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POTATO TUBERS QUALITY AS AFFECTED BY MODIFIED ATMOSPHERIC CONDITIONS AND PACKAGE TYPE DURING STORAGE

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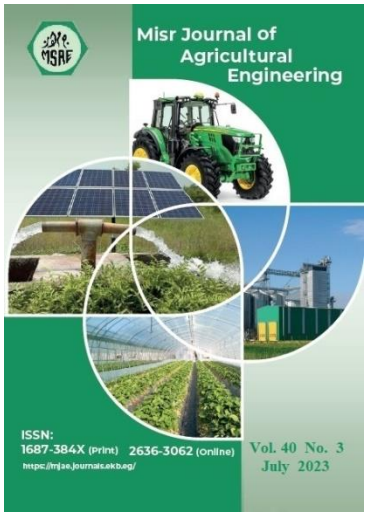

Keywords:
Potato tubers; Weight loss; Decay; TSS; Storage; Cold; Modified atmosphere.

ABSTRACT

The main aim of this study is to investigate the effect of modified atmospheric conditions and package type on the quality of potato tubers during storage. To achieve that, the effects of storage temperatures (6 and 23°C), types of packages (net and polyethylene) and number of holes perforated (2, 4 and 6 holes) on the weight loss, decay, sprouting, firmness, TSS, respiration rate and gas composition were studied. The accumulated weight losses were 64.64 and 5.98 % after 120 day of storage period for potato tubers packed in net package at 23 and 6 °C storage temperature, respectively. The highest values of the decay and sprouting percentage of potato tubers (25.46 and 100%) were found with the net package at 23 °C storage temperature. The highest value of the firmness of potato tubers was 5.26 % after 120 day of storage period for potato tubers packed in non-perforated package at 6 °C storage temperature. The TSS of potato tubers was decreased from 6.07 to 5.55 and 6.59 to 6.25 %, when the number of holes increased from 2 to 6 holes, respectively after 60 day of storage period at 6 and 23 °C storage temperature. The highest value of respiration rate and CO_2 concentration were 5.03 mL kg^{-1} h^{-1} and 6.50%, after 60 day for potato tubers packed in non-perforated package at 23 °C storage temperature. The highest value of O_2 concentration was 17.80 %, after 30 day for potato tubers packed in non-perforated package at 6 °C storage temperature.

1. INTRODUCTION

Potato (*Solanum tuberosum L.)* is one of the most important food crops worldwide. Potato tubers are an excellent staple food and represent the fourth highest with respect to worldwide production, after maize (*Zea mays L.*), rice (*Oryza sativa L.*), and wheat (*Triticum aestivum L.*) **(Fukuda *et al.*, 2019)**. Potato grows in over 100 countries worldwide and is one of the most widely planted vegetables worldwide. In addition, it is also the only tuber used as a major food crop. Potato has played an important role in human diet for a long

time and it is an important raw material for the industry as well **(Hong *et al.,* 2017)**. In 2019, about 432832 faddans were planted with potatoes in Egypt and a total production of about 5078374 tonnes according to (FAO).

The main objectives of storage are future consumption, future processing, and maintenance of seed reserve. Storage creates opportunity to look for high market price in later season as well as helps farmers to keep potato tuber as a seed to have their own seed sources for subsequent season It allows a better use of processing capacity, better tuning of production and consumption, and better quality of seed potatoes **(Kibar, 2012)**. Products such as potatoes belong to the group of semi perishable goods, which is a product with high natural moisture content. These products are more sensitive to quality loss than cereals because conservation using drying techniques cannot be applied. Storage losses are mainly caused by the processes like respiration, sprouting, evaporation of water from the tubers, spread of diseases, changes in the chemical composition and physical properties of the tuber and damage by extreme temperatures. To guarantee a top-quality product, storage conditions must be well controlled. The storage should minimize physiological losses and losses due to mechanical damage.

The available of traditional storage methods cannot keep the seed tuber until the next planting season free of damage. The reasons of using these methods were their availability, their low cost and the unavailability of improved storage facility that forced farmers to sell potato product immediately after harvesting at low price and buy seed during planting at very high cost. While cold storage may provide the necessary environment to prevent loss of weight, spoilage and sprouting, low temperature storage may cause freezing injuries which cause tubers to become soft and unusable **(Emragi *et al.,* 2021)**.

Modified atmosphere storage is one of the food preservation methods that maintains the natural quality of food products in addition to extending the storage life and suitable for wide varieties of agricultural and food products by reducing the respiration rate of food products and activity of insects or microorganisms in food **(Jayas and Jeyamkondan, 2002)** and it also preserves grain quality and maintains a high level of germination in the stored grain (Bera et al., 2008). Proper range of modified atmosphere by reducing oxygen and increasing carbon dioxide concentrations is beneficial for preserving fresh produce and extending shelf life **(Lee *et al.,* 2018)**.

Fruits and vegetables contain large portion of water (75-90%) and are therefore more susceptible to microbial damage. Freshly harvested produce has a short storage life, and they lose their freshness and quality rapidly if optimum conditions of temperature and relative humidity are not maintained. Fruits and vegetables are biologically active and continue their metabolism even after harvesting. It is imperative to store fresh produce and vegetables at optimum storage conditions so as to prevent them from microbial and physiological damage as their respiration rate spikes after the harvest **(Khater and Bahnasawy. 2018 and Kargwal *et al.,* 2020)**.

