjan, Cote d'Ivoire

Email: akely_pierre@yahoo.fr

Received 4 January 2016; accepted 15 March 2016; published 18 March 2016

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Abstract

Cassava root is shortly preserved after harvesting due to its tanning and rapid physiological decomposition. Consequently, the commercial value is reduced and the craving of its finishes products. With an aim of improving physiological quality, post harvest food value “the effects of bleaching and conservation in silo-pits were evaluated. Four (04) varieties of cassava: Bocou1, Bocou2, Bocou3 and Yavo were collected fresh and healthy in 13 months of maturity. They were subjected to a bleaching (65°C /15 - 30 s) followed by a kinetic conservation (7 days of intervals) in silo-pit (1 × 0.6 × 0.5 m). Results show that Bocou2 variety has the high proteins content (2.64% ± 0.01%), followed by hydrocyanic acid (8.21 ± 0.01 mg/100 g) and total carotenoids (26.7 µg/100 g). The conservation influences positively the protein content, reducing sugars content, the dries matter content and the total phenolic compounds for all the varieties excluded Bocou2 variety whose protein content drops. As regard of the fat contents, a weak increase is observed. The sensory analysis reveals that the boiled cassava of the Yavo variety is more appreciated followed by Bocou1 variety. Concerning the Attiéké, Bocou3 variety gives the more appreciated dish followed by the Yavo variety. In conclusion, the silo-pit conservation after bleaching improves the physiological quality of the cassava and the sensory taste even during 14 days. This study has a huge impact of reducing the post harvests losses and increases the commercial value of cassava in the world.

*Corresponding author.

Keywords

Cassava, Attiéké, Boiled, Post Conservation, Silo-Pit, Case, Sensory Quality

1. Introduction

Tuberous roots of cassava as well as yam tubers, taro, sweet potato and plantain found in tropical and subtropical areas are food substances used in natives populations food [1]-[3] and animal feed. Among the food substances, cassava root (*Manihot esculenta* Crantz) is one of the most important food products by the volume of its production and its consumption [4] in Africa, Europe and Asia. Originating from South America, cassava is a woody long-lived shrub, pertaining to the family of Euphorbiaceae [5]. It belongs to the principal plants with starch-based roots cultivated in the world [6]. And it is well consumed by more than 750 million people [7]. According to [8], approximately 215 million tons of cassava is cultivated in the world. And the contribution of Africa is estimated at 52.88% of the worldwide production. In Cote d'Ivoire, the annual production of cassava is estimated at 2.50 million tons [9]. Tuberous root of cassava is recognized as an important food stock [10] and a source of calories in the human diet in tropical areas [11]. Thus, it is mainly transformed in the human consumption in various artisanal and industrial forms. It is also employed for animal feed. Several derived products of cassava are marketed, of which the most known are: "gari", "Attiéké", "cossette", starch, "tapioca", "fufu", rough flour, cassava pulp [12]. In spite of its importance in the food (human and animal), the tuberous root of cassava is preserved with difficulty after the post harvest collects.

Indeed, one of the major constraints known in the harvest of cassava root in the developing countries remains its short life conservation post-harvest because of its rapid physiological decomposition ranging between 24 and 48 hours at room temperature (25°C - 35°C). This phenomenon has as a major drawback to reduce the craving, the commercial value of the cassava root [13]. The post-harvest losses of cassava are estimated at more than 30% for the periods of great production [14]. To minimize the post-harvest losses, several traditional techniques of conservation are used so as: conservation in hillock, by steeping in water, coating using mud, out of paraffin, silo-pits. Little spread these techniques extend the shelf life of cassava roots only of a few days [15]. Consequently, the use of the above-mentioned techniques on the ground is resulting most often not very satisfactory, except for storage in silo-pits. In this investigation, the conservation in silo-pit combined with bleaching is planned in order to reduce the post-harvest losses. Indeed, bleaching has the advantage of cleansing food of the residual micro-organisms and also of inactivating the enzymes in charge of the tanning or the deterioration of vitamins, of sensory quality as well as an oxidation limitation [16]. The overall study is finding a conservation method of the fresh roots of cassava to extend the roots shelf life. Specifically, the varietal influence post conservation on biochemical and sensory qualities of Attiéké and boiled cassava is carried out to determine the organoleptic characteristics of Attiéké and the boiled cassava.

