Effect of Some Postharvest Treatments on Removal of Emamectin benzoate and Quality of Cherry Tomato Fruits During Cold Storage

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ABSTRACT

This study aimed to evaluate the effect of dipping Cherry tomato fruits on ozonated water ، citric acid ،acetic acid، sodium bicarbonate ،distilled water and control as postharvest treatments on the removing of Emamectin benzoate as well as to evaluate the effect of these treatments on some visual and chemical qualities and storage ability at 10 C and 95% RH. The results indicated that all postharvest treatments removed the remaining of pesticide with different percentages without affecting the fruit quality postharvest .Also ،the ozonated water (20 Minutes) was found the most effective treatment for removing emamectin benzoate and maintaining fruit quality ،it would reduce weight loss percentage and gave fruits without decay and maintaining fruit firmness, TSS, total sugars content, ascorbic acid content, titratable acidity and lycopene content .Additionally, lower peroxidase activity ،with excellent appearance until 20 days when fruits stored at 10C and 95 % RH as compared with the other treatments and untreated control.

Keywords: Cherry Tomato – Emamectien benzoate -Postharvest treatment - Quality -Cold storage.

INTRODUCTION

Cherry tomato (*Solanum lycopersicum* L. Catalena VR) is a popular, small Fruit with a bright red color and an excellent taste. Tomatoes are nutritious due to high lycopene, ascorbic acid, and phenolic compounds (Souza et al., 2020). Preserving quality and extending shelf life are crucial for fruits and vegetables postharvest (Khawarizmi and Ding 2018). There are some postharvest treatments can preserve the fruits quality and increase their storage ability, as well as have high efficiency to remove pesticides from contaminated fruits (Swami et al., 2021, Hussnain et al., 2021 and Yang et al., 2019). Pesticides are widely used against pathogens, insects or weeds to prevent crop damage. It is estimated that between 30 and 40% of the crop is lost if plant protection products do not provide adequate protection (Caponio et al., 2023). In developing countries, where pesticide contamination is widespread, pesticides are used during the growing season until maturity and the proposed period between the last spraying and harvest is ignored resulting in accumulation of pesticide on and or in the internal parts of vegetables, causing serious diseases to consumers (Amir et al., 2019). Neurotoxicity, carcinogenesis, abnormal proliferation and cell development were repointed following consummation of fruits and vegetables contaminated with pesticides (Osman et al., 2017). It is essential to eliminate pesticide residues from vegetables to decrease the risk to human health (Wu et al., 2007).Traditional washing is a basic method to reduce pesticide

residues (Polat and Tiryaki, 2023). Ozone gas in water is a new method to reduce pesticide residues in fruits

and vegetables (Swami et al., 2021). This method also helps to maintain the produce´s quality and storage capacity produce (Tzortzakis and Chrysargyris, 2017). Citric acid, an organic acid, inhibits bacterial growth, improves disease resistance in produce, and can provide an effective way to maintain postharvest quality (Yang et al., 2019). Acetic acid is used as a preservative in food products and is environmentally safe (Alawlaqi and Alharbi, 2014). Inzaule et al. (2018) recommend the use sodium bicarbonate for tomatoes as a cost-effective sanitization option, where washing tomatoes with a 10% sodium bicarbonate solution effectively reduced residues. Also, it was found that vegetables soaked in different solutions of acetic acid, citric acid, carbonate sodium, bicarbonate sodium or tap water had less pesticide residues on the surface, proved to be as an effective tool for reducing pesticide residues on tomato fruits (Abdullah et al., 2016, Amir et al., 2019 and Hussnain et al., 2021).

MATERIALS AND METHODS

Treatments on the Quality and Storability of Fruits

Cherry tomato fruits were harvested at the pink color stage on the 5th and 15th of May in the 2020 and 2021 seasons, respectively from a private farm- in Alexandria governorate. Plants were sprayed with 120 gm/ feddan from emamectin benzoate (5.7 %) (Non –systemic insecticide which penetrates tissues by translaminar movement), after one day, fruit samples were collected, then transferred to the National Institute of Oceanography and Fisheries (NIOF) to analyze the residues of the pesticide immediately after 0, 5,10,15 and 20 days. Fruits were assigned as following: groups 1and 2 were immersed in ozonated water for 10 and 20 min, receptively, while 3 and 4 were immersed in 1 and 2% of citric acid, groups 5 and 6 were immersed in 1 and 2 % acetic acid, while groups 7 and 8 were immersed in 1 and 2 % of sodium bicarbonate, respectively. On the other hand, group 9 was immersed in distill water, while group 10 was left without washing and kept as control. The fruits were soaked for 10 minutes in all treatments the except ozonated water treatment, which was 10 minutes and increased to 20 minutes. All the fruits were dried with electric fans and packed into panetts, 25 fruits per panett. And then packed in polypropylene bags 30 µm thick. The samples were organized in a randomized pattern with three duplicates. each treatment consists of 21 panetts, to follow on the effect of previous treatments on some characteristics of cherry Tomato fruits. Fruits were stored at a temperature of 10 C and 95 % RH for 20 days at the postharvest laboratory, Faculty of Agriculture, Alexandria University. Samples were examined at an interval of 4 days for visual and chemical qualities:

Visual characters

The weight loss percentage was calculated according to Kader et al. (1973), using the following formula: Loss in weight% = Initial weight of the head - weight of the head at the sample date / the initial weight of the head x 100. Evaluation of General Appearance was conducted on a scale ranging from 9 to 1, where (9) represented excellent, (7) good, (5) fair, (3) bad, and (1) unsalable head grading, with a score of (5) or lower rendering the product unmarketable. The decay percentage was determined by comparing the number of fruits to the number of decayed fruits / the number of fruits x 100. Fruit firmness was assessed using an effigy pressure tester equipped with a 3\5 plunger (Effigy, 48011 Alfonse, Italy) inserted into the fruit pulp, with two readings recorded for each fruit. Firmness measurements were expressed as pounds per square inch (Lb/in2).

Chemical component

The total soluble solid percentage was calculated using an Abbe Leica digital refractometer. Each fruit sample's total sugars were extracted from 20 gm of thoroughly cut and blended flesh. Distilled water was used in the extraction (Loomis and Shull, 1937). Titratable acidity was calculated by titrating fruit juice with 0.1 N sodium hydroxide in the presence of phenolphthalein as an indicator, (A.O.A.C, 2000). Ascorbic acid (as specified for vitamin C) was evaluated using the titration technique published by (A.O.A.C, 2000) utilizing 2, 6 discolor phenol indophenols. Lycopene content was spectrophoto metrically determined by the method described by (A.O.A.C, 2000). The peroxidase enzyme activity was measured according to Ranganna (1991).

HPLC Analysis of Emamectin benzoate. As detailed by (Dolan, 2016)

Ozone generation . As detailed by Osman et al . (2017)

Statistical Analysis

Data underwent statistical analysis utilizing the analysis of variance as outlined by Snedecor and Cochran (1980). The Duncan multiple range test method was employed for comparing means based on the approach by Waller and Duncan (1969).