The shelf life of potatoes is extended by refrigerated storage which is the most widely utilized technique for prolonging the life of vegetables but modified atmosphere is a very important technique to maintain quality which is usually used in conjunction with refrigeration. It

extends the postharvest life of fresh fruit and vegetables because cooling alone is not enough to guarantee long-term quality **(Batu and Şen, 2013 and Ibrahim *et al.*, 2018)**.

Modified atmosphere can be achieved passively or actively. The passive MAP relies on the natural process of produce respiration and film permeability, while the active MAP is achieved by displacing the air within the package with a known mixture of gases to create an atmosphere that evolves during storage according to the produce respiration rate, the storage conditions, and film permeability **(Ghidelli and Pérez-Gago, 2018)**. Perforation in modified atmosphere packing are used to achieve higher transmission rates of gases and water vapour through commonly polymetric films **(González-Buesa *et al.*, 2008)**.

Potato tubers suffer a great deal of losses due to the unsuitable conditions of storage, modified atmosphere storage may provide the potato tubers during storage with an atmosphere of suitable temperature, CO_2 and O_2 which insures low loss, long shelf life, less sprouting and freeze injures, therefore, the main aim of this work is to study the effect of modified atmosphere conditions and packages on the quality and shelf life of potato tubers.

2. MATERIALS AND METHODS

The experiment was carried out at Horticulture Research Institute, Agriculture Research Center, Giza, Egypt, during 2022 season.

2.1. Materials:

2.1.1. Potato tubers:

Potato (*Solanum tuberosum L.)* Spunta variety was used for the experimental work at initial moisture content 76.81 %(w.b). Tuber samples of Spunta variety were studied over 2022 season. The tubers were cleaned properly and select tubers uniform, good in quality and free from diseases.

2.1.2. 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.

2.1.3. Packages type:

Two different type of package used to packed potato tubers were net and low density polyethylene LDPE bags 50 microns. The dimensions of package were 30 cm for length and 27 cm for width.

2.2. Methods:

2.2.1. Treatments:

The potato tubers were stored at two temperatures 6°C (86 ± 4 % relative humidity) and room temperature 23.0 ± 1.1°C (48 ± 10 % relative humidity) after packaging in different packages (net and low density polyethylene LDPE bags 50 microns) and number of hole perforated (2, 4 and 6 holes) compared with control (non-perforated). Table (1) shows the experimental design.

Table (1): The experimental design.

Variables	Levels	Variables Levels
Storage temperature	2	6 °C
		23°C
Package type	2	Net
		Polyethylene
Number of hole Perforated	3	2
		4
		6

2.2.2. Measurements:

2.2.2.1. Potato weight loss:

Potato samples were taken periodically every month intervals for tubers stored at different conditions. The accumulation loss in weight of tubers was due to the physiological activities (respiration and transpiration) was calculated as percentage throughout the experimental period. Then, loss in tubers weight per each interval during storage period was independently determined and estimated as a percentage of weight loss relative to the initial weight of tubers as described in the following equation.

$$\text{Weight Loss}(\%) = \frac{\text{Initial tubers weight - weight at inspect date}}{\text{Initial tubers weight}} \times 100 \qquad (1)$$

2.2.2.2. Tubers decay percentage:

Decayed tubers caused by either microbial pathogenesis or physiological disorder were periodical counted discarded. Thereafter, decay expressed as percent of discarded tubers from original number of stored tubers was recorded at each examines date.

2.2.2.3. Tubers sprouting percentage:

Potato sprouting percentages were determined every month for tubers stored at different conditions.

2.2.2.4. Chemical Properties:

The total soluble solids percent (TSS%) was measured by using a hand refractometer (ATAGO Co., LTD., Tokyo, Japan) on the fresh-cut lemon fruit, and the result was expressed as a percentage (%).

Reducing sugar was estimated calorimetrically using the Nelson arsenate–molybdate colorimetric method **(Nielsen, 2010)**.

A Magness and Taylor pressure tester measured tuber firmness (%) with a 7/18-inch plunger. Lightness potato color was measured by using a Minolta Chroma meter (Model CR 300, Japan).

2.2.4. Respiration rate and gas composition:

Respiration rate was measured by auto gas analyzer (checkmate 9900 O_2/CO_2, PBI Dansensor, Denmark). For each analysis, two potatoes were placed in 500ml container hermetically sealed with a silicone rubber septum for 2 h. After specified time, the head-space gas particularly CO2 was sucked through a hypodermic hollow needle and the respiration rate was measured.

3. RESULTS AND DISCUSSION

3.1. Accumulated weight loss of potato tubers:

Table (2) shows the effect of the different storage temperature (23 and 6 °C), different types of packages (net and low density polyethylene LDPE bags 50 microns) and different number of holes perforated (2, 4 and 6 holes) on the accumulated weight loss of potato tubers during experimental period. The results indicated that the accumulated weight loss of potato tubers increases with increasing experimental period and storage temperature and it decreased with increasing number of holes. It could be seen that the accumulated weight loss was increased from 2.04 to 5.98, 6.99 to 22.64, 3.12 to 17.15, 2.45 to 14.27 and 1.72 to 8.40%, when the storage period increased from 30 to 120 days, respectively, for net, non-perforated, perforated (2 holes), perforated (4 holes) and perforated (6 holes) of packages for potato tubers stored at temperature of 6 °C.

At 23 °C storage temperature, the results indicated that the accumulated weight loss increased from 4.0 to 64.64 %, when the experimental period increased from 30 to 120 days, respectively, for net package. While, it increased from 0 to 28.44 %, when the experimental period increased from 0 to 30 days, respectively, for package without perforated. The results also indicated that the accumulated weight loss increased from 16.45 to 26.79, 12.42 to 24.83 and 5.56 to 16.45 %, when the experimental period increased from 30 to 60 days, respectively, for packages perforated 2, 4 and 6 holes.

