Effect of humic acid and some treatments in storage behavior of hot pepper fruits (*Capsicum annuum*L.) hybrid Kizil F1

Laila TurkiFadala[1], Fatima Ali Hassan3 , Dhia Ahmed Taain[2]

[1-3] Department of Horticulture and Landscape - College of Agriculture - University of Basra, Iraq.

Abstract:

The experiment was carried out during the 2020-2022 growing seasons in unheated greenhouses at DhiQar University, south of Iraq, to investigate Effect of humic acid and some treatments in storage behavior of hot pepper fruits (*Capsicum annuum*L.) hybrid Kizil F1. The factorial experiment consisted of two factors: humic acid at(0, 1, and 2 g. l^{-1}) and post-harvest treatments (aqueous extract of jujube leaves at 75 g. l^{-1}, aqueous extract of pomegranate peels at5 ml. l^{-1}, calcium at 1.5 ml. l^{-1} and arginine acid at 200 mg. l^{-1}) in addition to the control treatment (distilled water only). Fruits were packed in 1kg polyethylene bags with eight holes of 5 mm diameter each and stored at 10 C° for two weeks. CRD design was used with three replicates for each treatment. The results were analyzed by the analysis of variance, and the means values were compared by the Revised Least Significant Difference Test at 0.05 probability. Results showed significant increases in the vitamin C content, total soluble solids, capsaicin, and phenolic substances in the fruits in humic acid treatments at 1 and 2 g.l^{-1}. On the other hand, significant decreases in the percentage of decay in the fruits treated with humic acid at 1 and 2 g.l^{-1}. The fruits treated with calcium recorded the lowest decay percentage compared to the rest of the treatments in both seasons for the pre and post-harvest treatments. The soaking method outperforms the spraying once in retaining fruit content of vitamin C. The interactions among the studied factors are most significant in their effect on most parameters.

Keywords: Arginine, Extract of pomegranate peels, Hot pepper, Humic acid,

Introduction

The fruits of hot pepper (*Capsicum annuum* L.) are high nutritional value, due to the presence of many important components such as plant pigments which are lutein, B-Carotene, B-cryptoxathin, eaxanthin, violaxanthin, capsaicin, capsanthin , capsorubin[1]. Capsaicin is responsible for the spicy taste in the fruit [2;3] and characterized by an enzymatic structure , anti-obesity and anti-inflammatory properties, activates the immune system and lowers blood pressure [4].

The fruits also contain vitamin C, a powerful antioxidant that strengthens the natural immunity to diseases, and vitamin A, a fat-soluble vitamin and important antioxidant that helps in reducing health risks caused by free radicals and helps in the formation of red blood cells. Green fruits are also rich in vitamin E, which is essential for the production of natural skin oils and prevents premature aging of the skin, in addition to their role in reducing the risk of lung cancer, stomach cancer and prostate cancer [5].

The developed agriculture is move away from the use of chemical fertilizers, chemical growth regulators and pesticides, due to their toxic effect on human and animal life [6,7]. Therefore, researchers in agriculture tended to find safer and more environmentally friendly materials. The use of plant extracts as an alternative to growth regulators is a natural

substance that does not leave any trace on humans and the environment [8]. The extract of jujube leaves and the extract of pomegranate peels, which contain flavonoids, a natural antioxidants compounds found in many plant parts, as well as containing saponins. They also have anti-viral, anti-bacterial and anti-fungal properties [9].

Humic acid stimulates root and vegetative growth, so the main purpose of using humic acid is to improve the nutritional status of the plant and thus increase production as a natural fertilizer alternative to industrial fertilizers [10, 11].

Arginine acid is one of the amino acids that play roles in many vital processes during the stages of plant growth and development, whether in its free form or as a component of proteins. It is also included in the synthesis of nucleotides and many coenzymes [12].

Calcium salts are used to increase the firmness of fruits and to treat many of the physiological disorders by controlling decay because the role of calcium in building the cell wall, activating the process of cell division and enzymes [13].So, to find out the effect of treatment with humic acid, spraying and soaking with aqueous extract of jujube leaves, aqueous extract of pomegranate peels, arginine and calcium on storage ability of hot pepper fruits hybrid Kizil F1 , this study was conducted.

Materials and methods:

The seedlings of hot pepper, hybrid Kizil F1, were planted in the greenhouse and all the processes are using in the production of this crop grown were conducted. A humic acid fertilizer was added at three levels 0, 1 and 2 g l^{-1}. Aqueous extract of jujube leaves at 75 g l^{-1} , aqueous extract of pomegranate peel at 5 g l^{-1} , calcium solution at 1.5 ml. l^{-1} , arginine acid at 200 mg l^{-1} in addition to control treatment (distilled water only) were sprayed three times, with an interval of 15 days between spray and another.

Some fruits were treated with ground addition of humic acid at the concentrations of (0 ,1,2) g.l^{-1} and sprayed with 1.5 ml.l^{-1} calcium , 200 mg.l^{-1} arginine acid, jujube leaves extract at a concentration of 75 g.l^{-1} and pomegranate peels extract at a concentration of 5 g.l^{-1} .The control treatment of fruits, was sprayed with distilled water only was taken, and after cleaning, the following treatments were performed on them for a period of 5 minutes:-

1. Soaking in jujube leaves extract at a concentration of 75 g.l^{-1}.
2. Soaking in pomegranate peels extract at a concentration of 5 g.l^{-1}.
3. Soaking in calcium solution at a concentration of 1.5 ml. l^{-1}.
4. Soaking in arginine at a concentration of 200 mg. l^{-1}.
5. Soaking in distilled water only (control).