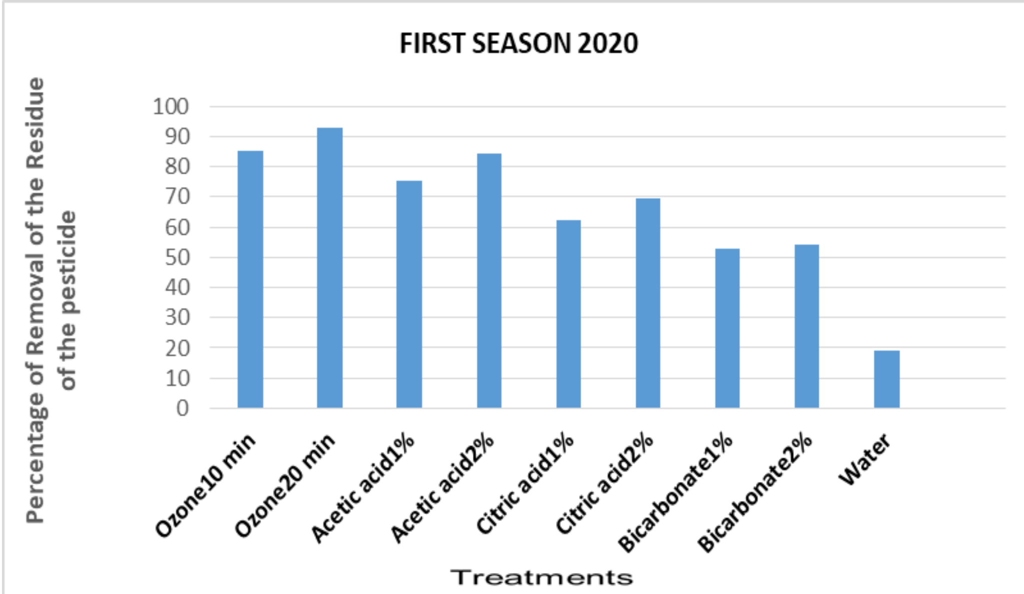
This study aimed to evaluate the effect of dipping fruits on different solutions postharvest on the quality of the fruits and removing the residual effect of the emamectine benzoat pesticide.

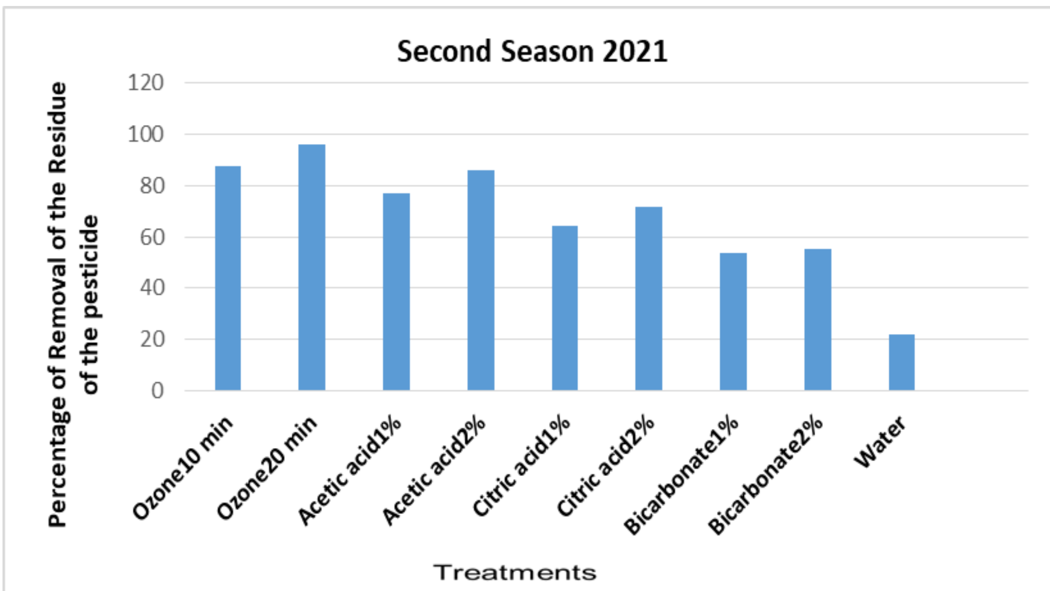
RESULTS AND DISCUSSION

Effect of Treatments on Removal of Pesticide Residual

The results, as shown in **Fig (1)** for the years 2020 and 2021, showed that all fruit soaking treatments were able to reduce the residual effect of the pesticide .The order of the treatments their ability to remove the residual trace of the pesticide as follows: ozonated water for 20 min ،followed by ozonated water for 10 min, acetic acid 2% and ،%1 citric acid 2 ،%1 ،%and then sodium bicarbonate 2%,1 %. It was also noted that higher concentrations of tested treatments had a higher ability to reduce the residual trace percentage of the pesticide .The removal rate during the two years under study was as follows, 92 ،85.26 ،95.35 ،88. ،69.44 ،77.18 ،75.58 ،86.27 ،84.34 ،87.59 ،52.31 ،55.64 ،54.98 ،64.37 ،62.21 ،71.57 ،.53.3respectively .The lowest percentages were for distilled water treatment 23.38 and 17.51at the first and second seasons , respectively .The present results are in parallel with many investigate (Caponio et al ،2023 ،.Hussnain et al ،2021 ،.Amir et al ،. 2019 and Abdullah et al .,2016) .Wang et al . (2019)illustrated that the ozone, or tri oxygen, is an inorganic molecule and much less stable than the diatomic allotrope O .2It breaks down to O_2or dioxygen. Compared to oxygen, ozone has greater oxidative potential. It can decompose organic chlorides, dioxins and other pollutants into carbon dioxide and other innocuous substances. Additionally ،it can oxidize toxic and hazardous substances, such as phenol and cyanide, into harmless substances.

Fig. 1. Effect of different treatments on removal percentage of pesticide residue of cherry tomato fruits during different cold storage periods in the 2020 and 2021





Effect of Treatments on Pesticide Residue and Removal percentage

Table (1) shows the effect of postharvest treatments on the residual effect of the pesticide. The results showed that soaking the fruits in ozonated water for 20 minutes had the lowest fruits in the level of pesticide residues and the highest percentage of removal of the remaining trace of the pesticide, followed by ozonated water treatment for 10 minutes and then 2% acetic acid, in comparison with control

Table (1). Effect of different treatments on residue levels and removal percentage of Emamectin benzoate of cherry tomato fruits during different cold storage periods in the 2020 and 2021 seasons.

Treatments	Cold Storage Period (Day)					
	0	5	10	15	20	Mean
	First Season 2020					
Control	1.838 a	0.982 c	0.577 h	0.136 w	ND	0.706 A
Ozone 10 Minute	0.277 r	0.128 y	ND	ND	ND	0.08 H
Removal %	85.26 (%)	92.99 (%)				
Ozone 20 Minute	0.132 x	0.108 A	ND	ND	ND	0.048 I
Removal %	92.88 (%)	94.13 (%)				
Citric Acid 1%	0.694 g	0.474 k	0.228 t	ND	ND	0.279 E
Removal %	62.21 (%)	74.23 (%)	87.60 (%)			
Citric Acid 2%	0.563 i	0.214 u	ND	ND	ND	0.155 F
Removal %	69.44 (%)	88.31(%)				
Acetic Acid 1%	0.448 l	0.327 o	ND	ND	ND	0.155 F
Removal %	75 58 (%)	82.16 (%)				
Acetic Acid 2%	0.287 p	0.262 s	ND	ND	ND	0.109 G
Removal %	84.34 (%)	85.70 (%)				
Bicarbonate Sodium 1%	0.878 d	0.494 j	0.284 q	ND	ND	0.331 C
Removal %	52.31 (%)	73.19 (%)	84.56 (%)			
Bicarbonate Sodium 2%	0.828 e	0.446 m	0.202 v	ND	ND	0.295 D
Removal %	54.98 (%)	75.75 (%)	89.07 (%)			
Distill Water	1.407 b	0.726 f	0.388 n	0.125 z	ND	0.529 B
Removal %	23.38 (%)	60.52 (%)	78.85 (%)	93.20 (%)		
Mean	0.734 A	0.416 B	0.167 C	0.026 D	ND	
	Second Season 2021					
Control	1.958 a	1.282 c	0.688 h	0.165 y	ND	0.818 A
Ozone 10 Minute	0.244 t	0.192 x	ND	ND	ND	0.081 I
(Removal %)	87.54 (%)	90.20 (%)				
Ozone 20 Minute	0.09 D	0.061 E	ND	ND	ND	0.031 J
(Removal %)	95.35 (%)	96.89 (%)				
Citric Acid 1%	0.697 g	0.416 n	0.211 v	ND	ND	0.265 E
Removal %	64.37 (%)	78.76 (%)	89.23 (%)			
Citric Acid 2%	0.556 j	0.395 o	0.165 y	ND	ND	0.223 F
(Removal %)	71.57 (%)	79.79 (%)	91.58 (%)			
Acetic Acid 1%	0.445 m	0.282 r	0.198 w	ND	ND	0.185 G
(Removal %)	77.18 (%)	85.66 (%)	89.84 (%)			
Acetic Acid 2%	0.268 s	0.225 u	0.108 A	ND	ND	0.120 H
(Removal %)	86.27 (%)	88.46 (%)	94.49 (%)			
Bicarbonate Sodium 1%	0.913 d	0.592 i	0.318 p	0.106 B	ND	0.385 C
(Removal %)	53.39 (%)	69.83 (%)	83.77 (%)	94.59 (%)		
Bicarbonate Sodium 2%	0.868 e	0.547 k	0.308 q	0.098 c	ND	0.364 D
(Removal %)	55.64 (%)	72.03 (%)	84.23 (%)	94.95 (%)		
Distill Water	1.616 b	0.863 f	0.466 l	0.116 z	ND	0.364 D
(Removal %)	17.51 (%)	56.00 (%)	76.16 (%)	94.03 (%)		
Mean	0.765 A	0.485 B	0.246 C	0.048 D	ND	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan, s multiple rang test.
*ND: Not detectable

