Effect of some postharvest treatments on quality and storability of cassava roots

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ABSTRACT

This study was conducted during the two successive seasons of 2015 and 2016 at El-Kanater El-Khairia Horticulture Research station and Vegetables Handling Research Department, Horticulture Research Institute, Giza Governorate. The aim of this study was to investigate the effect of some post-harvest treatments on quality and storability of cassava root (Indonesian cultivar).Roots were harvested from plants cultivated in sandy soil in mid of January during the two seasons, respectively. The roots were then divided into two groups for room temperature (25°C) and cold storage (5°C), each group was exposed to 10 treatments each with three replicates. Each replicate consisted of three roots. The treatments included dipping of roots for 5 minutes in:-ascorbic acid at 1 %, calcium chloride solution at 1 %, Bio-health solution at 1 %, Jasmine oil, chitosan at 1 %, wrapping in polypropylen film with 30 Mm thickness, Parafin Wax, Hydrogen peroxide solution at 1 %, hot water at 55°C and control (non-treated roots). All treatments were air-dried and packed in carton boxes (5 kg) then stored at 25 °C and 90-95 % relative humidity under room temperature (first group) or stored at 5° C in the refrigerator (second group).Roots were inspected each 5 days for room temperature storage and each 10 days for treatments healed in the cold storage. Complete randomize design with three replicates was used. Obtained results show that the lowest weight loss and decay percentages were recorded in cassava roots treated with H_2O_2 under room temperature and 5°C in the two tested seasons. On the other side, the highest weight loss, decay, dry matter, starch content and phenol percentages were detected in control treatment in the two tested seasons.

Key words: Cassava, storability, weight loss, decay and root chemical content.

Introduction

Cassava crop (*Manihot esculenta Crantz*) has high economic and nutritional value. According to FAO data, the production of 2013 was 263 thousand tons from a harvesting area of approximately 20.5 million hectares (FAO, 2014). A higher prediction of demand and production growth puts the 2020 production at 291 thousand tons (**Scott *et al.*, 2000**) however, cassava use in africa is equivalent to 62 % of the total world production, specially in sub Saharan African countries. In Egypt, the area planted with cassava still very limited and mainly for the experimentally and research purposes.

The important of cassava in the world is mainly a reflection of the agronomic advantages of the crop. However, if the contribution that cassava can make to the livelihoods of poor people is to be increased, there is a need to consider also its post-harvest handling, processing and marketing. There are three major limitations to the increased utilization of cassava roots; poor shelf life, low protein content and their naturally occurring cyanogens. Cassava utilization patterns vary considerably in different parts of the world, in Africa the majority of cassava produced (88 %) is used for human food with over 50 % used in the form of processed products. Animal feed and used of starch are only minor uses of the crop. The situation in asia is greatly influenced by the export of cassava chips by Thailand to the European community for used as animal feed (**Scott *et al.*, (2000)**.Cassava roots are very rich source of carbohydrates, most of carbohydrates are present as starch (31 % of fresh weigh) with smaller amounts of free sugars (less than 1 % of fresh weight). Cassava roots are low in protein (0.53 %) and fat (0.17 %).

Cassava is generally considered to have a high content of dietary fiber, magnesium, sodium, riboflavin, thiamin, nicotinic acid and citrate (**Bradbury and Holloway, 1988**). Iron and vitamin A are considered to be low. cassava has a very short shelf life and two types of post-harvest deterioration are recognized; primary physiological deterioration that involves internal discoloration due to increased of enzymes activity like polyphenol oxidase and peroxidase (**Uarrota *et al.*, 2015**) and this cause a loss of market acceptability. Secondary deterioration is due to microbial spoilage (**Booth and Coursey, 1974**). The simplest means of preserving cassava is to delay harvesting until crop is needed. Recently few studies were carried out to improve cassava storage, overcome the physiological deterioration, improve the storability and decrease the post-harvest losses.

Therefore, this study was carried out to investigate the effect of some post-harvest treatments on quality and storability of cassava.

Material and Methods

This study was conducted during the two successive seasons of 2015 and 2016 at El-Kanater El-Khairia Horticulture Research station and Vegetables Handling Research Department, Horticulture Research Institute, Giza Governorate. The aim of this study was to investigate the effect of some post-harvest treatments on quality and storability of cassava

root (Indonesian cultivar).Roots were harvested from plants cultivated in sandy soil in 10th and 14th of April during the two seasons, respectively at a private farm in Abo Sair District, Ismailia Governorate. All agricultural practices included soil preparation, fertilization, irrigation, pest and diseases control, harvesting were followed according to the recommendation of the ministry of Agriculture and land reclamation.

Roots were harvested during dormancy in mid-January in the two seasons and curing process was performed directly after harvest. Cassava roots were cured at 22 °C and 90-95 % relative humidity for 5 days for skin maturity and healing cuts and other injuries occurred during harvesting and handling (**Picha, 1986**). After curing, the roots were washed and then dried in a well-ventilated room. The roots were then divided into two groups for room temperature (25 °C) and cold storage (5 °C) each group was exposed to 10 treatments each with three replicates. Each replicate consisted of three roots. The treatments included dipping of roots for 5 minutes in:-

1- Ascorbic acid at 1 %.
2- Calcium chloride solution at 1 %.
3- Bio-health solution at 1 %, bio-health is blend of selected trichoderma harzianum is approx. 10% (approx × 10^7 spores and infection particles), the product type is water soluble granules
4- Jasmine oil: - Jasmine oil is one of the essential oils (Volatile oils) it is used as a growth retardant, roots were soaked in 5 mg/l of jasmine oil in the presence of ethyl alcohol.
5- Chitosan at 1 %.
6- Wrapping in Polypropylen film: Roots were wrapped in polypropylene film with 30 Mm thickness.
7- Parafin Wax: - Roots were dipped for 5 seconds in hot wax.
8- Hydrogen peroxide solution at 1 %.
9- Hot water at 55 °C.
10- Control (non-treated roots).