All treated fruits were packed into polyethylene bags of 1 kg capacity containing 8 holes of 5 mm diameter and stored at a temperature of 10 ° C in a refrigerated incubator for two weeks. The following characteristics were studied:

Percentage of decay=Weight of damaged fruits per package/Weight of total package of fruits*100

and the results were corrected to 20ºC. Vitamin C (mg.100 g^{-1}) determined according to Total soluble solids (T.S.S.) were measured by hand refractometer [14]. [15] .The capsaicin content of the fruits was determined by a spectrophotometer and according to the method described by Phenolic substances were determined by using Folin-Denis method mentioned[16].

The experiment was designed using a Complete Randomized Design (C.R.D) with three replications for a factorial experiment of three factors,. The mean values were compared using the least significant difference test under the 0.05 probability level [17].

Results and discussion

1. Decay percentage Table (1) that the lowest percentage of spoilage was recorded in the fruits of the spindle hybrid treated with humic acid at a concentration of 2 g.l-1 compared to plants treated with concentration 1 and 1 and plants not treated with humic acid and their culture (34.41 and 6.83)% in the gradations. In Gradations (21.34 and 8.45)

It appears from the same table that there are significant differences in the application method, as it is noted that the percentage of spoilage decreased by the soaking method, and recorded the lowest percentage (19.33 and 19.63) %, respectively, in both seasons, compared to the spraying method. As for the effect of the type of treatments, it was significant in this regard, as the treatment with calcium recorded the lowest percentage of damage compared to the rest of the treatments, with a decrease rate of (32.26, 22.33, 9.83 and 9.03)% and (32.59, 21.87, 9.78 and 8.73)%, respectively, in both seasons and did not differ. Plants treated with pomegranate peel extract compared to plants treated with arginine acid, and the percentage of damage to their fruits decreased compared to comparison plants and plants treated with Jujube extract, with a decrease of (24.87 and 13.35)%, (25.24 and 13.35)%, (31.38 and 14.67)%, and (26.10)

And (14.35)%, respectively, in both seasons. Likewise, the percentage of spoilage in the fruits of plants treated with Jujube leaves extract decreased compared to control plants, with a decrease rate of (12.78 and 13.72)%, respectively, in both seasons.

There was no damage when storing cayenne pepper, spinning variety, by air-drying at room temperature. Fruits during handling and storage are exposed to damage that varies according to the cause, as the damage may also occur as a result of infections with pathogens such as bacteria, fungi and yeasts [18].

The treatment with humic acid worked to reduce the percentage of decay, perhaps this is due to the fact that the effectiveness of humic acid is similar to the activities of natural hormones inside the plant, and this is reflected on the physiological and biological activities in the fruits, reducing the percentage of decay [19; 20] .The percentage of decay in fruits treated with calcium decreased, which is one of the important macro nutrients that play a major role in the formation of cell walls and cell membranes, the growth and development of fruits, as well as the quality of those fruits [21; 22]. Calcium plays a role in thickening the fruit wall because it enters the formation of calcium pectate, thus increasing the firmness of fruits, increasing their resistance to pathogens, delaying their ripening and reducing their damage. Calcium also has a role in regulating plant hormones, especially IAA, and works to increase the plant's efficiency in representing carbon dioxide [23]. Calcium has a role in the construction of phosphatidic acid, which enters the building of cell membranes [24], binds to pectins, and thus increases the resistance of cells to decomposition by pectin enzymes, pectin methylesterase and poly-galactosones, which are active in fruits during ripening, so the deficiency of this element leads to the decomposition of cell walls and membranes [25]. Fruits with a high content of calcium are resistant to microorganisms during storage, as the middle lamella prevent the entry of wall-dissolving enzymes resulting from pathogens **[26]**.

Post-harvest research revealed that the application of arginine can extend the shelf life of horticultural crops by delaying the ripening process. In addition, arginine protects plant cells from oxidative stress by biosynthesis of nitric oxide and reduces the accumulation of ROS [27]. Arginine works to increase the tolerance of fruits to chilling injury and plays a major role in activating many enzymes in fruits such as catalase enzyme, as amino acids are linked with phospholipids in the membranes and work to increase the effectiveness of these enzymes, but amino acids inhibit the enzymes responsible for the production of ethylene [28], and this confirms its role in delaying ripening and

reducing fruit decay, as many studies indicated the role of arginine treatment in reducing decay to tomatoes [29], pomegranate [30] and Pistachio [31]

Table1. Effect of adding humic acid, spraying and soaking with jujube extract, pomegranate peels, calcium and arginine on the percentage of decay of hot pepper, hybrid Kizil F1 fruits stored at 10°C both seasons.