2. Materials and Methods[#]

2.1. Cassava Root ("*Manihot esculenta* Crantz")

Mature (13 month of age) and fresh cassava roots of 04 varieties (Bocou1, Bocou2, Bocou3 and Yavo) were used in these experiments. The cassava roots weighed between 100 and 500 g. These tuberous roots of cassava were collected from an experimental field of Abengourou, (Cote d'Ivoire).

2.2. Procedure for Conservation and Post Harvest Bleaching

Unwound cassava root were freshly collected with equal dimensions and bleached (65°C/15 - 30 s). The cassava root were left to cool down at ambient temperature (25°C - 35°C) then buried in silo-pits (50 cm l × 50 cm L), lid with sand. Thus the cassava roots were preserved for 14 days. While conservation the physicochemical parameters were followed. Sample of 10 g were taken for analyses. The results are the mean value of 3 repetitions.

2.3. Biochemical and Physicochemical Characterization of Roots

The dry matter content was determined by the [17] method. The amount of ash was obtained after total incineration. [#]Bleaching after silo-pit conservation of 4 cassava varieties (Bocou1, Bocou2, Bocou3 and Yavo) for boiled cassava and Attiéké cooking.

tion in a furnace muffle at 550°C [18]. The lipid content was determined according to [19] method. The hydrocyanic acid content was determined by the titration method with silver nitrate content improved by [20]. The total proteins are determined by Kjeldhal [18] method. The fibres content were carried out according to [21] method. The total polyphenols content were determined by the method of [22]. The carotenoids were determined according to the method described by [23]. The reducing sugars are carried out according to the [24] method. The total starch content was determined according to [25] method.

2.4. Preparation of the Boiled Cassava and the Attiéké after Conservation

The preserved fresh roots were used for boiled cassava and the Attiéké preparation: The boiled cassava was prepared according to the method described by [26]. Hundred (1000) grams of Tuberoses roots of cassava were peeled, cut into pieces of 100 - 150 grams then washed with the tap water. The pieces were cooked during 20 minutes with boiling water (1 L at 100°C). The *Attiéké* was prepared according to the method described by [27]. Five (5) kg of cassava roots were peeled, cut into cossette and washed. The cossettes obtained were crushed after addition of 10% palm oil. The cassava dough obtained was fermented followed by a dewatering. Thus the mush cake obtained is crumbled, sieved and mechanically semolined. Afterward product was partially dried out and vapor cooked at 100°C resulting in Attiéké. The Attiéké and the boiled cassava obtained were subjected of sensory analysis.

2.5. Processing for Sensory Analyses

The sensory analyses were described by the [28]. Principle was based on a panel of 12 people (comprising of 6 girls and 6 boys) trained and selected in order to evaluate the sensory quality of the food. Regarding the boiled cassava, the sensory attributes considered were as follow: aspect (farinaceous or translucent), color (white or yellow), and texture (crumbly or hardness) taste (bitter or sweet), masticability (easy or difficult) and presence of fibers (little or much). These criteria are evaluated on a linear scale of interval ranging between lowest and high intensities (0 - 10). As for Attiéké, a hedonic test followed by a descriptive test tests were carried out. Sixty 60 candidates tested and classified the 4 types of obtained Attiéké according to the attribute preference [29]. For the descriptive test a panel of 12 people trained and selected to evaluate the sensory the sensory attribute of attieke. The sensory attributes such as color, presence of fibers, texture (adhesiveness) and flavour were evaluated using a nominal scale 1 to 5 according to the intensity and the nature of the descriptor. The general appreciation (little or much) as well as re-taste desire (slightly or much) for each sample was determined.

2.6. Statistical Analyses

The data were subject to analysis of variance (ANOVA) using SPSS software 16.0 for windows. Mean and standard were calculated and, when F values were significant at the $p < 0.05$ level, the mean difference was separated using the Turkey test.

