EFFECT OF STORAGE CONDITION AND PACKAGE TYPE ON THE QUALITY OF GARLIC DURING STORAGE

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ABSTRACT

The main aim of this work was to study the effect of storage system (cold, ventilated and traditional) and package type on the quality of garlic during storage. The results indicated that, the total accumulated weight loss increases with increasing the storage period. Storage system had a great effect on the losses, where, the traditional storage system recorded was 36.89 % compared with 11.47 and 12.33 % for the garlic stored in the cold and ventilated systems. The garlic stored in plastic bags recorded the highest accumulated weight loss (14.00%) when stored at ventilated storage system while the same package recorded the lowest weight losses (9.75%) when stored in the cold storage. The highest value of accumulated moisture loss (7.30%) was recorded by the garlic bulbs stored in clothes bags, while the lowest value of accumulated moisture loss (5.18%) was recorded for the garlic stored in plastic bags. Sprouting percent ranged from 14.00 to 21.79 % where the cold storage system recorded the lowest percentage, and the traditional system recorded the highest sprouting. Sprouting ranged from 17.53 to 24.86 % at ventilated system storage. The highest value of empty blubs percentage of garlic (11.03 %) was recorded by the garlic bulbs stored in plastic bags under ventilated storage system, while the lowest value of empty blubs percentage of garlic (2.15 %) was recorded for the garlic stored in plastic bags under cold storage system.

Keywords: *garlic storage – ventilated storage– cold storage – sprouting – empty bulbs - chemical composition*

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1. INTRODUCTION

Garlic (*Allium sativum L.*) is one of the most important vegetables throughout the world with a total harvested area of 1437.690 ha and an annual production of 24255.303 tons of dry bulbs **(FAO, 2013)**. The importance of garlic is due to its use not only for culinary but also for therapeutic and medicinal purposes in both traditional and modern medicine. It is consumed either as raw vegetable (fresh leaves or dried cloves), or after processing in the form of garlic oil, garlic extracts and garlic powder with differences in chemical composition and bioactive compounds content between the various forms **(Lanzotti *et al.*, 2014)**. Storage time is an involved and pivotal functional determinant for the garlic bioactive properties. As previously highlighted, antioxidant capacity of garlic cloves was maximum after 8 weeks of storage at 20 ± 2 °C, whereas for organosulfur compounds and polyphenols, the maximum content was observed between 6 and 8 weeks of storage, followed by a significant decrease after that time period **(Fei *et al.*, 2015)**. **Cantwell (2004)** has pointed out that garlic can be stored at room temperature (20 – 30 °C) for 1 or 2 months. However, the bulbs eventually lose their firmness and become spongy and discolored due to water loss. Dormancy ends quickly in garlic stored at temperatures between 5 and 18 °C; the optimum temperature is from -1 to 0 °C. White and purple garlic is harvested in the Bajio region of Mexico from February to August and then stored at room temperature. A complete study of quality changes under different conditions and how these conditions interact to determine the shelf life of the product has been lacking, nor have objective parameters to predict shelf life been determined. Six batches of 360 bulbs of garlic (*Allium sativum L.*) cv. Perla were stored for 190 days at 0 °C and 70% relative humidity (RH), 5, 20, 30 °C, and at room temperature (RT) (17.7 ± 7 °C). The weight loss, subjective firmness of the bulbs, clove penetration resistance, hue value, internal sprouting index, soluble solids and dry matter content of the cloves were recorded periodically. The weight loss and internal sprouting index had a negative correlation on the subjective firmness, penetration resistance, and hue of the cloves. Storage at 5, 20 °C, and RT induced sprouting, and subsequent growth influenced a loss of firmness and color. Complete sprouting (>100%) induced a weight loss of 9–11% at these temperatures. To maintain an