Effect of Treatments on the Quality and Storability of Fruits Visual characters

Weight loss percentage

Data in **Fig. (2)** revealed that the weight loss % of cherry tomato fruits rose when the storage duration was extended across two seasons. This is consistent with the finding of Gharezi et al. (2012) on cherry tomatoes, who stated that weight loss in fresh tomatoes is predominantly caused by transpiration and respiration.

Regarding the impact of postharvest treatments, the present findings indicated that significant disparities existed between postharvest treatments and the untreated control throughout the storage period. All postharvest treatments exhibited weight retention during storage in comparison to the untreated control. Additionally, cherry tomato fruits immersed in ozonated water for 20 minutes emerged as the most efficacious treatment in reducing weight loss percentage, followed by fruits treated with 10 minutes of ozonated water, showing noteworthy distinctions between the two in different seasons, and followed by acetic acid at a concentration of 2%. Kim et al. (2010) demonstrated that O_3 diminished weight loss by inhibiting enzymatic reactions, reducing fruit respiration and consequently minimizing weight loss. Generally, the interplay between postharvest treatments and storage durations significantly influenced the weight loss percentage across the two seasons. Following a storage period of 20 days, cherry tomato fruits immersed in ozonated water for 20 minutes exhibited the lowest weight loss value, in the contrast the untreated control displayed the highest weight loss percentage. Gharezi et al. (2012) investigated that acetic acid plays a crucial role in effectively managing the stored cherry tomatoes' weight loss, shrinkage, and moisture content.

General appearance (score): Data presented in **Fig. (3)** indicated a significant decrease in the general appearance (score) of cherry tomato fruits with the extension of storage duration in both seasons. These findings aligned with the observations of Shehata et al. (2021) regarding tomatoes, suggesting that the decline in the overall appearance of fruits may predominantly be attributed to a slight desiccation of the fruit surface rather than translucency or visible decay. Regarding the impact of postharvest treatments, the present findings indicated significant disparities between postharvest treatments and untreated control throughout the storage period. Cherry tomato fruits subjected to ozonated water treatments exhibited the highest appearance score compared to the untreated control. Specifically, fruits immersed in ozonated water for 20 minutes proved to be the most effective treatment in maintaining overall appearance. Fruits treated with acetic acid also showed positive results, while the untreated control displayed the lowest scores in this aspect across both seasons. This aligns with the findings of Aguayo et al. (2006) on tomatoes, Toivonen and Stan (2004) on green peppers, and Minas et al. (2020) on kiwifruits, who observed that ozone effectively delayed the climacteric ethylene rise and completely inhibited ethylene production in fruits during cold storage.

Gharezi et al. (2012) indicated that acetic acid performs a very important part in regulating weight reduction, shrinkage, color, flavor, firmness percentage, and moisture content of cherry tomatoes stored. For all these reasons, it maintained the general appearance of fruits.

Regarding the interaction effects, the data revealed that the fruits treated with ozonated water 20 minutes after 20 days from cold storage were found to be an excellent in general appearance followed by the ozonated water 10 min., acetic acid 2%, and citric acid 2% treatments maintained the good appearance of fruits until 20 days of storage compared to low concentration, while the sodium bicarbonate (2%) treatment showed good appearance until 15 days of cold storage in both seasons. The distilled water treatment gave a poor appearance after 20 days from the experiment. On the contrary, the untreated treatment (control) gave an unsalable appearance after 20 days during cold storage in both seasons.

Decay percentage:

Data presented in **Fig. (4)** illustrate a notable rise in decay percentage as the storage period in both seasons was extended. This observation could be attributed to the ongoing chemical and biochemical alterations occurring in fruits, such as changes in moisture concentration and the conversion of complex compounds into simpler forms that are more susceptible to fungal infections, for example, the transition from solid protopectin to soluble pectin as noted by Wills et al. (1998).

Analysis of postharvest treatments indicated significant variations in decay percentage between the treatments and control. Cherry tomato fruits treated with ozonated water either for 10 or 20 minutes, acetic acid at 1% and 2%, and citric acid at 1% and 2% exhibited no decay throughout the storage period, showing no notable differences in decay percentage between the treatments across two seasons. Conversely, the untreated control group displayed the highest decay percentage in both seasons. These findings align with the study done by Lin et al. (2019), who investigated ozone as a potent sanitizer with high oxidation-reduction potential. Additionally, Swami et al. (2021) discovered that ozonated water outperformed regular water washing in eliminating pesticide residues from grapes and green peppers. Also, Gharezi et al. (2012) illustrated that the acetic acid is a known surface sanitizer.

In general, the significance of the interaction between postharvest treatments and storage periods on decay percentage was notable in both seasons. Cherry tomato fruits treated with ozonated water for 10 and 20 minutes, acetic acid at 1 and 2%, as well as citric acid at 1 and 2%, displayed no signs of decay up to 20 days of storage at 10 $^{\circ}$C. Conversely, untreated fruits exhibited the highest decay percentage after 20 days in both seasons.

Fig. (2). Effect of different treatments on weight loss percentage of cherry tomato fruits during different cold storage periods in the 2020 and 2021 seasons.

