Chapter

The Role of Some Pre and Postharvest Applications on Storage Behavior and Protein Pattern of Date Palm Fruits *Phoenix dactylifera* L. cvs. Berhi and Breim

Dhia Ahmed Taain, Hamzah Abbas Hamzah and Abbas Mahdi Jasim

Abstract

Storage experiment was conducted to study the effect of some pre and postharvest natural control treatments which include ultraviolet light (UV) at the concentration of 1KGY for periods of (0, 5, 10) minutes, 1-MCP at the concentration of (0,0.5,1) ppm for 24 hour at 0°c, ozone (O3) at the concentration of 5 ppm for the periods of (0, 0.5, 1) hour, soaking in chitosan at the concentratons of (0,1,2) % and control treatment in addition to field-treated chitosan at the concentrations of 0%, 1%, and 2% by the aim of improving storage behavior of date palm fruits cvs. Berhi and Breim and determination the protein pattern of fruits after six months of storage at −10± 2°C. Results of the protein pattern showed that protein bundles on polyacrylamide gel differed by their molecular weights, the number of protein bundles, and Breim cultivar fruits treated with chitosan recorded the highest number of bundles of seven bundles and the highest molecular weight of (173.857) kDa for the first bundle.

Keywords: date palm fruits, Berhi and Breim, chitosan, ultraviolet light (UV), ozone (O3)

1. Introduction

The date palm, *Phoenix dactylifera* L., belongs to the family Arecaceae and is one of the subtropical fruit trees cultivated and spread in Iraq and some regions of the Middle East [1]. It is considered one of the most important fruit trees in Iraq because of its great nutritional and economic value. It is a sacred tree mentioned in all monotheistic religions. The evidence available at present indicates that the Sumerians were the first to be interested in the cultivation of the date palm, and used its fruits as basic food in the Tigris and Euphrates valleys for more than four thousand years BC [2].

The number of date palms in Iraq has decreased significantly in recent years due to the wars, the high salinity rate in soil and irrigation water, and the problem of the housing crisis that led to the bulldozing of many palm orchards, which led to a severe shortage of dates production. Therefore, it is important to take the necessary measures to develop the production of dates by increasing the number of planted palm trees, as well as increasing the yield, improving the qualities of fruits, and reducing the percentage of spoilage, especially the desired cultivars, such as Berhi and Breim, through conducting some of the pre- and post-harvest treatments and avoiding treatment of fruits with chemicals that have negative impact on consumer health, as consumer demand has increased recently for fruits whose production has bio-safety factors [3, 4].

Chitosan is a vital polymer, the second largest biomaterial after cellulose, which is found in the outer structure of crustaceans, insects, and fungal cell walls. It is also characterized by no toxicity and biological decay and has no local effects on living tissue. It is a compound with vital functions [5], which has attracted the interest of researchers in the last few years for its commercial uses. Chitosan is composed of glucosamine units, which are associated with each other with a type of beta-type (1–4) cyclic bonds. It possesses many free hydroxyl and amino acids that enable it to form ionic, hydrogen, and hydrofluidic bonds with other molecules such as fats and proteins [6, 7].

Cold storage of date palm fruits is one of the important means at present, which is used to try to keep those fruits in the rutab phase as long as possible, thus prolonging the display period of those fruits in the local markets in the rutab phase, as cold storage reduces pathogens and the vital activities of the fruits, especially the process of respiration and the production of ethylene [8]. The activity of ethylene can also be inhibited through the use of the compound 1-methylcyclopropene, which symbolizes (1-MCP) commercially called smart fresh, which is in the form of a white powder that can be dissolved with water and releases the active substance 1-methylcyclopropene in the form of gas, which prevents contact ethylene with its receptors in the cells, which leads to inhibiting the formation of ethylene, and this, in turn, delays the natural ripening processes in the fruit, which keeps it fresh and of good quality for a longer time [9]. Studies have shown that treatment with the compound (1-MCP) limits the rate of ethylene production in fruits, reduces their respiration rate, and delays their entry into the ripening phase compared to untreated fruits [10–13].

Ultraviolet treatment is one of the alternative methods that has spread to be effective in inactivating bacteria, protozoa, algae, and viruses. Ultraviolet rays have the ability to destroy microorganisms, as is the case with heat treatment, but it has better advantages than heat treatment, as it does not affect the sensory properties of fruits, and it has a lower cost than heat treatment from an economic point of view. The radiation treatment process makes foods free of dangerous substances that are commonly used to kill insects by fumigation, such as ethyl dibromide, methyl bromide, and phosphine. Ultraviolet radiation in the range of 250–260nm is lethal to most microorganisms and acts as a strong bactericide [14], in addition that the treatment is certified and approved by various international health organizations.

Ozone (O3) is one of the powerful disinfectants against a wide range of microorganisms [15]. Ozone has number of features that make it suitable as an ideal post-harvest treatment, quickly decomposes into oxygen without leaving any residue and is applied either as a gas or it is soluble in water, so it can effectively reduce post-harvest losses during storage for several crops [16–18].

The current study aims to improve the storage behavior of date palm fruits cvs. Berhi and Breim and determination the protein pattern of fruits after six months of storage at $-10 \pm 2°C$. Increasing the display period of the fruits of the two cultivars in the rutab phase for the longest possible period and improving their storage qualities and marketable of fruits through the use of some natural control treatments before and after harvest, especially chitosan, which is used according to the available references for the first time in the field of improving the yield, qualitative characteristics, and storage ability of the fruits of the two date palm cultivars. In addition to treat the fruits with some post-harvest treatments, which include the use of 1-MCP, ozone, and ultraviolet rays, and studying the physical and chemical changes of fruits during storage under the influence of these treatments.

2. Materials and methods

The storage experiment which was conducted, where the fruits of Berhi and Breim cultivars that treated with chitosan at the concentration of (0, 1, 2%) could be summarized as follows:

2.1 Chitosan extraction process

The shrimps were obtained from the local fish market in Basrah and the crusts were washed with water and dried by leaving them exposed to the sun. The method mentioned in [19], was followed for the extraction of chitin from the shrimp. The shrimp crust was crushed into small pieces using an electric mill then, the process of removal of the proteins (deprotienization) has been done by treating the crusts with sodium hydroxide solution at a concentration of 3.5% for two hours at a temperature of 65°c. by 1:10 (weight/volume). The mineral elements are removed in the process called demineralization by using a solution of hydrochloric acid at the concentration of 1 N for 1/2hour at room temperature by 1:15 (weight/volume). Crusts were washed well with water several times, then the pigment was removed by acetone and then by sodium hypochlorite solution at 0.315% for 5 minutes at room temperature by 1:10 (weight/volume). Finally, the white product was washed with distilled water and dried in an oven at 60° C for 24 hours to obtain the chitin.

Chitosan was prepared according to the method mentioned by [20] by removing the acetyl groups (Deacetylation) by treating with 50% sodium hydroxide at 1:10 (weight/volume) at 100°C for 20 hours to obtain chitosan with low molecular weight, and then dried at 110° C for 6 hours. The resulting chitosan is a white powder.

The viscosity was determined by the use of the Ostwald viscometer. After the preparation of the solution, the amount of time required to flow it at a certain distance at 25°. Molecular weight was determined depending on the viscosity of the solution according to [21]. The degree of removal of acetyl groups was determined by mixing 40 mg chitosan with 120 mg potassium bromide and then pressing and dried, then determined by using the Fourier Transform Infrared Spectroscopy (FTIR) Instrument.

The parameters of the product were measured as follows: Viscosity = 64.16 Centi Boyz, molecular weight 720 K, dalton, and the degree of removal of acetyl groups 87.6%.

Fruits have been brought after 18 weeks of pollination to the cold store in the early morning immediately after picking, then cleaned and each part of the three parts was divided into four parts for each cv. The first part was treated with ultraviolet rays at an amount of 1 kgY at intervals (0, 5, 10) minutes, and the second part was treated with ozone at 5 ppm at intervals of (0, 0.5, 1) an hour, and the third part was treated with the compound (1-MCP) at a concentration of (0, 0.5, 1) ppm for 24 hours under 0°C, and the fourth part was immersed in chitosan at the three concentrations (0, 1, 2%). Fruits were packed in the transparent plastic container automatically with six replicates for each concentration, then three replicates were stored at a temperature of $-10 \pm 2°C$ for six months and after that, the following characteristics were determined:

2.2 The protein pattern was determined according to the following method

Electrophoresis for proteins

1. Lyophilization of samples

   The samples were lyophilized by the freeze-dryer lyophilization technique, where the samples to be lyophilized were placed in plastic containers and then placed in a lyophilization device at a temperature of $-26°C$ until almost most of the water was removed, after which powdered was used in protein electrophoresis on polyacrylamide gel in the presence of sodium dodecyle sulfate (SDS) by SDS-PAGE method according to [22].

2. Identification and quantification of proteins:

   A. Sample preparation:

   2g of lyophilized samples were crushed with 14 ml of cooled acetone three times, then the powder was thoroughly mixed with the extraction solution consisting of 0.2M sodium phosphate, 5% SDS, and 4 molar urea pH 7.0. The extraction solution was prepared by dissolving 3.12g sodium phosphate dissolving NaH_2PO_4, 5 g SDS, and 24.024 g urea in a volume of distilled water, the pH was adjusted to 7.0 and the volume was filled to 100 ml with distilled water, and then centrifuged at 4000 cycles min^{-1} for 15 min. The protein was precipitated using acetone in a ratio of 1:4 (volume:volume) and centrifuged at a speed of 10,000 cycles min^{-1}, the filter was neglected, and the precipitate was taken and dissolved in the buffer solution of the sample.

   B. Electrophoresis: Protein electrophoresis was carried out on a Polyacrylamide gel using the Slab–electrophoresis method in the presence of SDS according to the method of [23] and described by [24].

3. The solutions used:

   A. Resolving gel buffer prepared at a concentration of 1.5 M by dissolving 18.2 g of Tris (hydroxymethyl) methylamine in 80 ml of distilled water, the pH adjusted to 8.8 using 1 M of hydrochloric acid and the volume completed to 100 ml with distilled water.

   B. Stacking gel buffer (pH = 6.8) was prepared at 0.5 M concentration by dissolving 6 g of Tris (hydroxymethyl) methylamine in 40 ml of distilled water, the pH adjusted to 6.8 using 1 M HCl, and the volume completed to 100 ml with distilled water.

   C. 10% SDS solution was prepared by dissolving 10 g of sodium dodecyl sulfate in a volume of distilled water and then, the volume completed to 100 ml with distilled water.

D. Electrode buffer was Prepared by dissolving 1.5 g of Tris (hydroxymethyl) methylamine and 2.7 g of glycine in an amount of distilled water and the volume completed to 500 ml with distilled water with the addition of 5 ml of 10% SDS solution.

E. Acryl amide stock solution was prepared by adding 29.2 g of acrylamide with 0.8 g of Bis-acryl amide in 60 ml of distilled water and the volume completed to 100 ml with distilled water. The solution is filtered through filter paper no. 1 and 4 ml of a 10% SDS solution is added to it.

F. Ammonium persulfate (Aps) solution was prepared immediately at a concentration of 1.5% by dissolving 0.15 g of Ammonium Persulfate (Aps) in 10 ml of distilled water.

G. TEMED (N,N,N,N-tetra methyl ethylene diamine).

H. Staining Solution (0.1) was prepared by dissolving 0.25 g of Coomassie brilliant blue R-250 in 250 ml of a mixture consisting of acetic acid: methyl alcohol: distilled water in a 1:4:5 ratio, respectively.

I. Detaining solution consisted of a mixture of acetic acid: methyl alcohol: and distilled water in a ratio of 1:4:5, respectively.

J. A solution of bromophenol blue (0.25%) was prepared by dissolving 0.25 g of bromophenol blue dye in a 50% solution of glycerol.

K. sample buffer consisted of SDS at a concentration of 10%, bromophenol blue at a concentration of 0.5%, bromoethanol at a concentration of 0.5%, and sucrose at 20%.

4. Method

A. Sample preparation: It was prepared by dissolving the precipitated protein after the precipitation treatment in the buffer solution of the sample, and then it was placed in a water bath for 5 minutes at the boiling point and left to cool to the laboratory temperature to transfer the sample later.

