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PHYSICO-CHEMICAL PARAMETERS OF EGGPLANTS (*SOLANUM AETHIOPICUM L.*) ACCORDING TO CONSERVATION TECHNIQUES

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Abstract: *In Côte d'Ivoire it is difficult to keep vegetables and fruits, especially eggplant, and this is due to a lack of proper storage techniques. The few processes used are expensive and inaccessible to most of the population. The purpose of this study is to determine appropriate eggplant conservation techniques. The aim is to determine some of the physico-chemical parameters including dry matter, oil content, protein and sugar content at different types of conservation (respective immersion in vinegar, kitchen salt and wood ash). Open air storage was used as a control. Analyzes were performed weekly during ten (10) weeks of storage. The results showed that the dry matter content reached the maximum values of 8.45% to 17.43% in saline preservation and 8.45% to 16.56% in ambient, the highest sugar content was observed in vinegar-based preservatives, 4.16, 4.33 and 4.66% in sugars total, and at the level of reducing sugars the highest levels are observed at the level of conservation with ash for a value of 3,90%. The highest protein concentrations were observed in vinegar 2.33% and ash 2.55%. However, the highest level of oil is observed in ash conservation 0.61% to twenty-four (24) days of preservation, the ash method also reveals the highest levels of minerals throughout conservation. The results therefore indicate that vinegar and ash conservation at the method level is positively different from that of the ambient environment and salt.*

Keywords: *preservation, methods, ash, vinegar, salt*

1. Introduction

Grown for its fruit and consumed as a fruit vegetable, eggplant is produced throughout the tropical regions of Africa, Latin America and Asia for the exploitation of its edible fruits [1]. These are ellipsoidal, ovoid or fusiform globose berries, which also have therapeutic virtues : sedative, carminative, anti-colic, antibacterial, anti-hypertensive, anti-tetanic [2]. Eggplant is consumed even less in Northern Europe and North America. It remains an Asian vegetable with a production of 93% of the world and marginally Mediterranean [1]. In Côte d'Ivoire, its cultivation is carried out throughout the territory, using generally traditional techniques. Despite the economic and food potential of African eggplant, little work has been done to improve the production techniques of this crop in Côte d'Ivoire. If all peri-urban and rural production in the country is able to fully satisfy local demand, the surplus crop is often wasted by lack of knowledge of good processing, conservation and storage

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techniques. Several research studies have been carried out on the conservation of our food. However, apart from the studies carried on the appearance of the fruit during its preservation [3], no less expensive preservation process has been put in place which could guarantee the availability and the physico-chemical quality of eggplants during the off-season or throughout the year. The rare conservation techniques encountered are mostly artisanal and based on dehydration of vegetable However, these methods not only cause the loss of many volatile or thermosensitive compounds, but also affect the organoleptic quality of fruit; this drastically lowers their market value. Conventional methods in vogue (controlled atmosphere, use of additives cold conditioning, etc.) remain quite expensive and inaccessible to the majority of Ivorian consumers and producers. This study was proposed with a view to finding solutions to this problem. This will identify conservation processes that will allow the physicochemical properties of eggplants to be maintained at lower costs.

2. Materials and methods

Materials

The plant material concerned the eggplant (*solanum aethiopicum* L.), cultivated on an experimental plot, carried out at the Jean Lorougnon Guédé University in Daloa, Côte d'Ivoire.

Method

Sampling

Healthy plants with no history of disease were selected and the species of eggplant used in this study was carefully harvested. Carefully transported to the laboratory, the selected fruits are stored in vinegar, kitchen salt, and wood ash. Open air storage will be used as a control treatment. For each treatment, four (04) batches of 500 grams of eggplants (including one batch per preservation technique) were treated. Also per batch, three (3) samples were formed thus giving twelve (12) samples per treatment. Analyzes (treatments) were carried out every three (3) days during one (1) month of storage. The treatments will be named T0, T1, T2, T4, T5, T6, T7, T8, T9 and T10 for the thirty (30) days of conservation. A total of one hundred and twenty (120) samples will be analyzed during this study.

Physico-chemical analysis

Dry matter and ash levels were determined using BIPEA methods [4]; the protein content was determined using the AOAC method [5] using Kjedhal; fat content according to BIPEA [4] using SOXHLET; the total sugar content according to Dubois and collaborators [6] using phenol and reducing sugar levels according to Benfeld [7] using 3,5-dinitro salicylic acid (DNS).

