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Effects of Cooking and Drying on Physico-Chemical Parameters of Aubergines (*Solanum aethiopicum*) during Conservation

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Abstract

In tropical Africa, eggplant is one of the most widely cultivated and consumed fruit vegetables. Despite its very high consumption, marketing remains informal and its post-harvest conservation, a real problem due to the lack and / or high costs of processing. The present study aims to improve processing and preservation techniques. Specifically, this will involve determining the physicochemical properties of eggplant powders from two production techniques, including without cooking (F Aub S C) and with cooking (F Aub A C). The control consists of unprocessed eggplant (Aub N T). The flours were kept in jars for 12 weeks and each week the physicochemical characteristics were determined there. The results showed, the humidity level remains higher in Aub N T (97.42 ± 1.31%); the fat content is higher in F Aub S C (2.88 ± 0.12% DM); the differences between the mineral contents of F Aub S C and F Aub A C are not significant. The proteins show higher concentrations in the F Aub S C (16.11 ± 0.11% DM), as do the contents of total and reducing sugars. In the end, the most beneficial effects are produced by storing eggplant flour without cooking (Aub S C).

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Keywords

Eggplant, Processing technique, Flour, Conservation.

Introduction

Owned by the *Solanaceae* family and the genus *Solanum* (Lester *et al.,* 2004), eggplant is an important part of the Mediterranean and Asian economies (Doganlar *et al.,* 2002). The plant is found in both America and Africa (Doganlar *et al.,* 2002). Its cultivation is possible in very varied climates (temperate, dry or humid tropical). It contains many cultivars that are distinguished in particular by the color, size and shape of the fruits (Furini *et al.,* 2004). In tropical Africa, eggplant is one of the most commonly grown and consumed fruit vegetables. It would be 3rd in consumption volume after tomatoes, onions and okra (Lester and Seck, 2004). The proportion of eggplant sold would increase to satisfy the supply of cities and exports to Europe, inter alia, from Uganda, Senegal and Côte d'Ivoire. With a production of 99,000 t/year, Côte d'Ivoire ranks 17th in the world and 3rd in Africa (Anonyme, 2017). Its cultivation is carried out by small producers living in rural and urban areas (Fondio *et al.,* 2007). Despite this economic and food potential, little work has been done to improve and popularize the processing and conservation techniques of this fruit-vegetable in Côte d'Ivoire. Also Despite its high consumption, the marketing of eggplant remains informal and its post-harvest conservation remains a real problem. Indeed, the attack on the micro-organisms and the injuries caused during the harvest lead to a lot of losses. All of this damage to culture and conservation negatively affects its marketability, health and nutritional quality (Kouamé *et al.*, 2016).

Conservation of fruit, particularly eggplant, is difficult due to a lack of appropriate storage techniques and the few processes used are expensive and not accessible to most of the population (Lepengue *et al.*, 2012).

This study aims to improve the processing and conservation techniques of eggplant commonly used in Côte d'Ivoire to better guide producers and consumers. Specifically, the physicochemical properties of eggplant powders derived from two processing techniques will be determined during their storage.

Materials and Methods

Biological Material

The biological material consists of the variety *Solanum aethiopicum*

Sampling

The healthy plants with no history of disease were selected on an experimental plot in the town of Daloa, Côte d'Ivoire. The selected fruits were harvested and stored in the open air until the orange color was obtained.

The eggplant flours obtained from two manufacturing techniques were divided by method type and kept for twelve (12) weeks. T0, T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12 are equivalent to conservation times, (with T0 being the initial sampling before conservation). A control is made of fresh eggplant of the same ripening time and stored in the open air (Aub N T).

Production of eggplant meal

Without cooking

The fruits harvested are cleared of inedible parts and then cleaned. Five kilograms (5 kg) of selected fruit are finely cut and placed in crucibles and then dried in the oven at a temperature of 70°C until a constant mass is obtained. Dried eggplants are then crushed in a blender and immediately stored in hermetically sealed jars (F Aub S C).

With cooking

The principle remains the same except that the cut eggplants are steamed for 10 minutes before being dried in the oven (F Aub A C).

Physical-chemical characteristics

Dry matter and ash levels were determined using BIPEA (1976) methods; the protein content was determined using the AOAC (2002) method using KJEDHAL; fat content according to BIPEA (1976) using SOXHLET; the total sugar content according to Dubois *et al.*, (1956) using phenol and reducing sugar levels according to Benfeld (1955) using 3,5-dinitro salycillic acid (DNS).