B. Preparation of the gel:

1. Preparation of the separation gel: Separation gel 7.5% acrylamide was prepared by mixing 14.55 ml of distilled water, 7.5 ml of acrylamide solution, 7.5 ml of buffer solution for separation gel, 0.3 ml of SDS solution, 150 µl of ammonium persulfate solution, and 15 µl of TEMED, leave to harden for an hour and a half.

Finally, removal of the gel: Carefully remove the gel from the two glass plates by adding a little water with a syringe to avoid tearing the gel. Then, the dyeing solution was added and left for a whole day. After that, the gel was removed from the dyeing basin and the dye removal solution was added to it, and the process of washing the gel continued until the bands appeared. It was photographed with an English-origin Gel Documentation Device.

2. Total soluble solids (T.S.S.) were measured by hand refractometer and the results were corrected to 20°C according to [25].

3. Total and reducing sugars (%) of fruits were determined according to Lane and Eynon method outlined in [26].

4. Total titratable acidity%): Total titratable acidity was determined according to the method outlined in [26].

2.3 Statistical analysis

A completely randomized design (CRD) was used for a factorial storage experiment with three factors: the first factor is field-treated with chitosan, the second factor is storage treatments with three concentrations for each treatment, and the third factor is different storage periods that include six months at −10°C. The analysis was done using the statistical program (SPSS), and the mean values were compared using the least significant difference test (R.L.S.D) at the level of significance (5%) [27].

3. Results and discussion

3.1 The protein pattern

As shown in **Figure 1**, the electrophoresis in acrylamide gel of fruits proteins of Berhi and Breim cultivars field-treated with 2% chitosan and postharvest treated with UV rays for 10 minutes, 1-MCP at a concentration of 1 ppm, ozone for 1 hour, and chitosan at a concentration of 2% in addition to control treatment, respectively.

Breim cultivar treated with chitosan recorded the highest height of bundle (180) for the second bundle, while Berhi cultivar treated with the compound (1-MCP) recorded the lowest bundle height of (104) for the first bundle. Berhi cultivar treated with the compound (1-MCP) recorded the largest bundle area of (14,112) for the fourth bundle, while Breim cultivar treated with ultraviolet rays recorded the smallest bundle area of (48) for the first bundle (**Figure 2 a–d**).

As shown in **Figure 3**, the number and sites of protein bundles and **Table 2** showed the changes in the number of protein bundles and their molecular weights (kilodalton). It is clear that Breim cultivar fruits treated with chitosan recorded the highest number of bundles of seven bundles, while the control treatments of the two cultivars as well as Breim cultivar fruits treated with ultraviolet rays recorded five bundles each, while all treatments of Berhi cultivar except the control treatment recorded four bundles, as well as the ozone-treated Breim cv. fruits, while the Breim cv. fruits treated with the compound (1-MCP) recorded the lowest number of bundles, which amounted to only three bundles.

The Breim cultivar treated with chitosan recorded the highest molecular weight of (173.857) kDa for the first bundle, while the lowest molecular weight was (32.00) kDa for the Breim dipped in chitosan for the seventh bundle, see **Table 1**.

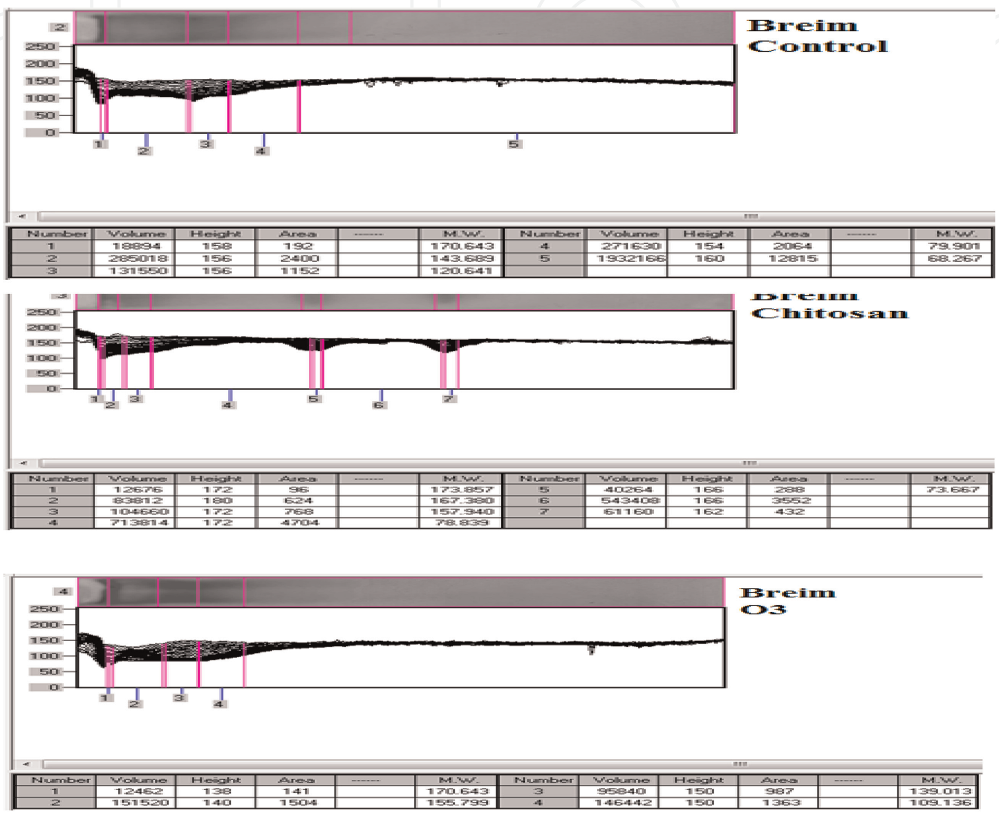
Figure 1.
The electrophoresis.

Through the results obtained from the gel-electrophoresis of the proteins of the date palm fruits of the Berhi and Breim cultivars, it is noted that there are significant differences in the number of protein bundles as well as the sites of their appearance between the control treatment and other treatments. There is no doubt that the dependence on the physical and chemical characteristics of the fruits is no longer sufficient to identify and distinguish among date cultivars and to detect commercial fraud for dates, especially after the processes of pressing them. Therefore, the recent trend is to use techniques such as electrophoresis to identify the protein patterns of dates and determine their behavior during storage. These differences in the protein pattern of the fruits mean that the fruits have differed in the process of gene expression.

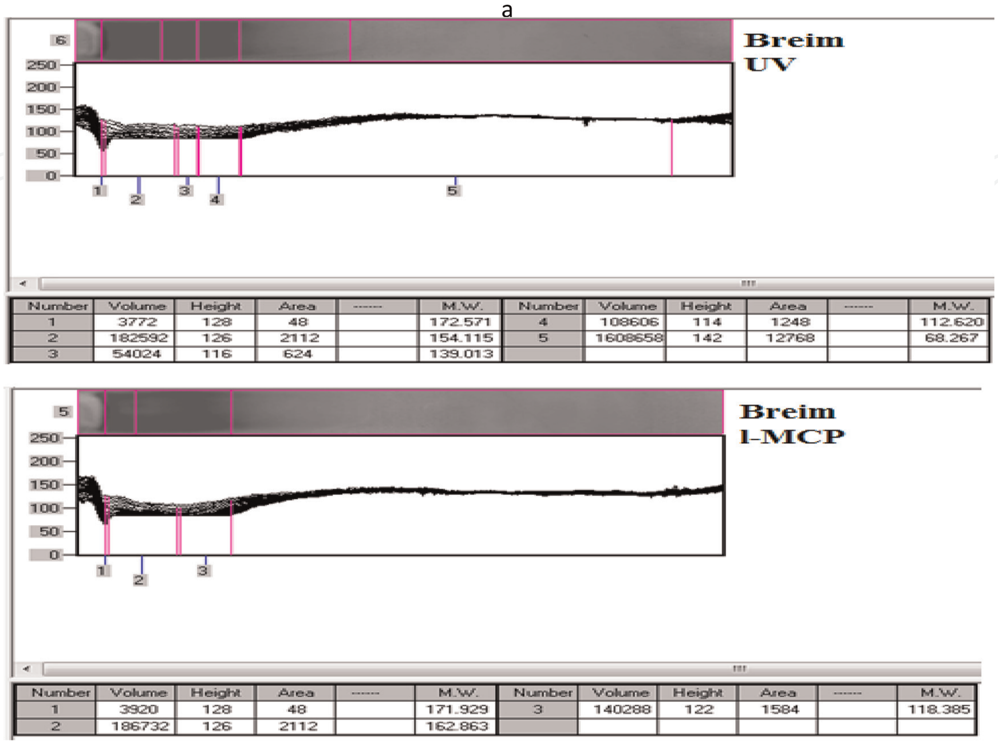
It is well known in recent years that changes in the process of gene expression played an important role in regulating the process of fruit growth and ripening, and scientific development in the field of molecular biology has led to a significant increase in our knowledge of the mechanisms in which the genes responsible for the ripening of fruits are regulated, and thus, there may be gene expression of heat shock proteins made fruits to bear low temperatures when freezing [28].

3.2 Total soluble solids

The results of **Tables 2** and **3** showed the effect of spraying chitosan, storage treatments, and storage periods, and the interaction among them on the percentage of total soluble solids in the fruits of the Berhi and Breim cultivars stored at a temperature of (−10 ± 2) °C for the two seasons 2014 and 2015. It is noted that spraying



a



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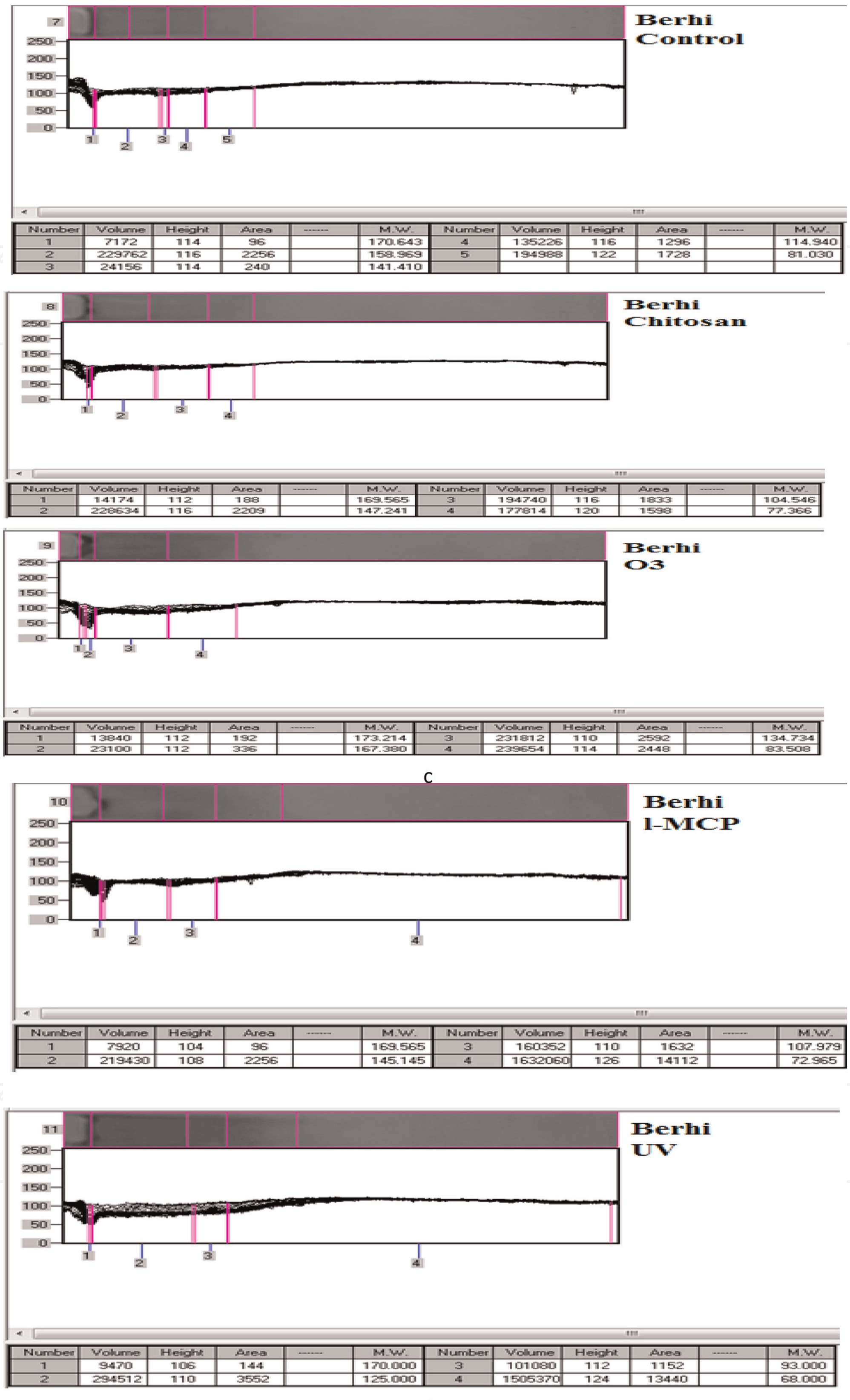