2022 -2021						2021 -2020						Add. method M	Humic acid H
H × M	Treatment type S					H × M	Treatment type S						
	S_4	S_3	S_2	S_1	S_0		S_4	S_3	S_2	S_1	S_0		
12.987	12.267	11.733	14.633	11.833	14.467	12.647	12.067	11.667	14.233	11.500	13.767	M_1	H_0
11.700	10.000	10.767	11.833	11.500	14.400	9.733	9.800	10.500	11.700	11.267	14.167	M_2	
10.107	10.670	7.497	8.933	11.667	11.767	9.133	10.333	7.100	8.567	11.67	11.400	M_1	H_1
7.633	6.200	6.867	7.033	7.967	10.100	11.487	5.800	6.467	6.700	7.567	9.700	M_2	
9.433	9.233	7.100	6.333	12.800	11.700	7.247	9.033	6.733	6.133	12.633	11.133	M_1	H_2
6.807	5.500	5.200	5.733	7.133	10.467	6.687	5.367	5.200	5.533	7.133	10.200	M_2	
1.36	0.57					1.27						L.S.D. (0.05)	
12.343	11.133	11.250	13.233	11.667	14.433	12.067	10.933	11.083	12.967	11.383	13.967	Mean values of treatment type	
6.783	7.633					9.417	10.550					L.S.D. (0.05)	
Mean values of humic acid						Mean values of humic acid							
12.343	11.133	11.250	13.233	11.667	14.433	12.067	10.933	11.083	12.967	11.383	13.967	H_0	H × S
8.870	8.435	7.182	7.983	9.817	10.933	8.490	8.067	6.783	7.633	9.417	10.550	H_1	
8.120	7.367	6.150	6.033	9.967	11.083	7.910	7.200	5.967	5.833	9.883	10.667	H_2	
												L.S.D. (0.05)	
Mean values of add. method						Mean values of add. method							
10.842	10.723	8.777	9.967	12.100	12.644	10.504	10.478	8.500	9.644	11.800	12.100	M_1	M × S
8.713	7.233	7.611	8.200	8.867	11.656	8.473	6.989	7.389	7.978	8.656	11.356	M_2	
0.79	0.32					0.73						L.S.D. (0.05)	

2. Vitamin C

Table 2 showed the effect of adding humic acid, spraying and soaking with jujube extract, pomegranate peels, calcium and arginine, and their interactions on the amount of vitamin C (mg.100 gm^{-1} fresh weight) of the fruits of the hybrid Kizil F1 stored at a temperature of 10 ° C.

It was noticed from the same table that there were significant differences when adding humic acid in the amount of vitamin C, as the fruits of the hybrid Kizil F1 treated with humic

acid at a concentration of 1 g.l⁻¹ were superior in that trait compared to the control fruits and fruits treated with humic acid at a concentration of 2 g.l⁻¹ with an increment percentage of up to (13.49 and 5.69)% and%(22.83 و 22.80) (sequentially in both seasons. Fruits treated with humic acid at a concentration of 2 g.l⁻¹ were superior to the control fruits with an increment percentage of (7.53 and 6.56)%, respectively, in both seasons. As for the effect of the addition method on the amount of vitamin C, it was significant, as the fruits treated by soaking outperformed compared to spraying method, with an increment percentage .(19.60 و19.19)%, respectively, in both seasons. The type of treatment showed a significant effect, as the fruits treated with calcium and arginine were superior compared to the rest of the treatments, with an increase rate of (16.40, 16.11, and 7.33)%, (16.43, 15.98, and 7.78)%, (17.85, 17.92, and 9.00)%, and (17.51, 17.06, and 17.51). (8.78)%, respectively, in both seasons, and those fruits did not differ significantly among themselves, and were followed in superiority by the fruits treated with pomegranate peel extract compared to the comparison fruits and the fruits treated with dam extract, with an increase rate of (8.11 and 8.18)% and (8.02 and 7.61)%, respectively, and those did not differ. The comparison fruits and the fruits treated with ujube leaves extract were significant among them in both seasons.The interaction betweenhumic acid and the method of application, its effect was significant, as the highest amount of vitamin C was in the fruits treated with humic acid at a concentration of 2 g.l-1 and sprayed with the treatments, which amounted to 2203.2 mg.100 gm-1 fresh weight in the first season, while in the second season it was The highest amount of vitamin C in the fruits treated with humic acid at a concentration of 1 gm.l-1 and soaked in the treatments, which amounted to 200.6 mg.100 gm-1 fresh weight, while it was The lowest amount of vitamin C was found in the fruits of spinach cultivar that were not treated with humic acid and sprayed with the treatments, which amounted to (130.3 and 127.0) mg.100 gm -1 fresh weight in both seasons,.

Vitamin C is highly sensitive to temperature and light, so high temperature leads to oxidation of this vitamin and converting it to dehydro ascorbic acid by the action of the enzyme oxidase and ascorbase [32]. The ground addition of humic acid led to the preservation of the amount of vitamin C in the fruits compared to the lack of addition, and this may be due to the role of humic acid in increasing carbohydrates that turn into vitamin C [33]. Fruits are rich in vitamin C, and this may be due to the fact that calcium works to maintain cellular membranes by preventing their decomposition and thus reduces their permeability and reduces the entry of oxygen into cells through these membranes, thus reducing the oxidation of vitamin C [25].

Results are agreed with [34] that the addition of 2%calcium chloride delayed the oxidation processes of ascorbic acid, which resulted in the preservation of its content in apple fruits during storage. Reducing the gas exchange process because it reduces the permeability of cell membranes and thus reduces the consumption of organic acids in fruits [35]. As for the effect of arginine, the results showed that spraying it on the plant worked to maintain the amount of vitamin C.

Table 2. Effect of adding humic acid, spraying and soaking with jujube extract, pomegranate peels, calcium and arginine on vitamin C mg.100g^{-1} fresh weight of hot pepper, hybrid Kizil F1 fruits stored at 10°C both seasons.