Statistical Analysis

A descriptive analysis of the results was performed using Microsoft Office Excel 2007 software, determining the standard averages and deviations. With the help of STATISTICA 7 software, the single-factor variance analysis (ANOVA) was performed on the data to determine the significant differences between the averages during conservation. Then, the significant statistical differences were highlighted by the Duncan test at the threshold of α= 0.05.

Results and Discussion

Change in moisture content during storage

During storage, the humidity levels of Aub N T range from 83.15 ± 1.22% to 97.42 ± 1.31%, those of F Aub S C range from 0.23 ± 0.03% to 2.83 ± 0.02% and then from 0.13 ± 0.01% to 1.02% 96 ± 0,03% for F Aub A C. The humidity level decreases significantly over time for each transformation mode. The water content is significantly higher in the Aub N T (Table 1).

Change in fat content during storage

The fat content during the storage of Aub N T is between 0,96 ± 0,00% MS and 2,96 ± 0,1%; in F Aub S C, between 0.97 ± 0.01 and 2.88 ± 0.12% MS, then 2.05 ± 0.03 and 1.2 ± 0.02% MS in F Aub A C. The fat content declines significantly over time for each processing mode from the first (T0 and T1) to the fourth (T4) week, when it remains constant throughout the shelf life (Table 2).

Change in ash content during storage

The ash content of Aub N T varies between 0,9 ± 0,03% and 1,18 ± 0,00% MS, that of F Aub S C is between 1,15 ± 0,00 and 1,29 ± 0,01% MS. F Aub A C shows values between 1.00 ± 0.04 and 1.22 ± 0.00% MS. Between storage times, the ash level remains statistically constant from the first to the twelfth week only in the F Aub S C; between processing modes, ash content was significantly higher in F Aub S C and F Aub A C (table 3).

Variation in protein content during conservation

The protein content of Aub N T ranges from 7.36 ± 0.22 and 15.73 ± 1.1% MS, the protein content of F Aub S C ranges from 8.01 ± 0.13 to 16.11 ± 0.11% MS. In F Aub A C the values vary between 10.30 ± 0.84 and 7.88 ± 0.41% MS. Protein levels were significantly higher in Aub S C (table 4).

Variation in total sugar content during storage

Total sugars of Aub N T show during storage, rates ranging from 10.9 ± 1.8 to 34.83 ± 1.1% dry matter (MS). F Aub S C contents range from 32.03 ± 2.03 to 39.19 ± 2.12% MS then 18.01 ± 0.09 and 38.09 ± 2.03% MS in F Aub A C. The total sugar content of eggplants decreased significantly in general in Aub N T and F Aub A C, when it oscillated in F Aub S C throughout conservation. Between processing modes, total sugar content remains significantly higher in F Aub S C (table 5).

Variation in reducing sugar content during storage

During storage, the content of reducing sugars of Aub N T varies between 8.97 ± 1.45% and 24.81 ± 0.8% of MS, that of F Aub S C is between 22.72 ± 1.03 and 35.45 ± 2% of MS, then between 10.18 ± 1 and 2 7,72 ± 1,58% MS for F Aub A C. The reducing sugar content of Aub N T decreased significantly after 2 weeks and then remained stable; at the level of the F Aub

A C, it decreases after 5 weeks then remains stable. Between processing modes, the content of reducing sugars remains significantly higher in F Aub S C (table 6**).**

Moisture levels reveal significant differences between conservation methods. The increase in unprocessed eggplant (Aub N T) is the result of decay during conservation due to advanced post-harvest maturation of eggplant. The presence of water in a food product is one of the main factors of its potential degradation, by multiplication of micro-organisms. However, the water content in both types of Flour obtained without cooking and with cooking (F Aub S C and F Aub A C) would come from residual humidity, which is very low following evaporative elimination of water after drying (Hincker, 2002). However, the observed differences and variations could be related to the effect of cooking before drying on residual water.