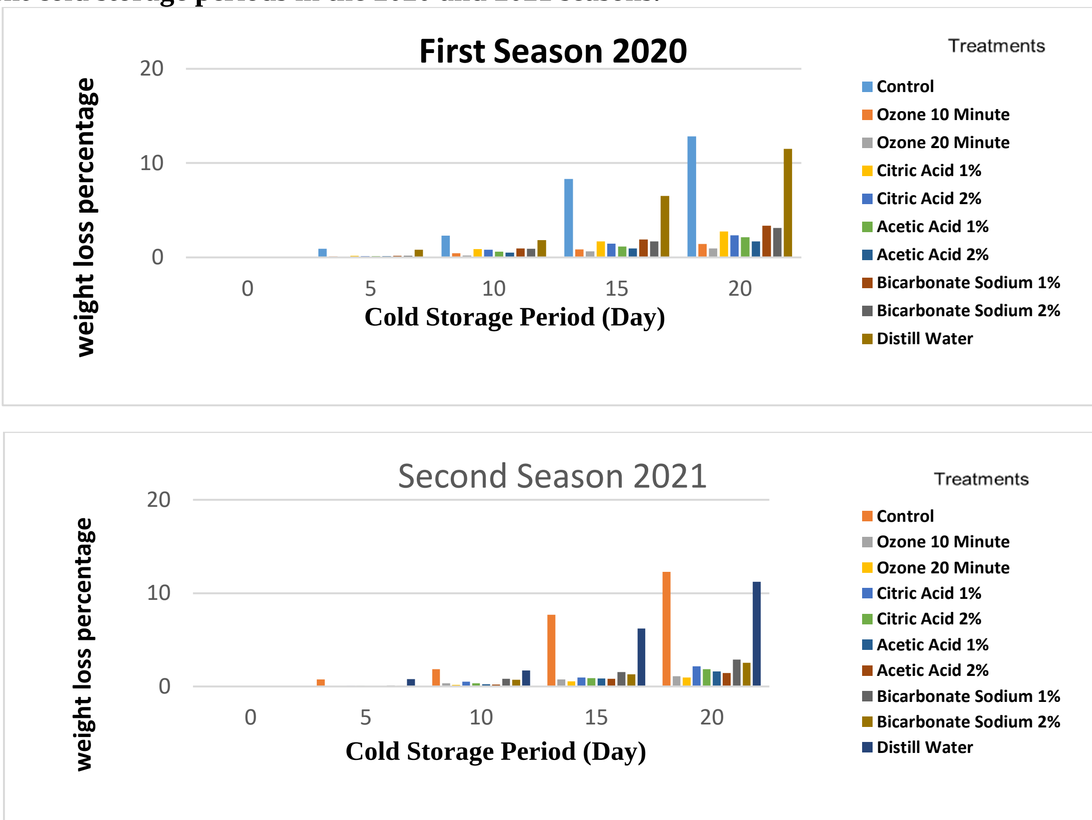


Fig. (3). Effect of different treatments on general appearance (Score) of cherry tomato fruits during different cold storage periods in the 2020 and 2021 seasons.

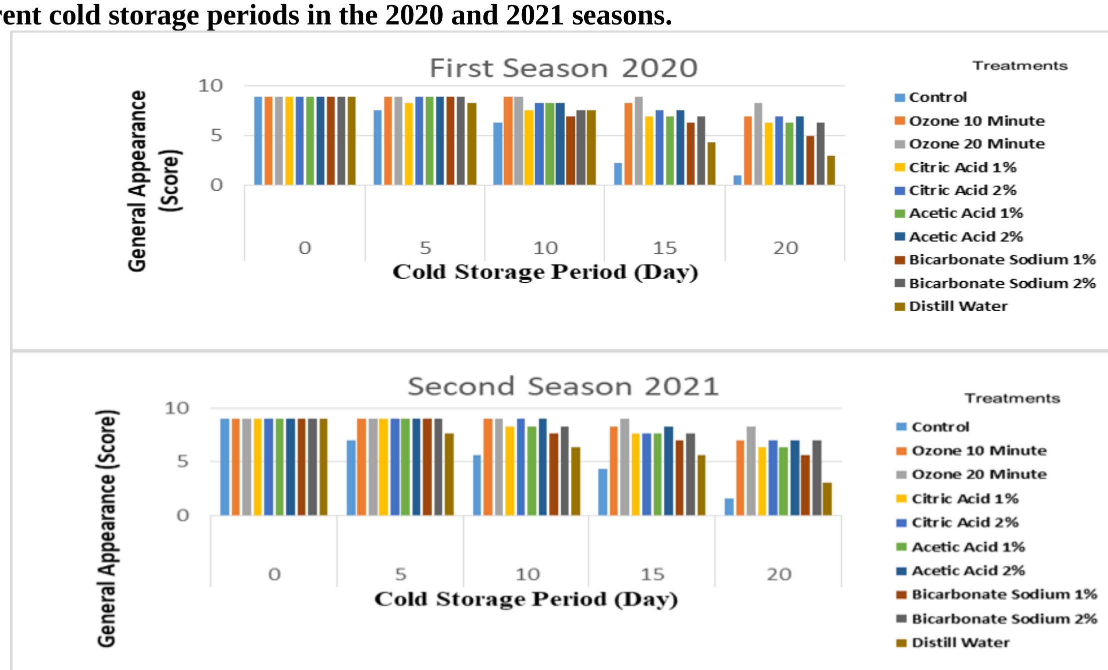
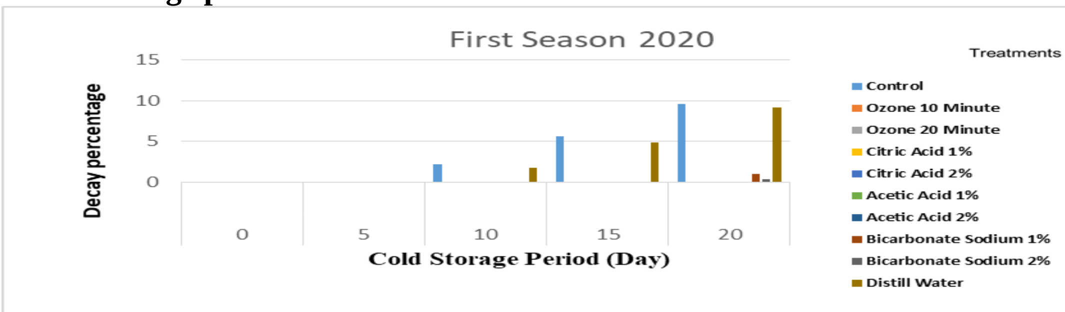
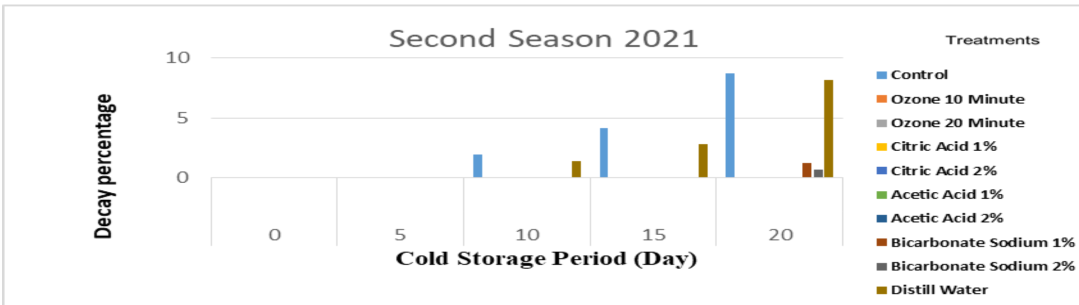


Fig.(4). Effect of different treatments on decay percentage of cherry tomato fruits during different cold storage periods in the 2020 and 2021 seasons.





Fruit firmness:

Data presented in **Fig. (5)** demonstrate a substantial decrease in fruit firmness of cherry tomatoes with the extension of storage duration across two seasons. This finding aligns with the conclusions drawn by Abou-zaid et al. (2020) and Gharezi et al. (2012) regarding cherry tomatoes. Mwaurah et al. (2020) elaborated that the softening of fruits occurs due to changes in cell wall composition, cell structure, and intracellular components, affecting the fruit's structure and ethylene synthesis.

Regarding the impact of postharvest interventions, the data indicates that all treatments significantly influence fruit firmness compared to untreated samples during storage in both seasons. Notably, cherry tomatoes immersed in ozonated water for 10 or 20 minutes exhibited the highest fruit firmness values during cold storage, with no significant variance between them, followed by the 2% acetic acid treatment. While other treatments maintained fruit firmness to some extent, they were comparatively less effective. The untreated control group recorded the lowest fruit firmness values. An et al. (2007) demonstrated that immersing asparagus in ozone-treated water led to an increase in lignin, cellulose, and hemicellulose contents in the cell wall. Furthermore, Gharezi et al. (2012) reported that acetic acid played a crucial role in regulating firmness and moisture levels in stored cherry tomatoes.