adequate safety margin for marketing, we propose an internal sprouting index of 50% to determining the effective shelf life of garlic cv. 'Perla'. In accordance with this criterion and in conditions studying, shelf life at 0 °C was 155 days; at 5 °C and RT it was 80 days; and at 20 °C it was 60 days. These results lead us to conclude that it is possible to estimate the shelf life of garlic using the internal sprouting index **(Vázquez-Barrios *et al.*, 2006)**. **Veríssimo *et al.* (2010)** observed that the antioxidant potential of garlic decreases, with the increasing temperature. Furthermore, **Atashi *et al.*, (2011)** by assessing the variations on the chlorophyll, carbohydrates, amylase and invertase enzymes contents in garlic under low temperatures, they observed qualitative and quantitative differences on the sugar contents of garlic, which consequently stimulated its sprouting. Garlic losses during storage represent a great loss on the national level and affects the price stability during the year, which are due to weight losses, sprouting and emptiness of bulbs, therefore, the main aim of this study is to reduce/minimize these losses, this will be achieved by studying the effect of storage condition and package type on these losses during storage.

2. MATERIALS AND METHODS

The main objective of the present study is to study the effect of storage conditions and package type on the quality of garlic during storage. The experiment was carried out at Agricultural and Bio-Systems Engineering Department Faculty of Agriculture Moshtohor, Benha University, Egypt, during 2017 season.

2.1. Materials:

2.1.1. Garlic:

The garlic was brought from the local market, at the beginning of the season, 2017.

2.1.2. Storage conditions:

The garlic blubs were stored using different systems as follows:-

- **Traditional system.**

Garlic was placed in pile and left in the open field Two hundred kilograms. (200 kg) garlic cloves were folded into a pile.

- **Ventilated storage system.**

Garlic was folded into different packages in room was air at ambient temperature. Air blower (Model C.C.P. Parma – Flow Rate 110 L

h^{-1} – RPM 2800 – Power 300 W 220V 50Hz, Italy) for moving air in the system.

- **Cold system.**

Garlic was folded into different packages in refrigeration room. Refrigeration room used in this study has dimensions of 3.0 m length, 3.0 m in width and 3.0 m height. It made of prefabricated insulated panels of thickness of 60 mm. The panels insulation are covered with precoated stainless steel sheet on both sides. Cooling unit (Model Egypt Nile – Range temperature 0 – 40 °C – RPM 2800 – Power 2 hp 380V 50Hz, Italy) for control air temperature and mist system increasing relative humidity of air.

2.2.3. Package types:

The garlic was stored at three different package types as follows: -

1. **Perforated cardboard.**

2.0 kg garlic was folded into a perforated cardboard package. The dimensions of perforated cardboard package are 30 cm long, 20 m wide and 20 cm high.

2. **Plastic.**

2.0 kg garlic was folded into a plastic package. The volume of plastic package is 10 L.

3. **Clothes.**

2.0 kg garlic was folded into a clothes package. The volume of clothes package is 10 L.

2.2. Methods:

2.2.1. Experimental design:

The treatments were arranged in a split plot design in three replications. Table (1) shows the experimental design.

Table (1): The experimental design.

Variables	Levels	Variables Levels
Storage conditions	3	Traditional system
		Ventilated system
		Cold system
Package types	3	Perforated cardboard
		Plastic
		Clothes

2.2.2. Measurements:

Temperature and relative humidity readings were recorded every hour at various locations in the storage systems. Temperature and relative humidity were recorded by using a HOBO Data Logger (Model HOBO U12 Temp/RH/Light-Range -20 to 70°C and 5 to 95% RH, USA). Garlic samples were taken randomly from different systems every 10 days to determine the total weight losses.

Samples were taken monthly to determine the moisture loss. Garlic samples were weighed every 10 day during storage. Garlic samples were dried using drying oven at 105 °C until a constant weight was obtained. The moisture content was calculated as follows:

$$MC = \frac{M_{wet} - M_{dry}}{M_{dry}} \times 100 \quad (1)$$

Where:

MC is the moisture content (% wb)

M_{wet} is the wet mass (kg)

M_{dry} is the dry mass (kg)

Garlic sprouting and empty bulbs percentages were determined by the end of storage period. Total contents of macro elements were evaluated after being digested according to **Chapman and Partt (1961)**. Nitrogen was determined by Kjeldahl digestion apparatus **(Bremmer and Mulvaney, 1982)**. Potassium, calcium and magnesium were determined by Photofatometer (Model Jenway PFP7 – Range 0 - 160 mmol L^{-1}, USA) and phosphorus (P) was determined colorimetrically following the **Murphy and Riley (1962)** method. Protein, fat, fibers and ash content were determined according to the method of **AOAC (1990)**.