Statistical Analyses

The data analysis was carried out using Microsoft Office Excel 2007 and STATISTICA 7 software, to determine the standard averages and deviations. One-factor variance analysis (ANOVA) was performed on the data to determine significant differences between averages during conservation. Then, the statistical differences were highlighted by the Duncan test at the threshold of $\alpha = 0.05$.

3. Results and discussion

Determination of dry matter content

Dry matter levels generally increase throughout the storage except for the control (Table 1). Values increase continuously from 8.45 to 17.53% (Cooking Salt), to 12.01% (vinegar) and to 13.96% (ash). The method of preservation with salt significantly reveals the highest values; then come the conservation with ash and then vinegar (Table 1).

Table 1

Change in dry matter ratio

Treatments	Witness	Cooking salt	Vinegar	Ash	P intra processing
T0	8.45±0.76 ^{bA}	8.45±0.76 ^{aA}	8.45±0.76 ^{aA}	8.45±0.76 ^{aA}	
T1	9.88±0.21 ^{cA}	9.22±0.37 ^{aA}	8.70±0.84 ^{aA}	9.08±0.96 ^{aA}	0.080
T2	14.01±1.12 ^{eB}	9.83±1.62 ^{aA}	9.01±0.21 ^{aA}	9.33±0.44 ^{aA}	0.002
T3	16.56±1.08 ^{fC}	12.33±0.87 ^{bB}	10.33±0.96 ^{bA}	11.66±0.87 ^{bA}	0.038
T4	15.94±0.26 ^{fB}	13.42±1.25 ^{bAB}	11.25±1.00 ^{bA}	12.25±1.11 ^{bA}	0.001
T5	15.03±0.33 ^{aC}	14.66±1.06 ^{abC}	10.95±0.36 ^{bA}	12.88±0.86 ^{bcB}	0.014
T6	11.10±0.86 ^{dA}	16.10±1.92 ^{bcC}	11.43±1.03 ^{bA}	13.33±1.17 ^{bcB}	0.024
T7	10.26±0.33 ^{cdA}	15.88±1.65 ^{bcC}	12.19±0.76 ^{bcB}	13.20±1.37 ^{bcB}	0.031
T8	6.13±0.11 ^{aA}	16.35±0.75 ^{cD}	11.88±0.66 ^{bB}	14.11±1.16 ^{cdC}	<0.001
T9	6.35±0.43 ^{aA}	17.33±1.18 ^{cD}	12.10±1.03 ^{bcB}	14.53±0.93 ^{cdC}	<0.001
T10	5.42±0.55 ^{aA}	17.53±0.96 ^{cD}	12.01±1.10 ^{bB}	13.96±0.65 ^{bcC}	<0.001
P intra matérial	<0.001	0.044	0.047	0.038	

Determination of oil content

Eggplant is found to be low in fat. However, variations were observed during storage with the highest T2 values of 0.51% (control), T4 values of 0.42% (salt), T5 values of 0.55% (vinegar) and then 0.61% for ash at T8. The highest rate, however, was observed preservation with ash (Table 2).

Table 2

Change in oil content

Treatments	Witness	Cooking salt	Vinegar	Ash	P intra processing
T0	0.23±0.00 ^{eA}	0.23±0.00 ^{aA}	0.23±0.00 ^{aA}	0.23±0.02 ^{aA}	
T1	0.28±0.01 ^{fB}	0.22±0.01 ^{aA}	0.23±0.02 ^{aA}	0.20±0.01 ^{aA}	0.040
T2	0.51±0.03 ^{iC}	0.33±0.02 ^{bcB}	0.26±0.01 ^{bA}	0.33±0.01 ^{bB}	0.002
T3	0.36±0.00 ^{gB}	0.33±0.00 ^{bcA}	0.33±0.00 ^{cA}	0.36±0.00 ^{cB}	0.028
T4	0.44±0.02 ^{hB}	0.42±0.02 ^{dB}	0.45±0.01 ^{eB}	0.35±0.01 ^{bcA}	0.042
T5	0.23±0.01 ^{eA}	0.33±.02 ^{bcB}	0.55±0.03 ^{fD}	0.44±0.03 ^{dC}	<0.001
T6	0.20±0.00 ^{dA}	0.40±0.00 ^{dB}	0.43±0.01 ^{eC}	0.43±0.02 ^{dC}	0.024
T7	0.16±0.00 ^{cA}	0.30±0.00 ^{bB}	0.49±0.04 ^{fC}	0.49±0.03 ^{deC}	0.021
T8	0.13±0.01 ^{bA}	0.35±0.01 ^{cB}	0.38±0.02 ^{dC}	0.61±0.01 ^{cdD}	<0.001
T9	0.11±0.00 ^{aA}	0.33±0.02 ^{bcB}	0.51±0.03 ^{fC}	0.53±0.03 ^{deC}	0.037
T10	0.11±0.00 ^{aA}	0.33±0.03 ^{bcB}	0.43±0.01 ^{eC}	0.46±0.00 ^{Dd}	<0.001
P intra matérial	<0.001	0.008	<0.001	0.001	