2022 -2021						2021 -2020						Add. method M	Humic acid H
H × M	Treatment type S					H × M	Treatment type S						
	S_4	S_3	S_2	S_1	S_0		S_4	S_3	S_2	S_1	S_0		
127.0	168.1	148.0	122.9	101.4	94.6	130.3	171.0	151.3	127.7	103.7	98.0	M_1	H_0
168.5	163.0	173.0	174.3	171.5	160.8	166.0	167.7	177.3	178.	173.7	164.7	M_2	
162.3	189.3	199.0	160.0	108.7	154.6	178.9	193.7	202.0	164.7	111.7	158.0	M_1	H_1
200.6	204.0	200.3	203.7	199.9	195.3	172.4	208.0	201.0	205.0	202.3	199.7	M_2	
176.0	183.3	169.3	165.0	185.7	176.7	203.2	187.7	172.7	168.0	188.0	178.3	M_1	H_2
187.3	199.3	207.3	191.7	178.3	160.0	190.9	204.7	211.0	195.0	181.3	162.3	M_2	
												L.S.D. (0.05)	
160.2	184.5	182.8	169.6	157.6	157.0		188.8	185.9	173.2	160.1	160.2	Mean values of treatment type	
	10.03						9.96					L.S.D. (0.05)	
Mean values of humic acid						Mean values of humic acid							
147.8	165.6	160.5	148.6	136.4	127.7	151.4	169.3	164.3	153.2	138.7	131.3	H_0	H × S
181.5	196.7	199.7	181.8	154.3	175.0	184.6	200.8	201.5	184.8	157.0	178.8	H_1	
181.7	191.3	188.3	178.3	182.0	168.3	184.9	196.2	191.8	181.5	184.7	170.3	H_2	
NS	7.72					N.S						L.S.D. (0.05)	
Mean values of add. method						Mean values of add. method							
194.65	196.69	201.28	196.58	191.26	187.46	197.29	199.00	204.78	198.89	193.67	190.11	M_1	M × S
206.79	214.48	211.50	211.13	206.67	190.18	210.64	218.33	215.56	214.56	210.67	194.11	M_2	
4.50	1.91					4.27						L.S.D. (0.05)	

3. The percentage of total soluble solids

Table 3 showed that there were significant differences when adding humic acid in the percentage of total soluble It is noted from table (44) that there are significant differences between the concentrations of humic acid in the percentage of total dissolved solids, as the fruits of the hybrid Ghazal at 10 °C were significantly superior in recording the highest percentage of total dissolved solids when treated with humic acid at a concentration of 2g.L-1 compared to The comparison fruits and those treated with humic acid at a concentration of 1g.l-1 increased by (8.20 and 8.74) and (8.96 and 9.63)% respectively in both seasons, and the comparison fruits did not differ from the fruits treated with humic acid at a concentration of 1g.l-1 in both seasons And it appears from the same table that there are significant differences in the method of addition, as the fruits of the soaked plants excelled compared to the sprayed fruits, with an increase rate of (18.47 and 19.95)%, respectively, in both seasons.

It is noted from the same table that the type of treatment had a significant effect on the percentage of total dissolved solids, as there was no significant difference between the fruits treated with calcium and the fruits treated with arginine acid, and both of them excelled compared to the rest of the treatments, with an increase rate of (7.09, 11.35 and 9.48)% and (5.52, (9.84 and 8.25)%, (7.27, 11.53 and 9.66)% and (7.89, 12.00 and 10.37)% respectively and in both seasons, and the fruits of the comparison did not differ with the fruits The treatment with pomegranate peel extract did not differ from the fruits treated with Jujube extract, and the comparison fruits excelled compared to the fruits treated with Jujube extract, with an increase rate of (3.79 and 11.09)%, respectively, in both seasons.

The reason for the superiority of the fruits treated with arginine acid with a high percentage of total soluble solids may be due to the fact that the addition of amino acids and their absorption by the plants led to an increase in the protein content and dry matter, thus increasing the content of fruits of total soluble solids . The superiority of the fruits treated with calcium maybe due to the fact that spraying plants in the field with calcium increased free calcium concentration in the cells and worked to maintain the integrity of their membranes [24]; [38], and the application of post-harvest calcium preserved the dry matter content of the fruits , as well as the role of calcium in reducing the breakdown of pectic soluble materials, which are part of the total soluble solids . These results agreed with [39].

Table3. Effect of adding humic acid, spraying and soaking with jujube extract, pomegranate peels, calcium and arginine on total soluble solids % in fruits of hot pepper, hybrid Kizil F1 stored at 10°C both seasons.