Figure 2.
a-d. some specifications of protein bundles for study parameters.

chitosan had a significant effect in decreasing the percentage of total soluble solids, the lowest percentage of total soluble solids was (36.12 and 35.72), (33.61 and 33.48)% for the fruits of the Berhi and Breim cultivars treated in the field with 2%chitosan for

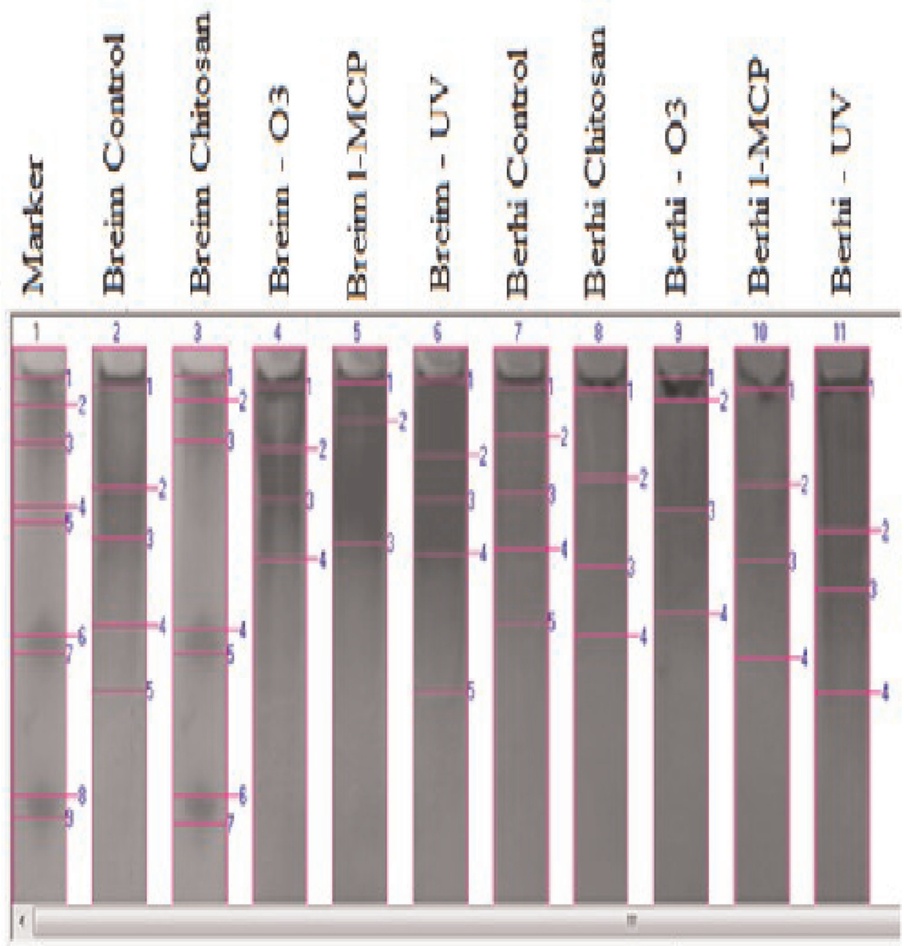

Figure 3.
The number and sites of protein bundles for the study parameters.

the two seasons, respectively, with a significant difference from the rest of the treatments, while it reached the highest percentage of total soluble solids (42.06 and 41.93)% and (37.38 and 44.98)% for the control fruits of Berhi and Breim cultivars for the two seasons, respectively. The results are consistent with [29], which referred to the effect of pre-harvest chitosan treatment in decreasing the percentage of soluble solids, and the untreated fruits had a higher percentage of soluble solids.

As for the effect of 1-MCP at a concentration of 1 ppm, it caused a reduction in the percentage of total soluble solids, which amounted to (37.64 and 37.38), (34.67 and 34.36)% for the fruits of Berhi and Breim cultivars for the two seasons, respectively, with a significant difference from the untreated fruits of the two cvs. For the same seasons, which amounted to (39.94 and 39.85), (36.24 and 35.87)%.

It was noted from the same table that the percentage of total soluble solids mild increased with the increment of the storage periods reached (42.03 and 41.89), (37.19 and 37.00)% for the fruits of the two cvs. For the two seasons, respectively after six months of storage, while the lowest percentage of total soluble solids was (35.55 and 34.88), (34.15 and 33.94%) for the fruits of the two cvs. For the two seasons, respectively, after one week of storage. This is may be due to that, the percentage of total soluble solids increasing by decreasing the percentage of the water content of the fruits.

As for the interaction effect between spraying chitosan and storage treatments, the results indicated that the fruits treated with 2% chitosan and (1-MCP) at a

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Berhi cultivar					No.bandles	Breim cultivar					No.bandles
UV	**1-mcp**	**O3**	**chitosan**	**control**		**UV**	**1-mcp**	**O3**	**chitosan**	**control**	
170.00	169.565	173.214	169.565	170.643	1	172.929	171.643	170.643	173.857	170.643	1
125.00	145.145	167.380	147.241	158.969	2	154.115	162.863	155.799	167.380	143.689	2
93.00	107.979	134.734	104.546	141.410	3	139.013	118.385	139.013	157.940	120.641	3
68.00	72.965	83.508	77.366	114.940	4	112.620		109.136	78.839	79.901	4
				81.030	5	68.267			73.667	68.267	5
					6				41.00		6
					7				32.00		7

Table 1.
Changes in the number of protein bundles and their molecular weights (kilodaltons) for the study parameters.

Field chitosan treatment	Storage treatments	2014						Field chitosan x Storage treatments	2015						Field chitosan x Storage treatments
		Storage period (month)							Storage period (month)						
		1	2	3	4	5	6		1	2	3	4	5	6	
0%	Control	38.13	40.23	42.40	44.4	46.66	49.00	43.47	40.03	40.23	42.86	44.60	46.33	48.26	43.72
	UV 5 min.	37.13	39.70	41.30	43.43	45.50	46.86	42.32	37.46	38.70	41.63	43.10	44.83	46.86	42.10
	UV 10 min.	37.03	39.63	41.13	43.30	45.53	46.73	42.22	38.36	39.70	41.70	43.30	45.20	46.13	42.40
	(1-MCP) 0.5 ppm	35.93	36.56	40.03	42.20	44.50	46.20	40.90	35.70	36.26	39.63	41.86	44.16	45.86	40.58
	(1-MCP) 1 ppm	35.70	37.63	39.90	42.06	44.46	45.73	40.91	35.60	37.63	39.23	41.80	44.23	45.46	40.66
	Ozone half an hour	37.40	39.86	41.46	43.56	45.80	47.00	42.51	37.63	39.96	41.56	43.66	45.86	47.26	42.66
	Ozone one hour	37.80	40.06	41.83	43.80	46.10	47.40	42.83	37.90	40.06	41.86	43.80	46.10	47.53	42.87
	(Chitosan) 1%	36.60	38.70	41.23	43.03	44.83	46.73	41.85	35.93	38.36	40.90	42.63	44.36	46.23	41.40
	(Chitosan) 2%	35.70	37.63	39.90	42.06	43.33	46.30	41.35	35.63	38.30	40.86	42.10	43.16	46.00	41.01
1%	Control	35.96	37.16	38.33	40.13	41.13	42.13	39.14	35.63	36.50	37.86	39.56	41.46	41.80	38.80
	UV 5 min.	35.30	36.00	37.50	39.30	40.23	41.13	38.24	35.16	35.26	37.16	38.96	40.06	40.80	37.90
	UV 10 min.	34.96	35.96	37.40	39.33	40.23	40.23	38.02	34.36	35.76	37.06	38.66	40.23	40.43	37.75
	(1-MCP) 0.5 ppm	33.86	35.00	36.40	38.20	39.60	40.13	37.20	33.66	34.66	36.23	37.90	39.36	39.80	36.93
	(1-MCP) 1 ppm	33.86	34.93	36.36	38.30	39.53	39.60	37.10	33.53	34.80	35.96	38.20	39.20	39.13	36.80
	Ozone half an hour	35.50	36.06	37.73	39.43	40.53	41.43	38.45	35.76	36.23	37.80	39.60	40.86	41.43	38.61
	Ozone one hour	35.73	36.20	38.00	39.70	40.73	41.70	38.67	36.06	36.30	38.33	39.76	40.73	41.70	38.81
	(Chitosan) 1%	34.80	35.33	36.86	38.50	39.80	40.73	37.67	34.33	35.03	36.46	38.16	39.33	40.53	37.31
	(Chitosan) 2%	34.23	35.10	37.30	38.36	39.50	40.40	37.48	33.96	35.10	37.06	38.06	39.16	40.03	37.23
2%	Control	34.06	35.20	36.60	38.06	39.06	40.26	37.21	34.73	34.43	36.26	38.06	38.06	39.93	37.02
	UV 5 min	32.93	33.93	35.60	36.36	38.70	39.06	36.10	32.60	33.60	35.26	36.36	38.70	38.40	35.82
	UV 10 min	32.83	33.76	35.46	36.43	38.60	38.70	35.96	32.50	33.43	35.46	36.43	38.26	38.70	35.80

Field chitosan treatment	**Storage treatments**	**2014**						**Field chitosan x Storage treatments**	**2015**						**Field chitosan x Storage treatments**
		Storage period (month)							**Storage period (month)**						
		1	**2**	**3**	**4**	**5**	**6**		**1**	**2**	**3**	**4**	**5**	**6**	
	(1-MCP) 0.5 ppm	31.93	32.93	34.60	35.36	37.33	38.06	35.03	31.60	32.60	34.26	35.20	37.00	37.93	34.76
	(1-MCP) 1 ppm	31.83	32.76	34.46	35.43	37.23	37.70	34.90	31.63	32.43	34.33	35.23	36.90	37.50	34.67
	Ozone half an hour	33.20	34.26	35.76	36.53	38.83	39.30	36.31	33.43	34.60	36.10	36.53	38.86	39.46	36.50
	Ozone one hour	33.36	34.66	36.06	36.80	39.03	39.60	36.58	33.70	34.66	36.33	36.80	39.30	39.66	36.74
	(Chitosan) 1%	32.93	33.86	35.00	35.80	38.16	37.76	35.58	32.60	33.46	34.83	35.46	37.83	37.36	35.26
	(Chitosan) 2%	32.66	33.50	35.30	35.43	37.86	37.66	35.40	32.46	33.26	34.96	35.10	37.53	36.96	35.05
								Mean of field chitosan treatment							Mean of field chitosan treatment
Field chitosan x Storage period	0%	37.28	38.90	41.30	43.12	45.04	46.73	42.06	37.13	38.8	41.13	42.98	44.91	46.62	41.93
	1%	34.79	35.57	37.19	38.85	40.16	40.78	37.89	34.71	35.51	37.10	38.7	40.04	40.62	37.794
	2%	34.58	33.71	35.35	36.24	38.24	38.57	36.12	32.80	33.60	35.31	36.13	38.04	38.43	35.72
								Mean of storage treatments							Mean of storage treatments
Storage treatments x Storage period	control	36.05	37.53	39.11	40.86	42.28	43.80	39.94	36.80	37.05	39.00	40.74	42.17	43.33	39.85
	UV 5 min.	35.12	36.54	38.13	39.70	41.47	42.35	38.88	35.07	35.85	38.02	39.47	41.20	42.02	38.60
	UV 10 min.	34.94	36.45	38.00	39.68	41.45	41.88	38.73	35.07	36.30	38.07	39.46	41.23	41.75	38.65
	(1-MCP) 0.5 ppm	33.91	34.83	37.01	38.58	40.47	41.46	37.71	33.65	34.51	36.71	38.32	40.17	41.20	37.43
	(1-MCP) 1 ppm	33.80	35.11	36.91	38.60	40.41	41.01	37.64	33.58	34.95	36.51	38.41	40.11	40.70	37.38
	Ozone half an hour	35.36	36.73	38.32	39.84	41.72	42.57	39.09	35.61	36.93	38.48	39.93	41.86	42.72	39.25
	Ozone one hour	35.63	36.97	38.63	40.10	41.95	41.90	39.36	35.88	37.01	38.84	40.12	42.04	42.96	39.48
	(Chitosan) 1%	34.77	35.96	37.70	39.11	40.93	41.74	38.37	34.28	35.62	37.40	38.75	40.51	41.37	37.99
	(Chitosan) 2%	34.40	35.74	37.90	38.74	40.23	41.45	38.08	34.02	35.55	37.63	38.42	39.95	41.00	37.76

Field chitosan treatment	**Storage treatments**	**2014**						**Field chitosan x Storage treatments**	**2015**						**Field chitosan x Storage treatments**
		Storage period (month)							**Storage period (month)**						
		1	**2**	**3**	**4**	**5**	**6**		**1**	**2**	**3**	**4**	**5**	**6**	
Mean of Storage period		35.55	36.06	37.95	39.40	41.14	42.03		34.88	35.97	37.85	39.29	41.02	41.89	

R.L.S.D. 5%	Field chitosan treatment	Storage treatments	Storage period	Field chitosan x Storage treatments	Storage treatments x Storage period	Storage treatments x Storage period	Triple interaction
2014	0.09	0.17	0.14	0.14	0.24	0.42	0.72
2015	0.05	0.10	0.08	0.17	0.14	0.25	0.43

Table 2.
Effect of field chitosan spraying, storage treatments, storage period, and interaction between them in the percentage of total soluble solids in the fruits of the Berhi cultivar stored at a temperature of (−10 ± 2) °C for the 2014 and 2015 seasons.