3. RESULTS AND DISCUSSION

3.1. Storage conditions:

Figures (1 and 2) show the average of temperature and relative humidity for the storage systems (cold, ventilated and traditional) under study. The average temperature ranged from 4.0 to 5.8, 30.0 to 33.2 and 18.4 to 34.8 °C for the cold storage, ventilated and traditional storage systems, respectively. It can be seen that the temperature in the traditional system

fluctuated from 34 °C during the day time to less than 18 °C during the night time. The relative humidity values ranged from 25.3 to 61.1, 43.2 to 58.7 and 26.1 to 99.8 %, for the same pervious order during the storage period.

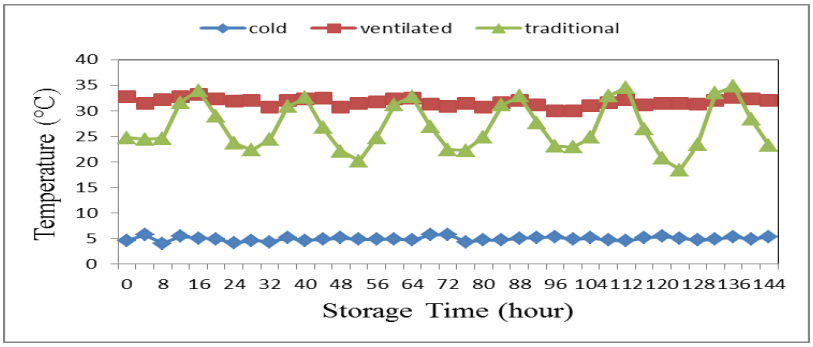

Figure (1): The average temperature for the storage systems.

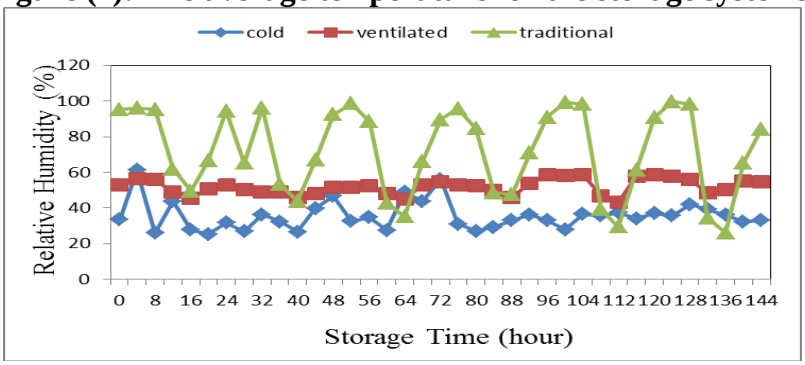

Figure (2): The average relative humidity for the storage systems.

3.2. Effect of storage conditions and packaging type on the accumulated losses of garlic moisture during the storage:

Table (2) shows the effect of different storage conditions (cold, ventilated and traditional) and different packages (clothes, plastic and perforated cardboard) on the accumulated moisture loss of garlic during the storage. The results indicated that the accumulated moisture loss of garlic increases with increasing storage period. It could be seen the accumulated moisture loss increased from 1.06 to 7.30, 1.05 to 7.22 and 0.97 to 6.79 % for garlic stored in clothes, plastic and cardboard packages, respectively under the cold storage system, when the storage time increased from 1 to 6 months.

Table (2): The effect of different storage conditions and different packages on the accumulated moisture loss of garlic during the storage.