3. Results

3.1. Physicochemical and Biochemical Characteristics of Four Varieties of Cassava Roots before Conservation

Figure 1 shows the aspect of sliced roots (standard and tests one) of the variety of Bocou2 taken as example at the end of 14 days conservation. In general, the bleached roots of the Bocou2 and Bocou1 varieties do not display any visible physiological decomposition. But some rotted roots were identified concerning the Bocou3 variety while tested. As for the Yavo variety, it is observed an appearance of brown spots and rots. However, all the standard roots (none bleached and bury) present an advanced stage of physiological decomposition. The physicochemical and biochemical characteristics of the different varieties (04) harvested before conservation are shown in **Table 1**. The results indicate that amongst the varieties, the Yavo is that which has the highest fibres content ($4.53\% \pm 0.03\%$) while the variety Bocou1 has the lowest content ($0.36\% \pm 0.06\%$). The Bocou2 contains the highest protein content ($2.64\% \pm 0.01\%$). As for the Bocou3 and Yavo varieties, they have the lowest proteins contents $0.84\% \pm 0.01\%$ and $0.88\% \pm 0.01\%$ respectively.

For the fat content, all the varieties have roughly the same contents. However, the Bocou1 has the highest

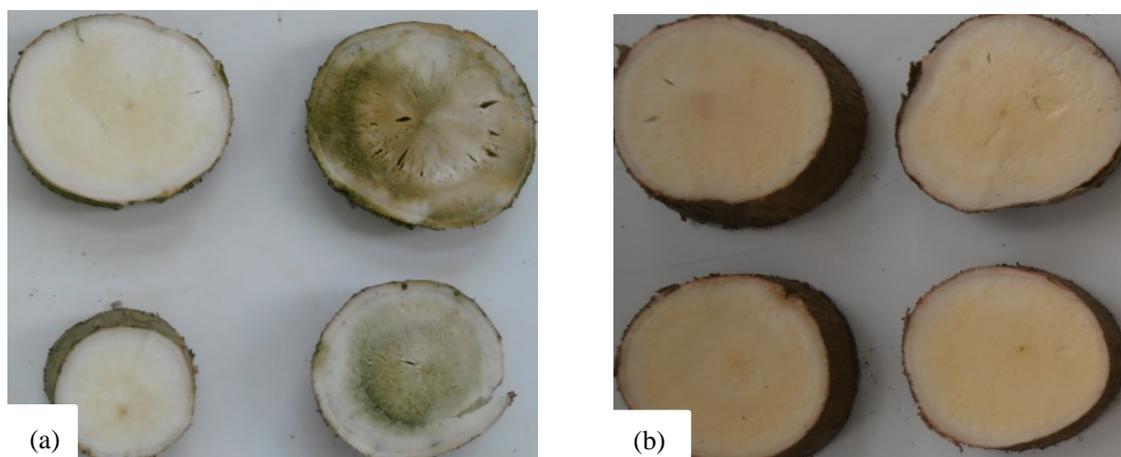


Figure 1. It shows the roots aspect of the Bocou2 variety after of 14 days of conservation. (a) Standard root before treatment; (b) Bury bleached roots).

Table 1. The physicochemical and biochemical characteristics of 04 varieties harvested before conservation.

	Bocou1	Bocou2	Bocou3	Yavo
Fibre*	0.36 ± 0.06 a	2.38 ± 0.02 c	1.41 ± 0.01 b	4.53 ± 0.03 d
Protein*	2.19 ± 0.01 b	2.64 ± 0.01 c	0.84 ± 0.03 a	0.88 ± 0.01 a
Fat*	0.91 ± 0.02 b	0.83 ± 0.01 ab	0.58 ± 0.04 a	0.49 ± 0.01 a
Reducing sugar*	0.18 ± 0.00 a	0.24 ± 0.00 b	0.19 ± 0.00 a	0.15 ± 0.00 a
Ash*	1.23 ± 0.12 b	1.00 ± 0.00 a	1.53 ± 0.12 c	1.63 ± 0.15 c
Dry matter*	88.46 ± 0.13 b	88.65 ± 0.26 b	94.82 ± 0.06 c	85.71 ± 0.02 a
Total phenolic (mg/100 g)	22.89 ± 0.23 a	32.78 ± 0.06 c	49.68 ± 0.07 d	25.43 ± 0.67 b
Starch*	62.27 ± 1.26 b	61.70 ± 0.4 b	64.40 ± 0.17 c	42.10 ± 0.26 a
Hydrocyanic*	6.12 ± 1.26 c	8.21 ± 0.01 d	5.12 ± 0.02 b	4.20 ± 0.15 a
Total carotenoid (ug/100 g)	1.00 ± 0.00	26.7 ± 0.00 c	2.00 ± 0.00 b	0.00 ± 0.00 a