Field chitosan treatment	Storage treatments	2014 Storage period (month)						Field chitosan x Storage treatments	2015 Storage period (month)						Field chitosan x Storage treatments
		1	2	3	4	5	6		1	2	3	4	5	6	
0%	control	36.20	36.53	36.73	37.80	40.83	42.76	38.47	35.73	36.20	36.46	37.46	40.50	42.43	38.13
	UV 5 min.	36.03	36.33	36.73	37.40	39.10	41.23	37.80	35.70	36.00	36.03	36.93	38.73	40.90	37.38
	UV 10 min.	36.00	36.30	36.53	37.40	39.43	41.10	37.79	35.73	36.10	36.03	37.03	39.06	40.50	37.41
	(1-MCP) 0.5 ppm	35.66	36.06	36.20	36.40	37.23	38.56	36.68	35.20	35.73	35.86	36.06	36.90	38.30	36.34
	(1-MCP) 1 ppm	35.63	36.10	36.20	36.40	37.23	38.63	36.70	35.46	35.76	36.16	36.06	36.90	38.30	36.44
	Ozone half an hour	36.06	36.26	36.53	36.80	39.13	40.53	37.55	36.26	36.43	36.53	36.96	39.13	40.73	37.67
	Ozone one hour	36.03	36.06	36.46	36.86	38.86	40.23	37.42	36.23	36.26	36.46	36.86	38.86	40.56	37.54
	(Chitosan) 1%	35.76	35.80	36.46	36.56	38.40	39.20	37.03	35.46	35.03	35.96	36.16	37.93	38.93	36.58
	(Chitosan) 2%	35.60	35.66	36.40	36.60	38.20	39.23	36.95	34.90	35.10	36.16	36.26	38.13	38.90	36.57
1%	Control	34.03	34.33	34.66	36.00	37.06	38.06	35.69	33.70	34.00	34.33	34.86	36.40	37.73	35.17
	UV 5 min.	33.96	34.16	34.50	35.30	36.70	35.86	35.08	33.70	34.13	33.86	35.20	35.70	35.53	34.68
	UV 10 min.	34.03	34.33	34.53	35.20	36.60	36.60	35.21	33.70	33.33	34.20	34.83	35.93	36.26	34.71
	(1-MCP) 0.5 ppm	33.60	33.63	34.06	34.40	35.36	35.93	34.50	33.26	33.30	33.73	34.06	35.03	35.60	34.16
	(1-MCP) 1 ppm	33.50	33.60	33.96	33.93	35.30	35.76	34.34	33.16	33.20	33.63	33.60	35.10	35.43	34.02
	Ozone half an hour	34.03	34.36	34.43	34.70	35.06	36.36	34.82	34.06	34.50	34.60	34.83	35.26	36.53	34.96
	Ozone one hour	34.00	34.20	34.36	34.83	35.10	36.23	34.78	34.06	34.30	34.56	34.90	35.23	36.43	34.91
	(Chitosan) 1%	33.60	33.86	33.80	34.36	35.30	36.66	34.60	33.23	33.53	33.40	34.10	34.96	36.20	34.23
	(Chitosan) 2%	35.30	33.96	33.63	34.23	35.13	36.50	34.51	33.26	33.56	33.30	33.96	34.96	36.26	34.22
2%	Control	33.00	33.23	33.70	34.66	35.40	37.33	34.55	32.80	32.90	33.36	34.53	35.30	37.00	34.31
	UV 5 min.	33.06	33.30	33.46	33.73	34.63	35.56	33.96	32.73	33.30	33.13	33.46	34.30	35.23	33.69
	UV 10 min.	33.10	33.13	33.36	33.70	34.63	35.26	33.86	32.76	32.80	33.36	33.36	34.63	34.93	33.68

Field chitosan treatment	**Storage treatments**	**2014**						**Field chitosan x Storage treatments**	**2015**						**Field chitosan x Storage treatments**
		Storage period (month)							**Storage period (month)**						
		1	**2**	**3**	**4**	**5**	**6**		**1**	**2**	**3**	**4**	**5**	**6**	
	(1-MCP) 0.5 ppm	32.50	33.06	32.73	32.80	34.10	34.00	33.20	32.16	32.73	32.40	32.46	33.76	33.50	32.83
	(1-MCP) 1 ppm	32.50	32.63	32.63	32.76	33.43	33.93	32.98	32.16	32.30	32.30	32.36	33.10	33.53	32.62
	Ozone half an hour	33.00	33.26	33.56	34.06	34.53	35.06	33.91	33.16	33.30	33.63	34.20	34.50	35.27	34.01
	Ozone one hour	32.96	33.23	33.46	33.86	34.73	34.80	33.84	33.06	33.40	33.60	33.90	34.80	34.93	33.95
	(Chitosan) 1%	32.63	32.70	32.83	33.16	34.60	35.10	33.50	32.36	32.36	32.50	33.00	34.26	34.40	33.15
	(Chitosan) 2%	32.66	32.66	32.73	33.00	34.43	35.10	33.43	32.43	32.36	32.43	32.83	33.90	34.90	33.14
								Mean of field chitosan treatment							Mean of field chitosan treatment
Field chitosan x Storage period	0%	35.88	36.12	36.474	36.915	38.715	40.167	37.38	35.63	35.84	36.18	36.64	38.46	39.95	37.12
	1%	33.82	34.05	34.219	34.774	35.700	36.370	34.82	33.57	33.76	33.95	34.48	35.39	36.219	34.56
	2%	32.75	32.97	33.063	33.415	34.437	35.044	33.61	32.62	32.82	32.96	33.3	34.28	34.85	33.48
								Mean of storage treatments							Mean of storage treatments
Storage treatments x Storage period	Control	34.41	34.70	35.03	36.15	37.76	39.38	36.24	34.07	34.36	34.72	35.62	37.40	39.05	35.87
	UV 5 min.	34.35	34.60	34.90	35.47	36.81	37.55	35.61	34.04	34.47	34.34	35.20	36.24	37.22	35.25
	UV 10 min.	34.37	34.58	34.81	35.43	36.88	37.65	35.62	34.06	34.07	34.53	35.16	36.54	37.23	35.27
	(1-MCP) 0.5 ppm	33.92	34.25	34.33	34.53	35.56	36.16	34.79	33.54	33.92	34.00	34.20	35.23	35.80	34.45
	(1-MCP) 1 ppm	33.87	34.11	34.26	34.36	35.32	36.11	34.67	33.60	33.75	34.03	34.01	35.03	35.75	34.36
	Ozone half an hour	34.36	34.63	34.84	35.18	36.24	37.32	35.43	34.50	34.74	34.92	35.33	36.30	37.51	35.55
	Ozone one hour	34.33	34.50	34.76	34.86	35.83	37.07	35.35	34.45	34.65	34.87	35.22	36.30	37.31	35.47
	(Chitosan) 1%	34.00	34.12	34.36	34.70	36.10	36.98	35.04	33.68	33.64	33.95	34.42	35.72	36.51	34.65
	(Chitosan) 2%	33.96	34.10	34.25	34.61	35.92	36.94	34.96	33.53	33.67	33.96	34.35	35.66	36.68	34.6

Field chitosan treatment	Storage treatments	2014						Field chitosan x Storage treatments	2015						Field chitosan x Storage treatments
		Storage period (month)							Storage period (month)						
		1	2	3	4	5	6		1	2	3	4	5	6	
Mean of Storage period		34.15	34.38	34.58	35.03	36.28	37.19		33.94	34.14	34.36	34.83	36.04	37.00	

R.L.S.D. 5%	Field chitosan treatment	Storage treatments	Storage period	Field chitosan x Storage treatments	Storage treatments x Storage period	Storage treatments x Storage period	Triple interaction
2014	0.05	0.10	0.08	0.17	0.14	0.25	0.434
2015	0.05	0.10	0.08	0.17	0.14	0.25	0.434

Table 3.
Effect of field chitosan spraying, storage treatments, storage period and interaction between them in the percentage of total soluble solids in the fruits of the Breim cultivar stored at a temperature of (−10 ± 2) °C for the 2014 and 2015 seasons.

concentration of 1 ppm significantly decreased the percentage of total soluble solids, as it was the lowest percentage of total soluble solids (34.90 and 34. 67), (32.98 and 32.83%) was in the fruits of the Berhi and Breim cultivars for the two seasons, respectively, while the highest percentage of total soluble solids was (43.47 and 43.72%) and (38.47 and 38.13%) for the untreated fruits of the two seasons, respectively and this is in the same line with [30]. The results also showed that the effect of the interaction between spraying with chitosan and the storage periods had a significant effect, as the lowest percentage of total soluble solids was (38.57 and 38.43), (35.04 and (34.85%) for the fruits of the two cultivars treated with chitosan at a concentration of 2% at the end of the storage period for the two seasons, respectively. The highest percentage of total soluble solids was (46.73 and 46.62), (40.16 and 39.95%) for the untreated fruits of the two cultivars for the two seasons, respectively, at the end of the storage periods. Findings are in agreement with the results obtained by [8].

The interaction between storage treatments and storage periods had a significant effect, as the lowest percentage of total soluble solids was (41.01 and 40.70), (36.11 and 35.75%) for the fruits of the Berhi and Breim treated with (1-MCP) at a concentration of 1 ppm at the end of the storage periods for the two seasons, respectively. The highest percentage of total soluble solids was (43.80 and 43.33%) and (39.38 and 39.05%) for the control fruits of the Berhi and Breim cultivars at the end of the storage periods for the two seasons, respectively. Regarding the effect of the interaction among the spraying chitosan, postharvest treatments, and storage periods, the lowest percentage of total soluble solids was (37.66 and 36.96), (33.93 and 33.50%) for the Berhi fruits sprayed with 2% chitosan and dipped in 2% chitosan and for the Breim fruits treated with (1-MCP) at a concentration of 1 ppm for the two seasons at the end of the storage period of (six months), respectively, while, the highest percentage of total soluble solids was (49.00 and 48.26%) and (42.76 and 42.43)% in the fruits of the two cultivars sprayed with 0% chitosan and control treatment at the end of the storage period, respectively.