Determination of raw the content of mineral

Ash also in small amounts in eggplant (<0.5%), shows different variations throughout conservation. The highest value (0.26%) was observed at T3 preservation in ash. They are also raised at T2 in vinegar and salt, respectively (0.21%) and (0.23%), and then (0.24%) at the T4 control level. The ash-based method, however, reveals the highest rates throughout the shelf-life (Table 3).

Table 3

Change in raw ash content

Treatments	**Witness**	**Cooking salt**	**Vinegar**	**Ash**	**P intra processing**
T0	0.15±0.00 ^{dA}	0.15±0.00 ^{bA}	0.15±0.00 ^{bA}	0.15±0.00 ^{aA}	
T1	0.12±0.00 ^{bA}	0.22±0.00 ^{deD}	0.15±0.01 ^{bB}	0.18±0.00 ^{bC}	<0.001
T2	0.21±0.01 ^{eA}	0.23±0.00 ^{eB}	0.21±0.01 ^{dA}	0.23±0.01 ^{dB}	0.042
T3	0.16±0.01 ^{dB}	0.13±0.01 ^{aA}	0.13±0.00 ^{aA}	0.26±0.00 ^{eC}	<0.001
T4	024±0.01 ^{fC}	0.12±0.00 ^{aA}	0.15±0.00 ^{bB}	0.25±0.01 ^{deC}	0.014
T5	0.13±0.00 ^{cA}	0.16±0.01 ^{bB}	0.15±0.00 ^{bB}	0.18±0.01 ^{bC}	<0.001
T6	0.20±0.01 ^{eB}	0.18±0.01 ^{cB}	0.13±0.00 ^{aA}	0.23±0.01 ^{dC}	0.004
T7	0.16±0.00 ^{dA}	0.18±0.00 ^{cB}	0.19±0.01 ^{cdBC}	0.20±0.00 ^{cC}	0.011
T8	0.10±0.00 ^{aA}	0.15±0.00 ^{bB}	0.20±0.00 ^{dD}	0.18±0.01 ^{bC}	<0.001
T9	0.12±0.00 ^{bA}	0.23±0.01 ^{eC}	0.18±0.01 ^{cB}	0.23±0.01 ^{dC}	<0.001
T10	0.12±0.00 ^{bA}	0.21±0.01 ^{dC}	0.13±0.00 ^{aB}	0.24±0.00 ^{dD}	<0.001
P intra matérial	<0.001	0.001	<0.001	0.008	

NB: the assigned values of the same letter in lowercase and bold are not significantly different between retention times. The assigned values of the same uppercase letter are not significantly different between retention modes

Determination of protein content

Protein levels generally increased significantly from T0 to T3 (from 1.55 to 1.96%) and decreased to 1.22% in the control. Variations are rather different in other conservation methods. Indeed, the levels increase from 1.55 to 1.92 % (T4), 2.33 % (T3), 2.25 % (T4)
respectively for the storage using salt, vinegar and ash. The highest protein concentrations are observed significantly in vinegar and ash preservatives (Table 4).