Table (2): Effect of the different storage temperature, different types of packages and different number of holes perforated on the accumulated weight loss of potato tubers during experimental period.

Storage Temperature, °C	Packages type	Storage Period, day			
		30	60	90	120
		Accumulated Weight Loss, %			
23	Net (control)	4.00	8.05	46.10	64.64
	Non- perforated	28.44	-	-	-
	perforated(2 holes)	16.45	26.79	-	-
	perforated(4 holes)	12.42	24.83	-	-
	perforated(6 holes)	5.56	16.45	-	-
6	Net (control)	2.04	2.79	3	5.98
	Non- perforated	6.99	14.32	18.54	22.64
	perforated(2 holes)	3.12	4.06	15.72	17.15
	perforated(4 holes)	2.45	3.33	11.40	14.27
	perforated(6 holes)	1.72	2.85	7.16	8.40

Regarding the results, the highest value of the accumulated weight loss of potato tubers with found storage temperature of 23°C for all types of packages. On the other hand, the lowest values of the accumulated weight loss of potato tubers with found storage temperature of 6°C for all types of packages. It could be seen that the accumulated weight loss was 64.64 and 5.98 % after 120 day of storage period for potato tubers packed in net package at 23 and 6 °C storage temperature, respectively. Also, the accumulated weight loss was 26.79, 24.83 and 16.45 and 4.06, 3.33 and 2.85 % after 60 day of storage period for potato tubers packed in package perforated 2, 4 and 6 holes, respectively, at 23 and 6 °C storage temperature.

According to data in table (2) the highest value of the accumulated weight loss of potato tubers (64.64%) was found with the net package at 23 °C storage temperature, while, the lowest value of the accumulated weight loss of potato tubers (5.98%) was found with the net package at 6 °C storage temperature. These resulted could be explained by that fact that lowering the storage temperature (both decrease in cold temperature and higher relative humidity) play an important role in retarding their repining process and thereby prolonged the storage periods of tubers and kept them unspoiled. Increasing weight loss in a relatively high temperature environment may be due to increased tubers respiratory activity. These results agreed with those obtained by **Emragi *et al.* (2022)**

3.2. Decay percentage of potato tubers:

Table (3) shows the effect of the different storage temperature (23 and 6 °C), different types of packages (net and low density polyethylene LDPE bags 50 microns) and different number of holes perforated (2, 4 and 6 holes) on the decay percentage of potato tubers during experimental period. The results indicated that the decay percentage of potato tubers increases with increasing experimental period and storage temperature and it decreased with increasing number of holes. It could be seen that the decay percentage was increased from 3.92 to 16.84, 2.22 to 15.28, 1.96 to 13.97 and 1.96 to 10.05%, when the storage period increased from 30 to 120 days, respectively, for non-perforated, perforated (2 holes), perforated (4 holes) and perforated (6 holes) of packages for potato tubers stored at temperature of 6 °C compared 0.0% of decay percentage for potato tubers stored in net package.

At 23 °C storage temperature, the results indicated that the decay percentage increased from 0.0 to 25.46 %, when the experimental period increased from 30 to 120 days, respectively, for net package. While, it increased from 0 to 21.39 %, when the experimental period increased from 0 to 30 days, respectively, for package without perforated. The results also indicated that the decay percentage increased from 10.71 to 22.22, 8.21 to 12.50 and 5.88 to 11.33 %, when the experimental period increased from 30 to 60 days, respectively, for packages perforated 2, 4 and 6 holes.

Table (3): Effect of the different storage temperature, different types of packages and different number of holes perforated on the decay percentage of potato tubers during experimental period.

Storage Temperature, °C	Packages type	Storage Period, day			
		30	60	90	120
		Decay percentage, %			
23	Net (control)	0.00	0.00	12.50	25.46
	Non- perforated	21.39	-	-	-
	perforated(2 holes)	10.71	22.22	-	-
	perforated(4 holes)	8.21	12.50	-	-
	perforated(6 holes)	5.88	11.33	-	-
6	Net (control)	0.00	0.00	0.00	0.00
	Non- perforated	3.92	4.44	16.30	16.84
	perforated(2 holes)	2.22	6.55	15.00	15.28
	perforated(4 holes)	1.96	2.22	12.01	13.97
	perforated(6 holes)	1.96	2.22	6.14	10.05

Concerning the results, the highest value of the decay percentage of potato tubers with found storage temperature of 23°C for all types of packages. On the other hand, the lowest values of the decay percentage of potato tubers with found storage temperature of 6°C for all types of packages. It could be seen that the highest value of decay percentage of potato tubers was 25.46 % after 120 day of storage period for potato tubers packed in net package at 23 °C storage temperature. Also, the decay percentage of potato tubers was 22.22, 12.50 and 11.33 and 6.55, 2.22 and 2.22 % after 60 day of storage period for potato tubers packed in package perforated 2, 4 and 6 holes, respectively, at 23 and 6 °C storage temperature. According to data in table (3) the highest value of the decay percentage of potato tubers (25.46%) was found with the net package at 23 °C storage temperature, while, the lowest value of the decay percentage of potato tubers (0.0%) was found with the net package at 6 °C storage temperature.