3.3 Total sugars

The results of **Tables 4** and **5** showed the effect of spraying chitosan in the field, storage treatments and storage period, and the interaction between them on the percentage of total sugars in the fruits of the Berhi and Breim cultivars stored at a temperature of (-10 ± 2) °C for the two seasons 2014 and 2015. It is noted that spraying with field chitosan had a significant effect in reducing the percentage of total sugars where the lowest percentage of total sugars was (49.92 and 49.49), (47.21 and 47.07%) for the fruits of the mentioned cultivars that were field-treated with 2% chitosan for the two seasons, respectively, with a significant difference from the rest of the treatments, while the highest percentages of total sugars were (55.86 and 55.73), (50.98 and 50.70%) in the control fruits of mentioned cultivars for the two seasons, respectively. As for the effect of storage treatments, it was noted that it worked to reducetotal sugars percentage, which reached (51.44 and 51.18), (48.27 and 47.96%) for the fruits of the Berhi cultivar for the first season and Breim cultivar for the two seasons treated with the compound 1-MCP at a concentration of 1 ppm and at a concentration of 0.5 ppm for the Berhi cv. in the second season, respectively, with a significant difference from the control treatment, which amounted to (53.65 and 53.56%), (49.73 and 52.65%)for Berhi and Breim cultivars for the two seasons, respectively.

Field chitosan treatment	Storage treatments	2014						Field chitosan x Storage treatments	2015						Field chitosan x Storage treatments
		Storage period (month)							Storage period (month)						
		1	2	3	4	5	6		1	2	3	4	5	6	
0%	Control	53.83	54.03	56.66	58.40	60.13	62.06	57.52	53.83	54.03	56.66	58.40	60.13	62.06	57.52
	UV 5 min.	51.26	52.50	55.43	56.90	58.63	60.66	55.90	51.26	52.50	55.43	56.90	58.63	60.66	55.90
	UV 10 min	52.16	53.50	55.50	57.10	59.00	59.93	56.20	52.16	53.50	55.50	57.10	59.00	59.93	56.20
	(1-MCP) 0.5 ppm	49.73	50.36	53.83	56.00	58.30	60.00	54.70	49.50	50.06	53.43	55.66	57.96	59.66	54.38
	(1-MCP) 1 ppm	49.50	51.43	53.70	55.86	58.26	59.53	54.71	49.40	51.43	53.03	55.60	58.03	59.26	54.46
	Ozone half an hour	51.20	53.66	55.26	57.36	59.60	60.80	56.31	51.43	53.76	55.36	57.46	59.66	61.06	56.46
	Ozone one hour	51.60	53.86	55.63	57.60	59.90	61.20	56.63	51.70	53.86	55.66	57.60	59.90	61.33	56.67
	(Chitosan) 1%	50.40	52.50	55.03	56.83	58.63	60.53	55.65	49.73	52.16	54.70	56.43	58.16	60.03	55.20
	(Chitosan) 2%	50.10	52.43	54.90	56.23	57.13	60.10	55.15	49.43	52.10	54.66	55.90	56.96	59.80	54.81
1%	Control	49.76	50.96	52.13	53.93	54.93	55.93	52.94	49.43	50.30	51.66	53.36	55.26	55.60	52.60
	UV 5 min.	49.10	49.80	51.30	53.10	54.03	54.93	52.04	48.96	49.06	50.96	52.76	53.86	54.60	51.70
	UV 10 min	48.76	49.76	51.20	53.13	54.03	54.03	51.82	48.16	49.56	50.86	52.46	54.03	54.23	51.5
	(1-MCP) 0.5 ppm	47.66	48.80	50.20	52.00	53.40	53.93	51.00	47.46	48.46	50.03	51.70	53.16	53.60	50.73
	(1-MCP) 1 ppm	47.66	48.73	50.16	52.10	53.33	53.40	50.90	47.33	48.60	49.76	52.00	53.00	52.93	50.60
	Ozone half an hour	49.30	49.86	51.53	53.23	54.33	55.23	52.25	49.56	50.03	51.60	53.40	54.66	55.23	52.41
	Ozone one hour	49.53	50.00	51.80	53.50	54.53	55.50	52.47	49.86	50.10	52.13	53.56	54.53	55.50	52.61
	(Chitosan) 1%	48.60	49.13	50.66	52.30	53.60	54.53	51.47	48.13	48.83	50.26	51.96	53.13	54.33	51.11
	(Chitosan) 2%	48.03	48.90	51.10	52.16	53.30	54.20	51.28	47.76	48.90	50.86	51.86	52.96	53.83	51.03
2%	Control	47.86	49.00	50.40	51.86	52.86	54.06	51.01	48.53	48.23	50.06	51.86	52.53	53.73	50.82
	UV 5 min.	46.73	47.73	49.40	50.16	52.50	52.86	49.90	46.40	47.40	49.06	50.16	52.50	52.20	49.62
	UV 10 min	46.63	47.56	49.26	50.23	52.40	52.50	49.76	46.30	47.23	49.26	50.23	52.06	52.50	49.62

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Field chitosan treatment	Storage treatments	2014						Field chitosan x Storage treatments	2015						Field chitosan x Storage treatments
		Storage period (month)							Storage period (month)						
		1	2	3	4	5	6		1	2	3	4	5	6	
	(1-MCP) 0.5 ppm	45.73	46.73	48.40	49.16	51.13	51.86	48.83	45.40	46.40	48.06	49.00	50.80	51.73	48.56
	(1-MCP) 1 ppm	45.63	46.56	48.26	49.23	51.03	51.50	48.70	45.43	46.23	46.23	49.03	50.70	51.30	48.47
	Ozone half an hour	47.00	48.06	49.56	50.33	52.63	53.10	50.11	47.23	48.40	49.90	50.33	52.66	53.26	50.30
	Ozone one hour	46.63	48.46	49.86	50.60	52.83	53.40	50.38	47.50	48.46	50.13	50.60	53.10	53.46	50.54
	(Chitosan) 1%	46.73	47.66	48.80	49.60	51.96	51.56	49.38	46.40	47.26	48.63	49.26	51.63	51.16	49.06
	(Chitosan) 2%	46.46	47.30	49.10	49.23	51.66	51.46	49.20	46.26	47.06	48.76	48.90	51.33	50.76	48.85
								Mean of field chitosan treatment							Mean of field chitosan treatment
Field chitosan x Storage period	0%	51.08	52.700	55.107	56.922	58.844	60.537	55.86	50.93	52.6	54.93	56.78	58.71	60.42	55.73
	1%	48.59	49.374	50.996	52.656	53.963	54.581	51.69	48.51	49.31	50.90	52.56	53.8	54.42	51.59
	2%	48.38	47.519	49.156	50.048	52.041	52.370	49.92	46.60	47.40	48.89	49.93	51.92	52.23	49.49
								Mean of storage treatments							MEAN of field chitosan treatment
Storage treatments x Storage period	control	50.60	50.856	52.800	54.544	55.978	57.60	53.65	50.60	50.80	52.80	54.54	55.97	57.13	53.65
	UV 5 min	48.87	49.656	51.822	53.278	55.000	56.15	52.40	48.87	49.65	51.82	53.27	55.00	55.82	52.40
	UV 10 min	48.87	50.100	51.878	53.267	55.033	55.68	52.45	48.87	50.10	51.87	53.267	55.03	55.55	52.45
	(1-MCP) 0.5 ppm	47.71	48.633	50.811	52.389	54.278	55.26	51.51	47.45	48.31	50.51	52.12	53.97	55.00	51.23
	(1-MCP) 1 ppm	47.60	48.911	50.711	52.400	54.211	54.81	51.44	47.38	48.75	50.31	52.21	53.91	54.50	51.18
	Ozone half an hour	49.16	50.533	52.122	53.644	55.522	56.37	52.89	49.41	50.73	52.28	53.73	55.66	56.52	53.05
	Ozone one hour	49.43	50.778	52.433	53.900	55.756	56.70	53.16	49.68	50.81	52.64	53.92	55.84	56.76	53.28

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Field chitosan treatment	Storage treatments	2014						Field chitosan x Storage treatments	2015						Field chitosan x Storage treatments
		Storage period (month)							Storage period (month)						
		1	2	3	4	5	6		1	2	3	4	5	6	
	(Chitosan) 1%	51.17	49.767	51.500	52.911	54.733	55.54	52.60	48.08	49.42	51.20	52.55	54.31	55.17	51.79
	(Chitosan) 2%	50.77	49.544	51.700	52.544	54.033	55.25	52.30	47.82	49.35	51.43	52.22	53.75	54.80	51.56
mean of Storage period		49.35	49.86	51.75	53.20	54.94	55.83		48.68	49.76	51.65	53.09	54.82	55.69	

R.L.S.D. 5%	Field chitosan treatment	Storage treatments	Storage period	Field chitosan x Storage treatments	Storage treatments x Storage period	Storage treatments x Storage period	Triple interaction
2014	0.09	0.17	0.14	0.29	0.24	0.42	0.72
2015	0.05	0.10	0.08	0.17	0.14	0.25	0.434

Table 4.
Effect of field chitosan spraying, storage treatments, storage period and interaction between them in the percentage of total sugars in the fruits of the Berhi cultivar stored at a temperature of (−10 ± 2) °C for the 2014 and 2015 seasons.

Field chitosan treatment	Storage treatments	2014						Field chitosan x Storage treatments	2015						Field chitosan x Storage treatments
		Storage period (month)							Storage period (month)						
		1	2	3	4	5	6		1	2	3	4	5	6	
0%	Control	49.80	50.13	50.33	51.40	54.43	56.36	52.07	49.33	49.80	50.06	50.06	54.10	56.03	51.73
	UV 5 min	49.63	49.93	50.33	51.00	52.70	54.83	51.40	49.30	49.60	49.63	50.53	52.33	54.50	50.98
	UV 10 min	49.60	49.90	50.13	51.00	53.03	54.70	51.39	49.33	49.70	49.63	50.63	52.66	54.10	51.01
	(1-MCP) 0.5 ppm	49.80	49.26	49.66	49.80	50.00	52.16	50.28	48.80	49.33	49.46	49.66	50.50	51.90	49.94
	(1-MCP) 1 ppm	49.23	49.70	49.80	50.00	50.83	52.23	50.30	49.06	49.36	49.76	49.66	50.50	51.90	50.04
	Ozone half an hour	49.66	49.86	50.13	50.40	52.73	54.13	51.15	49.87	50.03	50.13	50.56	52.73	54.33	51.27
	Ozone one hour	49.63	49.66	50.06	50.46	52.46	53.83	51.02	49.83	49.86	50.06	50.46	52.46	54.16	51.14
	(Chitosan) 1%	49.36	49.40	50.06	50.16	52.00	52.80	50.63	49.06	48.63	49.56	49.76	51.53	52.53	50.18
	(Chitosan) 2%	49.20	49.26	50.00	50.20	51.80	52.83	50.55	48.50	48.70	49.76	49.86	51.73	52.50	50.17
1%	Control	47.63	47.93	48.26	49.60	50.66	51.66	49.29	47.30	47.60	47.93	48.46	50.00	51.33	48.77
	UV 5 min	47.56	47.76	48.10	48.90	50.30	49.46	48.68	47.30	47.73	47.46	47.80	49.30	49.13	48.28
	UV 10 min	47.63	47.93	48.13	48.80	50.20	50.20	48.81	47.30	46.93	47.80	48.43	49.53	49.86	48.31
	(1-MCP) 0.5 ppm	47.20	47.23	47.66	48.00	48.96	49.53	48.10	46.86	46.90	47.33	47.66	48.63	49.20	47.76
	(1-MCP) 1 ppm	47.10	47.20	47.56	47.53	48.90	49.36	47.94	46.76	46.80	47.23	47.20	48.70	49.03	47.62
	Ozone half an hour	47.63	47.96	48.03	48.30	48.66	49.96	48.42	47.66	48.10	48.20	48.43	48.87	50.13	48.56
	Ozone one hour	47.60	47.80	47.96	48.43	48.70	49.83	48.38	47.67	47.90	48.16	48.50	48.83	50.03	48.51
	(Chitosan) 1%	47.20	47.46	47.40	47.96	48.90	50.26	48.20	46.83	47.13	47.00	47.70	48.56	49.80	47.83
	(Chitosan) 2%	47.23	47.56	47.23	47.83	48.73	50.10	48.11	46.86	47.16	46.90	47.56	48.56	49.86	47.82
2%	Control	46.60	46.83	47.30	48.26	49.00	50.93	48.15	46.40	46.50	46.96	48.13	48.90	50.60	47.91
	UV 5 min	46.66	46.90	47.06	47.33	48.23	49.16	47.56	46.33	46.90	46.73	47.06	47.90	48.83	47.29
	UV 10 min	46.70	46.73	46.96	47.30	48.23	48.86	47.46	46.36	46.40	46.96	47.23	48.23	48.53	47.28