Mean values ± standard deviation, n = 3. Value in column following by letters (a, b, c, or d) is significantly different at 5% according to SNK test (*% MS).

content (0.91% ± 0.02%). With regard to the reducing sugar contents, the Bocou2 with a content of 0.24% ± 0.00% has the highest content followed by the Bocou3 with 0.19% ± 0.00%. The ash content is ranging between 1.00% ± 0.00% and 1.63% ± 0.15%. But, the Bocou3 and Yavo varieties show the highest content which are of 1.63% ± 0.15% and 1.53% ± 0.12% respectively. The Bocou2 variety has the lowest ash content (1.00% ± 0.00%). As a whole, all the varieties contain high dry matters content. The Bocou3 shows high content (94.82 ± 0.06) and the Yavo variety, the low value (85.71% ± 0.02%). The contents of phenolic compounds are variable. Thus, the Bocou1 has the low total polyphenol content (22.89 ± 0.23 mg/100 g) whereas the Bocou3 contains the highest content (49.68 ± 0.07 mg/100 g). The contents in starch varieties are looked fairly weak. Indeed, they vary between 42.10% ± 0.26% (Yavo variety) and 64.40% ± 0.17% (Bocou3 Variety). The highest carotenoids content is obtained by the Bocou2 variety (26.7 µg/100 g) and the lowest value by the Bocou3 (2.00 ± 0.00 µg/100 g). As for the Yavo variety, it does not contain any carotenoid trace.

3.2. Physicochemical and Biochemical Characteristics of Four Varieties of Cassava Roots after Conservation

The physicochemical characteristics of the variety of cassava roots tested after 14 days of conservation in silo-pits after bleaching are determined (Table 2). After 14 days of conservation, it is noted an increase in the

Table 2. The physicochemical and biochemical characteristics of 04 varieties harvested after 14 days silo-pit conservation.

	Bocou1	Bocou2	Bocou3	Yavo
Fibre*	0.32 ± 0.02 a	1.68 ± 0.01 c	0.34 ± 0.00 a	1.36 ± 0.06 b
Protein*	2.61 ± 0.02 c	0.43 ± 0.02 a	1.32 ± 0.02 b	1.40 ± 0.04 b
Fat*	0.88 ± 0.01 b	0.90 ± 0.06 b	0.57 ± 0.02 a	0.58 ± 0.03 a
Reducing sugar*	0.54 ± 0.00 b	0.38 ± 0.00 a	0.35 ± 0.00 a	0.37 ± 0.00 a
Ash*	1.20 ± 0.00 b	0.80 ± 0.00 a	2.03 ± 0.01 c	2.23 ± 0.06 d
Dry matter*	89.66 ± 0.06 b	93.98 ± 0.06 c	85.32 ± 0.03 a	94.70 ± 0.03 d
Total phenolic (mg/100 g)	90.62 ± 0.57 c	41.68 ± 1.11 a	41.72 ± 0.07 a	50.36 ± 0.03 b
Starch*	52.87 ± 3.02 b	38.47 ± 0.95 a	57.20 ± 1.01 bc	58.10 ± 0.66 c
Hydrocyanic*	9.21 ± 0.08 d	8.87 ± 0.49 c	6.16 ± 0.06 b	5.11 ± 0.02 a
Total carotenoid (ug/100 g)	0.00 ± 0.00 a	10.6 ± 0.00 b	0.00 ± 0.00 a	0.00 ± 0.00 a

Mean values ± standard deviation, n = 3. Value in column following by letters (a, b, c, or d) is significantly different at 5% according to SNK test (* % MS).

fiber contents for the Bocou2, Bocou3 and Yavo varieties while there remains constant for the Bocou1 variety. The proteins contents increase for all the varieties except the Bocou2 variety of which the protein content drops significantly. Concerning the fat contents a weak increase is observed in Bocou2 and Yavo. However, the Bocou1 variety presents a low fat content ($0.91\% \pm 0.02\%$ to $0.88\% \pm 0.01\%$). For the percentage of reducing sugars, an increase is observed at all the varieties. As for the ash contents, they decrease for the Bocou2 variety. They remain constant for the Bocou1 variety while they increase for Bocou3 and Yavo. At the dry matter composition level, all the varieties present an increase except the Bocou3 variety whose content drops significantly ($94.82\% \pm 0.06\%$ to $85.32\% \pm 0.03\%$). After conservation, the total polyphenols contents increase for the varieties of Bocou 1, Bocou2 and Yavo. However, for the Bocou3 variety a significant decrease is observed. Thus, this content varies from 49.68 ± 0.07 to 41.72 ± 0.07 (mg/100 g). A decrease in starch content of the varieties Bocou1, Bocou2 and Bocou3 was noted. As for the Yavo variety, it presents an increase of 16%. The hydrocyanic acid contents remain constant for the Bocou2 variety and increase for the Bocou1, Bocou3 and Yavo varieties. The carotenoids contents drop for the Bocou2 variety while no carotenoid trace is observed after conservation in the other varieties.