The interaction between postharvest treatments and storage periods was found to be statistically significant in both seasons. Following 20 days at 10°C, cherry tomato fruits that were immersed in ozonated water for 20 minutes exhibited the highest level of fruit firmness after the storage period. This was closely followed by fruits treated with ozonated water for 10 minutes, and then by fruits treated with acetic acid at a concentration of 2%. Conversely, the lowest fruit firmness value was observed in the untreated control group during the same period in both seasons.

Chemical component:

Total soluble solids (TSS) percentage:

The data presented in **Fig (6)** demonstrates a significant decrease in the total soluble solids of cherry tomato fruits as the storage period extends in both seasons. These findings align with the results reported by Abou-Zaid et al. (2020) regarding cherry tomatoes. It was observed that the total soluble solids of all experimental treatments declined with the increase in storage duration. The reduction in total soluble solids over time is a natural occurrence, possibly attributed to moisture loss during storage. The decrease in TSS is linked to the oxidative degradation of sugars due to respiration and overripening, as suggested by Antala et al. (2014). Furthermore, the impact of postharvest treatments on the TSS% of fruits during storage showed significant variations between the treated and untreated control groups when fruits were dipped in ozonated water for 20 min. more TSS % was retained, followed by ozone treatments for 10 min. then acetic acid 2 % treatment. Untreated control showed the lowest value of TSS %. Gharezi et al. (2012) indicating that acetic acid, plays a very effective role in controlling the compositional changes such as the total soluble solids content of cherry tomatoes stored

In general, a significant interaction effect was observed in both seasons. Following 20 days at 10°C, fruits immersed in ozonated water for 20 min exhibited notably higher TSS%, surpassing the ozone treatments for 10 minutes without any statistically significant variances between them during the first season. Conversely, the ozonated water 20 min treatment displayed the highest TSS% in the second season. Meanwhile, the untreated control group yielded the lowest values during the same period in both seasons.

Total sugars:

The data presented in **Fig (7)** indicated a significant impact of the storage period on the total sugar content of fruits. A notable decrease in total sugars was observed with the prolongation of the storage period in both seasons. This decline in total sugar content in tomato fruit during storage may be attributed to the utilization of total sugar in the respiration process (Shehata et al., 2021).

Regarding the influence of postharvest treatments, the data showed significant variations among all postharvest treatments and the untreated control in the total sugar content of fruits throughout storage. Fruits treated with ozonated water for 20 minutes had the highest total sugar content, followed by ozone treatments for 10 minutes in both seasons. Conversely, distilled water treatment exhibited lowest total sugar followed by the untreated control group. Elevation in fructose and glucose levels in tomato slices exposed to an ozonated atmosphere, were recorded Aguayo et al. (2006).

Gharezi et al. (2012) reported that acetic acid plays a crucial role in regulating the total sugar content of cherry tomatoes stored.

In general, the correlation between postharvest interventions and storage durations exhibited a notable impact on the overall content of sugar in the two respective seasons. Following a storage duration of 20 days at a temperature of 10°C, it was observed that fruits subjected to various postharvest treatments displayed the highest levels of total sugar content, compared to the untreated control group.

Titratable acidity:

The results presented in **Fig (8)** indicate a noticeable decrease in titratable acidity with an increase in storage period during both seasons. This finding aligns with previous studies by Gharezi et al. (2012) on cherry tomatoes and Rodoni et al. (2010) on tomatoes, suggesting that the decline in fruit acidity during storage may be due to the rapid oxidation of pyruvic acid and other acids to carbon dioxide.

It was observed that postharvest treatments significantly influenced titratable acidity (T.A) during the storage period in both seasons. All postharvest treatments effectively slowed down the reduction in titratable acidity compared to the control group in both seasons. Particularly, the 20min. ozonated water treatment demonstrated the best ability to maintain titratable acidity levels compared to the untreated control in both seasons.

Furthermore, there was a significant interaction between postharvest treatments and storage periods in both seasons. After 20 days at 10°C, fruits treated with ozonated water for 20 minutes exhibited notably higher titratable acidity content, followed by fruits treated with ozone for 10 minutes, showing significant differences between them. In contrast, the untreated control group displayed the lowest titratable acidity levels during the same period in both seasons.

Fig. (5). Effect of different treatments on firmness (Lb/in^2) of cherry tomato fruits during different cold storage periods in the 2020 and 2021 seasons.

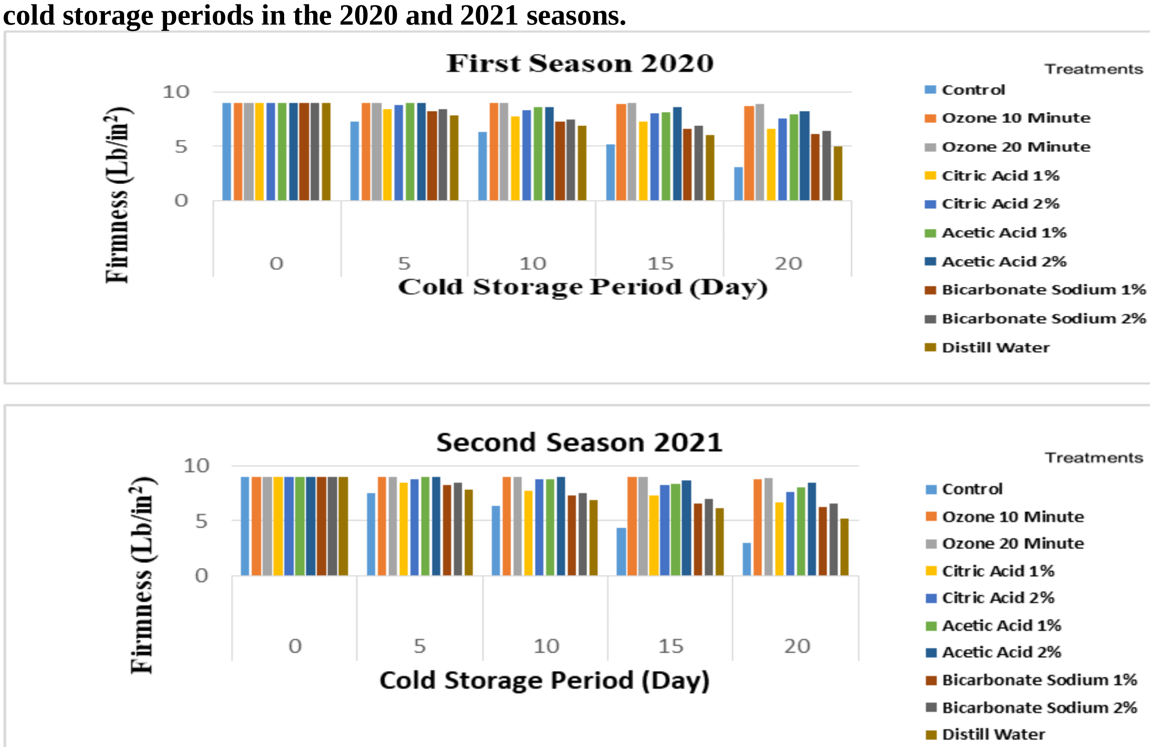
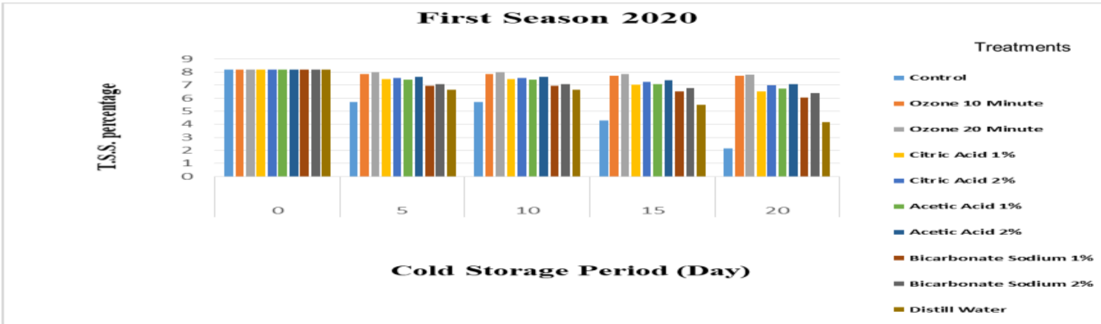