Storage Time (month)	Storage System						
	Cold Storage			Ventilated Storage			Traditional
	Clothes	plastic	Cardboard	Clothes	Plastic	cardboard	
	Accumulated Moisture Losses, %						
1	1.06	1.05	0.97	0.89	1.08	0.83	0.69
2	2.21	2.33	2.18	1.71	1.64	1.89	1.38
3	3.85	3.80	3.47	2.85	2.46	2.63	2.17
4	5.14	5.05	4.95	3.55	3.29	3.62	2.81
5	6.35	6.18	5.64	4.43	4.22	4.42	3.78
6	7.30	7.22	6.79	5.25	5.18	5.38	4.39

In the ventilated system, the accumulated moisture loss increased from 0.89 to 5.25, 1.08 to 5.18 and 0.83 to 5.38 % for garlic stored in clothes, plastic and cardboard packages, respectively, when the storage time increased from 1 to 6 months. The accumulated moisture loss increased from 0.69 to 4.39 % for the garlic stored in the traditional system, when the storage time increased from 1 to 6 months. The results also indicate that the accumulative moisture loss of garlic during storage was increased in cold storage system more than those of room temperature system and traditional system. It could be seen that the accumulated moisture losses of garlic were 7.30, 7.22 and 6.79 % for garlic stored in clothes, plastic and cardboard packages, respectively, at the end of period storage under the cold storage system. While, the accumulated moisture losses of garlic were 5.25, 5.18 and 5.38 % for garlic stored in clothes, plastic and cardboard packages, respectively, at the end of period storage under the ventilated storage system. The moisture content is considered one of the most important factors in maintaining product quality. The rate of water loss from the commodities depends upon the water pressure deficit between the commodity and the surrounding ambient air, which is influenced by the temperature and relative humidity. Concerning the effect of package type, under the cold storage system, the highest value of accumulated moisture loss (7.30 %) was recorded by the garlic bulbs stored in clothes bags while the lowest value of accumulated moisture loss (6.79 %) was recorded for the garlic stored in perforated cardboard

bags. At the ventilated storage system, the highest value of accumulated moisture loss (5.38 %) was recorded by the garlic bulbs stored in perforated cardboard bags while the lowest value of accumulated moisture loss (5.18 %) was recorded for the garlic stored in plastic bags. Regression analysis was carried out to find a relation between the accumulated moisture loss and both storage systems and packages type. Equation (2) shows the most appropriate form for the relationship between the accumulated moisture losses as a function of storage period under different packages type at different storage systems. The constants of these equations and coefficient of determination are listed in Table (3).

$$ML = a + \mathrm{bT} \qquad (2)$$

Where:-

WL is the accumulated moisture loss of garlic (%)

T is the storage period (month)

Table (3): The constants a, b and coefficient of determination for accumulated moisture loss at the different storage systems and the different packages type.

Storage System	Packages Type	Constants		R^2
		A	b	
Cold Storage	Clothes	-0.173	1.283	0.993
	Plastic	-0.093	1.247	0.996
	Carton	-0.096	1.170	0.991
Ventilated Storage	Clothes	0.047	0.876	0.996
	Plastic	0.071	0.831	0.992
	Carton	-0.005	0.895	0.998
Traditional Storage		-0.097	0.753	0.997

3.3. Effect of storage conditions and packaging type on the accumulated weight losses of garlic during the storage:

Table (4) shows the effect of different storage conditions (cold, ventilated and traditional) and different packages (clothes, plastic and perforated cardboard) on the accumulated weight loss of garlic during the storage. The results indicated that the accumulated weight loss of garlic increases with increasing storage period. It could be seen the accumulated weight loss increased from 0.35 to 13.75, 0.15 to 9.75 and 0.50 to 10.90 % for garlic stored in clothes, plastic and cardboard packages, respectively

under the cold storage system, when the storage time increased from 10 to 160 days. In the ventilated system, the accumulated weight loss increased from 0.70 to 12.15, 0.65 to 14.00 and 0.75 to 10.50 % for garlic stored in clothes, plastic and cardboard packages, respectively, when the storage time increased from 10 to 160 days. The accumulated weight loss increased from 2.47 to 36.89 % for the garlic stored in the traditional system, when the storage time increased from 10 to 160 days. Generally, the higher storage temperature, the higher vapor pressure deficit, the higher weight losses of fruits. These results were in agreement with those obtained by **Khater and Bahnasawy (2016)**.

Table (4): The effect of different storage conditions and different packages on the accumulated weight loss of garlic during the storage.