3.3. Influence of the Conservation on Organoleptic Characteristics of Attiéké and Boiled Cassava of Four Varieties

For the sensory analyses, on the one hand, the descriptive test carried out after conservation shows that the Bocou2 variety obtains constantly the highest note for the color attribute (4.00 ± 0.00) corresponding to Yellow color comparatively to the other varieties which give beige Attiéké. Thus, at fibers attribute presence level, the Yavo variety obtains the strongest note (3.50 ± 0.67) and presents one Attiéké with few fibers while the Bocou2 variety has the weakest note (2.67 ± 0.65) with Attiéké having the most fibers. Concerning the descriptor odor, no significant difference is observed. All the varieties give one Attiéké having an acidulous odor. Thus after conservation for texture (adhesivity), the Bocou2 variety gives one Attiéké slight sticking with a weak note (2.42 ± 0.00). But the Yavo variety has the strongest note (3.00 ± 0.87) with one Attiéké fairly sticking. As for the taste of Attiéké, no significant difference was observed. Indeed, the Attiéqués obtained have all a little sweetened taste before and after conservation (Figure 2).

As regards the general appreciation, Bocou3 variety is that which gives more appreciated Attiéké after conservation followed by the Yavo variety. The Bocou1 variety is classified as first followed by Yavo variety as second according to the hedonic test (Figure 3). However, the Bocou3 and Bocou2 varieties were not well appreciated by the tasters and were classified respectively in third and fourth positions.

3.4. Boiled Cassava

The organoleptic characteristics of the different varieties studied after 14 days of conservation are stated in Table 3. After 14 days of conservation, the Yavo and Bocou3 varieties obtain smallest values due to their floury

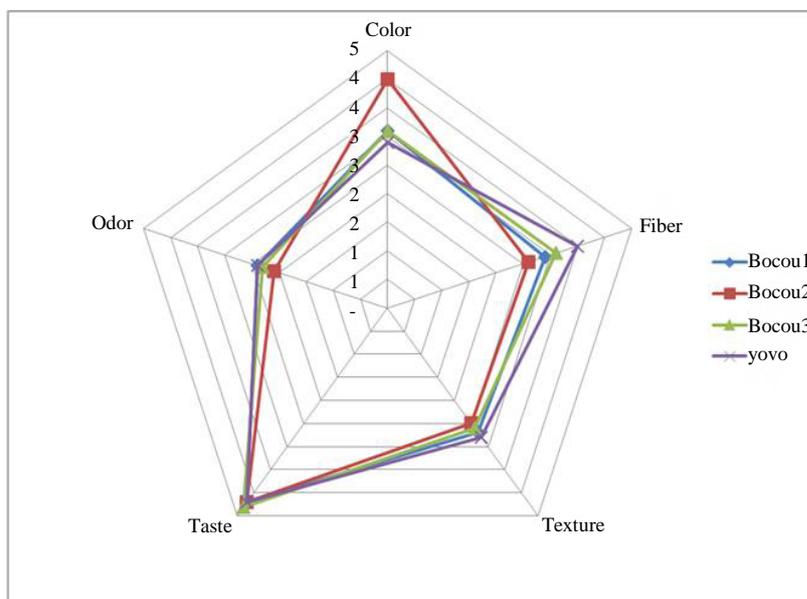


Figure 2. Sensory profile of different types of Attiéké after conservation.