Fig. (6). Effect of treatments on T.S.S. percentage of cherry tomato fruits during different cold storage periods in the 2020 and 2021 seasons



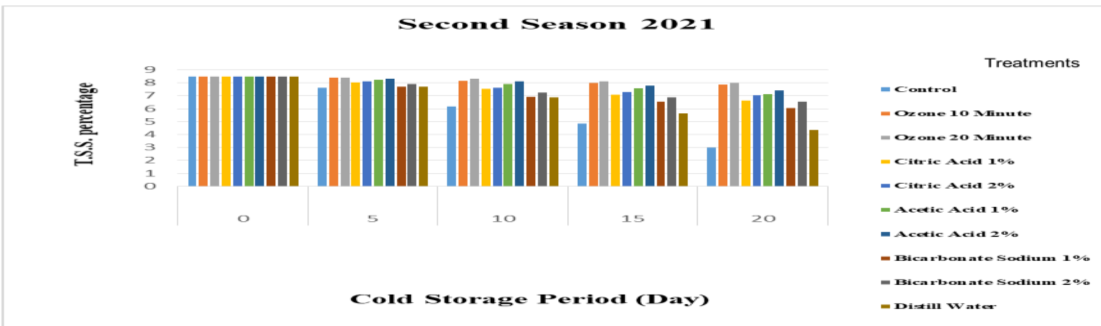
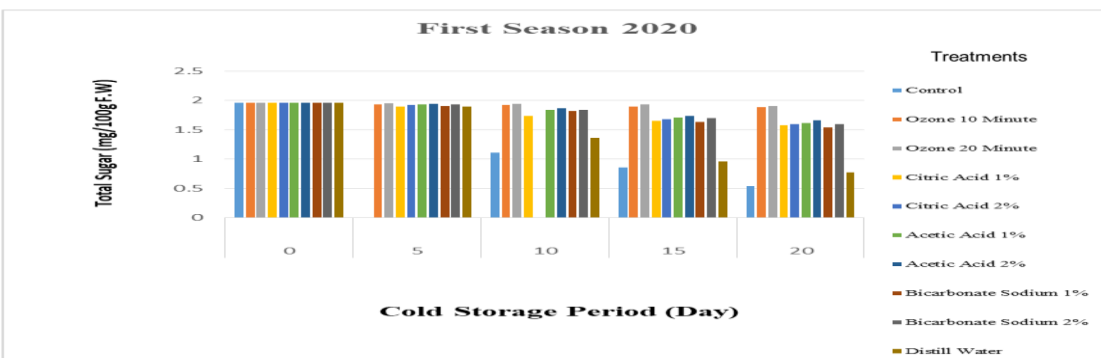


Fig. (7). Effect of treatments on total sugar (mg/100g F.W) of cherry tomato fruits during different cold storage periods in the 2020 and 2021 seasons



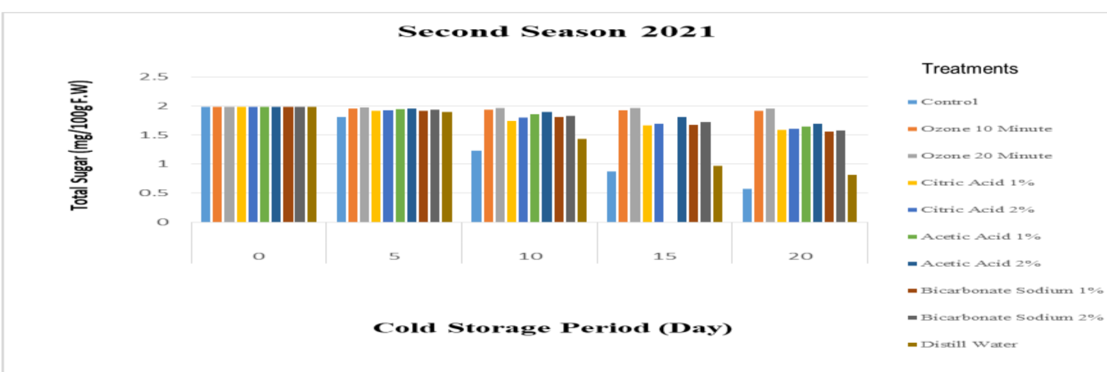
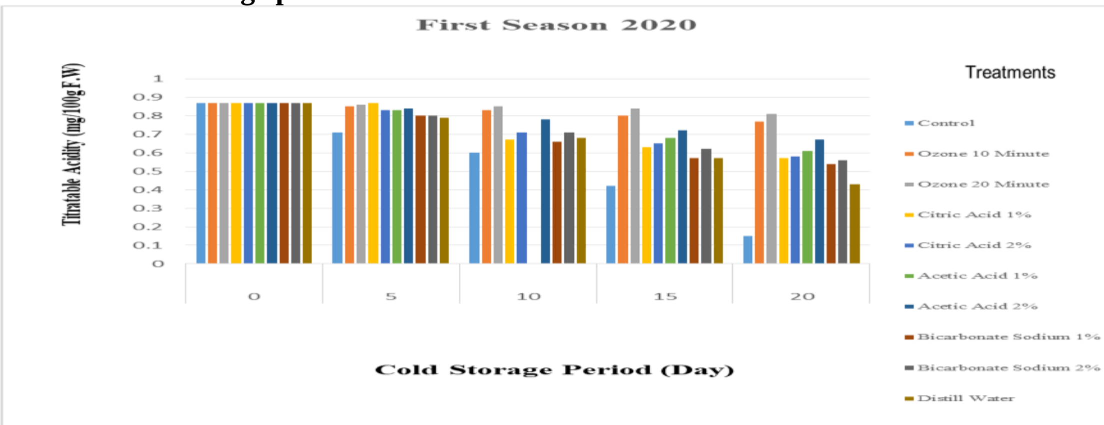
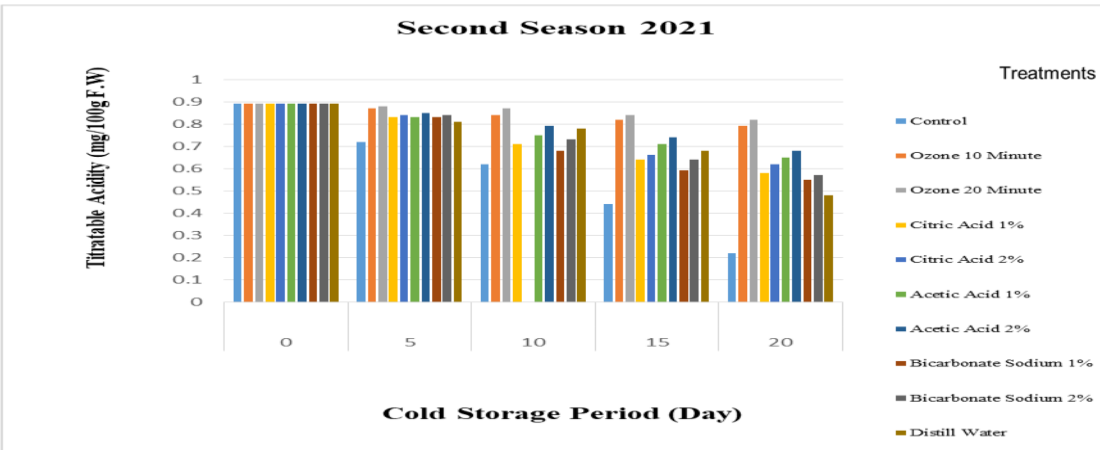


Fig. (8). Effect of treatments on Titratable acidity (mg/100g F.W) of cherry tomato fruits during different cold storage periods in the 2020 and 2021 seasons.