Storage Time (day)	Storage System						
	Cold Storage			Ventilated Storage			Traditional
	clothes	plastic	Cardboard	clothes	plastic	cardboard	
	Accumulated Weight Losses, %						
10	0.35	0.15	0.50	0.70	0.65	0.75	2.47
20	0.75	0.50	1.00	1.25	1.15	1.10	4.91
30	1.25	0.75	1.60	1.75	1.85	1.60	7.32
40	1.90	1.15	2.00	2.50	2.50	2.15	9.71
50	2.65	1.65	2.60	3.00	3.35	2.65	12.08
60	3.15	2.10	3.00	3.60	4.15	3.25	14.43
70	3.90	2.65	3.60	4.35	5.10	3.85	16.77
80	4.75	3.85	4.10	5.00	5.85	4.35	19.09
90	5.75	4.35	4.85	5.75	6.65	4.90	21.39
100	6.85	5.35	5.50	6.65	7.75	5.75	23.66
110	7.75	5.90	6.25	7.60	8.50	6.50	25.92
120	9.00	6.50	7.10	8.60	9.65	7.35	28.15
130	10.35	7.10	8.10	9.60	10.65	8.10	30.36
140	11.00	7.85	8.75	10.35	11.65	8.75	32.56
150	12.60	8.75	10.00	11.25	12.65	9.60	34.73
160	13.75	9.75	10.90	12.15	14.00	10.50	36.89

Concerning the effect of package type, under the cold storage system, the highest value of accumulated weight loss (13.75 %) was recorded by the garlic bulbs stored in clothes bags while the lowest value of accumulated

weight loss (9.75 %) was recorded for the garlic stored in plastic bags. At the ventilated storage system, the highest value of accumulated weight loss (14.00 %) was recorded by the garlic bulbs stored in plastic bags while the lowest value of accumulated weight loss (10.50 %) was recorded for the garlic stored in carton (perforated cardboard) bags. This trend was in agreement with the results obtained by **Bahnasawy and Dabee (2006)**.

Regression analysis was carried out to find a relation between the accumulated weight loss and both storage systems and packages type. Equation (3) shows the most appropriate form for the relationship between the accumulated weight losses as a function of storage period under different packages type at different storage systems. The constants of these equations and coefficient of determination are listed in Table (5).

$$WL = a + bT \quad (3)$$

Where:-

WL is the accumulated weight loss of garlic (%)

T is the storage period (day)

Table (5): The constants a, b and coefficient of determination for accumulated weight loss at the different storage systems and the different packages type.

Storage System	Packages Type	Constants		R^2
		A	b	
Cold Storage	Clothes	-1.711	0.091	0.978
	Plastic	-1.284	0.065	0.984
	Carton	-0.769	0.068	0.980
Ventilated Storage	Clothes	-0.708	0.078	0.990
	Plastic	-0.938	0.089	0.993
	Carton	-0.483	0.065	0.989
Traditional Storage		0.523	0.229	0.999

3.4. Effect of storage systems and packaging type on the garlic sprouting during the storage:

Figure (3) shows the effect of different storage systems (cold, ventilated and traditional) and different packages (clothes, plastic and perforated cardboard) on the sprouting percentage of garlic during the storage. The results indicated that the garlic sprouting were 21.79 ± 2.25, 14.62 ± 2.09 and 14.00 ± 3.07 % for garlic stored in clothes, plastic and cardboard

packages, respectively under the cold storage system at the end of period storage. In the ventilated storage, the garlic sprouting were 17.53 ± 3.07, 24.86 ± 2.44 and 18.16 ± 1.81 % for garlic stored in clothes, plastic and cardboard packages, respectively, while, it was 20.63 ± 5.97 % for garlic stored under traditional system.

Concerning the effect of package type, under the cold storage system, the highest value of sprouting percentage of garlic (21.79 %) was recorded by the garlic bulbs stored in clothes bags while the lowest value of sprouting percentage of garlic (14.00 %) was recorded for the garlic stored in perforated cardboard bags. At the ventilated storage system, the highest value of sprouting percentage of garlic (24.86 %) was recorded by the garlic bulbs stored in plastic bags while the lowest value of sprouting percentage of garlic (17.53 %) was recorded for the garlic stored in clothes bags.