All treatments were air-dried and packed in carton boxes (5 kg) then stored at 25 °C and 90-95 % relative humidity under room temperature (first group) or stored at 5° C in the refrigerator (second group).Roots were inspected each 5 days for room temperature storage and each 10 days for treatments healed in the cold storage. Complete randomized design with three replicates was used.

A- Data recorded:-

1- Weight loss percentage.

Weight loss was recorded at the start of the experiment and 5 or 10 days intervals according to the storage method. It was expressed a percentage of weight loss relative to the initial weight.

Weight loss % = [(A-B/A)] x 100

Where, A = the initial weight, B = weight at inspection data.

2- Decay percentage:-

Roots in each treatment were assessed for the percentage of surface showing visible rotting every 5 and 10 days for room temperature and cold storage, respectively. Decay was calculated for each treatment based on the over 10 % of the surface shows visible rooting of each root. Roots showing extensive rooting (over 50 % surface) were removed from the experiment (**Wenzhang *et al.*, 2004**). Decay was determined as scores, 1 = none, 2= slight, 3 = moderate, 4 = moderately severe and 5 = severe.

3- Dry matter percent:-

One hundred gram of fresh roots were weight and then dried at 70 °C in the oven until a constant weight and percentage of dry matter was then calculated as B/A x 100.

Where, A = Sample weight before drying.
B = Sample weight after drying.

4- Starch %:-

This revised method consists of extraction of the starch with perchloric acid, precipitation with iodine under conditions that have been shown to be quantitative, decomposition of the iodine complex, and determination of the sugar produced by hydrolysis of the starch. A maximum of 250 mg of dry tissue is required; proportionality smaller quantities are sufficient if the starch content is greater than 1 %. The fundamental values of the starch from a given tissue have been determined, in terms of sugar titration and in comparison with standard such as a preparation of potato starch **(A.O.A.C., 1990).**

% Starch = [50 mL blank – mL sample) x 0.90/mg sample] x (N/0.005) x G x 100.

5- Total phenols:-

Samples of 100 g of each fresh stem segments in root were extracted by 80 % phenol at 0 °C for 2 h as described by**(A.O.A.C., 1990).**Total Phenolics were determined by using Folin Denis colorimetric method in extract at wavelength of 750 u (**A.O.A.C, 1990**). The concentration of phenolics was adjusted by using the standard curve of pyrogallol and calculated as mg .per 100 g dry weight.

B- Statistical analysis:-

Data were statistically analyzed using the analysis of variance described by **Snedecor & Cochran, (1990).** The method of Duncan multiple range test was applied for the comparison between means according to **Waller and Duncan (1969)**

Results and Discussions

Weight loss:

Results in Tables (1, 2, 3 and 4) show that the lowest weight loss was recorded in cassava roots treated with H_2O_2 under room temperature and 5°C in the two tested seasons. On the other side, the highest weight loss was detected in control treatment. As for the storage period effect, data show that the highest weight loss was detected in the end of the storage period (20 days at room temperature and 40 days at

5°C), on the other hand the lowest loss weight was found at 5 °C time (before storage at 5 °C or room temperature in the two tested seasons.

As regards to the effect of interaction, results show that the lowest weight loss was detected to roots treated with H_2O_2 and stored for 5, 10, 15 and 20 day at room temperature or 10, 20, 30 and 40 days at cold storage at 5 °C in the two tested seasons. On the other side, the highest weight loss was recorded to untreated roots and stored for 20 days at room temperature or for 40 days at cold storage in the two tested years. The results are in agreement with those of **Sunmala and Bukoye (2011), El-Sayed (2013), Hsinchen (2015) and Abdel Gayed *et al.*, (2017)**.

Table 1. Effect of some post-harvest treatments on weight loss (%) of cassava roots stored on room temperature during 2015/2016 season.

Treatment	0 Time	5 days	10 days	15 days	20 days	Mean
Ascorbic acid	0.00s	3.84o-q	7.61j	9.51gh	12.67cd	6.73C
Chloride calcium ($CaCl_2$)	0.00s	3.24q	4.54m-p	7.88ij	10.00fg	5.13F
Bio-health	0.00s	3.87n-q	5.36k-m	7.88ij	11.00e	5.62E
Jasmine oil	0.00s	4.62l-p	7.18j	10.18e-g	14.25b	7.25B
Chitocan	0.00s	4.76l-o	7.67j	10.67ef	13.33c	7.29B
Stritch film	0.00s	3.67pq	5.99k	8.67hi	12.00d	6.07D
Wax	0.00s	4.40m-p	5.63k	7.85ij	10.81ef	5.74DE
Hydrogen peroxide (H_2O_2)	0.00s	1.59r	2.99q	4.89l-n	7.60j	3.41G
Hot water	0.00s	3.07q	5.33k-m	8.92h	12.00d	5.87DE
Control	0.00s	3.89n-q	7.63j	12.03d	18.64a	8.44A
Mean	0.00E	3.70D	5.99C	8.85B	12.23A	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test.

Table 2. Effect of some post-harvest treatments on weight loss (%) of cassava roots stored on room temperature during 2016/2017 season.