Ascorbic acid content:

The data presented in **Table (2)** demonstrate a significant decrease in the ascorbic acid content of fruits with the extension of the storage period in both seasons, under findings by Abou-zaid et al. (2020) in cherry tomatoes. This reduction in ascorbic acid levels during storage may be attributed to the utilization of ascorbic acid in the respiration process or its oxidation, as suggested by Shehata et al. (2021).

In terms of postharvest treatments, the data reveal that all postharvest methods were notably effective in preventing the degradation of ascorbic acid during storage compared to the untreated control group. Additionally, cherry tomato fruits treated with ozonated water for 20 and 10 minutes exhibited the most effective preservation of ascorbic acid content with significant differences between them, followed by treatments with 2% and 1% acetic acid, which also displayed significant differences. The untreated control group yielded the lowest values. Gharezi et al. (2012) demonstrating that acetic acid helps to limit the decrease in ascorbic acid content of stored cherry tomatoes.

The interaction between treatments and storage periods was found to be significant in both seasons. Fruits immersed in ozonated water for 20 minutes showed significantly higher levels of ascorbic acid after 20 days at 10˚C, followed by fruits treated with ozone for 10 minutes, with significant differences between them. Conversely, the untreated control group exhibited the lowest levels during the same period in both seasons.

Lycopene Content:

Data presented in **Table (3)** indicate a notable increase in the lycopene content of fruits with the extension of storage duration across both seasons. These findings align with those reported by Abou-zaid et al. (2020) and Gharezi et al. (2012) in their studies on cherry tomato fruits. It was observed that all treatments exhibited a considerable rise in lycopene levels throughout the storage period. Yadav *et al*. (2009) suggested that this elevation could be attributed to the degradation of chlorophyll and the enhanced synthesis of lycopene, contributing to the distinct color development during the ripening of tomatoes. Regarding the impact of postharvest treatments, the data indicate significant variances between the treatments and the control group during cold storage. However, fruits dipped in ozonated water for 20 min. gave the lowest values in lycopene content during storage followed by dipping ozone for 10 min., and then acetic acid 2% treatment. The highest value of lycopene content was obtained from untreated control. Gharezi et al. (2012) indicated that acetic acid, was found to be effective in controlling the lycopene content of cherry tomatoes stored. Fruits subjected to acetic acid treatment exhibited a notable delay in the biosynthesis of lycopene, potentially linked to retardation in ripening attributed to a decrease in respiration rate. Similar findings have been documented by Brandt et al. (2009) in tomato.

The interplay between postharvest interventions and storage durations significantly influenced the lycopene content across the two seasons. Following a storage period for 20 days at 10˚C, the lycopene content was the lowest after ozonated water treatment for 20 minutes, while the untreated control yielded the highest values. The control treatment demonstrated the highest lycopene levels.

Table (2). Effect of different treatments on ascorbic acid (mg/100g F.W) of cherry tomato fruits during different cold storage periods in the 2020 and 2021 seasons.

Treatments	Cold Storage Period (Day)					
	0	5	10	15	20	Mean
	First Season 2020					
Control	26.42 a	24.82 r	18.41 c	8.24 G	4.03 H	16.38 J
Ozone 10 Minute	26.42 a	26.39 b	26.34 de	26.28 f	25.28 n	26.14 B
Ozone 20 Minute	26.42 a	26.41 a	26.39 b	26.34 de	26.22 g	26.35 A
Citric Acid 1%	26.42 a	26.07 i	25.05 q	23.58 u	21.12 A	24.45 F
Citric Acid 2%	26.42 a	26.34 de	25.53 k	24.32 s	22.32 x	24.99 E
Acetic Acid 1%	26.42 a	26.36 cd	26.18h	25.16 o	23.17 v	25.46 D
Acetic Acid 2%	26.42 a	26.37 c	26.28 f	25.48 l	24.26 t	25.76 C
Bicarbonate Sodium 1%	26.42 a	26.02 j	25.14p	21.18 z	18.32 D	23.42 H
Bicarbonate Sodium 2%	26.42 a	26.06 j	25.33 m	22.43 w	20.08 B	24.06 G
Distill Water	26.42 a	25.07 q	21.36 y	17.54 E	12.73 F	20.62 I
Mean	26.42 A	25.99 B	24.60 C	22.06 D	19.75 E	
	Second Season 2021					Mean
Control	26.55 a	25.23 r	19.13 C	19.18 G	4.25 H	16.87 J
Ozone 10 Minute	26.55 a	26.53 ab	26.48 c	25.84 l	25.48 p	26.17 B
Ozone 20 Minute	26.55 a	26.54 a	25.08 s	26.41 e	26.25 h	26.45 A
Citric Acid 1%	26.55 a	26.09 j	25.65 n	23.66 v	21.28 A	24.53 F
Citric Acid 2%	26.55 a	26.38 f	26.22 i	24.48 u	22.46 y	25.10
Acetic Acid 1%	26.55 a	26.42 e	26.32 g	25.32 q	23.53 w	25.61 D
Acetic Acid 2%	26.55 a	26.46 d	25.22 r	25.74 m	24.53 t	25.92 C
Bicarbonate Sodium 1%	26.55 a	26.05 k	25.52 o	21.84 z	18.63 D	23.66 H
Bicarbonate Sodium 2%	26.55 a	26.07 jk	22.48 y	22.63 x	20.14 B	24.18 G
Distill Water	26.55 a	25.22 r	24.48 y	18.38 E	13.24 F	21.17 I
Mean	26.55 A	26.10 B	24.86 C	22.35 D	19.98 E	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan' s multiple rang test.

Table (3). Effect of different treatments on lycopene (mg/100g F.W) of cherry tomato fruits during different cold storage periods in the 2020 and 2021 seasons.

Treatments	Cold Storage Period (Day)					
	0	5	10	15	20	Mean
	First Season 2020					
Control	0.87 B	1.26 s	1.58 m	3.31 b	4.52 a	2.31 A
Ozone 10 Minute	0.87 B	0.89 C	0.93 A	0.97 y	1.51 n	1.03 I
Ozone 20 Minute	0.87 B	0.88 CD	0.89 C	0.94 zA	1.28 r	0.97 J
Citric Acid 1%	0.87 B	0.95 Z	1.14 v	1.47 o	1.96 f	1.28 E
Citric Acid 2%	0.87 B	0.93 A	1.06 w	1.42 p	1.89 h	1.23 F
Acetic Acid 1%	0.87 B	0.90 B	0.99 x	1.27 s	1.76 j	1.16 G
Acetic Acid 2%	0.87 B	0.88 CD	0.98 xy	1.15 u	1.67 k	1.11 H
Bicarbonate Sodium 1%	0.87 B	0.99 x	1.38 q	1.86 i	2.63 d	1.54 C
Bicarbonate Sodium 2%	0.87 B	0.98 xy	1.25 t	1.65 l	2.27 e	1.40 D
Distill Water	0.87 B	1.07 w	1.47 o	1.94 g	3.15 c	1.70 B
Mean	0.87 E	0.97 D	1.17 C	1.60 B	2.26 A	
	Second Season 2021					Mean
Control	0.85 z	1.24 q	1.56 k	3.25 b	4.47 a	2.27 A
Ozone 10 Minute	0.85 z	0.87 xy	0.92 w	0.98 tu	1.42 m	1.00 I
Ozone 20 Minute	0.85 z	0.86 yz	0.88 x	0.93 w	1.26 p	0.96 J
Citric Acid 1%	0.85 z	0.96 v	1.12 r	1.43 m	1.93 f	1.26 E
Citric Acid 2%	0.85 z	0.92 w	1.03 s	1.38 n	1.88 g	1.21 F
Acetic Acid 1%	0.85 z	0.89 x	0.99 t	1.24 q	1.75 h	1.14 G
Acetic Acid 2%	0.85 z	0.87 xy	0.96 v	1.12 r	1.62 j	1.08 H
Bicarbonate Sodium 1%	0.85 z	0.98 tu	1.36 o	1.87	2.58 d	1.53 C
Bicarbonate Sodium 2%	0.85 z	0.97 uv	1.25 pq	1.63 i	2.24 e	1.39 D
Distill Water	0.85 z	1.03 s	1.48 l	1.92 f	3.13 c	1.68 B
Mean	0.85 E	0.96 D	1.15 C	1.58 B	2.23 A	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan' s multiple rang test.