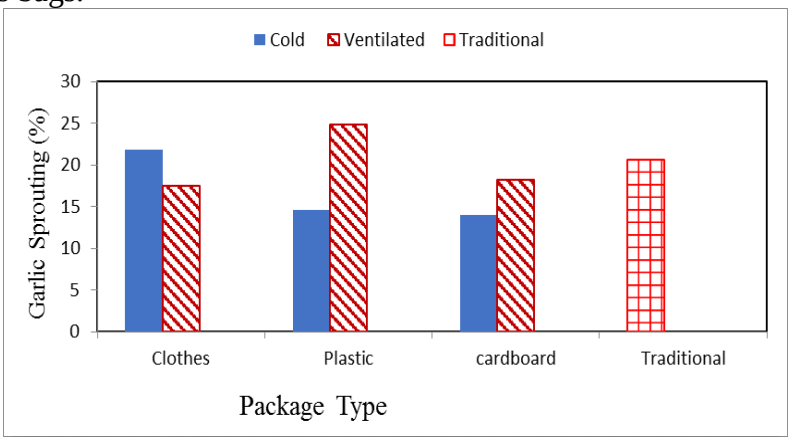

Figure (3): The effect of different storage systems and different packages on the sprouting of garlic during the storage.

3.5. Effect of storage systems and packaging type on the garlic empty bulb percentage during the storage:

Figure (4) show the effect of different storage systems (cold, ventilated and traditional) and different packages (clothes, plastic and perforated cardboard) on the empty blub percentage of garlic during the storage. The results indicated that the garlic empty were 2.39 ± 0.82, 2.15 ± 0.89 and 3.18 ± 0.72 % for garlic stored in clothes, plastic and cardboard packages, respectively under the cold storage system at the end of period storage. In the ventilated storage, the garlic empty were 8.80 ± 1.32, 11.03 ± 1.26

and 10.25 ± 1.37 % for garlic stored in clothes, plastic and cardboard packages, respectively, while, it was 7.92 ± 1.05 % for garlic stored under traditional system.

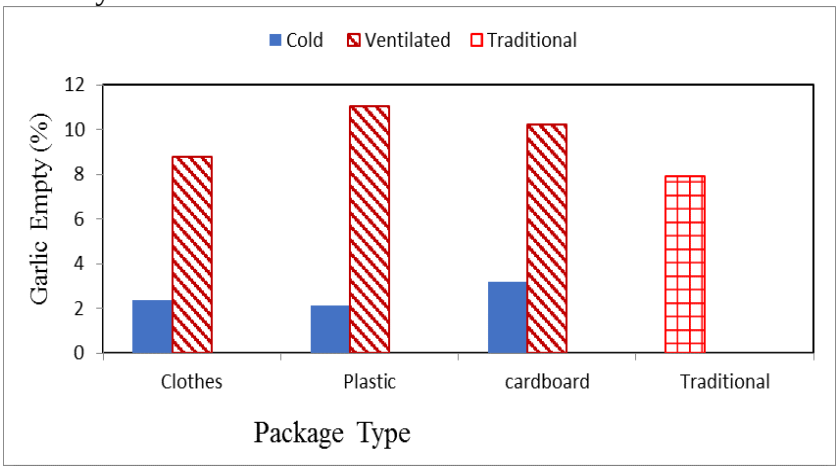

Figure (4): The effect of different storage systems and different packages on the empty bulb of garlic during the storage.

Concerning the effect of package type, under the cold storage system, the highest value of empty blubs percentage of garlic (3.18 %) was recorded by the garlic bulbs stored in perforated cardboard bags while the lowest value of empty blubs percentage of garlic (2.15 %) was recorded for the garlic stored in plastic bags. At the ventilated storage system, the highest value of empty blubs percentage of garlic (11.03 %) was recorded by the garlic bulbs stored in plastic bags while the lowest value of empty blubs percentage of garlic (8.80 %) was recorded for the garlic stored in clothes bags.