2022 -2021						2021 -2020						Add. method M	Humic acid H
H × M	Treatment type S					H × M	Treatment type S						
	S_4	S_3	S_2	S_1	S_0		S_4	S_3	S_2	S_1	S_0		
6.127	5.667	6.500	6.433	6.433	5.600	6.327	5.900	6.600	6.733	6.567	5.833	M_1	H_0
7.855	9.110	8.567	7.833	6.900	6.867	8.080	9.333	8.900	8.000	7.167	7.000	M_2	
6.987	6.580	6.573	6.447	6.000	9.333	7.167	6.800	6.733	6.600	6.100	9.600	M_1	H_1
7.049	7.300	7.700	7.100	7.067	6.077	7.481	8.333	7.940	7.400	7.367	6.367	M_2	
6.720	7.067	6.467	5.933	5.433	8.700	6.947	7.200	6.633	6.133	5.900	8.867	M_1	H_2
8.233	9.267	9.100	8.067	8.133	6.600	8.393	9.433	9.100	8.267	8.367	6.800	M_2	
0.5181	0.1799					0.4024						L.S.D. (0.05)	
5.863	6.067	6.250	6.133	5.967	4.900	6.047	6.200	6.550	6.317	6.100	5.067	Mean values of treatment type	
6.050	5.550					5.700	6.550					L.S.D. (0.05)	
Mean values of humic acid						Mean values of humic acid							
5.863	6.067	6.250	6.133	5.967	4.900	6.047	6.200	6.550	6.317	6.100	5.067	H_0	H × S
5.831	6.118	5.787	5.400	5.500	6.350	6.017	6.233	6.050	5.550	5.700	6.550	H_1	
6.393	7.020	6.800	5.867	5.680	6.600	6.543	7.200	7.000	6.033	5.800	6.683	H_2	
												L.S.D. (0.05)	
Mean values of add. method						Mean values of add. method							
5.482	5.447	5.468	5.189	5.067	6.242	5.678	5.533	5.778	5.389	5.233	6.456	M_1	M × S
6.576	7.357	7.090	6.411	6.364	5.658	6.727	7.556	7.289	6.544	6.500	5.744	M_2	
0.32	0.11					0.26						L.S.D. (0.05)	

4. Capsaicin ($mg.kg^{-1}$)

It is noted from table (48) that there are significant differences between the concentrations of humic acid, as the fruits of the hybrid Yarn stocked at a temperature of 10 C and treated with humic acid at two concentrations (1 and 2) gm.l-1 were significantly superior compared to the comparison fruits, with an increase of (16.09 and 24.59)%. And (17.16 and 19.10)%, respectively, in both seasons, and the fruits treated with humic acid at a concentration of 2 gm.l-1 excelled compared to the fruits treated with a concentration of 1 gm.l-1, with an increase of 7.32%, respectively, in the first season only, and the treated fruits did not differ. with humic acid at two concentrations (1 and 2) g.l-1, were significantly different from each other in the second season.The method of addition had a significant effect on the amount

of capsaicin for a variety of yarn, and in the first season only, where the soaking method was superior compared to the spraying method, with an increase of 7.50%.

It is noted from the same table that the type of treatment had a significant effect on the fruit content of capsaicin alkaloid (mg.kg), as the comparison fruits excelled compared to all treatments in the first season with an increase rate of (2.92, 6.85, 3.99 and 11.33)%, respectively, and the fruits treated with extract did not differ. From j ujube leaves extract the fruits treated with calcium and excelled compared to the fruits treated with pomegranate peel extract and arginine in the first season with an increase rate of (3.81 and 8.17)% and (2.74 and 7.05)%, respectively, and the fruits treated with pomegranate peel extract excelled compared to the treated fruits.with arginine acid in the first season with an increase of 4.19% sequentially, and in the second seasonthere was no significant difference between the comparison fruits and the fruits treated with extracts of Jujube , pomegranate and calcium on the one hand, just as there was no significant difference between the fruits treated with the extract of pomegranate peels, calcium and arginine on the other hand, and the comparison fruits excelled And the fruits treated with Jujube leaves extract compared to the fruits treated with arginine, with an increase rate of (8.64 and 8.08)%, respectively, in that season.

The percentage of phenolic substances

Table 5 showed the effect of adding humic acid,Table (5) shows the effect of adding humic acid, spraying and soaking with Jujube extract, pomegranate peels, calcium and arginine on the percentage of phenolic substances in the fruits of the Gazelle hybrid cayenne pepper stored at a temperature of 10 °C. The hybrid spindle treated with humic acid at a concentration of 2 g.l-1 was significantly compared to the fruits not treated with humic acid and the fruits treated with humic acid at a concentration of 1 g.l-1 in both seasons, with an increase rate of (123.07 and 12.98)% and (115.51 and 9.64)%, respectively. The fruits treated with humic acid at a concentration of 1 g.l-1 were superior compared to the comparison fruits, with an increase rate of (97.43 and 96.55)% in both seasons.It appears from the same table that there were significant differences between the treatments of the addition method, as the fruits of the soaked plants excelled in the second season only compared to the sprayed fruits, with an increase of 2.04%. It is noted from the same table that the type of treatment had a significant effect on the percentage of total phenolic substances in both seasons, as the fruits treated with calcium and arginine did not differ significantly between them in both seasons and excelled compared to the rest of the treatments with an increase rate of (128.18, 26.13 and 27.41)% and (134.54, 29.64). And (30.96)%, (154.16, 22.61, and 25.12)%, and (165.62, 28.14, and 30.76)%, respectively, and the fruits treated with Jujube leaves extract and the fruits treated with pomegranate peel extract did not differ

Storage temperature has a significant impact on the content of phenolic substances in fruits, as high temperatures and exposure of fruits to light as well as the enzymatic activity of polyphenol oxidase and peroxidase that work on the oxidation of phenolic substances and their transformation into Quinone's, which enters a series of reactions that eventually lead to the formation of the brown pigment of melanin [40] . These results are in agreement with what [41] concluded that the highest percentage of phenolic compounds in okra fruits were when stored at a temperature of 10°C ±2. [42] showed that the dried chili fruits had a decrease in the percentage of phenolic substances when stored at a temperature of 30 ° C for a period of five months, and at a higher rate than when they were reduced at a temperature of 25 ° C, and the lowest decrease was at a temperature of 20 ° C.