Oil levels in eggplants show a general decline throughout the shelf life. The use of oil as one of eggplant energy sources, either in catabolic activities resulting in the formation of carbohydrates or in lipogenesis (Assa, 2007), may explain this decline in rates. However, the highest values observed in flour with cooking after 4 weeks of storage would be due to drying conditions that could alter the product or give it new properties (Noumi, 2011)

The ash levels obtained during the work revealed higher values in our uncooked processed eggplants. This processing method would more effectively guarantee the benefits of drying by preserving the quantity of mineral salts. These results are consistent with those of Rozis, (1995). Low rates observed with the cooking method could be explained by evaporative losses of certain volatile minerals. However, ash levels during storage are higher in eggplant flour than in unprocessed eggplant.

The decrease in protein content is more intense in cooking flour as in unprocessed fruit. In the latter, this decline is the result of tissue degeneration resulting in a loss of the food value of the product (Hincker, 2005). Constant amounts of protein observed in uncooked eggplant powder over 5 weeks of storage may be due to the stability of protein molecules during processing and the low level of residual water in the final product, as opposed to possible denaturation during cooking (Benhamou *et al.*, 2008).

Table.1 Variation in humidity

TRAITEMENT	Aub N T	F Aub S C	F Aub A C	P intra processing
To	83,15±2,22 ^{cA}	0,23±0,03 ^{dB}	0,13±0,01 ^{dC}	<0,001
T1	86,20±1,90 ^{bA}	2,56±0,01 ^{aB}	1,96±0,09 ^{aC}	<0,001
T2	89,05±2,28 ^{abA}	2,33±0,02 ^{bB}	1,15±0,01 ^{bcC}	<0,001
T3	93,33±3,01 ^{aA}	1,45±0,01 ^{cB}	1,24±0,03 ^{bC}	<0,001
T4	94,11±2,43 ^{aA}	1,55±0,10 ^{cB}	1,13±0,02 ^{cC}	<0,001
T5	93,42±3,31 ^{aA}	1,43±0,01 ^{cB}	1,19±0,03 ^{bcC}	<0,001
P intra matérial	0,021	0,008	0,001	

Table.2 Variation in oil content (w/o dry matter)

TRAITEMENT	Aub N T	F Aub S C	F Aub A C	P intra processing
To	2,96±0,10 ^{aA}	2,83±0,12 ^{aA}	2,05±0,03 ^{aB}	0,024
T1	2,22±0,17 ^{bB}	2,60±0,09 ^{bA}	1,83±0,11 ^{bC}	<0,001
T2	1,60±0,03 ^{cB}	2,30±0,07 ^{cdA}	1,69±0,08 ^{bB}	0,031
T3	1,13±0,03 ^{dB}	1,35±0,01 ^{cA}	1,38±0,02 ^{cA}	0,044
T4	1,11±0,00 ^{dC}	1,22±0,10 ^{dB}	1,51±0,13 ^{bcA}	<0,001
T5	1,11±0,01 ^{dB}	1,13±0,03 ^{dB}	1,43±0,05 ^{cA}	0,037
P intra matérial	0,008	0,001	<0,001	

Table.3 Variation in raw ash content (w/w dry matter)

TRAITEMENT	Aub N T	F Aub S C	F Aub A C	P intra processing
To	1,13±0,03 ^{cA}	1,16±0,01 ^{bA}	1,00±0,04 ^{bB}	0,002
T1	1,10±0,01 ^{eB}	1,18±0,01 ^{cA}	1,03±0,00 ^{aC}	0,004
T2	1,16±0,00 ^{dB}	1,18±0,00 ^{cA}	1,10±0,01 ^{cdC}	<0,001
T3	0,90±0,06 ^{aC}	1,15±0,00 ^{bA}	1,10±0,00 ^{dB}	0,001
T4	1,09±0,00 ^{bA}	1,23±0,01 ^{eC}	1,18±0,01 ^{cB}	<0,001
T5	1,12±0,04 ^{bA}	1,21±0,01 ^{dB}	1,13±0,00 ^{aA}	0,014
P intra matérial	<0,001	0,001	<0,001	

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.