3.6. Effect of storage system and packaging type on the chemical composition of garlic before and after storage:

Table (5) shows the effect of storage system and package type on the chemical composition of garlic before and after storage. The results indicate that the nitrogen (N) was increased from 1.71 to 2.28, 1.71 to 1.80 and 1.71 to 2.22 % for garlic stored in clothes, plastic and cardboard packages, respectively under the cold storage system at the end of period storage. In the ventilated storage, the nitrogen (N) was increased from 1.71 to 2.41, 1.71 to 1.72 and 1.71 to 2.41 % for garlic stored in clothes, plastic and cardboard packages, respectively under the cold storage

system at the end of period storage, while, it was increased from 1.71 to 2.90 % for garlic stored under traditional system.

Table (5): The effect of storage system and package type on the chemical composition of garlic before and after storage.

Element		Storage System						
		Cooling System			Ventilated			Traditional
		clothes	Plastic	Cardboard	clothes	Plastic	Cardboard	
		Chemical Composition, %						
Nitrogen	Before	1.71	1.71	1.71	1.71	1.71	1.71	1.71
	After	2.28	1.80	2.22	2.41	1.72	2.41	2.90
Phosphorus	Before	0.18	0.18	0.18	0.18	0.18	0.18	0.18
	After	0.10	0.16	0.13	0.12	0.16	0.11	0.13
Potassium	Before	0.69	0.69	0.69	0.69	0.69	0.69	0.69
	After	0.71	1.03	1.03	0.80	1.18	0.72	0.93
Calcium	Before	0.20	0.20	0.20	0.20	0.20	0.20	0.20
	After	0.21	0.31	0.25	0.26	0.32	0.21	0.24
Magnesium	Before	0.09	0.09	0.09	0.09	0.09	0.09	0.09
	After	0.03	0.05	0.05	0.04	0.05	0.04	0.04
Protein	Before	10.69	10.69	10.69	10.69	10.69	10.69	10.69
	After	14.25	11.25	13.88	15.06	10.75	15.06	18.13
Fat	Before	0.34	0.34	0.34	0.34	0.34	0.34	0.34
	After	0.33	0.32	0.33	0.30	0.31	0.32	0.29
Ash	Before	1.63	1.63	1.63	1.63	1.63	1.63	1.63
	After	1.66	1.65	1.66	1.66	1.67	1.66	1.67
Fiber	Before	2.13	2.13	2.13	2.13	2.13	2.13	2.13
	After	2.18	2.19	2.18	2.20	2.18	2.19	2.21
Carbohydrate	Before	27.53	27.53	27.53	27.53	27.53	27.53	27.53
	After	31.83	31.98	31.61	32.23	32.29	32.41	33.05

The results also, indicate that the phosphorus (P) was decreased from 0.18 to 0.10, 0.18 to 0.13 and 0.18 to 0.13 % for garlic stored in clothes, plastic and cardboard packages, respectively under the cold storage system at the end of period storage. In the ventilated storage, the phosphorus (P) was decreased from 0.18 to 0.12, 0.18 to 0.16 and 0.18 to 0.11 % for garlic stored in clothes, plastic and cardboard packages, respectively under the cold storage system at the end of period storage, while, it was decreased 0.18 to 0.13 % for garlic stored under traditional system.The result revealed that potassium (K) was increased from 0.69 to 0.92, 0.69 to 0.90 % for both cold and ventilated storage, respectively and it increased from 0.69 to 0.93 % for the garlic stored traditionally. The calcium (Ca) was increased from 0.20 to 0.26, 0.20 to 0.79 and 0.20 to 0.24 % for garlic stored under cold, ventilated and traditional storage, respectively. The magnesium (Mg) was decreased from decreased from 0.09 to 0.03, 0.09