Field chitosan treatment	Storage treatments	2014						Field chitosan x Storage treatments	2015						Field chitosan x Storage treatments
		Storage period (month)							Storage period (month)						
		1	2	3	4	5	6		1	2	3	4	5	6	
	(1-MCP) 0.5 ppm	46.10	46.66	46.33	46.40	47.70	47.60	46.80	45.76	46.33	46.00	46.06	47.36	47.10	46.43
	(1-MCP) 1 ppm	46.10	46.23	46.23	46.36	47.03	47.53	46.58	45.76	45.90	45.90	45.96	46.70	47.13	46.22
	Ozone half an hour	46.60	46.86	47.16	47.66	48.13	48.66	47.51	46.76	46.90	47.23	47.00	48.10	48.86	47.61
	Ozone one hour	46.56	46.83	47.06	47.46	48.33	48.66	47.44	46.66	47.00	47.20	47.50	48.40	48.53	47.55
	(Chitosan) 1%	46.23	46.30	46.43	46.76	48.20	48.70	47.10	45.96	45.96	46.10	46.60	47.86	48.00	46.75
	(Chitosan) 2%	46.26	46.26	46.33	46.60	48.03	48.70	47.03	46.03	45.96	46.03	46.43	47.50	48.50	46.74
								Mean of field chitosan treatment							Mean of field chitosan treatment
Field chitosan x Storage period	0%	49.48	49.72	50.07	50.51	52.31	53.76	50.98	49.23	49.44	49.78	50.13	52.06	53.55	50.70
	1%	47.42	47.65	47.81	48.37	49.30	49.97	48.42	47.17	47.36	47.55	47.971	48.99	49.81	48.14
	2%	46.35	46.57	46.66	47.01	48.03	48.64	47.21	46.22	46.42	46.56	46.88	47.88	48.45	47.07
								Mean of storage treatments							Mean of storage treatments
Storage treatments x Storage period	control	47.90	48.19	48.52	49.64	51.33	52.81	49.73	47.67	47.96	48.32	49.22	51.00	52.65	49.47
	UV 5 min	47.93	48.16	48.41	48.98	50.26	51.07	49.13	47.64	48.07	47.94	48.80	49.84	50.82	48.85
	UV 10 min	47.91	48.18	48.30	48.90	50.38	51.03	49.11	47.67	47.67	48.13	48.76	50.14	50.83	48.87
	(1-MCP) 0.5 ppm	47.52	47.85	47.93	48.13	49.16	49.76	48.39	47.14	47.52	47.60	47.80	48.83	49.40	48.05
	(1-MCP) 1 ppm	47.47	47.71	47.86	47.96	48.92	49.71	48.27	47.20	47.35	47.63	47.61	48.63	49.35	47.96
	Ozone half an hour	47.96	48.23	48.44	48.78	49.84	50.92	49.03	48.10	48.34	48.52	48.93	49.90	51.11	49.15
	Ozone one hour	47.93	48.10	48.36	48.78	49.83	50.68	48.95	48.05	48.25	48.47	48.82	49.90	50.91	49.07
	(Chitosan) 1%	47.60	47.72	47.96	48.30	49.70	50.58	48.64	47.28	47.24	47.55	48.02	49.32	50.11	48.25
	(Chitosan) 2%	47.56	47.70	47.85	48.21	49.52	50.54	48.56	47.13	47.27	47.56	47.95	49.26	50.28	48.24

Field chitosan treatment	Storage treatments	2014						Field chitosan x Storage treatments	2015						Field chitosan x Storage treatments
		Storage period (month)							Storage period (month)						
		1	2	3	4	5	6		1	2	3	4	5	6	
Mean of Storage period		47.75	47.98	48.18	48.63	49.88	50.79		47.54	47.74	47.96	48.43	49.64	50.60	

R.L.S.D. 5%	Field chitosan treatment	Storage treatments	Storage period	Field chitosan x Storage treatments	Storage treatments x Storage period	Storage treatments x Storage period	Triple interaction
2014	0.05	0.10	0.08	0.17	0.14	0.25	0.43
2015	0.05	0.10	0.08	0.17	0.14	0.25	0.43
2015	0.03	0.06	0.05	0.11	0.09	0.15	0.27

Table 5.
Effect of field chitosan spraying, storage treatments, storage period and interaction between them in the percentage of total sugars in the fruits of the Breim cultivar stored at a temperature of (−10 ± 2) °C for the 2014 and 2015 seasons.

The storage period had a clear effect, as it was noted from the two mentioned tables that the percentage of total sugars increases with the increment in the storage period, where the highest percentages of total sugars reached (55.83 and 55.69), (50.79 and 50.60%) for the fruits of the two seasons after six months of storage, while the lowest percentages of total sugars were (49.35 and 48.68), (47.75 and 47.54%) for the fruits of the mentioned cultivars for the two seasons, respectively, after one week of storage. The reason may be due to that the percentage of total sugars increases by decreasing the percentage of water content in the fruits [31]. As for the effect of the interaction between spraying with chitosan in the field and storage treatments, the results indicated that the fruits treated with 2% chitosan and stored with the compound (1-MCP) at a concentration of 1 ppm worked significantly in reducing the percentage of total sugars, where it was the lowest percentage of total sugars (48.70 and 48.47), (46.58 and 46.22%) for the fruits of the studied cultivars for the two seasons respectively, while the highest percentages of total sugars were (57.52 and 57.52), (52.07 and 51.73%) for the control fruits of the studied cultivars.

The results also showed that the interaction between spraying chitosan in the field and the storage period had a significant effect, as the lowest percentage of total sugars was (52.37 and 52.23), (48.64 and 48.45%) for the fruits of the Berhi and Breim cultivars treated in the field with 2% chitosan at the end of the storage period for the two seasons respectively. The highest percentage of total sugars was (60.53 and 60.42) (53.76 and 53.55%) for the control fruits of the two cultivars for the two seasons, respectively after six months of storage. The results showed that the interaction between storage treatments and storage period had a significant effect, as the lowest percentage of total sugars reached (54.81 and 54.50), (49.71 and 49.35%) for the fruits of the studied cultivars treated with the compound (1-MCP) at a concentration of 1 ppm at the end of the storage period for the two seasons respectively. The highest percentage of total sugars was (57.60 and 57.13%) and (52.81 and 52.65%) for the control fruits of the studied cultivars, for the two seasons, respectively after six months of the storage.

The interaction among the three factors (spraying chitosan in the field, storage treatments, and storage period) had a significant effect. It was noted that the highest percentage of total sugars were (62.06 and 62.06%), (56.36 and 56.03%) in the pre and post-untreated fruits of the Berhi and Breim cultivars after six months of storage for the two seasons respectively.

3.4 Total titratable acidity

The results of **Tables 6** and **7** showed the effect of spraying chitosan in the field, storage treatments and storage period, and the interaction among them on the percentage of total titratable acidity in the fruits of the Berhi and Breim cultivars stored at a temperature of -10 ± 2°C for the two seasons 2014 and 2015. It is noted that field chitosan spraying had a significant effect on the preservation of the total titratable acidity percentage, where the highest percentage of total titratable acidity was (0.293 and 0.275), (0.287 and 0.313)% for the fruits of the two cultivars Berhi and Breim, field-treated with 2% chitosan for the two seasons, respectively, with a significant difference from the rest of the treatments, while the lowest percentage reached to (0.244 and 0.230), (0.246 and 0.246%) in the control fruits of Berhi and Breim cultivars for the two seasons, respectively. The results are consistent with [29], which indicated that the effect of pre-harvest chitosan spraying in all treatments led to an increase in acidity compared to the control treatment, except for the concentration of

Field chitosan treatment	Storage treatments	2014 Storage period (month) 1	2	3	4	5	6	Field chitosan x Storage treatments	2015 Storage period (month) 1	2	3	4	5	6	Field chitosan x Storage treatments
0%	Control	0.203	0.206	0.196	0.193	0.190	0.186	0.196	0.170	0.166	0.156	0.153	0.150	0.146	0.157
	UV 5 min	0.216	0.210	0.213	0.206	0.206	0.196	0.208	0.176	0.170	0.173	0.166	0.166	0.156	0.168
	UV 10 min	0.230	0.220	0.226	0.220	0.213	0.210	0.220	0.190	0.180	0.186	0.180	0.173	0.170	0.180
	(1-MCP) 0.5 ppm	0.267	0.253	0.240	0.235	0.230	0.223	0.241	0.290	0.285	0.275	0.270	0.250	0.243	0.269
	(1-MCP) 1 ppm	0.250	0.248	0.241	0.233	0.236	0.220	0.238	0.287	0.270	0.266	0.253	0.256	0.240	0.262
	Ozone half an hour	0.240	0.330	0.323	0.250	0.230	0.223	0.266	0.220	0.310	0.303	0.230	0.210	0.203	0.246
	Ozone one hour	0.170	0.340	0.320	0.240	0.226	0.216	0.252	0.150	0.320	0.300	0.220	0.206	0.196	0.232
	(Chitosan) 1%	0.206	0.196	0.290	0.240	0.230	0.216	0.230	0.186	0.176	0.270	0.220	0.210	0.196	0.210
	(Chitosan) 2%	0.203	0.206	0.253	0.206	0.226	0.216	0.218	0.183	0.186	0.233	0.186	0.206	0.196	0.198
1%	Control	0.223	0.220	0.216	0.213	0.210	0.203	0.214	0.183	0.180	0.176	0.173	0.170	0.163	0.174
	UV 5 min	0.250	0.240	0.236	0.236	0.230	0.220	0.235	0.210	0.200	0.196	0.196	0.190	0.180	0.195
	UV 10 min	0.253	0.243	0.240	0.240	0.240	0.230	0.241	0.213	0.203	0.200	0.200	0.200	0.190	0.201
	(1-MCP) 0.5 ppm	0.320	0.300	0.236	0.270	0.236	0.236	0.266	0.340	0.320	0.256	0.290	0.256	0.256	0.286
	(1-MCP) 1 ppm	0.280	0.286	0.300	0.283	0.243	0.213	0.273	0.300	0.306	0.320	0.303	0.263	0.270	0.293
	Ozone half an hour	0.306	0.300	0.236	0.276	0.233	0.236	0.265	0.286	0.280	0.216	0.256	0.213	0.216	0.245
	Ozone one hour	0.280	0.286	0.290	0.280	0.250	0.243	0.271	0.260	0.266	0.270	0.260	0.230	0.223	0.251
	(Chitosan) 1%	0.306	0.300	0.236	0.276	0.233	0.236	0.265	0.286	0.280	0.216	0.256	0.213	0.216	0.245
	(Chitosan) 2%	0.280	0.286	0.300	0.280	0.250	0.243	0.273	0.260	0.266	0.280	0.260	0.230	0.223	0.253
2%	Control	0.246	0.243	0.236	0.223	0.216	0.213	0.230	0.206	0.203	0.196	0.183	0.176	0.173	0.190
	UV 5 min	0.276	0.270	0.266	0.263	0.250	0.250	0.262	0.236	0.230	0.226	0.223	0.210	0.210	0.222
	UV 10 min	0.276	0.273	0.266	0.266	0.270	0.260	0.268	0.236	0.233	0.226	0.226	0.230	0.220	0.228

