Journal of Horticultural Science & Ornamental Plants 16 (1): 28-36, 2024
ISSN 2079-2158

DOI: 10.5829/idosi.jhsop.2024.28.36

Effect of Propionic Acid Levels on Keeping Quality of Cherry Tomato under Cold Storage Conditions

Mohamed A.A. Abdullah, Manal M. Attia and Mona I. Abdelrehim

Department of Postharvest and Handling of Vegetable Crops,
Horticulture Research Institute, Agricultural Research Center, Giza, Egypt

Abstract: This study was conducted over two consecutive seasons in 2021 and 2022 on cherry tomato cv Katalina 522 harvested at the turning stage (approximately 25% red color) from a private farm in greenhouses conditions of Wadi Natrun, Elbeheira Governorate, Egypt. The effect of propionic acid on postharvest quality and extend shelf life of cherry tomato fruits during cold storage at 10°C was studied by treating fruits in 0.15, 0.25, 0.35 and 0.45% propionic acid concentration for 1 minute. Soaking fruits in tap water was used as a control. This research focused on evaluating various levels of propionic acid influenced the quality attributes of the fruits, including Weight loss, decay, firmness, overall appearance and chemical composition of fruits were determined during cold storage period. In addition, the study aimed to determine the optimal concentration of propionic acid that could extend the shelf life and maintain the quality of cherry tomatoes under cold storage conditions. The results showed that the 1-min treated with propionic acid at 0.35% had a significant increase visual appearance and had a significant reduction in decay score, fruit weight percentage after 35 days after storage (DAS). Moreover, this treatment maintained total soluble sugars (TSS), total titratable acidity TA and vitamin C content compared to other treatments and control.

Key words: Propionic Acid・Keeping Quality・Cherry Tomato・Shelf Life

INTRODUCTION

Cherry tomatoes (*Lycopersicon esculentum* L.) are considered one of the export vegetable crops in Egypt; Cherry tomatoes are mainly exported to European Union markets. It represents where about 593 greenhouses are grown in the autumn season, with an area of 163, 800 square meters and a total production volume is 1, 480 tons [1]. Where Cherry tomato fruits have increased in popularity due to their high content of sugars and health-promoting compounds as well as convenience of use; they are consumed either as an ingredient (such as in salads) or alone [2, 3]. In addition the cherry tomato is a storehouse of antioxidants such as Lycopene, ascorbic acid and phenolic compounds [4]. In addition, Cherry tomatoes are climacteric fruits and highly perishable and most climacteric fruits have a concise life span, usually 2-3 weeks and are susceptible to various. Cherry tomatoes should be stored at 10°C or higher to avoid chilling injury.

Propionic acid (PA) is a naturally occurring carboxylic acid with the chemical formula CH_3CH_2-COOH. It is also a liquid with a pungent and unpleasant smell somewhat resembling body odor. Propionic acid was equally effective in inhibiting mold growth in a laboratory assay [5]. Besides Propionic acid may reasonably be considered one of the most economical organic acids for field applications of those tested [5]. Recently, research has reported that propionic acid is effective in keeping the quality of fruits and reducing decay [6].

Hence, this study aimed to study the effect of propionic acid (PA) levels on keeping quality of cherry tomato under cold storage conditions.

MATERIALS AND METHODS

Cherry tomatoes (*Lycopersicon esculentum* Mill) cv Katalina 522 grown under greenhouse conditions of Wadi Natrun, Elbeheira Governorate, Egypt. During two

Corresponding Author: Mohamed A.A. Abdullah, Department of Postharvest and Handling of Vegetable Crops, Horticulture Research Institute, Agricultural Research Center, Giza, Egypt.

successive seasons of 2021 and 2022. Fruits were transported to the laboratory of the post-harvest and handling of vegetable crops department at Giza governorate within 2.5 hours after harvesting. Uniform fruits of the same size (15-25 mm in diameter), shape and free from visual damage or defects, washed initially with water, then air dried.

Propionic acid (PA) is the chemical formula CH_3CH_2-COOH, a product of Sigma-Aldrich Chemie GmbH. Propionic were prepared in 4 concentrates of 0.15%, 0.25%, 0.35% and 0.45% propionic acid for 1-minute.

Fruits were divided into five groups for the following treatments and each group treated with different concentration with PA in addition to control (dipping fruits in tap water).

Eighteen replicates were prepared for each treatment; each replicate consisted of a bag containing 500 gm of fruits. The samples were taken randomly in three replicates arranged in a factorial complete randomized design and stored at 10°C and 90-95% relative humidity for 35 days. The treatments were examined immediately after harvest and every seven days intervals for the following parameters.