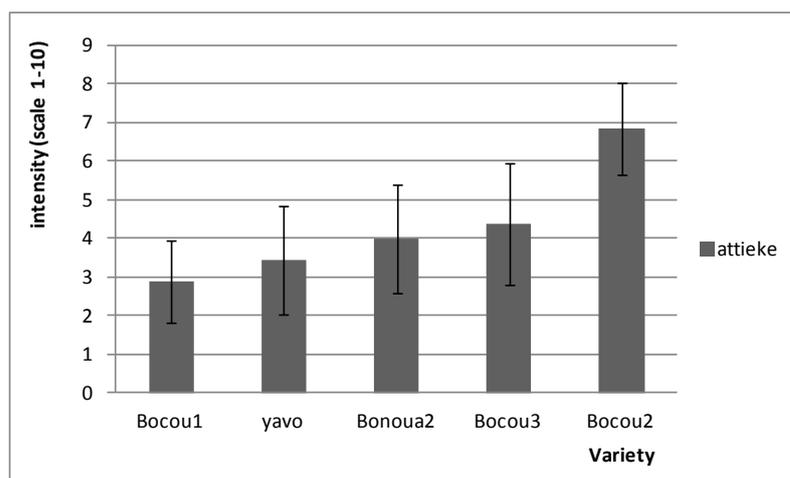


Figure 3. Classification of different types of Attiéké according to the general appreciation.

aspect. The Bocou2 variety has boiled cassava the most translucent. For the color criteria, the Bocou2 variety gives always a boiled cassava of yellow color. The boiled cassava of the Bocou1 variety has the whitest color. It is observed a drop of fibers in Bocou3 and Yavo varieties after 14 days of conservation. As for the Bocou1 and Bocou2 varieties, it is noted a weak increase in fibers content. As a whole, all the varieties have a friable texture (easy to crumble between fingers) after conservation except the Bocou2 variety which gives the hardest boiled cassava. The boiled cassava of the Bocou1 variety has the sweetest taste with the value of 7.03 ± 1.38 . The Bocou3 variety is gives the bitterest boiled cassava with a value of 3.68 ± 0.53 . Concerning the masticability, the Bocou3 and Yavo varieties have obtained the smallest notes which are 2.53 ± 0.03 and 3.12 ± 0.41 respectively. Regarding the general appreciation, the Yavo variety gives the more appreciated boiled cassava after conservation followed by the Bocou1 variety.

4. General Discussion

After 14 days of conservation, the bleached roots of the Bocou2 and Bocou1 varieties do not have any physio

Table 3. Organoleptic characteristics of 04 varieties of cassava roots harvested after 14 days silo-pit conservation.

	Bocou1	Bocou2	Bocou3	Yavo
Time of conservation	T 0	T 0	T 0	T 0
	T14	T14	T14	T14
Aspect	2.87 ± 2.62 abcdef	5.73 ± 2.22 abcdef	3.02 ± 1.64 ab	4.24 ± 3.14 abcd
	4.53 ± 2.84 abcde	7.34 ± 2.34 def	3.36 ± 2.33 abc	3.38 ± 2.07 abc
Color	2.52 ± 1.87 a	9.22 ± 1.20 e	2.97 ± 1.6 ab	2.69 ± 1.74 ab
	3.13 ± 1.53 ab	8.89 ± 1.28 e	5.67 ± 1.64 cd	3.80 ± 2.27 ab
Fiber	1.28 ± 1.04 a	2.32 ± 1.42 abc	2.68 ± 2.64 abc	3.74 ± 2.57 abc
	1.97 ± 1.63 abc	2.93 ± 2.94 abc	2.53 ± 1.64 abc	1.62 ± 1.32 abc
Texture	1.92 ± 1.20 a	5.16 ± 2.88 bcd	3.07 ± 2.13 ab	1.86 ± 1.45 a
	4.73 ± 3.19 bc	7.91 ± 2.46 d	2.63 ± 2.28 ab	4.42 ± 2.75 abc
Taste	6.05 ± 2.05 bcd	3.53 ± 2.34 ab	5.71 ± 2.29 abcd	6.14 ± 2.54 bcd
	7.03 ± 1.38 d	6.16 ± 2.34 bcd	3.68 ± 2.53 abc	6.58 ± 1.66 cd
Masticability	1.70 ± 1.22 a	4.46 ± 2.51 abcd	2.88 ± 1.79 ab	1.83 ± 1.52 a
	4.07 ± 2.05 abcd	6.42 ± 2.09 cd	2.54 ± 2.03 ab	3.12 ± 2.41 abc