3.3. Sprouting percentage of potato tubers:

Table (4) shows the effect of the different storage temperature (23 and 6 °C), different types of packages (net and low density polyethylene LDPE bags 50 microns) and different number of holes perforated (2, 4 and 6 holes) on the sprouting percentage of potato tubers during experimental period. The results indicated that the sprouting percentage increased from 0.0 to 100.0 %, when the experimental period increased from 30 to 120 days, respectively, for net package. While, it increased from 0 to 55.51 %, when the experimental period increased from 0 to 30 days, respectively, for package without perforated. The results also indicated that the sprouting percentage increased from 12.01 to 97.92, 6.55 to 96.19 and 10.19 to 100.0 %, when the experimental period increased from 30 to 60 days, respectively, for packages perforated 2, 4 and 6 holes for potato tubers stored at temperature of 23 °C compared 0.0% of sprouting percentage for potato tubers stored at temperature of 6 °C in all types of packages.

Table (4): Effect of the different storage temperature, different types of packages and different number of holes perforated on the sprouting percentage of potato tubers during experimental period.

Storage Temperature, °C	Packages type	Storage Period, day			
		30	60	90	120
		Sprouting Percentage, %			
23	Net (control)	0.00	72.22	100.00	100.00
	Non- perforated	55.51	-	-	-
	perforated(2 holes)	12.01	97.92	-	-
	perforated(4 holes)	6.55	96.19	-	-
	perforated(6 holes)	10.19	100.00	-	-
6	Net (control)	0.00	0.00	0.00	0.00
	Non- perforated	0.00	0.00	0.00	0.00
	perforated(2 holes)	0.00	0.00	0.00	0.00
	perforated(4 holes)	0.00	0.00	0.00	0.00
	perforated(6 holes)	0.00	0.00	0.00	0.00

3.4. Firmness of potato tubers:

Table (5) shows the effect of the different storage temperature (23 and 6 °C), different types of packages (net and low density polyethylene LDPE bags 50 microns) and different number of holes perforated (2, 4 and 6 holes) on the firmness of potato tubers during experimental

period. The results indicated that the firmness of potato tubers decreases with increasing experimental period, storage temperature and number of holes. It could be seen that the firmness was decreased from 5.60 to 5.03, 5.60 to 5.26, 5.60 to 5.13, 5.60 to 5.07 and 5.60 to 5.04%, when the storage period increased from 0 to 120 days, respectively, for net, non-perforated, perforated (2 holes), perforated (4 holes) and perforated (6 holes) of packages for potato tubers stored at temperature of 6 °C.

Table (5): Effect of the different storage temperature, different types of packages and different number of holes perforated on the firmness of potato tubers during experimental period.

Storage Temperature, °C	Packages type	Storage Period, day				
		0	30	60	90	120
		Firmness of potato tubers, %				
23	Net (control)	5.60	5.14	5.07	5.06	4.81
	Non- perforated	5.60	5.49	-	-	-
	perforated(2 holes)	5.60	5.42	5.32	-	-
	perforated(4 holes)	5.60	5.35	5.29	-	-
	perforated(6 holes)	5.60	5.19	5.11	-	-
6	Net (control)	5.60	5.32	5.19	5.11	5.03
	Non- perforated	5.60	5.52	5.52	5.43	5.26
	perforated(2 holes)	5.60	5.49	5.44	5.39	5.13
	perforated(4 holes)	5.60	5.43	5.35	5.31	5.07
	perforated(6 holes)	5.60	5.36	5.32	5.24	5.04

At 23 °C storage temperature, the results indicated that the firmness decreased from 5.60 to 4.81 %, when the experimental period increased from 0 to 120 days, respectively, for net package. While, it decreased from 5.60 to 5.49 %, when the experimental period increased from 0 to 30 days, respectively, for package without perforated. The results also indicated that the firmness decreased from 5.60 to 5.32, 5.60 to 5.29 and 5.60 to 5.11 %, when the experimental period increased from 0 to 60 days, respectively, for packages perforated 2, 4 and 6 holes.

Regarding the results, the highest value of the firmness of potato tubers with found storage temperature of 6°C for all types of packages. On the other hand, the lowest values of the firmness of potato tubers with found storage temperature of 23°C for all types of packages. It could be seen that the highest value of the firmness of potato tubers was 5.26 % after 120 day of storage period for potato tubers packed in non-perforated package at 6 °C storage temperature. Also, the results indicated that the firmness decreases with increasing number of holes. It could be seen that the firmness of potato tubers was decreased from 5.32 to 5.11 and 5.44 to 5.32 %, when the number of holes increased from 2 to 6 holes, respectively after 60 day of storage period at 23 and 6 °C storage temperature. The present results concerning the beneficial effect of the relative lower temperature of storage on remaining fruits with more firmer flesh may be due to the retardation influence of cold temperature on activities of pesctinase and cellulase which are the main enzymes responsible for flesh softening.

3.5. Total soluble solids (TSS) of potato tubers:

Table (6) shows the effect of the different storage temperature (23 and 6 °C), different types of packages (net and low density polyethylene LDPE bags 50 microns) and different number

of holes perforated (2, 4 and 6 holes) on the total soluble solids (TSS) of potato tubers during experimental period. The results indicated that the TSS of potato tubers increases with increasing experimental period, storage temperature and it decreases with increasing number of holes. It could be seen that the TSS was increased from 4.54 to 6.25, 4.54 to 8.34, 4.54 to 6.90, 4.54 to 6.80 and 4.54 to 6.38%, when the storage period increased from 0 to 120 days, respectively, for net, non-perforated, perforated (2 holes), perforated (4 holes) and perforated (6 holes) of packages for potato tubers stored at temperature of 6 °C.