Field chitosan treatment	Storage treatments	2014						Field chitosan x Storage treatments	2015						Field chitosan x Storage treatments
		Storage period (month)							Storage period (month)						
		1	2	3	4	5	6		1	2	3	4	5	6	
	(1-MCP) 0.5 ppm	0.340	0.360	0.350	0.283	0.250	0.280	0.310	0.360	0.380	0.370	0.303	0.270	0.300	0.330
	(1-MCP) 1 ppm	0.340	0.350	0.356	0.293	0.273	0.290	0.317	0.360	0.370	0.376	0.313	0.293	0.310	0.337
	Ozone half an hour	0.333	0.360	0.350	0.283	0.250	0.280	0.309	0.313	0.340	0.330	0.263	0.230	0.260	0.289
	Ozone one hour	0.340	0.350	0.350	0.290	0.273	0.273	0.312	0.320	0.330	0.330	0.270	0.253	0.253	0.292
	(Chitosan) 1%	0.346	0.360	0.350	0.283	0.250	0.280	0.317	0.326	0.340	0.330	0.263	0.230	0.260	0.291
	(Chitosan) 2%	0.340	0.366	0.350	0.286	0.280	0.283	0.317	0.320	0.346	0.330	0.266	0.260	0.263	0.297
								Mean of field chitosan treatment							Mean of field chitosan treatment
Field chitosan x Storage period	0%	0.221	0.245	0.256	0.225	0.221	0.212	0.230	0.205	0.229	0.240	0.208	0.203	0.194	0.213
	1%	0.277	0.273	0.254	0.261	0.2361	0.228	0.255	0.259	0.255	0.236	0.243	0.218	0.215	0.238
	2%	0.315	0.325	0.319	0.274	0.256	0.267	0.293	0.297	0.308	0.301	0.256	0.239	0.249	0.275
								Mean of storage treatments							Mean of storage treatments
Storage treatments x Storage period	Control	0.224	0.223	0.216	0.210	0.205	0.201	0.213	0.186	0.183	0.176	0.170	0.165	0.161	0.173
	UV 5 min	0.247	0.240	0.238	0.235	0.228	0.222	0.235	0.207	0.200	0.198	0.195	0.188	0.182	0.195
	UV 10 min	0.253	0.245	0.244	0.242	0.241	0.233	0.243	0.213	0.205	0.204	0.202	0.201	0.193	0.203
	(1-MCP) 0.5 ppm	0.360	0.331	0.305	0.267	0.238	0.246	0.291	0.380	0.351	0.325	0.287	0.258	0.266	0.311
	(1-MCP) 1 ppm	0.442	0.327	0.324	0.270	0.251	0.253	0.311	0.462	0.347	0.344	0.344	0.271	0.273	0.331
	Ozone half an hour	0.293	0.330	0.303	0.270	0.237	0.246	0.280	0.273	0.310	0.283	0.250	0.217	0.226	0.260
	Ozone one hour	0.263	0.325	0.320	0.270	0.250	0.244	0.278	0.243	0.305	0.300	0.250	0.230	0.224	0.258
	(Chitosan) 1%	0.286	0.285	0.292	0.266	0.237	0.244	0.268	0.266	0.265	0.272	0.246	0.217	0.224	0.248
	(Chitosan) 2%	0.274	0.286	0.301	0.257	0.252	0.247	0.270	0.254	0.267	0.281	0.237	0.232	0.227	0.250

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Field chitosan treatment	Storage treatments	2014						Field chitosan x Storage treatments	2015						Field chitosan x Storage treatments
		Storage period (month)							Storage period (month)						
		1	2	3	4	5	6		1	2	3	4	5	6	
Mean of Storage period		0.293	0.288	0.282	0.254	0.237	0.237		0.276	0.270	0.264	0.242	0.219	0.219	
R.L.S.D. 5%	Field chitosan treatment		Storage treatments		Storage period			Field chitosan x Storage treatments		Storage treatments x Storage period			Storage treatments x Storage period		Triple interaction
2014	0.005	0.009	0.008	0.017	0.013	0.024	0.041								
2015	0.005	0.009	0.008	0.017	0.013	0.024	0.041								

Table 6.

Effect of field chitosan spraying, storage treatments, storage period and interaction between them in the percentage of total titratable acidity in the fruits of the Berhi cultivar stored at a temperature of (−10 ± 2) °C for the 2014 and 2015 seasons.

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Field chitosan treatment	Storage treatments	2014						Field chitosan x Storage treatments	2015						Field chitosan x Storage treatments
		Storage period (month)							Storage period (month)						
		1	2	3	4	5	6		1	2	3	4	5	6	
0%	Control	0.243	0.253	0.253	0.240	0.220	0.213	0.237	0.263	0.273	0.273	0.260	0.240	0.233	0.257
	UV 5 min	0.280	0.260	0.196	0.230	0.196	0.196	0.226	0.340	0.320	0.256	0.290	0.256	0.256	0.286
	UV 10 min	0.240	0.246	0.260	0.243	0.203	0.210	0.233	0.300	0.306	0.320	0.303	0.263	0.270	0.293
	(1-MCP) 0.5 ppm	0.320	0.300	.236	0.270	0.236	0.236	0.266	0.360	0.340	0.276	0.310	0.276	0.276	0.306
	(1-MCP) 1 ppm	0.280	0.286	0.300	0.283	0.243	0.225	0.273	0.320	0.326	0.340	0.323	0.283	0.290	0.313
	Ozone half an hour	0.290	0.270	0.206	0.240	0.206	0.206	0.236	0.260	0.240	0.176	0.210	0.176	0.176	0.206
	Ozone one hour	0.250	0.256	0.270	0.253	0.213	0.220	0.243	0.220	0.226	0.240	0.223	0.183	0.190	0.213
	(Chitosan) 1%	0.300	0.280	0.216	0.250	0.216	0.216	0.246	0.340	0.320	0.256	0.290	0.256	0.256	0.286
	(Chitosan) 2%	0.260	0.266	0.280	0.263	0.223	0.230	0.253	0.300	0.306	0.320	0.303	0.263	0.270	0.293
1%	Control	0.250	0.306	0.273	0.246	0.203	0.213	0.248	0.270	0.326	0.293	0.266	0.223	0.233	0.268
	UV 5 min	0.380	0.293	0.290	0.210	0.190	0.183	0.257	0.440	0.440	0.350	0.270	0.250	0.243	0.317
	UV 10 min	0.366	0.306	0.276	0.193	0.196	0.180	0.303	0.726	0.366	0.336	0.253	0.256	0.240	0.363
	(1-MCP) 0.5 ppm	0.273	0.333	0.330	0.250	0.230	0.223	0.273	0.313	0.373	0.370	0.290	0.270	0.263	0.313
	(1-MCP) 1 ppm	0.270	0.346	0.316	0.233	0.236	0.220	0.270	0.310	0.386	0.356	0.273	0.276	0.260	0.310
	Ozone half an hour	0.223	0.303	0.300	0.220	0.200	0.193	0.240	0.193	0.273	0.270	0.190	0.170	0.163	0.210
	Ozone one hour	0.353	0.316	0.286	0.203	0.206	0.190	0.259	0.323	0.286	0.256	0.173	0.176	0.160	0.229
	(Chitosan) 1%	0.286	0.313	0.310	0.230	0.210	0.203	0.258	0.326	0.353	0.350	0.270	0.250	0.243	0.298
	(Chitosan) 2%	0.350	0.326	0.296	0.213	0.216	0.200	0.267	0.390	0.366	0.336	0.253	0.256	0.240	0.307
2%	Control	0.280	0.276	0.290	0.223	0.230	0.243	0.257	0.300	0.296	0.310	0.243	0.250	0.263	0.277
	UV 5 min	0.300	0.320	0.310	0.243	0.210	0.240	0.270	0.360	0.380	0.370	0.303	0.270	0.300	0.330
	UV 10 min	0.300	0.310	0.316	0.253	0.233	0.250	0.277	0.360	0.360	0.376	0.313	0.293	0.310	0.337

Field chitosan treatment	Storage treatments	2014						Field chitosan x Storage treatments	2015						Field chitosan x Storage treatments
		Storage period (month)							Storage period (month)						
		1	2	3	4	5	6		1	2	3	4	5	6	
	(1-MCP) 0.5 ppm	0.340	0.360	0.350	0.283	0.250	0.280	0.310	0.380	0.400	0.390	0.323	0.290	0.320	0.350
	(1-MCP) 1 ppm	0.340	0.350	0.356	0.293	0.273	0.290	0.317	0.380	0.390	0.396	0.333	0.313	0.330	0.357
	Ozone half an hour	0.310	0.330	0.320	0.253	0.220	0.250	0.280	0.280	0.300	0.290	0.223	0.190	0.220	0.250
	Ozone one hour	0.310	0.320	0.326	0.263	0.243	0.260	0.287	0.280	0.290	0.296	0.233	0.213	0.230	0.257
	(Chitosan) 1%	0.320	0.340	0.330	0.263	0.230	0.260	0.290	0.360	0.380	0.370	0.303	0.270	0.300	0.330
	(Chitosan) 2%	0.320	0.330	0.336	0.273	0.253	0.270	0.297	0.360	0.370	0.376	0.313	0.293	0.310	0.337
								Mean of field chitosan treatment							Mean of field chitosan treatment
Field chitosan x Storage period	0%	0.273	0.268	0.246	0.252	0.217	0.220	0.246	0.300	0.295	0.273	0.279	0.244	0.246	0.273
	1%	0.339	0.316	0.297	0.222	0.210	0.200	0.264	0.365	0.352	0.324	0.248	0.236	0.227	0.292
	2%	0.313	0.326	0.326	0.261	0.2381	0.260	0.287	0.34	0.351	0.352	0.287	0.264	0.287	0.313
								Mean of storage treatments							Mean of storage treatments
Storage treatments x Storage period	Control	0.257	0.278	0.272	0.236	0.217	0.223	0.247	0.277	0.298	0.292	0.256	0.237	0.243	0.267
	UV 5 min	0.320	0.291	0.265	0.227	0.198	0.206	0.251	0.380	0.351	0.325	0.287	0.258	0.266	0.311
	UV 10 min	0.402	0.287	0.284	0.230	0.211	0.213	0.271	0.462	0.347	0.344	0.290	0.271	0.273	0.331
	(1-MCP) 0.5 ppm	0.311	0.331	0.305	0.267	0.238	0.246	0.283	0.351	0.371	0.345	0.307	0.278	0.286	0.323
	(1-MCP) 1 ppm	0.296	0.327	0.324	0.270	0.251	0.253	0.287	0.336	0.367	0.364	0.310	0.291	0.293	0.327
	Ozone half an hour	0.274	0.301	0.275	0.237	0.208	0.216	0.252	0.244	0.271	0.245	0.207	0.178	0.186	0.222
	Ozone one hour	0.304	0.297	0.294	0.240	0.221	0.223	0.263	0.274	0.267	0.264	0.210	0.191	0.193	0.233
	(Chitosan) 1%	0.302	0.311	0.285	0.247	0.218	0.226	0.265	0.342	0.351	0.325	0.287	0.258	0.266	0.305
	(Chitosan) 2%	0.310	0.307	0.304	0.250	0.231	0.223	0.272	0.350	0.347	0.344	0.290	0.271	0.273	0.312

Field chitosan treatment	Storage treatments	2014						Field chitosan x Storage treatments	2015						Field chitosan x Storage treatments
		Storage period (month)							Storage period (month)						
		1	2	3	4	5	6		1	2	3	4	5	6	
Mean of Storage period		0.308	0.303	0.290	0.245	0.222	0.227		0.335	0.330	0.316	0.271	0.248	0.253	

R.L.S.D. 5%	Field chitosan treatment	Storage treatments	Storage period	Field chitosan x Storage treatments	Storage treatments x Storage period	Storage treatments x Storage period	Triple interaction
2014	0.005	0.009	0.008	0.017	0.013	0.024	0.041
2015	0.005	0.009	0.008	0.017	0.013	0.024	0.041

Table 7.
Effect of field chitosan spraying, storage treatments, storage period and interaction between them in the percentage of total titratable acidity in the fruits of the Breim cultivar stored at a temperature of (−10 ± 2) °C for the 2014 and 2015 seasons.

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1% chitosan, which decreased this treatment with no significant differences in both seasons. Li and Yu (2000) found a decrease in the acidity of peach fruits during the storage period and at the end of the storage period, and an increase in acidity on fruits treated with chitosan, while in other fruits such as mango, the acidity decreased slowly, and linked this decrease with loss of quality [32, 33].