Treatment	0 Time	5 days	10 days	15 days	20 days	Mean
Ascorbic acid	0.00q	5.53k-m	8.17ij	11.05ef	13.33c	7.62B
Chloride calcium ($CaCl_2$)	0.00q	3.00o	5.00mn	8.00ij	10.67ef	5.33E
Bio-health	0.00q	3.00o	5.00mn	8.77hi	11.67de	5.69DE
Jasmine oil	0.00q	5.75k-m	7.33j	11.00ef	14.33b	7.68B
Chitocan	0.00q	4.99mn	8.61hi	11.33de	14.33b	7.85B
Stritch film	0.00q	4.09n	6.33kl	9.33gh	12.33d	6.42C
Wax	0.00q	4.31n	6.39k	8.37hi	11.00ef	6.01CD
Hydrogen peroxide (H_2O_2)	0.00q	1.66p	2.92o	5.33lm	10.06fg	3.99F
Hot water	0.00q	2.67o	6.00k-m	9.33gh	12.33d	6.07CD
Control	0.00q	6.00k-m	8.33hi	12.33d	20.33a	9.40A
Mean	0.00E	4.10D	6.41C	9.49B	13.04A	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test.

Table 3. Effect of some post-harvest treatments on weight loss of cassava roots stored at 5°C temperature during 2015/2016 season.

Treatment	0 Time	10 days	20 days	30 days	40 days	Mean
Ascorbic acid	0.00u	2.27m-r	3.99h-j	6.44cd	9.27b	4.40B
Chloride calcium ($CaCl_2$)	0.00u	1.70p-s	2.89k-p	3.96h-j	5.32ef	2.76D
Bio-health	0.00u	1.45q-t	2.54l-q	4.06g-j	5.59d-f	2.73D
Jasmine oil	0.00u	2.04n-r	3.00j-n	5.48d-f	10.00b	4.11B
Chitocan	0.00u	2.02n-r	3.26i-m	4.83f-h	6.90c	3.40C
Stritch film	0.00u	2.04n-r	3.67i-k	4.84f-h	5.92c-e	3.29C
Wax	0.00u	1.22r-t	2.84k-o	3.45i-l	5.06e-g	2.52DE
Hydrogen peroxide (H_2O_2)	0.00u	0.62tu	0.91s-u	1.32r-t	1.86o-s	0.94F
Hot water	0.00u	1.56q-t	2.46l-q	3.43i-l	3.95h-j	2.28E
Control	0.00u	2.33m-r	4.14g-i	6.49c	11.74a	4.94A
Mean	0.00E	1.73D	2.96C	4.43B	6.56A	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test.

Table 4. Effect of some post-harvest treatments on weight loss of cassava roots stored at 5°C temperature during 2016/2017 season.

Treatment	0 Time	10 days	20 days	30 days	40 days	Mean
Ascorbic acid	0.00v	2.14q-s	3.45l-p	5.33f-h	8.67c	**3.92C**
Chloride calcium ($CaCl_2$)	0.00v	2.16q-s	2.94n-r	4.00j-m	5.00f-j	**2.82E**
Bio-health	0.00v	2.03rs	3.13m-q	4.29i-l	5.73d-g	**3.04DE**
Jasmine oil	0.00v	2.39q-s	3.58k-o	5.67e-g	11.67b	**4.66B**
Chitocan	0.00v	2.60o-s	4.86g-j	6.67d	9.33c	**4.69B**
Stritch film	0.00v	2.25q-s	3.06m-r	4.58h-k	6.00d-f	**3.18DE**
Wax	0.00v	2.46p-s	3.82k-n	4.99f-j	5.63e-g	**3.38D**
Hydrogen peroxide (H_2O_2)	0.00v	0.55uv	1.09tu	1.70st	2.31q-s	**1.13F**
Hot water	0.00v	2.07q-s	2.50p-s	4.54h-k	5.26f-i	**2.87E**
Control	0.00v	2.33q-s	4.33h-l	6.33de	13.67a	**5.33A**
Mean	**0.00E**	**2.10D**	**3.28C**	**4.81B**	**7.33A**	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test.

Decay percentage.

Generally, all used post-harvest treatments decreased decay percentage in cassava roots stored at 5°C or room temperature in the two tested experimental seasons as compared with control (non-treated roots). Data show that the lowest decay percentage was found under room temperature storage in roots treated with bio-health, jasmine oil, polyethylene film and wax in the first season, as well as calcium chloride bio-health and jasmine oil in the second season Tables (5 & 6). While under cold storage (5°C), the lowest decay percentage was recorded from bio-health and polyethylene in the first season as well as from bio-health and wax treatments in the second season (Tables 7 &8).

Regarding the interaction effect between post-harvest treatments and storage period on decay percentage, results show that the decay percentage was the lowest by most used post-harvest treatments until 15 days under room temperature and until 30 days under cold storage (5°C) in the two tested seasons. On the other side, control treatment gave the highest decay percentage under cold storage and room temperature in two tested seasons. The low decay percentage due to the used post-harvest treatment could be attributed to reduce respiration rate, marinating water content in roots, decreased fungus and bacterial population specially under cold storage. Our results are in the same line with those obtained by **Abd El-Hafeez (2013), Ismail (2015) and Abdel Gayed (2017).**

Table 5. Effect of some post-harvest treatments on decay % of cassava roots stored on room temperature during 2015/2016 season.

Treatment	0 Time	5 days	10 days	15 days	20 days	Mean
Ascorbic acid	1.00h	1.00h	1.00h	2.00f	2.67d	**1.53BC**
Chloride calcium ($CaCl_2$)	1.00h	1.00h	1.00h	1.00h	2.67d	**1.33D**
Bio-health	1.00h	1.00h	1.00h	1.00h	2.00f	**1.20E**
Jasmine oil	1.00h	1.00h	1.00h	1.00h	2.33e	**1.27DE**
Chitocan	1.00h	1.00h	1.00h	1.00h	2.67d	**1.33D**
Stritch film	1.00h	1.00h	1.00h	1.00h	2.33e	**1.27DE**
Wax	1.00h	1.00h	1.00h	1.00h	2.00f	**1.20E**
Hydrogen peroxide (H_2O_2)	1.00h	1.00h	1.00h	1.67g	2.67d	**1.47C**
Hot water	1.00h	1.00h	1.00h	2.00f	3.00c	**1.60B**
Control	1.00h	1.00h	2.67d	3.33b	4.33a	**2.47A**
Mean	**1.00D**	**1.00D**	**1.17C**	**1.50B**	**2.67A**	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test.