to 0.05 and 0.09 to 0.05 % for garlic stored in clothes, plastic and cardboard packages, respectively under the cold storage system at the end of period storage. In the ventilated storage, the magnesium (Mg) was decreased from 0.09 to 0.04, 0.09 to 0.05 and 0.09 to 0.04 % for garlic stored in clothes, plastic and cardboard packages, respectively under the cold storage system at the end of period storage, while, it was decreased 0.09 to 0.04 % for garlic stored under traditional system. The protein was increased from 10.69 to 14.25, 10.69 to 13.62 and 10.69 to 18.13 % for garlic stored under cold, ventilated and traditional storage, respectively. Fat content was decreased 0.34 to 0.33, 0.34 to 0.31 and 0.34 to 0.29 % for garlic stored under cold, ventilated and traditional storage, respectively. Ash content increased from 1.630 to 1.657, 1.630 to 1.667 and 1.63 to 1.670 % for garlic stored under cold, ventilated and traditional storage, respectively. Fiber was increased from 2.13 to 2.18 and 2.13 to 2.19 % for both cold and ventilated storage systems, respectively and it increased from 2.13 to 2.21 % for the garlic stored traditionally. Garlic content from carbohydrates increased from 27.53 to 31.81, 27.53 to 32.31 % for both cold and ventilated storage systems, respectively, while it increased from 27.53 to 33.05 % for the traditional storage system.

4. CONCLUSIONS

An experimental study was carried out successively to study the effect of storage system and package type on the quality of garlic during storage. The obtained results can be summarized as follows:

- The highest value of accumulated moisture loss (7.30%) was recorded by the garlic bulbs stored in clothes bags, while the lowest value of accumulated moisture loss (5.18%) was recorded for the garlic stored in plastic bags.
- The total accumulated weight loss recorded was 36.89 % for the garlic stored traditionally, compared with 11.47 and 12.33 % for the garlic stored in the cold and ventilated systems. The garlic stored in plastic bags recorded the highest accumulated weight loss (14.00%) when stored at ventilated storage system while the same package recorded the lowest weight losses (9.75%) when stored in the cold storage.
- Sprouting percent ranged from 14.00 to 21.79 % where the cold storage system recorded the lowest percentage, and the traditional

system recorded the highest sprouting. Sprouting ranged from 17.53 to 24.86 % at ventilated system storage.

- The highest value of empty blubs percentage of garlic (11.03 %) was recorded by the garlic bulbs stored in plastic bags under ventilated storage system, while the lowest value of empty blubs percentage of garlic (2.15 %) was recorded for the garlic stored in plastic bags under cold storage system.

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الملخص العربى

تأثير ظروف التخزين ونوع العبوات على جودة الثوم اثناء التخزين

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يهدف هذا البحث الى دراسة تأثير ظروف التخزين ونوع العبوات على جودة الثوم أثناء التخزين. وقد تم تقدير الفاقد الكلى فى الوزن والمحتوى الرطوبى اثناء التخزين. وكذلك تم تقدير نسبة التزريع والتفريغ في الابصال وايضا التركيب الكيميائى قبل وبعد التخزين. وقد اظهرت النتائج ان الفاقد التراكمى فى الوزن لابصال الثوم زاد بطول فترة التخزين وكان لنظام التخزين تأثير واضح على الفاقد فى الوزن حيث كان اعلها النظام المبرد (٣٦,٨٩%) مقارنة بالانظمة الاخرى كانت ١١,٤٧ و١٢,٣٣ % لنظامى التخزين المبرد والمهوى على الترتيب. كان للعبوات تأثير على الفاقد فى الوزن التراكمى حيث كانت اقلها للعبوات البلاستيك (٩,٧٥%) للتخزين المبرد واعلاها للنفس العبوات (١٤,٠٠%) للتخزين المهوى. كانت اعلى قيمة للفقد الرطوبى التراكمى (٧,٣٠%) لابصال الثوم المخزنة فى عبوات الخيش واقلها (٥,١٨%) لابصال الثوم المخزنة فى عبوات البلاستيك. تراوحت نسبة التزريع من ١٤,٠٠ الى ٢١,٧٩% فى نظام التخزين المبرد الذى سجل اقل قيمة، وقد سجل النظام المهوى نسبة تزريع ما بين ١٧,٥٣ الى ٢٤,٦٨%. كانت اعلى قيمة لنسبة التفريغ (١١,٠٣%) لابصال الثوم المخزنة فى عبوات بلاستيك في نظام التخزين المهوى، بينما كانت اقل قيمة لنسبة التفريغ (٢,١٣%) لابصال الثوم المخزنة في عبوات بلاستيك في نظام التخزين المبرد.

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