Table 4. Effect of adding humic acid, spraying and soaking with jujube extract, pomegranate peels, calcium and arginine on capsaicin mg.kg in fruits of hot pepper, hybrid Kizil F1 stored at 10°C both seasons.

2022 -2021						2021 -2020						Add. method M	Humic acid H
H × M	Treatment type S					H × M	Treatment type S						
	S_4	S_3	S_2	S_1	S_0		S_4	S_3	S_2	S_1	S_0		
61.00	68.00	59.67	66.67	59.33	51.33	51.40	53.00	53.00	55.67	55.33	40.00	M_1	H_0
55.16	58.13	57.67	57.00	49.67	53.33	57.00	58.00	61.67	63.33	58.00	44.00	M_2	
51.70	55.00	54.00	51.00	55.33	43.17	53.27	57.00	56.67	54.67	57.33	40.67	M_1	H_1
74.68	67.33	69.20	75.87	70.07	90.93	75.07	61.00	71.67	78.67	72.00	92.00	M_2	
73.31	60.53	70.33	76.67	74.00	85.00	75.53	70.00	74.67	79.33	72.00	81.67	M_1	H_2
63.73	62.00	68.33	67.67	69.00	51.67	83.73	85.00	83.67	82.33	78.33	89.33	M_2	
14.20						6.75						L.S.D. (0.05)	
84.06	76.78	79.36	79.69	82.99	82.13		75.50	80.83	78.67	81.67	84.06	Mean values of treatment type	
	4.17						1.49					L.S.D. (0.05)	
Mean values of humic acid						Mean values of humic acid							
71.54	70.20	72.81	70.13	74.63	69.94	70.57	68.50	74.83	68.83	73.33	67.33	H_0	H × S
83.82	80.68	81.85	83.18	86.18	87.20	81.93	77.17	79.33	80.00	80.83	92.33	H_1	
85.21	79.47	83.42	85.77	88.15	89.27	87.93	80.83	88.33	87.17	90.83	92.50	H_2	
3.23	7.23					1.15	2.59					L.S.D. (0.05)	
Mean values of addition mthod						Mean values of addition mthod							
79.10	78.29	76.83	77.89	79.99	82.52	77.24	78.11	81.67	72.00	78.56	75.89	M_1	M × S
81.28	75.28	81.88	81.50	85.99	81.75	83.04	72.89	80.00	85.33	84.78	92.22	M_2	
N.S	5.90					0.94	2.11					L.S.D. (0.05)	

Table 5. Effect of adding humic acid, spraying and soaking with jujube extract, pomegranate peels, calcium and arginine on phenolic substances % in fruits of hot pepper, hybrid Kizil F1 stored at 10°C both seasons.

2022 -2021						2021 -2020						Add. method M	Humic acid H
H × M	Treatment type S					H × M	Treatment type S						
	S_4	S_3	S_2	S_1	S_0		S_4	S_3	S_2	S_1	S_0		
0.118	0.118	0.127	0.127	0.118	0.100	0.120	0.127	0.133	0.126	0.118	0.100	M_1	H_0
0.114	0.126	0.118	0.122	0.116	0.090	0.113	0.113	0.116	0.118	0.120	0.100	M_2	
0.219	0.286	0.273	0.226	0.223	0.089	0.228	0.290	0.283	0.233	0.233	0.100	M_1	H_1
0.236	0.310	0.300	0.253	0.230	0.090	0.235	0.296	0.286	0.250	0.216	0.126	M_2	
0.250	0.340	0.320	0.213	0.280	0.100	0.265	0.356	0.340	0.230	0.280	0.120	M_1	H_2
0.250	0.350	0.330	0.230	0.230	0.110	0.258	0.366	0.350	0.230	0.230	0.113	M_2	
0.010	0.023					0.010	0.022					L.S.D. (0.05)	
0.110	0.255	0.244	0.195	0.199	0.096		0.258	0.251	0.197	0.199	0.110	Mean values of treatment type	
	0.009						0.009					L.S.D. (0.05)	
Mean values of humic acid						Mean values of humic acid							
0.116	0.122	0.123	0.124	0.117	0.095	0.117	0.120	0.124	0.122	0.119	0.100	H_0	H × S
0.228	0.298	0.286	0.240	0.226	0.089	0.231	0.293	0.285	0.241	0.225	0.113	H_1	
0.250	0.345	0.325	0.221	0.255	0.105	0.261	0.361	0.345	0.230	0.255	0.167	H_2	
0.016	0.007					0.016						L.S.D. (0.05)	
Mean values of add. method						Mean values of add. method							
0.196	0.248	0.240	0.189	0.207	0.096	0.204	0.258	0.252	0.196	0.210	0.106	M_1	M × S
0.200	0.262	0.249	0.201	0.192	0.096	0.202	0.259	0.250	0.199	0.188	0.113	M_2	

Conclusions

It is clear from the current study that adding humic acid at concentrations of (1 and 2) g. l^{-1} had an important role in improving the most of studied characteristics and the shelf life of hot pepperfruits during the storage at 10°C by reducing the percentage of decay and retaining the highest content of vitamin C , total soluble solids, capsaicin and phenolic substances**.** fruits soaked with arginine had a superiority in retaining the amount of vitamin C**.**

References

1. Villa-Rivera, M.G.; Ochoa-Alejo, N. 2020. Chili pepper carotenoids: Nutraceutical properties and mechanisms of action. Molecules 25, 5573.
2. Barbero, G.F.; Liazid, A.; Azaroual, L.; Palma, M.; Barroso, C.G. 2016.Capsaicinoid contents

in peppers and pepper-related spicy foods. Int. J. Food Prop., 19, 485–493.