Table 6. Effect of some post-harvest treatments on decay (%) of cassava roots stored on room temperature during 2016/2017 season.

Treatment	0 Time	5 days	10 days	15 days	20 days	Mean
Ascorbic acid	1.00h	1.00h	1.00h	2.33f	3.00d	**1.67B**
Chloride calcium ($CaCl_2$)	1.00h	1.00h	1.00h	1.00h	3.00d	**1.40CD**
Bio-health	1.00h	1.00h	1.00h	1.00h	2.67e	**1.33D**
Jasmine oil	1.00h	1.00h	1.00h	1.00h	3.00d	**1.40CD**
Chitocan	1.00h	1.00h	1.00h	1.00h	3.33c	**1.47C**
Stritch film	1.00h	1.00h	1.00h	2.00g	3.33c	**1.67B**
Wax	1.00h	1.00h	1.00h	1.00h	3.33c	**1.47C**
Hydrogen peroxide (H_2O_2)	1.00h	1.00h	1.00h	2.00g	3.00d	**1.60B**
Hot water	1.00h	1.00h	1.00h	2.00g	3.33c	**1.67B**
Control	1.00h	1.00h	3.00d	4.33b	5.00a	**2.87A**
Mean	**1.00D**	**1.00D**	**1.20C**	**1.77B**	**3.30A**	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test

Table 7. Effect of some post-harvest treatments on decay (%) of cassava roots stored at5 °C temperature during 2015/2016 season.

Treatment	0 Time	10 days	20 days	30 days	40 days	Mean
Ascorbic acid	1.00j	1.00j	1.00j	2.00g	3.33c	**1.67C**
Chloride calcium ($CaCl_2$)	1.00j	1.00j	1.00j	1.00j	2.67e	**1.33F**
Bio-health	1.00j	1.00j	1.00j	1.00j	1.00j	**1.00I**
Jasmine oil	1.00j	1.00j	1.00j	1.00j	3.00d	**1.40E**
Chitocan	1.00j	1.00j	1.00j	1.00j	1.67h	**1.13H**
Stritch film	1.00j	1.00j	1.00j	1.00j	1.00j	**1.00I**
Wax	1.00j	1.00j	1.67h	1.00j	1.33i	**1.20G**
Hydrogen peroxide (H_2O_2)	1.00j	1.00j	1.00j	2.33f	3.33c	**1.73B**
Hot water	1.00j	1.00j	1.00j	1.67h	3.00d	**1.53D**
Control	1.00j	1.00j	3.33c	4.00b	4.67a	**2.80A**
Mean	**1.00D**	**1.00D**	**1.30C**	**1.60B**	**2.50A**	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test.

Table 8. Effect of some post-harvest treatments on decay (%) of cassava roots stored at 5°C temperature during 2016/2017 season.

Treatment	0 Time	10 days	20 days	30 days	40 days	Mean
Ascorbic acid	1.00g	1.00g	1.00g	1.67f	3.00c	**1.53C**
Chloride calcium ($CaCl_2$)	1.00g	1.00g	1.00g	1.00g	2.33d	**1.27E**
Bio-health	1.00g	1.00g	1.00g	1.00g	1.00g	**1.00G**
Jasmine oil	1.00g	1.00g	1.00g	1.00g	2.00e	**1.20F**
Chitocan	1.00g	1.00g	1.00g	1.00g	2.33d	**1.27E**
Stritch film	1.00g	1.00g	1.00g	1.00g	2.33d	**1.27E**
Wax	1.00g	1.00g	1.00g	1.00g	1.00g	**1.00G**
Hydrogen peroxide (H_2O_2)	1.00g	1.00g	1.00g	2.00e	3.33b	**1.67B**
Hot water	1.00g	1.00g	1.00g	2.00e	2.33d	**1.47D**
Control	1.00g	1.00g	2.00e	4.00a	3.00c	**2.20A**
Mean	**1.00D**	**1.00D**	**1.10C**	**1.47B**	**2.37A**	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test.

Dry matter:

As regard to the effect of some post-harvest treatments on dry matter content of cassava roots under room temperature, results presented in Tables (9 & 10) show that, the highest values were detected to calcium chloride, Chitosan and hydrogen peroxide in the two tested seasons. On the other side, the lowest values were recorded to control and hot water treatments in the two tested years in addition to bio-health in the first season.

Concerning, the effect of storage period on dry matter of cassava, data indicate that there were steady significant decrement in dry matter of roots with increasing storage period until the end of the storage period (20 days) under room temperature.

Regarding the effect of the interaction between the post-harvest treatments and storage period, results

show that non stored roots (control) of all tested treatments showed the highest values of interaction, in addition to roots stored for five days and treated with calcium chloride, jasmine oil, Chitosan, wax and hydrogen peroxide in the two tested seasons. Obtained results are in the same line with those found by **El-Sayed (2013), Oliveiro *et al*., (2014) and Bello and Badejo (2017)**.

Concerning dry matter in roots under cold storage (5°C), results in Tables (11 & 12) show that the highest dry matter content were obtained from roots treated with calcium chloride, Chitosan and hydrogen peroxide in the two tested seasons. On the other hand, the lowest values were given from hot water and control treatment with significant difference between them, in addition to bio-health and control in the second season. Data on the effect of the storage period show also that there were continuously significant decrement in dry matter content with increasing the storage period up to 40 days of storage in the two tested seasons.