Table 4

Change in protein content

Treatments	Witness	Cooking salt	Vinegar	Ash	**P intra processing**
T0	1.55±0.06 ^{cA}	1.55±0.06 ^{abA}	1.55±0.06 ^{aA}	1.55±0.06 ^{aA}	
T1	1.88±0.11 ^{deC}	1.52±0.03 ^{aA}	1.70±0.04 ^{bB}	1.88±0.09 ^{bC}	0.022
T2	1.81±0.05 ^{deA}	1.71±.12 ^{bcA}	2.01±0.11 ^{dB}	1.83±0.14 ^{bAB}	0.041
T3	1.96±0.10 ^{eB}	1.83±0.03 ^{cA}	2.33±0.13 ^{eC}	2.16±0.07 ^{cC}	0.002
T4	1.84±0.02 ^{dA}	1.92±0.15 ^{dAB}	1.95±0.03 ^{cB}	2.25±0.11 ^{dC}	<0.001
T5	1.73±0.10 ^{dAB}	1.66±0.06 ^{bA}	1.83±0.10 ^{bcB}	1.88±0.06 ^{bB}	0.013
T6	1.60±0.01 ^{cA}	1.70±0.02 ^{bB}	2.13±0.03 ^{dD}	1.93±0.10 ^{bC}	<0.001
T7	1.46±0.10 ^{bcA}	1.88±0.11 ^{cdBC}	2.19±0.16 ^{deC}	2.00±0.13 ^{bcC}	0.001
T8	1.53±0.13 ^{cA}	1.65±0.05 ^{bA}	1.88±0.13 ^{bcB}	2.11±0.11 ^{cC}	<0.001
T9	1.33±0.02 ^{aA}	1.53±0.10 ^{abB}	2.18±0.06 ^{deD}	1.93±0.03 ^{bC}	<0.001
T10	1.22±0.11 ^{aA}	1.48±0.06 ^{aB}	2.01±0.10 ^{dC}	2.06±0.15 ^{bcC}	0.021
P intra matérial	0.001	<0.001	<0.001	0.018	

Determination of sugar content

Total sugar content

T3 is the storage time when the sugar concentrations are higher. Thus, the values are 4.16, 4.33 and 4.66%, respectively in the control, the vinegar and ash method. Concentrations observed at the saline method are rather lower. The values then vary inhomogeneously and significantly at the level of the four (4) storage methods up to T10. The highest levels of total sugars are observed in vinegar and ash preservatives (Table 5).

Table 5

Change in total sugar content

Treatments	Witness	Cooking salt	Vinegar	Ask	P intra processing
To	3.95±0.11 ^{eA}	3.95±0.11 ^{dA}	3.95±0.11 ^{dA}	3.95±0.11 ^{bA}	
T1	3.88±0.22 ^{eB}	3.22±0.13 ^{cA}	3.70±0.14 ^{cdB}	3.83±0.16 ^{bB}	0.040
T2	4.01±0.26 ^{efA}	3.83±0.22 ^{dA}	4.01±0.21 ^{dA}	3.93±0.14 ^{bA}	0.052
T3	4.16±0.33 ^{efB}	3.33±0.17 ^{cA}	4.33±0.26 ^{eB}	4.66±0.37 ^{dBC}	0.038
T4	3.74±0.21 ^{eA}	3.42±0.25 ^{cA}	4.25±0.10 ^{eB}	4.25±0.11 ^{cB}	0.026
T5	3.83±0.10 ^{eB}	3.66±0.06 ^{cdA}	3.95±0.16 ^{dB}	3.88±0.20 ^{bB}	0.044
T6	2.60±0.20 ^{dB}	2.10±0.12 ^{aA}	3.43±0.23 ^{cC}	3.33±0.17 ^{aC}	0.020
T7	1.46±0.10 ^{abA}	2.88±0.11 ^{bcB}	4.19±0.26 ^{deC}	4.20±0.30 ^{cC}	0.001
T8	1.53±0.09 ^{bA}	2.35±0.15 ^{abB}	3.88±0.33 ^{cdC}	4.11±0.16 ^{bcC}	0.003
T9	2.03±0.26 ^{cA}	2.33±0.18 ^{abAB}	2.48±0.16 ^{bB}	3.53±0.33 ^{abC}	<0.001
T10	1.33±0.11 ^{aA}	2.53±0.26 ^{bC}	2.01±0.10 ^{aB}	3.96±0.15 ^{bD}	<0.001
P intra material	<0.001	0.001	<0.001	0.014	

Reducing sugar content

The reduced sugar levels of the eggplant studied are similar to those of total sugar. However, the highest values observed during retention are 2.83% (T3), 3.66% (T2), 3.75% (T4), 3.90% (T7); in the control and in the methods of conservation based on salt, vinegar and ash, respectively. The control records the lowest concentrations at T7 (1.00%). Ash and vinegar get the highest levels of reducing sugars during conservation (Table 6).