3. Al-Taey, D.K.A. (2018). The Role of GA and Organic Matter to Reduce the Salinity Effect on Growth and Leaves Contents of Elements and Antioxidant in Pepper. Plant Archive. 18(1): 479-488.

4. Shimoda K, Nishida K, Hamada H. 2009. Enzymatic synthesis and antiobese properties of β-maltooligosaccharides of capsaicin and 8-nordihydrocapsaicin. Biochemistry Insights.;67:2256-2261

5. Díaz-Laviada I. 2010. Effect of capsaicin on prostate cancer cells, Future Oncology, 6(10): 1545-1550.

6. Awatif N.Jerry, H. A. Abd-Alwahd and Dhia Ahmed Taai(2007) A STUDY OF STORABILITY OF FIVE CULTIVARS OF TOMATO FRUITS GROWN IN BASRAH, *Basrah J.Agric. Sci.* 20(1).1-15.

7. Jasman AK, Slomy AK, Sahib MR, AL-Taey DKA and Abd Ali A. 2019. Evaluation of Mirabilis jalapa and Conocarpus erectus Extracts against Bemisiatabaci and Myzuspersicae on Solanum melongena Plants under Laboratory and Field Conditions. *Biopestic.Int.*15(1):39-44.
8. Slomy A.K. , A. K. Jasman., F. J. Kadhim., D.K.A. AL-Taey and M. R. Sahib. (2019). STUDY IMPACT OF SOME BIOFACTORS ON THE EGGPLANT SOLANUM MELONGENA L. VEGETATIVE CHARACTERISTICS UNDER GLASS HOUSES CONDITIONS. *Int. J. Agricult. Stat. Sci.* Vol. 15 (1) :371-374.
9. Taain, D.A. 2014. The role of some plant extracts and storage temperature in improving storage ability of date palm fruits cv. Dayri (*Phoenix dactylifera*L. cv. Dayri). Advances in Agriculture and Botanics-International Journal of the Bioflux Society.6(1):26-32.
10. Akinremi, O.O. ; R.L. Janzen; R.L. Lemke; F.J. Larney. 2000. Response of canola, wheat and green beans to leonardite additions. Canadian Journal of Soil Science ,80:437-443.
11. Al-Taey, D.K.A., M.J.H. Al-Shareefi , A.K. MijweL, A. RZ. Al-Tawaha, A. RM. Al-Tawaha.(2019). The beneficial effects of bio-fertilizers combinations and humic acid on growth, yield parameters and nitrogen content of broccoli grown under drip irrigation system. *Bulgarian Journal of Agricultural Science,* 25 (5), 959–966.
12. Hassan, H S A, Sarrwy, S M A, Mostafa , EAM.2010. Effect of foliar spraying with liquid organin fertilizer, some micronutrients and gibberellins on leaf mineral content, fruit set, yield and fruit quality of Hollywood plum trees. Agriculture and Biology Journal of North America; 1(4):638-643.
13. Taain, D.A. 2011 Effect of Storage Temperatures and Postharvest Calcium Salts Treatments on Storability of Jujube Fruits (*Zizphusmauritiana*Lam.cv.Tufahi). Annals of Agri. Sci. J., Moshtohor, 49(4) :447-453.

14. AOAC. 1990.Official Method of Analysis,Association of official Analytical Chemists,Washington,D.C.USA.

15. Dalali, B.K. and Al – Hakim, S.H. 1987 . Food Analysis, University of Mosul, Iraq.

16. Sadasivam , S. and A. Mannikam. 1992. Capsaicin . In Biochemical methods for agricultural sciences (pp 193-194). New Delhi : Wiley Eastern Limited.

17. Al-Rawi, K.M. and Khalaf Allah, A.M. 1980. Design and analysis of agricultural experiments .Mosul ,Iraq.

18. Dementeva,M.E. & M.E.Vegonski.1988.Diseases of fruits,vegetables and potatoes during storage.Moscow.231PP.

19. Nardi, S.; D. Pizzeghello, and S. G. Pandalai . 2004 . Rhizosphere : A communication between plant and soil. Recent Res. Development in Crop Sci., 1(2): 349-360.

20. Al-Taey, D.K.A., Z.N. A. Kamaluddin and H. H. S. Al-Kazemy .(2022) Impact of Zytonic-M and organic fertilizer on growth and yield of hybrid tomato Awahr (F1) under saline conditions, International Journal of Vegetable Science, **28(4) :1-6** DOI: 10.1080/19315260.2022.2070569

21. Kadir, S.A. 2004. Fruit quality at harvest of 'Jonathan' apple treated with foliar applied calcium chloride. J. of Plant Nutr.27: 1991-2006.