Weight Loss Percentage: Was estimated according to the following equation: Weight loss% = [(Initial weight - weight of fruits at sampling date) / Initial weight of fruits] x 100.

Decay Score: Was determined as a score system of 1 = none, 2 = slight, 3 = moderate, 4 = moderately severe, 5 = severe. This depends on the decay percentage of fruits.

General Appearance: Was determined as a score system of excellent> 9, good > 7 to 8.9, fair > 5 to 6.9, poor > 3 to 4.9 and unassailable> 2.9. The scale depends on morphological defects such as shriveling, fresh appearance, color change of fruits and decay. Fruits rating (5) or below are considered unmarketable.

Total Soluble Solids Percentage (TSS): Was determined as a composite juice sample by digital refractometer of model Abbe Leica [7].

Firmness: Was measured in kg/cm^2 by digital force Gauge model FGV 50 A, Shimpo Instrument Co, Japan, with a total capacity of $20kg/cm^2$ and resolution of $0.01kg/cm^2$ using cone cone-pointed head.

Titratable Acidity: Was determined by titration of blended flesh against NHOH 0.01 N using phenolphthalein indicator [7]. The results were calculated as mg. citric acid per 100 g fresh weight.

Total Sugars: Using the Nelson [8] and Somogyi [9] Method were determined colormetrically using spectrophotometer model 6305 UV/visible range with 520 nm wavelength [10].

Ascorbic Acid Content: Was determined using the dye 2, 6-dichloro-phenol indophenols method [7].

Lycopene Content: Was measured using the Ito and Horie [11] method. This method contains two main steps, extraction of juiced tomato to get lycopene extract and standard, then measuring the absorbance value of the solution (purity check) at 505 nm (U-1900 spectrophotometer, Hitachi, Japan) using a solvent blank, acetone and absorbance value used to get the lycopene content of the samples and calculated lycopene content using equation: lycopene content = 10× absorbance value ÷ 0.315 × sample value (g).

Statistical Analysis: Data from the two seasons were arranged and statistically analyzed using Costatic C. The comparison among means of the different treatments was determined using Duncan's test., The data were tabulated and statistically analyzed according to a factorial complete randomized design [12].

RESULTS AND DISCUSSIONS

Weight Loss %: Weight loss percentage was significantly affected by all treatments of dipping fruits in PA at different concentration during various storage period Table 1. The study found a significant increase in cherry tomato fruit weight loss as the storage period extended, leading to diminished fruit quality and shriveling [6]. Specifically, after 35 days of storage at 10°C, weight loss percentages recorded 1.96% and 2.33 % across both seasons.

The primary factors contributing to weight loss in fresh tomatoes include physiological and metabolic processes such as transpiration and respiration, which impact fruit quality and economic viability [13, 14]. This aligns with previous findings by Ibrahim and Abdullah [15] on tomatoes and sweet peppers, as well as Abdullah and Ibrahim [16] on cherry tomatoes, showing that longer storage durations increase fruit weight loss percentages.

Table 1: Effect of propionic acid treatments on weight loss % of cherry tomatoes during cold storage

Treatments	Days of storage	First season		Second season	
Control	0	0.0	s	0.0	r
	7	1.113	n	1.187	n
	14	1.387	j	1.553	j
	21	1.687	f	2.357	d
	28	1.887	d	2.617	b
	35	2.473	a	2.913	a
Propionic acid 0.15%	0	0.0	s	0.0	r
	7	0.987	p	1.113	o
	14	1.273	l	1.483	k
	21	1.510	h	1.973	g
	28	1.733	e	2.353	d
	35	2.137	b	2.533	c
Propionic acid 0.25%	0	0.0	s	0.0	r
	7	0.927	q	0.983	p
	14	1.103	n	1.227	m
	21	1.320	k	1.573	j
	28	1.443	i	1.837	h
	35	1.730	e	2.037	f
Propionic acid 0.35%	0	0.0	s	0.0	r
	7	0.813	r	0.887	q
	14	1.033	o	1.113	o
	21	1.203	m	1.413	l
	28	1.347	k	1.630	i
	35	1.530	h	1.827	h
Propionic acid 0.45%	0	0.0	s	0.0	r
	7	0.983	p	0.987	p
	14	1.183	m	1.420	l
	21	1.430	i	1.820	h
	28	1.563	g	2.080	e
	35	1.943	c	2.343	d
Control		1.709	A	2.125	A
Propionic acid 0.15%		1.528	B	1.891	B
Propionic acid 0.25%		1.305	D	1.531	D
Propionic acid 0.35%		1.185	E	1.374	E
Propionic acid 0.45%		1.421	C	1.730	C
	0		F		F
	7	0.965	E	1.031	E
	14	1.196	D	1.359	D
	21	1.430	C	1.827	C
	28	1.595	B	2.103	B
	35	1.963	A	2.331	A

Values followed by the same letter (s) are not significantly different at 5 %.