At 23 °C storage temperature, the results indicated that the TSS increased from 4.54 to 5.90 %, when the experimental period increased from 0 to 120 days, respectively, for net package. While, it increased from 4.54 to 5.00 %, when the experimental period increased from 0 to 30 days, respectively, for package without perforated. The results also indicated that the TSS increased from 4.54 to 6.07, 4.54 to 6.00 and 4.54 to 5.55 %, when the experimental period increased from 0 to 60 days, respectively, for packages perforated 2, 4 and 6 holes.

Table (6): Effect of the different storage temperature, different types of packages and different number of holes perforated on the TSS of potato tubers during experimental period.

Storage Temperature, °C	Packages type	Storage Period, day				
		0	30	60	90	120
		TSS of potato tubers, %				
23	Net (control)	4.54	4.62	5.43	5.44	5.90
	Non- perforated	4.54	5.00	-	-	-
	perforated(2 holes)	4.54	4.98	6.07	-	-
	perforated(4 holes)	4.54	4.97	6.00	-	-
	perforated(6 holes)	4.54	4.88	5.55	-	-
6	Net (control)	4.54	5.15	6.00	6.20	6.25
	Non- perforated	4.54	5.97	6.95	7.00	8.34
	perforated(2 holes)	4.54	5.37	6.59	6.62	6.90
	perforated(4 holes)	4.54	5.37	6.40	6.42	6.80
	perforated(6 holes)	4.54	5.02	6.25	6.35	6.38

Regarding the results, the highest value of the TSS of potato tubers with found storage temperature of 6°C for all types of packages. On the other hand, the lowest values of the TSS of potato tubers with found storage temperature of 23°C for all types of packages. It could be seen that the highest value of TSS of potato tubers was 8.34 % after 120 day of storage period for potato tubers packed in non-perforated package at 6 °C storage temperature. Also, the results indicated that the TSS decreases with increasing number of holes. It could be seen that the TSS of potato tubers was decreased from 6.07 to 5.55 and 6.59 to 6.25 %, when the number of holes increased from 2 to 6 holes, respectively after 60 day of storage period at 6 and 23 °C storage temperature.

3.6. Lightness of potato tubers:

Table (7) shows the effect of the different storage temperature (23 and 6 °C), different types of packages (net and low density polyethylene LDPE bags 50 microns) and different number of holes perforated (2, 4 and 6 holes) on the lightness of potato tubers during experimental period. The results indicated that the lightness of potato tubers decreases with increasing experimental period, storage temperature and it increases with increasing number of holes. It

could be seen that the lightness was decreased from 72.05 to 66.33, 72.05 to 60.99, 72.05 to 64.77, 72.05 to 65.79 and 72.05 to 66.01%, when the storage period increased from 0 to 120 days, respectively, for net, non-perforated, perforated (2 holes), perforated (4 holes) and perforated (6 holes) of packages for potato tubers stored at temperature of 6 °C.

At 23 °C storage temperature, the results indicated that the lightness decreased from 72.05 to 68.65 %, when the experimental period increased from 0 to 120 days, respectively, for net package. While, it decreased from 72.05 to 67.22 %, when the experimental period increased from 0 to 30 days, respectively, for package without perforated. The results also indicated that the lightness decreased from 72.05 to 67.22, 72.05 to 68.73 and 72.05 to 68.73 %, when the experimental period increased from 0 to 60 days, respectively, for packages perforated 2, 4 and 6 holes.

Table (7): Effect of the different storage temperature, different types of packages and different number of holes perforated on the lightness of potato tubers during experimental period.

Storage Temperature, °C	Packages type	Storage Period, day				
		0	30	60	90	120
		Lightness of potato tubers, %				
23	Net (control)	72.05	71.85	70.99	70.14	68.65
	Non- perforated	72.05	67.02	-	-	-
	perforated(2 holes)	72.05	68.13	67.22	-	-
	perforated(4 holes)	72.05	70.54	68.73	-	-
	perforated(6 holes)	72.05	70.65	68.73	-	-
6	Net (control)	72.05	70.94	68.28	67.52	66.33
	Non- perforated	72.05	64.46	64.61	63.45	60.99
	perforated(2 holes)	72.05	66.42	65.19	66.06	64.77
	perforated(4 holes)	72.05	66.91	66.60	67.16	65.79
	perforated(6 holes)	72.05	68.02	67.81	67.40	66.01

Regarding the results, the highest value of the lightness of potato tubers with found storage temperature of 23°C for all types of packages. On the other hand, the lowest values of the lightness of potato tubers with found storage temperature of 6°C for all types of packages. It could be seen that the highest value of lightness of potato tubers was 68.65 % after 120 day of storage period for potato tubers packed in net package at 23 °C storage temperature. Also, the results indicated that the lightness increases with increasing number of holes. It could be seen that the lightness of potato tubers was increased from 68.13 to 70.65 and 66.91 to 68.02 %, when the number of holes increased from 2 to 6 holes, respectively after 60 day of storage period at 6 and 23 °C storage temperature.

3.7. Respiration rate and gas composition:

3.7.1. Respiration rate of potato tubers:

Figure (1) shows the effect of the different storage temperature (23 and 6 °C) and different number of holes perforated (0, 2, 4 and 6 holes) on the respiration rate of potato tubers during experimental period. The results indicated that the respiration rate of potato tubers increases with increasing experimental period, storage temperature and it increases with increasing number of holes. It could be seen that the respiration rate was decreased from 2.9 to 1.44, 2.43 to 1.10, 2.16 to 1.08 and 1.77 to 1.05 mL kg^{-1} h^{-1}, when the storage period increased from 0 to

120 days, respectively, for non-perforated, perforated (2 holes), perforated (4 holes) and perforated (6 holes) of packages for potato tubers stored at temperature of 6 °C.