Results indicate also that there were a significant effect for the interaction between the used post-harvest treatment and the storage on dry matter content in roots whereas, the highest values were detected to non-stored roots (0 time) for all tested treatments in the two tested seasons, in addition to those stored for 10 days and treated with calcium chloride, Chitosan and hydrogen peroxide in the first year. On the other side, the lowest values were shown from roots stored for forty days and treated with hot water in the first season and bio-health in the second season followed by control in the two seasons.

Table 9. Effect of some post-harvest treatments on dry matter percentages of cassava roots stored on room temperature during 2015/2016 season.

Treatment	0 Time	5 days	10 days	15 days	20 days	Mean
Ascorbic acid	41.33a	39.46bc	37.18ef	35.15gh	32.14j	**37.05C**
Chloride calcium ($CaCl_2$)	41.33a	41.26a	38.14de	37.15ef	35.24gh	**38.63A**
Bio-health	41.33a	38.11de	34.14hi	31.21jk	28.79m	**34.72E**
Jasmine oil	41.33a	40.23ab	38.17de	36.21fg	33.67i	**37.92B**
Chitocan	41.33a	41.08a	39.34bc	37.23ef	35.44g	**38.88A**
Stritch film	41.33a	39.15b-d	35.18gh	32.28j	30.12l	**35.61D**
Wax	41.33a	40.28ab	37.29ef	35.25gh	32.22j	**37.27C**
Hydrogen peroxide (H_2O_2)	41.33a	40.90a	39.05cd	37.36ef	35.51g	**38.83A**
Hot water	41.33a	35.81g	34.24hi	28.80m	27.62n	**33.56F**
Control	41.33a	37.15ef	35.48g	30.51kl	28.25mn	**34.55E**
Mean	**41.33A**	**39.34B**	**36.82C**	**34.12D**	**31.90E**	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test.

Table 10. Effect of some post-harvest treatments on dry matter of cassava roots stored on room temperature during 2016/2017 season.

Treatment	0 Time	5 days	10 days	15 days	20 days	Mean
Ascorbic acid	39.23a	38.49a-c	35.50e	33.45g-i	30.32m	**35.40B**
Chloride calcium ($CaCl_2$)	39.23a	39.21a	37.32cd	35.45e	33.45g-i	**36.93A**
Bio-health	39.23a	37.20d	34.17f-h	31.52kl	28.22n	**34.07D**
Jasmine oil	39.23a	38.59ab	35.34ef	33.65g-i	30.42lm	**35.45B**
Chitocan	39.23a	39.49a	37.43b-d	35.57e	33.59g-i	**37.06A**
Stritch film	39.23a	38.19a-d	35.19ef	32.55i-k	29.32m	**34.90C**
Wax	39.23a	38.95a	35.48e	33.47g-i	32.10jk	**35.85B**
Hydrogen peroxide (H_2O_2)	39.23a	39.12a	37.25d	35.67e	33.86gh	**37.02A**
Hot water	39.23a	34.51e-g	31.82jk	27.76n	24.88o	**31.64E**
Control	39.23a	35.08ef	32.95h-j	27.82n	25.19o	**32.05E**
Mean	**39.23A**	**37.88B**	**35.25C**	**32.69D**	**30.13E**	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test.

Table 11. Effect of some post-harvest treatments on dry matter of cassava roots stored at 5°C temperature during 2015/2016 season.

Treatment	0 Time	10 days	20 days	30 days	40 days	Mean
Ascorbic acid	41.33a	40.52bc	38.43f-i	33.43n	35.19kl	**37.78C**
Chloride calcium ($CaCl_2$)	41.33a	41.27ab	39.81c-e	38.73fg	37.19j	**39.67A**
Bio-health	41.33a	39.93cd	37.87g-j	35.87k	34.25mn	**37.85C**
Jasmine oil	41.33a	40.15cd	38.61f-h	37.53ij	35.34kl	**38.73B**
Chitocan	41.33a	41.32a	39.96cd	38.80fg	37.32j	**39.74A**
Stritch film	41.33a	40.22c	38.71fg	37.53ij	35.49kl	**38.66B**
Wax	41.33a	40.35bc	38.91f	37.73h-j	35.35kl	**38.74B**
Hydrogen peroxide (H_2O_2)	41.33a	41.29a	39.97cd	38.80fg	37.29j	**39.74A**
Hot water	41.33a	39.03ef	37.50ij	34.07mn	32.35o	**36.86E**
Control	41.33a	39.27d-f	37.71h-j	34.62lm	33.38n	**37.26D**
Mean	**41.40A**	**40.34B**	**38.75C**	**36.71D**	**35.31E**	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test.

Table 12. Effect of some post-harvest treatments on dry matter of cassava roots stored at 5°C temperature during 2016/2017 season.

Treatment	0 Time	10 days	20 days	30 days	40 days	Mean
Ascorbic acid	39.15a	38.20d	36.29fg	34.34kl	33.17n	**36.23CD**
Chloride calcium ($CaCl_2$)	39.15a	38.70bc	37.31e	36.35fg	35.39h	**37.38A**
Bio-health	39.15a	38.07d	36.00g	34.20l	32.07o	**35.90E**
Jasmine oil	39.15a	38.44b-d	36.39f	34.51j-l	33.74m	**36.45B**
Chitocan	39.15a	38.69bc	37.48e	36.49f	35.51h	**37.47A**
Stritch film	39.15a	38.27d	36.20fg	34.24l	33.51m	**36.27CD**
Wax	39.15a	38.37cd	36.37fg	34.37kl	33.60m	**36.37BC**
Hydrogen peroxide (H_2O_2)	39.15a	38.75b	37.45e	36.48f	34.84ij	**37.34A**
Hot water	39.15a	38.11d	36.10fg	34.67i-k	32.82n	**36.17D**
Control	39.15a	38.27d	36.30fg	34.93i	33.07n	**36.34BC**
Mean	**39.15A**	**38.39B**	**36.59C**	**35.06D**	**33.77E**	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test.