Peroxidase activity:

The data presented in **Table (4)** indicate a significant increase in the peroxidase content of fruits as the storage period was extended until the conclusion of storage in both seasons. Regarding the impact of various treatments, the data showed significant differences between these treatments and the control group throughout the storage period. However, fruits treated with ozonated water for 20 or 10 minutes exhibited the lowest levels of peroxidase activity during storage, with no significant variance between them in the first season. Nonetheless, a notable difference was observed between them in the second season. The highest peroxidase activity value was observed in the control group during cold storage in both seasons. Overall, there was a significant interaction between treatments and storage periods that influenced peroxidase activity in both seasons. Following a storage period of 20 days at 10°C, the lowest peroxidase activity values were recorded in fruits treated with ozonated water for 20 minutes, while the highest values were obtained from the control group.

Table (4). Effect of different treatments on peroxidase (mg/100g F.W) of cherry tomato fruits during different cold storage periods in the 2020 and 2021 seasons.

Treatments	Cold Storage Period (Day)					
	0	5	10	15	20	Mean
	First Season 2020					
Control	5.49 w	6.24 lm	6.83 gh	7.92 c	8.95 a	7.09 A
Ozone 10 Minute	5.49 w	5.53 vw	5.56 u-w	5.66 s-w	5.89 o-r	5.62 F
Ozone 20 Minute	5.49 w	5.51 vw	5.53 vw	5.56 u-w	5.72 r-v	5.64 F
Citric Acid 1%	5.49 w	5.68 s-w	6.02 n-p	6.48 jk	7.05 f	6.15 D
Citric Acid 2%	5.49 w	5.63 t-w	5.97 n-q	6.38 kl	6.93 fg	6.08 D
Acetic Acid 1%	5.49 w	5.58 u-w	5.86 p-s	6.15 mn	6.61 ij	5.94 E
Acetic Acid 2%	5.49 w	5.55 u-w	5.82 p-t	5.95 n-q	6.52 jk	5.87 E
Bicarbonate Sodium 1%	5.49 w	5.79 q-t	6.11 mn	6.73 hi	7.92 c	6.41 C
Bicarbonate Sodium 2%	5.49 w	5.74 r-u	6.38 kl	6.55 i-k	7.73 d	6.38 C
Distill Water	5.49 w	6.08 m-o	6.83 gh	7.34 e	8.72 b	6.89 B
Mean	5.49 E	5.73 D	6.09 C	6.47 B	7.20 A	
	Second Season 2021					Mean
Control	5.32 D	5.98 r	6.78 h	7.89 c	8.87 a	6.97 A
Ozone 10 Minute	5.32 D	5.35 C	5.43 A	5.62 v	5.86 t	5.52 I
Ozone 20 Minute	5.32 D	5.33 D	5.36 BC	5.46 z	5.63 v	5.42 J
Citric Acid 1%	5.32 D	5.48 y	5.98 r	6.35 l	6.95 f	6.02 E
Citric Acid 2%	5.32 D	5.46 z	5.92 s	6.22 n	6.78 h	5.94 F
Acetic Acid 1%	5.32 D	5.42 A	5.86 t	6.08 p	6.38 k	5.81 G
Acetic Acid 2%	5.32 D	5.37 B	5.72 u	5.92 s	6.33 m	5.73 H
Bicarbonate Sodium 1%	5.32 D	5.58 w	6.13 o	6.84 g	7.88 c	6.35 C
Bicarbonate Sodium 2%	5.32 D	5.54 x	6.05 q	6.58 j	7.63 d	6.22 D
Distill Water	5.32 D	5.85 t	6.62 i	7.44 e	8.55 b	6.76 B
Mean	5.32 E	5.54 D	5.99 C	6.44 B	7.09A	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan, s multiple rang test.

CONCLUSION

From the aforementioned findings, it can be inferred that cherry tomatoes immersed in ozonated water for 20 minutes proved to be the most efficient method for eliminating residual pesticides, with preserving fruit quality. This treatment resulted in a decrease in weight loss, prevented decay, and maintained the firmness, TSS, ascorbic acid, lycopene, and total sugar content of the fruits. Furthermore, it ensured excellent fruit appearance even after a 20-day storage period at 10°C and 95% RH.

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الملخص العربي

تأثير بعض معاملات بعد الحصاد علي التخلص من الأثر المتبقي للأيمامكتين بنزوات و الجودة علي ثمار الطماطم الشيري اثناء التخزين المبرد

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اجريت هذه الدراسة على ثمار طماطم الشيري (كتالينا F1) - من مزرعة خاصة – محافظة الإسكندرية خلال موسمين متتاليين عامي 2020 و 2021. هدفت هذه الدراسة إلى تقييم تأثير نقع الثمارفي (تركيزين) من المعاملات الأتية (الماء المعالج بالأوزون 10 دقائق ، 20 دقيقة) ، حامض الستريك(1% ،2%) ، حامض الخليك (1%،2%) ، بيكربونات الصوديوم(1%،2%) ، ماء مقطر ، كنترول (بدون معاملة)) بعد الحصاد على إزالة الأثر المتبقي من مبيد امامكتين بنزوات ولتقييم تأثير هذه المعاملات علي بعض صفات الجودة والقدرة التخزينية لثمار طماطم الشيري أثناء التخزين المبرد عند درجة حرارة 10 درجة مئوية ورطوبة نسبية قدرها 95%. أشارت النتائج إلى أن جميع معاملات ما بعد الحصاد كانت لها القدرة علي ازالة الأثر المتبقي للمبيد بنسب مختلفة ، كما كان لها القدرة علي المحافظة على صفات الجودة للثمارتحت الدراسة مقارنة بالكنترول . أوضحت النتائج أن المعاملة بالماء المعالج بالأوزون لمدة 20 دقيقة كانت الأفضل لأزالة الاثر المتبقي للمبيد و أكثر المعاملات فعالية في الحفاظ على جودة الثمار حيث اعطت اقل نسبة فقد الوزن للثمار، كما لم تظهراي تلف للثمار المعاملة بها حتي نهاية التجربة، علاوة علي انها حافظت علي اعلي صلابة للثمار و أعلي محتوى للمواد الصلبة الذائبة والسكريات الكلية ومحتوى حامض الأسكوربيك ومحتوى T.A والليكوبين ، في حين حافظت علي انخفاض نشاط البيروكسيديزوكذلك أعطت الثمار مظهراً ممتازاً حتى 20 يوماً من التخزين عند درجة حرارة 10 درجة مئوية ورطوبة نسبية قدرها 95% مقارنة بالمعاملات الأخرى والكنترول(غير المعامل).