Mean values ± standard deviation, n = 3. Value in column following by letters (a, b, c, or d) is significantly different at 5% according to SNK test.

logical decomposition. These results are in accordance with [30] which also observed any physiological decomposition after 14 days conservation of two varieties of tuberoses cassava roots (HMC-1 and MPER 183). That could be due to the high contents in dry matters of these varieties which would influence their shelf lives and would confer their good aptitudes for a long storage [31]. Thus, after conservation, an increase in protein, reducing sugars, dry matter contents and total phenolic compounds were observed. According to [32], the increase in the dry matter would be due to the progressive reduction of water content of the tubers during storage. Moreover, the increase in the total polyphenols content would be due to the degradation of coloured complexes like proanthocyanidic [33]. With regard to proteins, there would be accumulation of those during the conservation [13]. They would be enzymes mostly implied in the detoxification of the reactive oxygen species, in the metabolism of the wall, the lesions and the stress response, as well as the biosynthesis of the secondary metabolites [13]. The reduction in the reducing sugar contents as well as ashes contents could be attributed to their loss in the soaking water [34]. Thus, the increase in hardness of the Bocou2 variety during conservation could be due to a lignification of cassava roots during the growing. Indeed, cassava roots become more fibrous and more lignified when their age increases. This lignification is due to the increase in the polysaccharides content of the cellular walls which involve the increase in the firmness of the cassava tubers after harvesting [35]. Also the observed hardness after conservation would be due to bleaching with the warm water which gelatinizes the starch or the partial hydrolysis. This hydrolysis of the starch permeabilizes the cellular membrane facilitating the water exit of the cell [16]. The high content in reducing sugars of the Yavo variety after conservation would tend to make it much more perishable than the other varieties [36]. The pronounced yellow colouring observed onto the Bocou2 variety would be justified by its high content of carotenoids in particular by beta-carotene. However, the contents in carotenoids show that whatever the variety, there are slightly important losses. This could be explained by the heat transfer, very important during bleaching which resulting in progressive beta-carotene degradation in time [16]. These results are in accordance with those obtained by [37] which showed that the molecules of beta-carotene are liposoluble and heat sensitive. Thus they are mainly destroyed by heat under the bleaching conditions. During bleaching, the inner temperature of the product tends very quickly towards that of the medium heating. That could explain the extent of the losses [16]. The boiled cassavas of the Yavo and Bocou1 varieties are more appreciated probably because of their color, texture and flavour [38]. Thus, the sensory criteria which influenced the acceptability of the boiled cassavas of the Yavo and Bocou1 varieties are the taste, the flavour and the color [34]. The sensory descriptors which make it possible to distinguish these two varieties would be the crumble component of the texture and the easy masticability of the boiled cassava [34]. According to [35], the crumbly is positively linked with the fibers content of the cassava roots. Thus, more the variety is rich in fibers, more it is hard and less crumble [35]. The appreciation of Attiéké obtained with the Bocou1 va-

riety by panelists but not by the consuming waver could be due to its taste, odor as well as its color that seem principal features characteristic of Attiéké according to [39]. Anyway the bitterness noted at the Bocou2 variety would not be only related to the presence of cyanogenetic compounds. According to [40], there exist several compounds of which the IAG (Isopropyl- β -D-Apiofuranosyl-(1 - 6)- β -D-Glucopyranoside) which would contribute more to the bitterness of the cassava, contrary with the linamarine.

5. Conclusion

The conservation method of the fresh roots of cassava in silo-pits after bleaching is contributed to extend the roots shelf life up to 14 days. Consequently, an increase in proteins, reducing sugars, dry matter contents and total phenolic compounds is noticed after conservation. The Bocou2 variety is most well preserved followed by the Bocou1 variety contrary to the Yavo and Bocou3 varieties which are fairly well preserved. However, after conservation, all the varieties have a crumbly texture except the Bocou2 variety which provides the hardest boiled cassava. As regards Attiéké, the Bocou3 variety is the one that provides after conservation the more appreciated food followed by the Yavo variety. For the next, it is planned to study the shelf life in order to determine the maximum storage limit and preserving of the physicochemical and organoleptic characteristics as well as the best fields of application of these varieties.

Acknowledgements

We wish to acknowledge the technical and financial support of PAES-UEMOA and Agricultural Programme of Productivity in West Africa (PPAAO/WAAPP).

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