Starch percentage:-

As shown in Tables (13 & 14), the highest starch percentages were obtained from roots treated with Chitosan and hydrogen peroxide in the two tested years in addition to calcium chloride in the second season. On the other side, the lowest values were obtained from hot water and control treatments in the two tested seasons. As for the effect of storage period on starch percentage, results showed that generally, starch percentage decreased significantly in the first season by increasing the storage period. While, in the second season, it increased until 10 days from storage and then decreased until the end of the storage period (20 days) as found by **Ismail (2015)** who found similar results.

As regards to the interaction effect, results showed that, the highest values of starch percentage were obtained from all tested treatments in the first season at 5 °C time, while roots treated with calcium chloride, jasmine oil, Chitosan, polyethylene film and hydrogen peroxide and stored for 5 days gave the highest values (Tables, 15 & 6) The lowest values of starch percentage were obtained from hot water and control treatments with significant difference between them in both experimental seasons. The results agree with those of **El-Sayed *et al.*, (2013), Ezeotha and Oti (2013) and Abd El-Hafeez (2014).**

Regarding to the effect of the used post-harvest treatments on starch content under cold storage at 5°C, results show that the highest values were observed from roots treated with calcium chloride, Chitosan and hydrogen peroxide in the two seasons. On the other side the lowest values were obtained from control and hot water in the two tested seasons.

As respect to the effect of storage period on starch percentage under low temperature, results indicate that it decreased significantly with increasing the storage period in the first year, while in the second season it increased up to 10 days the then decreased until the end of the storage period.

Respecting the interaction effect, the highest values were obtained from all tested treatments in either non stored roots and those stored for 10 days except those treated with hot water and control and stored for ten days in the two tested years. Moreover, the lowest value of interaction effect were detected to control roots and those treated with hot water and stored for 40 days in the two tested years with significant difference between them in the second season.

Table 13. Effect of some post-harvest treatments on starch (%) of cassava roots stored on room temperature during 2015/2016 season.

Treatment	0 Time	5 days	10 days	15 days	20 days	Mean
Ascorbic acid	27.97a	25.57f-h	25.23kl	22.93p	20.11r-t	**24.56D**
Chloride calcium	27.97a	27.33bc	26.80d-f	26.00ij	24.87mn	**26.59B**
Bio-health	27.97a	25.70j	24.10o	21.43q	18.87v	**23.61E**
Jasmine oil	27.97a	26.68e-g	25.37k	23.10p	20.44r	**24.71C**
Chitocan	27.97a	27.50b	27.10cd	26.24hi	24.99lm	**26.76A**
Stritch film	27.97a	26.47f-h	25.34kl	23.03p	20.00s-u	**24.56D**
Wax	27.97a	26.23hi	25.13k-m	22.89p	19.85tu	**24.42D**
Hydrogen peroxide	27.97a	27.40bc	26.95de	26.42gh	25.01k-m	**26.75A**
Hot water	27.97a	24.63n	22.73p	19.70u	17.20x	**22.45G**
Control	27.97a	24.83mn	22.90p	20.28rs	17.55w	**22.70F**
Mean	**27.97A**	**26.33B**	**25.17C**	**23.20D**	**20.89E**	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test.

Table 14. Effect of some post-harvest treatments on starch (%) of cassava roots stored on room temperature during 2016/2017 season.

Treatment	0 Time	5 days	10 days	15 days	20 days	Mean
Ascorbic acid	26.77h-j	29.07bc	26.27kl	24.90op	22.43t	**25.89C**
Chloride calcium	26.77h-j	29.40ab	28.27e	27.33fg	25.57n	**27.47A**
Bio-health	26.77h-j	28.20e	26.03lm	23.14s	20.18w	**24.86D**
Jasmine oil	26.77h-j	29.17a-c	26.33j-l	25.10o	22.27t	**25.93BC**
Chitocan	26.77h-j	29.53a	28.43de	27.47f	25.73mn	**27.59A**
Stritch film	26.77h-j	29.17a-c	27.03gh	25.00o	22.53t	**26.10B**
Wax	26.77h-j	28.80cd	26.87hi	24.53p	22.33t	**25.86C**
Hydrogen peroxide	26.77h-j	29.27ab	28.50de	27.53f	25.81mn	**27.58A**
Hot water	26.77h-j	26.00lm	24.00r	21.07v	18.14y	**23.19F**
Control	26.77h-j	26.50i-k	24.20qr	21.51u	18.74x	**23.54E**
Mean	**26.77B**	**28.51A**	**26.59C**	**24.76D**	**22.37E**	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test.

Table 15. Effect of some post-harvest treatments on starch (%) of cassava roots stored at 5°C temperature during 2015/2016 season.