At 23 °C storage temperature, the results also indicated that the respiration rate increased from 3.87 to 5.03, 3.39 to 3.49 and 3.14 to 3.31 mL kg^{-1} h^{-1}, when the experimental period increased from 0 to 60 days, respectively, for packages perforated 2, 4 and 6 holes.

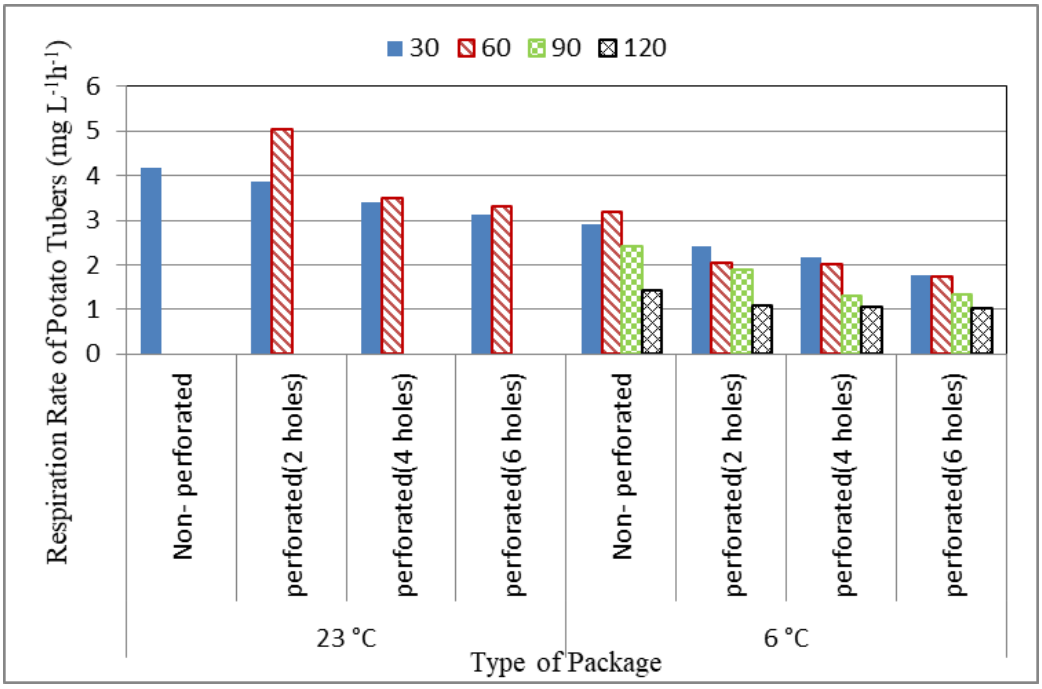

Figure (1): Effect of the different storage temperature and different number of holes perforated on the respiration rate of potato tubers during experimental period.

Regarding the results, the highest value of the respiration rate of potato tubers with found storage temperature of 23°C for all types of packages. On the other hand, the lowest values of the respiration rate of potato tubers with found storage temperature of 6°C for all types of packages. It could be seen that the highest value of respiration rate of potato tubers was 5.03 mL kg^{-1} h^{-1}, after 60 day of storage period for potato tubers packed in non-perforated package at 23 °C storage temperature. Also, the results indicated that the respiration rate decreases with increasing number of holes. It could be seen that the respiration rate of potato tubers was decreased from 4.18 to 3.14 and 2.90 to 1.77 mL kg^{-1} h^{-1}, when the number of holes increased from 2 to 6 holes, respectively after 30 day of storage period at 23 and 6 °C storage temperature.

3.7.2. CO_2 concentration:

Figure (2) shows the effect of the different storage temperature (23 and 6 °C) and different number of holes perforated (0, 2, 4 and 6 holes) on the CO_2 concentration during experimental period. The results indicated that the CO_2 concentration increases with increasing experimental period, storage temperature and it decreases with increasing number of holes. It could be seen that the CO_2 concentration was increased from 2.50 to 3.87, 2.33 to 2.90, 2.43 to 2.70 and 1.80 to 2.40 %, when the storage period increased from 0 to 120 days, respectively, for non-perforated, perforated (2 holes), perforated (4 holes) and perforated (6 holes) of packages for potato tubers stored at temperature of 6 °C.

At 23 °C storage temperature, the results also indicated that the CO_2 concentration increased from 3.63 to 6.50, 2.70 to 5.03 and 2.60 to 5.0 %, when the experimental period increased from 0 to 60 days, respectively, for packages perforated 2, 4 and 6 holes.