Table.4 Variation in protein content (w/w to dry matter)

TRAITEMENT	Aub N T	F Aub S C	F Aub A C	P intra processing
To	34,83±1,10 ^{aA}	35,27±1,81 ^{abA}	35,90±1,45 ^{bA}	0,064
T1	23,60±1,81 ^{bB}	30,27±1,54 ^{cA}	31,18±2,09 ^{cA}	0,042
T2	13,27±0,96 ^{deB}	38,18±2,73 ^{aA}	38,09±2,36 ^{aA}	0,031
T3	13,90±0,59 ^{dB}	37,36±1,45 ^{aA}	35,27±3,00 ^{bcA}	0,028
T4	18,45±2,36 ^{cC}	32,09±2,33 ^{bcA}	22,54±1,45 ^{dB}	<0,001
T5	12,33±1,01 ^{eC}	35,96±1,36 ^{abA}	18,01±0,91 ^{eB}	<0,001
P intra matérial	<0,001	0,014	<0,001	

Table.5 Variation in total sugar content (w/o dry matter)

TRAITEMENT	Aub N T	F Aub S C	F Aub A C	P intra processing
To	34,83±1,10 ^{aA}	35,27±1,81 ^{abA}	35,90±1,45 ^{bA}	0,064
T1	23,60±1,81 ^{bB}	30,27±1,54 ^{cA}	31,18±2,09 ^{cA}	0,042
T2	13,27±0,96 ^{deB}	38,18±2,73 ^{aA}	38,09±2,36 ^{aA}	0,031
T3	13,90±0,59 ^{dB}	37,36±1,45 ^{aA}	35,27±3,00 ^{bcA}	0,028
T4	18,45±2,36 ^{cC}	32,09±2,33 ^{bcA}	22,54±1,45 ^{dB}	<0,001
T5	12,33±1,01 ^{eC}	35,96±1,36 ^{abA}	18,01±0,91 ^{eB}	<0,001
P intra matérial	<0,001	0,014	<0,001	

Table.6 Variation in reducing sugar content (p/r dry matter)

TRAITEMENT	Aub N T	F Aub S C	F Aub A C	P intra processing
To	24,81±0,81 ^{aAB}	26,11±1,09 ^{bB}	27,72±2,54 ^{dC}	0,064
T1	19,09±1,45 ^{bAB}	22,72±1,72 ^{cB}	21,18±1,23 ^{cB}	0,042
T2	9,09±0,18 ^{dA}	35,45±2,00 ^{aD}	31,48±2,09 ^{cC}	0,031
T3	9,36±0,21 ^{dA}	34,63±2,09 ^{aD}	27,09±0,23 ^{cdC}	0,028
T4	10,63±0,37 ^{cA}	22,09±1,23 ^{cC}	2,00±0,11 ^{bB}	<0,001
T5	9,18±0,54 ^{dA}	27,45±2,36 ^{bD}	1,41±0,13 ^{aB}	<0,001
P intra matérial	0,018	0,034	<0,001	

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.

Total sugar levels show higher values for eggplant flour throughout the shelf life. Reduced metabolic activities due to the very low humidity in eggplant meal may explain the slowdown in the degradation process of constituent sugars. Drying will limit the action of enzymes, thus inhibiting catabolic reactions of sugars (Kapseu, 1999). The decrease in total sugar levels in unprocessed fruit would therefore be the fact that, after harvesting, eggplants would no longer receive nutrients due to the cessation of photosynthesis. This would lead to a reduction in their masses, heat production and the release of water.

The product tends to wilt and provides a favorable breeding ground for microbial proliferation, thus intensifying the metabolic and catabolic activities of the plant (Hincker, 2002).

The majority of eggplant sugars, reducing sugars show variations in content identical to that of total sugars. The highest values are also obtained in eggplant flour without cooking and then in eggplant flour with cooking. Indeed, drying as a processing and preservation technology also constitutes a process of concentration of certain substances such as sugars; This may explain the high levels (Belem *et al.*, 2017). The main crossroads of most biochemical activities (Assa, 2007), the different concentrations of reducing sugars observed during conservation would reflect the intensity of the reactions that occur in our different forms of eggplant studied. However, eggplant flours obtained without cooking are more concentrated in reducing sugars than flours obtained with cooking.

During this study, two processing techniques (Flour obtained without cooking and flour obtained with cooking) and translated into preservation mode were used. The results showed that the mature eggplant after harvest, then mural, is largely suitable for processing.

But still, the transformation of eggplants into flour improves the availability and the conservation of the various components. The most positive results are achieved by keeping eggplant flour uncooked. The production of eggplant flour without cooking for the purpose of long-term preservation in quality and quantity can therefore be a valid means for supplementary domestic use.

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