Treatment	0 Time	10 days	20 days	30 days	40 days	Mean
Ascorbic acid	27.97a	27.53a-c	26.07gh	24.13mn	21.67r	**25.47B**
Chloride calcium ($CaCl_2$)	27.97a	27.77ab	26.83ef	25.73h-j	24.77l	**26.51A**
Bio-health	27.97a	27.06c-e	25.30jk	21.97r	19.73u	**24.40C**
Jasmine oil	27.97a	27.47a-d	25.60h-j	23.57op	22.60q	**25.44B**
Chitocan	27.97a	27.87a	26.93e	25.83hi	24.93kl	**26.71A**
Stritch film	27.97a	27.33b-e	25.67h-j	23.73n-p	22.83q	**25.51B**
Wax	27.97a	27.13c-e	25.37i-k	23.50p	22.60q	**25.31B**
Hydrogen peroxide (H_2O_2)	27.97a	27.93a	27.00de	25.67h-j	24.07mn	**26.53A**
Hot water	27.97a	26.00gh	24.00m-o	20.33t	18.30v	**23.32E**
Control	27.97a	26.40fg	24.23m	20.83s	18.67v	**23.62D**
Mean	**27.97A**	**27.25B**	**25.70C**	**23.53D**	**22.02E**	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test.

Table 16. Effect of some post-harvest treatments on starch (%) of cassava roots stored at 5°C temperature during 2016/2017 season.

Treatment	0 Time	10 days	20 days	30 days	40 days	Mean
Ascorbic acid	30.10a	29.60bc	28.00g	26.00j	24.13no	**27.57B**
Chloride calcium ($CaCl_2$)	30.10a	29.77ab	29.03d-f	28.13g	26.73hi	**28.75A**
Bio-health	30.10a	29.27c-e	27.13h	25.03l	22.53p	**26.81C**
Jasmine oil	30.10a	29.63a-c	28.13g	26.13j	24.27no	**27.65B**
Chitocan	30.10a	29.83ab	28.90ef	28.03g	26.60i	**28.69A**
Stritch film	30.10a	29.43b-d	27.87g	25.93j	24.10no	**27.49B**
Wax	30.10a	29.50bc	27.87g	25.47k	24.70lm	**27.53B**
Hydrogen peroxide (H_2O_2)	30.10a	29.73ab	29.00ef	28.13g	26.77hi	**28.75A**
Hot water	30.10a	28.67f	26.67i	23.87o	19.63r	**25.79E**
Control	30.10a	28.90ef	26.97hi	24.43mn	21.07q	**26.29D**
Mean	**26.77B**	**29.43A**	**27.96C**	**26.12D**	**24.05E**	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test.

Phenols content in roots:-

Phenols content is one of the very important defense components in plants against diseases. Results in Tables (17, 18, 19 & 20) show clearly that the highest phenols content was obtained from roots treated with ascorbic acid in the two tested seasons. On the other side, the lowest values were obtained from those treated with hot water and control in the two tested years with significant difference between them in the first season. Regarding the effect of the storage period on phenolic compounds, it decreased significantly with increasing the storage period under even room temperature or cold storage (5°C).

Results of the interaction show that the highest values were detected to non- stored roots (0 time) under all used post-harvest treatments. On the other side, the lowest values of interaction were obtained from non-stored roots and hot water treatment after 20 or 40 days of storage under both room temperature and cold storage at 5°C respectively. Similar results were obtained by **Aguayo *et al.*, (2017).**

Table 17. Effect of some post-harvest treatments on phenols of cassava roots stored on room temperature during 2015/2016 season.

Treatment	0 Time	5 days	10 days	15 days	20 days	Mean
Ascorbic acid	10.35a	9.97b	9.17ef	8.00m	6.97r	**8.89A**
Chloride calcium ($CaCl_2$)	10.35a	9.80b	9.00fg	7.87m-o	6.73s	**8.75B**
Bio-health	10.35a	9.00fg	7.93mn	6.77s	5.63v	**7.94E**
Jasmine oil	10.35a	9.40cd	8.53jk	7.53q	6.10u	**8.38D**
Chitocan	10.35a	9.50c	8.73hi	7.73op	6.53t	**8.57C**
Stritch film	10.35a	9.30de	8.33l	7.50q	6.53t	**8.40D**
Wax	10.35a	9.30de	8.40kl	7.47q	6.47t	**8.40D**
Hydrogen peroxide (H_2O_2)	10.35a	9.53c	8.67ij	7.77no	6.53t	**8.57C**
Hot water	10.35a	8.73hi	7.57pq	6.03u	5.03x	**7.54G**
Control	10.35a	8.87gh	7.73op	6.33t	5.33w	**7.72F**
Mean	**10.35A**	**9.34B**	**8.41C**	**7.30D**	**6.19E**	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test.

Table 18. Effect of some post-harvest treatments on phenols of cassava roots stored on room temperature during 2016/2017 season.

Treatment	0 Time	5 days	10 days	15 days	20 days	Mean
Ascorbic acid	12.20a	11.37b	11.00c	9.60i	8.87m	**10.61A**
Chloride calcium ($CaCl_2$)	12.20a	11.10c	10.47e-g	9.60i	8.50n	**10.37B**
Bio-health	12.20a	10.73d	9.47ij	7.80p	5.83s	**9.21F**
Jasmine oil	12.20a	11.00c	10.33fg	9.00lm	7.73pq	**10.05D**
Chitocan	12.20a	11.20bc	10.27gh	9.40ij	8.27no	**10.27C**
Stritch film	12.20a	10.73d	10.23gh	9.23j-l	7.57pq	**9.99DE**
Wax	12.20a	10.60de	10.03h	9.13kl	7.53q	**9.90E**
Hydrogen peroxide (H_2O_2)	12.20a	11.13bc	10.30fg	9.47ij	8.23o	**10.27C**
Hot water	12.20a	10.40e-g	9.00lm	7.20r	5.00t	**8.76G**
Control	12.20a	10.53d-f	9.27jk	7.10r	5.20t	**8.86G**
Mean	**12.20A**	**10.88B**	**10.04C**	**8.75D**	**7.27E**	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test.

Table 19. Effect of some post-harvest treatments on phenols of cassava roots stored at °C temperature during 2015/2016 season.