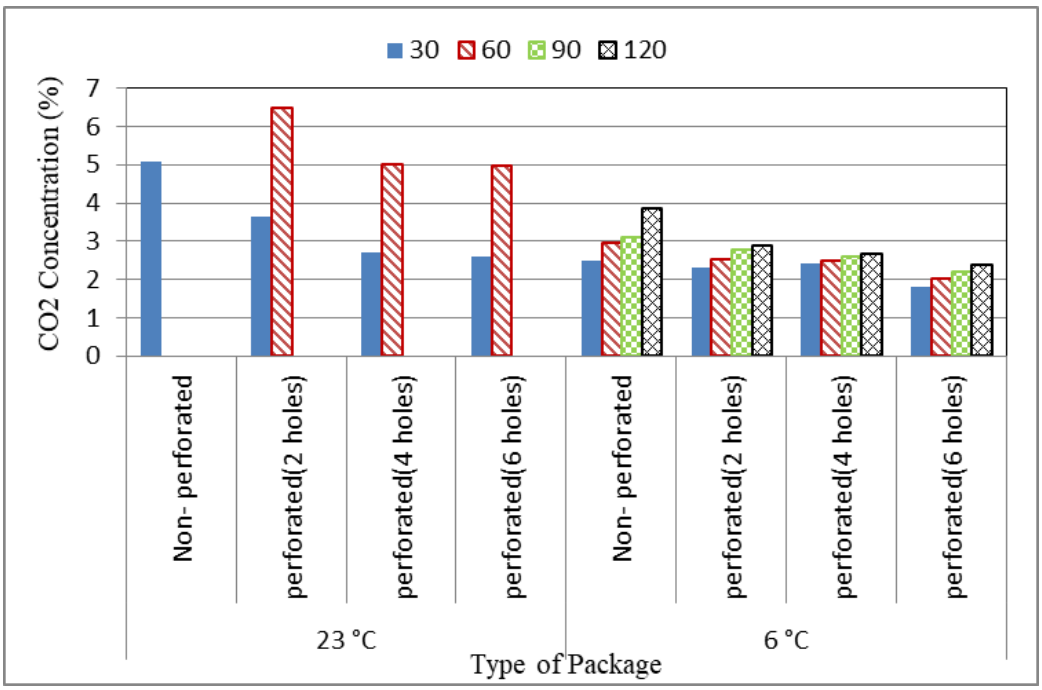

Figure (2): Effect of the different storage temperature and different number of holes perforated on the CO_2 concentration during experimental period.

Regarding the results, the highest value of the CO_2 concentration with found storage temperature of 23°C for all types of packages. On the other hand, the lowest values of the CO_2 concentration with found storage temperature of 6°C for all types of packages. It could be seen that the highest value of CO_2 concentration was 6.50 %, after 60 day of storage period for potato tubers packed in non-perforated package at 23 °C storage temperature. Also, the results indicated that the CO_2 concentration decreases with increasing number of holes. It could be seen that the CO_2 concentration was decreased from 6.50 to 5.00 and 2.97 to 2.23 %, when the number of holes increased from 2 to 6 holes, respectively after 60 day of storage period at 23 and 6 °C storage temperature.

3.7.3. O_2 concentration:

Figure (3) shows the effect of the different storage temperature (23 and 6 °C) and different number of holes perforated (0, 2, 4 and 6 holes) on the O_2 concentration during experimental period. The results indicated that the O_2 concentration decreases with increasing experimental period, storage temperature and it increases with increasing number of holes. It could be seen that the O_2 concentration was decreased from 17.37 to 13.43, 17.43 to 16.07, 17.80 to 16.50 and 18.36 to 17.40 %, when the storage period increased from 0 to 120 days, respectively, for non-perforated, perforated (2 holes), perforated (4 holes) and perforated (6 holes) of packages for potato tubers stored at temperature of 6 °C.

At 23 °C storage temperature, the results also indicated that the O_2 concentration decreased from 13.60 to 10.97, 15.86 to 10.27 and 16.97 to 13.97 %, when the experimental period increased from 0 to 60 days, respectively, for packages perforated 2, 4 and 6 holes.

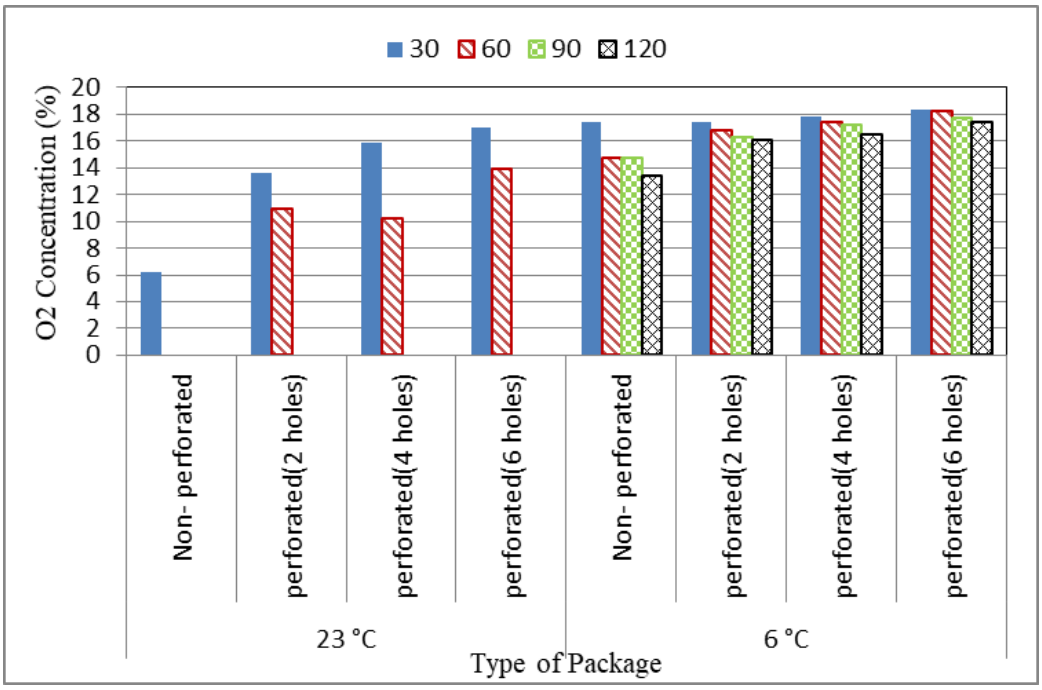

Figure (3): Effect of the different storage temperature and different number of holes perforated on the O_2 concentration during experimental period.