22. Lateef, M.A. A.M. Noori, Y. M Saleh, D.K.A. Al-Taey.2021. The effect of foliar spraying with salicylic acid and calcium chloride on the growth, yield, and storage traits of two Strawberry cultivars,Fragaria×ananassaDuch. *Int. J. Agricult. Stat. Sci.*,17(2):611-615. DocID: https://connectjournals.com/03899.2021.17.611

23. Abu Dhahi, Y. M. and M.A. Al-Younes .1988. Plant Nutrition Guide. Dar Al-Kutub for Printing and Publishing, Ministry of Higher Education and Scientific Research - Iraq.

24. Al-Sahaf, F.H. 1989. Applied Plant Nutrition, Dar Al-Hikma Press, Ministry of Higher Education and Scientific Research, Iraq: 258 p.

25. Dris, R. 1998 . Effect of preharvest calcium treatments on postharvest quality Apples grow in Finland . University of Helsinki –Department of Plant Production– Horticulture Section – Publication 34 . Helsinki ,Finland.

26. Usten, N.H. ; Yokas, A.L. ; Saygili, H. 2006. Influence of potassium and calcium level on severity of tomato pith necrosis and yield of greenhouse tomatoes. *ISHS ActaHortic*808: 345–350.

27. Hasan, M.H.; Naveed, R.; Rehman, U.; Malik, A.U.; Haider, M.W.; Ahmed, Z.; Khan, A.; Anwar, R. 2019. Pre-storage Application of L-arginine Alleviates Chilling Injury and Maintains Postharvest Quality of Cucumber (Cucumissativus). Int. J. Hortic. Sci. Technol. 2, 102–108.

28. Ronchi,V.N.; Caligo M. A. ; Nozzolini M.; Luccarini G. 1985. Stimulation of carrot somatic embryogenesis by proline Plant Growth RegulatorsAbstract,11:375.

29. Zhang, X.; Min, D.; Li, F.; Ji, N.; Meng, D.; Li, L. 2017. Synergistic effects of l-arginine and methyl salicylate on alleviating postharvest disease caused by botrysiscinerea in tomato fruit. J. Agric. Food Chem., 24, 4890–4896.

30. Babalar, M.; Pirzad, F.; Ali, M.; Sarcheshmeh, A.; Talaei, A.; Lessani, H. 2018 Arginine treatment attenuates chilling injury of pomegranate fruit during cold storage by enhancing antioxidant system activity. Postharvest Biol. Technol. 137, 31–37.

31. Eslami, M.; Nasibi, F.; Kalantari, K.; Khezri, M.; Oloumi, H. (2019) Effect of exogenous application of-arginine and sodium nitroprusside on fruit abscission and physiological disorders of pistachio (Pistaciavera L.) Scions. Int. J. Hortic. Sci. Technol. 6, 51–62.

32. Taain, D.A., A.M. Jasim and J.H.H. Al-Hiji (2014). A study of storage behavior of okra fruits (*Abelmoschusesculuntus*L.Moenthcv.Khnesri). International Journal of Farming and Allied Science, 3**(7):** 760-766.

33. Yildirim,E. 2007.foliar and soil fertilization of humic acid effect productivity and quality of tomato,plant soil sci.57(2):182-186.

34. Hayat; I.; T. Masud and H.A. Rathore. 2005. Effect of coating and wrapping materials on the shelf of apple (*Malus domestica*. c.vBrokh). Department of Food Technology, University of

Arid Agriculture Rawalpindi. Internet Journal SafetyV(5) 24-34.

35. Faust, M. 1972. The effect of calcium on respiration of apples J. Amer. Soc. Hort. Sci. 97: 437-439.

36. Azarmi, R., M. T. Giglou, and B. Hajieghrari. 2009. The effect of sheep-manure vermicompost on quantitative and qualitative properties of cucumber (*Cucumissativus*L.) grown in the greenhouse. Afr. J. Biotechnol.8(19):4953–4957.
37. Aminifard M. H. ; H. Aroiee ; M. Azizi ; H. Nemati and H. Z. E. Jaafar 2012.Effect of humic acid on antioxidant activities and fruit quality of hot pepper (*Capsicum annuum* L.). Journal of Herbs, Spices & Medicinal Plants, 18:360–369.
38. Al- Duraid M.H. , K. A. Al-Taey, and A. H. J. Al-Kikhani.(2019) Effect of Phenylalanine and Naphthalene Acetic Acid on Growth, Yield and Antioxidant Activity of Fenugreek Trigonellafoenum-graecum. IOP Conf. Series: Earth and Environmental Science; 388 (2019) 012073 doi:10.1088/1755-1315/388/1/012073

39. Youssef, Z. S. R. 2013. The effect of arginine acid and calcium nitrate on some growth characteristics, yield and storage ability of tomato fruits *Lycopersiconesculentum* Mill. Master Thesis, College of Agriculture, University of Baghdad, Republic of Iraq.

40. Minawi, S. N. A. and M. O. Ali .2007. Biochemistry, 1st edition. Al-Mutanabbi Library, Saudi Arabia: PP.137-160 .
41. Tamura J. and Minamide, T. 1983. Harvesting maturity handling and storage of okra pods . Bulletin of the University of Osaka Prefecture Series B . V 36 : 87 – 97

42. Iqbal Q., Muhammad A., Muhammad R. A., Agustin A., Khurram Z.1, Aamir N. and Tanveer A. 2015. Stability of Capsaicinoids and Antioxidants in Dry Hot Peppers under Different Packaging and Storage Temperatures. Foods, 4, 51-64.