Treatment	0 Time	10 days	20 days	30 days	40 days	Mean
Ascorbic acid	10.35a	10.10ab	9.40ef	8.40k-m	7.50rs	**9.15A**
Chloride calcium ($CaCl_2$)	10.35a	9.93bc	9.23fg	8.13m-o	7.27st	**8.98B**
Bio-health	10.35a	9.23fg	8.27l-n	7.17tu	5.87x	**8.18G**
Jasmine oil	10.35a	9.67c-e	8.87hi	7.80pq	6.90uv	**8.72D**
Chitocan	10.35a	9.83bc	9.00gh	8.00n-p	7.13tu	**8.86C**
Stritch film	10.35a	9.53de	8.67i-j	7.60qr	6.77vw	**8.58EF**
Wax	10.35a	9.47ef	8.53j-l	7.50rs	6.60w	**8.49F**
Hydrogen peroxide (H_2O_2)	10.35a	9.77cd	8.80h-j	7.63qr	6.83vw	**8.68DE**
Hot water	10.35a	8.93hi	7.87o-q	6.60w	5.40y	**7.83I**
Control	10.35a	9.07gh	8.10no	6.73vw	5.53y	**7.96H**
Mean	**10.35A**	**9.55B**	**8.67C**	**7.56D**	**6.58E**	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test.

Table 20. Effect of some post-harvest treatments on phenols of cassava roots stored at °C temperature during 2016/2017 season.

Treatment	0 Time	10 days	20 days	30 days	40 days	Mean
Ascorbic acid	12.20a	11.70b	11.20ef	10.20j	9.27m	**10.91A**
Chloride calcium ($CaCl_2$)	12.20a	11.40c-e	10.87gh	9.83k	8.80n	**10.62C**
Bio-health	12.20a	11.07fg	9.93k	8.10p	6.10r	**9.48E**
Jasmine oil	12.20a	11.27d-f	10.67hi	9.50l	8.33o	**10.39D**
Chitocan	12.20a	11.47b-d	10.83g-i	9.70kl	8.77n	**10.59C**
Stritch film	12.20a	11.17ef	9.90k	8.03p	6.03r	**9.47E**
Wax	12.20a	11.17ef	9.83k	8.03p	6.17r	**9.48E**
Hydrogen peroxide (H_2O_2)	12.20a	11.50b-d	11.53bc	9.80k	8.77n	**10.76B**
Hot water	12.20a	10.20j	8.07p	6.07r	4.17t	**8.14G**
Control	12.20a	10.60i	8.77n	6.67q	5.03s	**8.65F**
Mean	**12.20A**	**11.15B**	**10.16C**	**8.59D**	**7.14E**	

Values with the same capital letters in the column and the row are not statistically different. The same small letters in the interaction are not statistically different, according to Duncan's Multiple Range test.

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تأثير بعض معاملات ما بعد الحصاد على الجودة والقدرة التخزينية لجذور الكسافا

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١– قسم البساتين – كلية الزراعة – جامعة بنها.
٢– معهد بحوث البساتين – مركز البحوث الزراعية.

اجريت هذه الدراسة خلال الموسمين ٢٠١٥و٢٠١٦ فى قسم تدوال الخضر بمعهد البساتين التابع لمركز البحوث الزراعية وذلك لدراسة تاثير بعض معاملات مابعد الحصاد على الجودة والقدرة التخزينية للكسافا (الصنف الاندونيسي) تم حصاد الجذور المنزرعة من تربة رملية فى منتصف يناير فى موسمى الدراسة وقد تم تقسيم الجذور الى مجموعتين كل مجموعة مكونة من ١٠ معاملات وهى معاملة الجذور بغمسها فى حمض الاسكوربيك بتركيز ١% لمدة ٥دقائق و كلوريد الكالسيوم بتركيز ١% لمدة ٥دقائق وبيوهليث بتركيز ١% لمدة ٥دقائق و زيت الياسيمين بتركيز ١% لمدة ٥دقائق والشيتوسان بتركيز ١% لمدة ٥دقائق اوتغليف الجذور فى البولى بروبلين بسمك ٣٠ميكرون وشمع البرافين بتركيز ١% لمدة ٥دقائق وفوق اكسيد الهيدروجين بتركيز ١% لمدة ٥دقائق والماء الساخن (٥٥°م)بالاضافة للكنترول وكل معاملة مكررة ٣مكررات وكل مكرة تحتوى على ٣جذور حيث تم تجفيف الجذور بعد الغمس وتعبئتها فى كراتين ورق سعتها ٥كجم وتم تخزينها على درجة حرارة الغرفة ورطوبة نسبية ٩٠–٩٥%وكذلك تخزينها فى ثلاجات على درجة حرارة ٥°م ورطوبة نسبية ٩٠–٩٥% ثم فرز الجذور كل ٥ ايام فى درجة حرارة الغرفة وكل ١٠ ايام فى الثلاجات . وقد اظهرت النتائج المتحصل عليها ان غمس جذور الكسافا فى جميع المواد المستخدمة ادى الى زيادة القدرة التخزينية وصفات الجودة للجذور بالمقارنة بالكنترول . وفى هذا الخصوص تفوقت معاملة غمس الجذور فى محلول فوق اكسيد الهيدروجين بتركيز ١% لمدة ٥دقائق الى الحصول على اقل فقد للوزن واقل نسبة تالف واقل نسبة فينولات واعلى نسبة مادة جافة ونشا سواء عند التخزين فى درجة حرارة الغرفة او فى درجة حرارة منخفضة.

الكلمات الدالة:– الكسافا – القدرة التخزينية – الفقد فى الوزن– نسبة التلف– المكونات الكيميائية للجذور.