Regarding the results, the highest value of the O_2 concentration with found storage temperature of 6°C for all types of packages. On the other hand, the lowest values of the O_2 concentration with found storage temperature of 23°C for all types of packages. It could be seen that the highest value of O_2 concentration was 17.80 %, after 30 day of storage period for potato tubers packed in non-perforated package at 6 °C storage temperature. Also, the results indicated that the O_2 concentration increases with increasing number of holes. It could be seen that the O_2 concentration was increased from 10.97 to 13.97 and 16.77 to18.27 %, when the number of holes increased from 2 to 6 holes, respectively after 60 day of storage period at 23 and 6 °C storage temperature.

4. CONCLUSIONS

The experiment was carried out to study the effect of modified atmospheric conditions and package type on the quality of potato tubers during storage. To achieve that, study the effect of storage temperatures, types of packages and number of holes perforated on the weight loss, decay, sprouting, firmness, TSS, respiration rate and gas composition. The obtained results can be summarized as follows:

- The results indicated that, the accumulated weight loss was 64.64 and 5.98 % after 120 day of storage period for potato tubers packed in net package at 23 and 6 °C storage temperature, respectively.
- The decay percentage of potato tubers was 22.22, 12.50 and 11.33 and 6.55, 2.22 and 2.22 % after 60 day of storage period for potato tubers packed in package perforated 2, 4 and 6 holes, respectively, at 23 and 6 °C storage temperature.
- The highest value of the firmness of potato tubers was 5.26 % after 120 day of storage period for potato tubers packed in non-perforated package at 6 °C storage temperature.

- The TSS of potato tubers was decreased from 6.07 to 5.55 and 6.59 to 6.25 %, when the number of holes increased from 2 to 6 holes, respectively after 60 day of storage period at 6 and 23 °C storage temperature.
- The highest value of respiration rate and CO_2 concentration were 5.03 mL kg^{-1} h^{-1} and 6.50%, after 60 day of storage period for potato tubers packed in non-perforated package at 23 °C storage temperature.
- The highest value of O_2 concentration was 17.80 %, after 30 day of storage period for potato tubers packed in non-perforated package at 6 °C storage temperature.
- Future studied could be carried out on the effect different levels of RH and temperature on the quality and shelf-life of potato tubers.

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أثر ظروف التخزين فى الاجواء المعدلة ونوع العبوة على جودة درنات البطاطس اثناء التخزين

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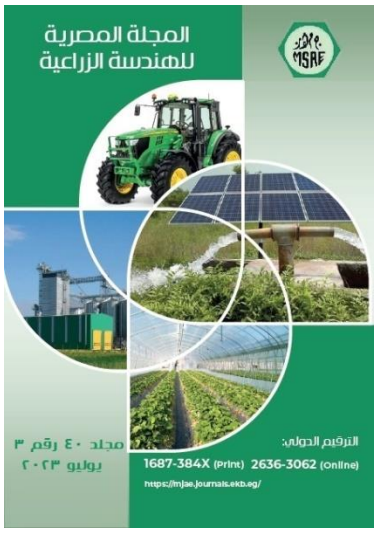

الكلمات المفتاحية:
درنات البطاطس؛ الفاقد فى الوزن؛ نسبة التالف؛ المواد الصلبة الكلية الذائبــة؛ معدل التنفس؛ تركيز الغازات

الملخص العربى

يهدف هذا البحث الى دراسة تأثير ظروف التخزين فى الاجواء المعدلة ونوع العبوة على جودة درنات البطاطس اثناء التخزين. وكانت اهم النتائج المتحصل عليها: كان متوسط قيمة الفاقد فى الوزن التراكمى لدرنات البطاطس هو ٦٤,٦٤ و٥,٩٨% بعد ١٢٠ يوم تخزين فى العبوات الشبكية المخزنة فى درجة حرارة ٢٣ و٦ درجات مئوية على الترتيب. زات نسبة درنات البطاطس التالفة ونسبة التزريع فى الدرنات بزيادة مدة التخزين ودرجة حرارة التخزين. كانت اعلى قيمة لصلابة درنات البطاطس هى ٥,٢٦% للدرنات المخزنة بدون تعبئة فى درجة حرارة ٦ درجات مئوية بعد ١٢٠ يوم تخزين. انخفضت نسبة المواد الصلبة الذائبة الكلية من ٦,٠٧ الى ٥,٥٥ ومن ٦,٥٩ الى ٦,٢٥ % بزيادة عدد الثقوب فى العبوة من ٢ الى ٦ ثقوب على الترتيب بعد ٦٠ يوم تخزين لدرنات البطاطسعلى درجات حرارة تخزين ٦ و٢٣ درجة مئوية. كانت اعلى قيمة لمعدل التنفس وتركيز نسبة ثانى اكسيد الكربون هى ٥,٠٣ ملتر لكل كجم لكل ساعة و ٦,٥٠% على الترتيب لدرنات البطاطس المخزنة بعبوات غير مثقبة بعد ٦٠ يوم تخزين على درجة حرارة ٢٣ درجة مئوية. كانت اعلى قيمة لتركيز نسبة الاكسجين هى ١٧,٨٠% لدرنات البطاطس المخزنة بعبوات غير مثقبة بعد ٣٠ يوم تخزين على درجة حرارة ٦ درجة مئوية.