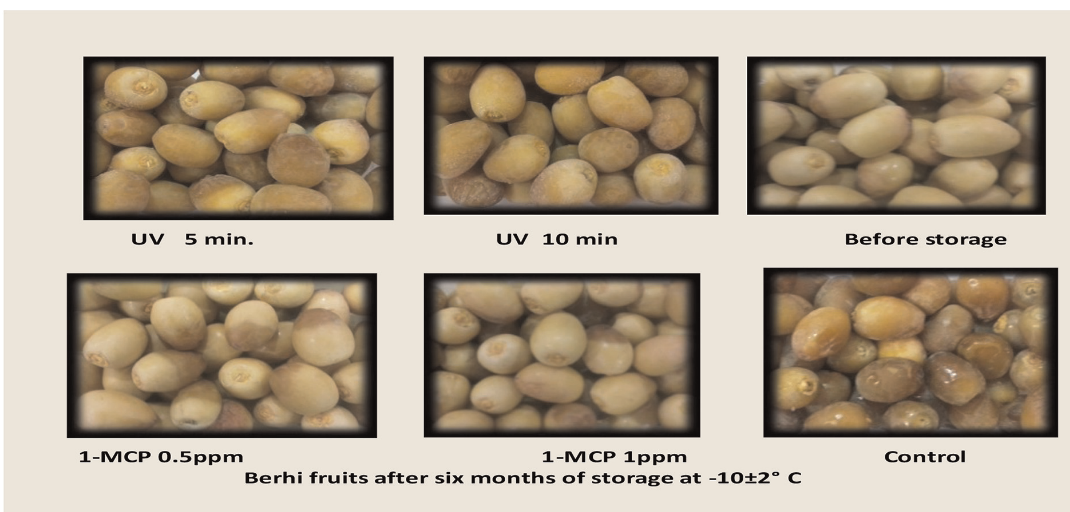
As for the effect of storage treatments, the highest value of acidity percentage was (0.311 and 0.3931), (0.287 and 0.327%) for the fruits of the two cultivars Berhi and Breim treated with the compound (1-MCP) at a concentration of 1 ppm for the two seasons respectively with a significant difference from the control treatment which amounted to (0.213, 0.161%) and (0.247, 0.222%) for Berhi and Breim cultivars for the two seasons respectively, except for Breim cultivar for the second season. The storage period had a clear effect, as it was noted from the mentioned table that the percentage of total titratable acidity decreased, with the increment of the storage period, where the lowest percentage of total titratable acidity reached (0.222, 0.219) and (0.227, 0.248%) for Berhi and Breim fruits after 5 months of storage for the two seasons, respectively. As for the effect of the interaction between spraying chitosan in the field and storage treatments, the results indicated that the fruits treated in the field with 2% chitosan and stored with the compound (1-MCP) at a concentration of 1 ppm have worked to maintain the highest percentage of total titratable acidity (0.317, 0.337) and (0.317, 0.357%), while the lowest percentage of total titratable acidity was (0.196, 0.157) and (0.226, 0.213)% for the fruits of the Berhi cultivar treated with 0% chitosan in the field for the control treatment for the two seasons and for the fruits of the Breim cultivar treated with ultraviolet rays for (5) minutes for the first season and with the compound (1-MCP) at a concentration of 1 ppm for the second season respectively.

The results also showed that the effect of the interaction between spraying chitosan in the field and the storage period had a significant effect, as the highest percentage of total titratable acidity reached (0.260, 0.287) and (0.267, 0.249%) for the fruits of the Berhi and Breim cultivars treated in the field with 2% chitosan at the end of the storage period for the two seasons respectively. As for the lowest percentage of total acidity, it was (0.222, 0.227) and (0.211, 0.194%) for the fruits of the Berhi cultivar field-treated with chitosan at a concentration of 1% and for the fruits of the Breim cultivar for the comparison treatment at the end of the storage period. The results also showed that the effect of the interaction between the storage treatments and the storage period had a significant effect, as the highest percentage of total titratable acidity was (0.253, 0.273) and (0.253, 0.293%) for the fruits of the Berhi cultivar treated with the compound (1-MCP) at a concentration of 1 ppm at the end of the storage period for the two seasons, respectively.

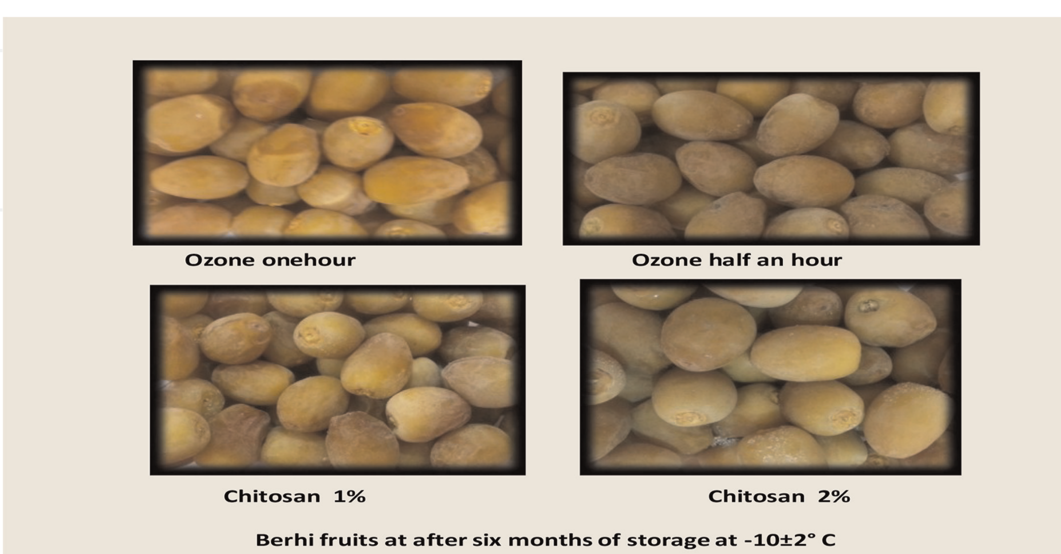
The effect of the interaction between the three factors was spraying chitosan in the field, storage treatments, and storage period. It was noted that the highest percentage of total titratable acidity was (0.290, 0.310) and (0.290, 0.330%) for the fruits of the Berhi and Breim cultivars treated with 2% chitosan and with the compound 1-MCP0 at a concentration of 0.5 ppm at the end of the storage period for the two seasons respectively, while the lowest percentage of total acidity was (0.186, 0.146) for the fruits of the Berhi cultivar treated in the field with chitosan at a concentration of 0% for the comparison treatment at the end of the storage period for the two seasons respectively, and (0.180, 0.176%) for the fruits of Breim cultivar treated in the field with chitosan at a concentration of 1% and UV rays for 10 minutes for the first season and field treated with chitosan at a concentration of 1% and ozone for one hour for the second season at the end of the storage period.

The results of the present study indicate the role of the treatments in improving the qualitative characteristics of date palm fruits of the two cultivars, Berhi and Breim, which were stored by freezing. No doubt that preserving the palm fruits in the rutab stage (fresh stage) after harvesting is one of the priorities of the technology of storing these fruits, especially the soft ones such as Berhi and Breim, which are characterized by an excellent flavor as well as price is higher compared to other cultivars. Refrigerated storage of fruits, in principle, aims to reduce the vital activities that occur [31] in fruits, especially the process of respiration [2]. In addition to limit the growth of microorganisms, especially fungi. The studies showed that the high temperatures after harvesting, and during storage lead to an acceleration of physiological processes, increase affection of pathogens, and the speed of consumption of food stored in the fruis, thus storage ability decreases.

The process of ripening fruits as mentioned by [8] is a series of changes in the color, taste, and composition making fruits in an edible state, as is known, the process



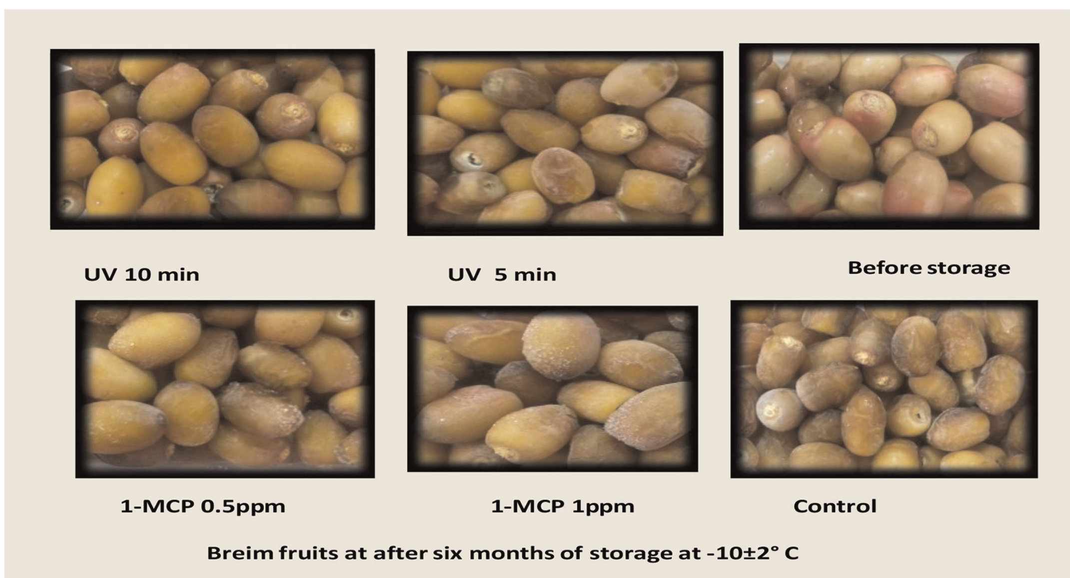
a



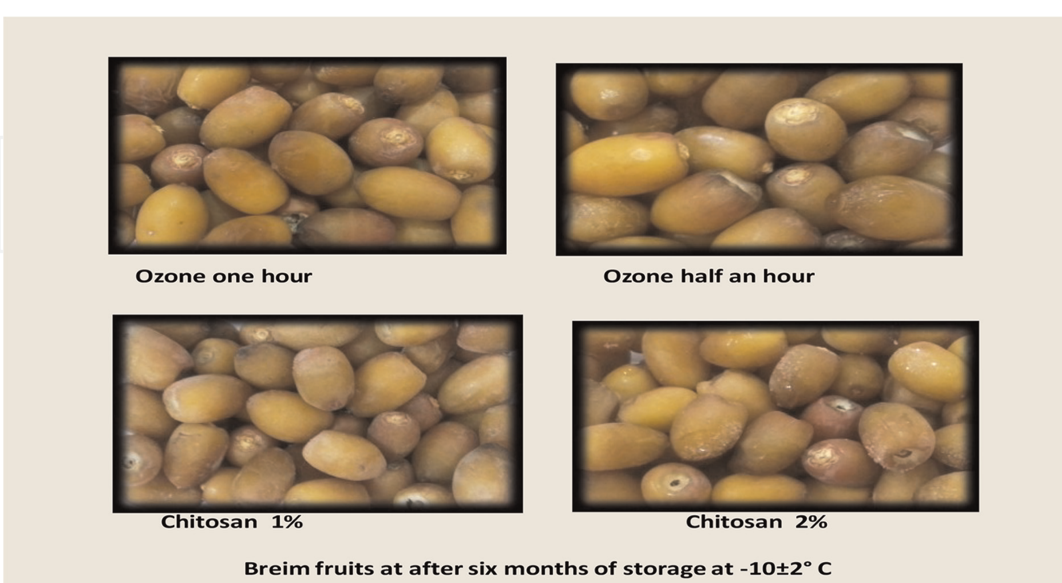
b

Figure 4.
(a, b) Berhi fruits after six months of storage at -10 ± 2 *°C.*

of ripening is a complex process in which many factors interaction, making the fruits finally edible. Concerning the date palm fruits, the changes that occur at maturity are identical to those that occur in the climacteric fruits, which is closely related to changes in respiratory rate. Khalal stage has been considered as the maturity stage (completeness of growth, while the rutab stage is the stage of ripening. Undoubtedly, controlling the ripening process requires first lowering the temperature, as low temperatures slow down respiration, ethylene production, and vital activity of fruits, especially the enzymatic activity [2]. Results in the same line with [34] who mentioned that the low temperature (0 °C) led to a decrease in the respiration rate of date palm fruits, cv. Breim, and no climacteric rise was observed in them climatically, while it was observed in the stored fruits at room storage temperature.



c



d

Figure 5.
(c, d). Breim fruits after six months of storage at -10 ± 2 *°C.*

4. Conclusions and recommendations

1. The spraying of pre-harvest chitosan improved the storage ability of the Berhi and Breim fruits.

2. The storage treatments (ultraviolet rays, ozone, 1-MCP and immersion in chitosan) improved the storage ability of the fruits.

3. Through the study of the protein pattern, new proteins were identified during storage, as well as a distinction between the two cultivars after pressing and packing the fruits, so we recommend using this technique for the purpose of detecting fraud cases in palm fruits of different cultivars, especially after pressing and packing dates.

4. The treatments that were used in the experiment are considered natural alternatives, so we recommend using them before and after harvest to increase the yield, improve its qualitative characteristics, and improve the storage ability of the fruits, as shown in **Figures 4** and **5**.

Author details

Dhia Ahmed Taain*, Hamzah Abbas Hamzah and Abbas Mahdi Jasim
Department of Horticulture and Landscape Design, College of Agriculture, University of Basrah, Iraq

*Address all correspondence to: golden_fruitb@yahoo.com

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