Table 6

Variation in reducing sugar content

Treatments	Witness	Cooking salt	Vinegar	Ash	P intra processing
To	2.10±0.03 ^{bA}	2.10±0.03 ^{cA}	2.10±0.03 ^{bA}	2.10±0.03 ^{aA}	
T1	2.90±0.12 ^{eC}	2.10±0.10 ^{cA}	2.60±0.10 ^{cBC}	2.83±0.21 ^{cC}	<0.001
T2	3.53±0.14 ^{dB}	2.83±0.11 ^{eA}	3.41±0.23 ^{dB}	3.43±0.24 ^{deB}	0.043
T3	3.66±0.23 ^{dBC}	2.03±0.18 ^{bA}	3.30±0.13 ^{dB}	3.88±0.17 ^{eC}	<0.001
T4	2.44±0.21 ^{cdB}	2.12±0.05 ^{bcA}	3.75±0.10 ^{eC}	3.75±0.11 ^{eC}	0.026
T5	2.73±0.09 ^{deAB}	2.66±0.16 ^{dA}	3.05±0.28 ^{dC}	2.88±0.12 ^{cB}	0.002
T6	2.10±0.16 ^{bcAB}	1.80±0.12 ^{aA}	2.33±0.23 ^{cB}	2.50±0.19 ^{bB}	0.012
T7	1.00±0.02 ^{aA}	2.01±0.10 ^{bB}	3.49±0.12 ^{cC}	3.90±0.22 ^{eD}	<0.001
T8	1.03±0.01 ^{aA}	1.95±0.15 ^{abB}	2.98±0.23 ^{cdC}	3.81±0.17 ^{eD}	<0.001
T9	1.77±0.03 ^{bA}	1.66±0.13 ^{aA}	2.00±0.11 ^{bB}	2.43±0.23 ^{bC}	<0.001
T10	1.01±0.06 ^{aA}	1.83±0.12 ^{aC}	1.41±0.13 ^{aB}	3.02±0.26 ^{cD}	<0.001
P intra matérial	0.018	<0.001	<0.001	0.034	

NB: the assigned values of the same letter in lowercase and bold are not significantly different between retention times. The assigned values of the same uppercase letter are not significantly different between retention modes

Increases in the dry matter rate indicate that the methods used would be favorable. This would be linked to the evaporation phenomenon (more intense with the saline method) in dry storage cases and then to the phenomenon of osmosis during storage in the vinegar. Decreases in the dry matter rate in the control would be the cause of decay observed beyond the twelve (12) days of storage. Extending the green lifespan of eggplants in our study suggests that different treatments would positively alter the interactions of fruits with the surrounding environment [3].

The observed fat levels would indicate that oil would not be the main energy reserve in eggplants due to the low levels observed. However, their variations during conservation would be related to their uses in either catabolic activities resulting in the formation of carbohydrates or lipogenesis [8].

Low ash levels in eggplants also show higher values in the ash-based method. The constitution of the conservation environment may be at the origin of this difference [9]. The minerals would come from the wood ash used.

The different variations observed are due to the use of different ash constituents in biochemical activities during conservation [10].

The variations in the different percentages of protein observed could be due to the different hydrolysis and metabolic reactions. Synthetic responses would be earlier in open-air and vinegar preservation where aqueous medium (vinegar) would promote the resumption of metabolic activities [11]. Rather than in drier environments, however, the high values observed in ash conservation may be due to the involvement of the constituent mineral elements in different synthesis reactions.

The total sugar concentrations falling at the saline method could be related to the different interactions between the fruit and the medium. According to the work of El Jaafari [12], salinity led to the formation of aggregates in soil nutrients, resulting in pseudocimentation of the environment, severely impeding synthesis. Differences in the proportions of sugars observed at all times in other conservation conditions would be related to the different post-harvest metabolic reactions that take place during conservation [13]. Retention in vinegar as well as the mineral elements that make up wood ash would further enhance glucid syntheses.

Studies show that eggplant fruits are mainly reduced sugars. According to Lewis [14], the major source of fructose in the plant is sucrose, which, after cleavage, releases equimolecular amounts of fructose and glucose. This carbohydrate source would be quickly catabolized at the harvest of fruits, resulting in a high concentration of reducing sugars, which constitute the crossroads of most biochemical activities. Sucrose and polysaccharides are used as precursors of synthesis, by conversion to glucose and fructose [8]. Thus the different variations observed would be the result of reactions of neoglucogenesis and/or glycolysis [15]. Vinegar and ash would be more beneficial for neoglucogenesis or non-reducing sugar cleavage activities, hence higher levels.

4. Conclusion

The objective of this study was to highlight the impact of different conservation methods on the green life of eggplants. To achieve this, the physicochemical characteristics were carried out on the fruits. The results therefore indicate that vinegar and ash conservation at the method level is positively different from that of the ambient environment and salt. However, further studies on organoleptic tests could clearly differentiate between these two conservation methods.

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