Regarding propionic acid treatments, all concentrations significantly differed from the control, with the 0.35% propionic acid treatment exhibiting the lowest fruit weight loss percentage, followed by the 0.25% concentration. Similar results were reported by Sang and Hai [17] in Vietnamese purple passion fruit, indicating propionic acid's potential to reduce storage-related weight loss and preserve fruit quality in cherry tomatoes.

The study found significant effects from the interaction between propionic acid concentrations and storage periods in both seasons. Specifically, cherry tomato fruits treated with 0.35% propionic acid exhibited the lowest weight loss percentages after the 35-day storage period, followed by those treated with 0.25% propionic acid, when compared to control fruits. These highlight the beneficial impact of propionic acid in reducing weight loss and preserving fruit quality during storage.

These findings underscore the practical application of propionic acid as a strategy to enhance the shelf life and economic value of cherry tomato fruits during storage.

Decay Score: The score of decay fruits in the treated and control fruit during the storage period is presented in Table 2. Data showed that the decay score increased with increasing storage period and the decay score was 2.4 score (slight decay) at the end of the storage period. These findings align with earlier research conducted by Huyen and Duc [6] which recorded that high weight loss has a relation with high decay.

As depicted in Table 2, cherry tomato fruits subjected to treatments demonstrated enhanced resistance to decay during storage, showing comparable effectiveness among these treatments. Cherry tomato fruits treated with propionic acid of 0.35% recorded the lowest decay score (1.33) after 35 days of storage followed by using 0.25% and 0.45% of propionic acid. The control treatment recorded the highest decay score after 35 days of storage period (3.33). This may be due to the inhibitory effect of propionic acid on postharvest disease. Similar results were found by Huyen and Duc [6] and Liu *et al.* [17] on passion fruits and Sang and Hai [18] on pears.

The interaction between storage period and treatments showed that after 35 days of storage, fruits treated with propionic acid 0.35% recorded the lowest score of decay in both seasons compared with other treatments and with control fruits. This pattern aligns with findings from Liu *et al.* [17] on Vietnamese purple passion fruit.

General Appearance: Variation in product quality and freshness was created by using different concentrations of propionic acid Table 3. Overall visual quality is an important factor influencing the marketability of a food product. Results in Table 3, showed that the general appearance (score) of cherry tomato fruits declined with

Table 2: Effect of propionic acid treatments on decay (score) of cherry tomatoes during cold storage

Treatments	Days of storage	First season		Second season	
Control	0	1.000	g	1.000	d
	7	1.000	g	1.000	d
	14	1.000	g	1.000	d
	21	1.000	g	1.000	d
	28	2.667	bc	3.000	b
	35	3.333	a	3.667	a
Propionic acid 0.15%	0	1.000	g	1.000	d
	7	1.000	g	1.000	d
	14	1.000	g	1.000	d
	21	1.000	g	1.000	d
	28	2.000	de	2.333	c
	35	3.000	ab	3.333	ab
Propionic acid 0.25%	0	1.000	g	1.000	d
	7	1.000	g	1.000	d
	14	1.000	g	1.000	d
	21	1.000	g	1.000	d
	28	1.333	fg	1.333	d
	35	2.000	de	2.333	c
Propionic acid 0.35%	0	1.000	g	1.000	d
	7	1.000	g	1.000	d
	14	1.000	g	1.000	d
	21	1.000	g	1.000	d
	28	1.000	g	1.000	d
	35	1.333	fg	1.333	d
Propionic acid 0.45%	0	1.000	g	1.000	d
	7	1.000	g	1.000	d
	14	1.000	g	1.000	d
	21	1.000	g	1.000	d
	28	1.667	ef	2.000	c
	35	2.333	cd	2.333	c
Control		1.709	A	1.778	A
Propionic acid 0.15%		1.528	B	1.611	A
Propionic acid 0.25%		1.305	D	1.278	B
Propionic acid 0.35%		1.185	E	1.056	C
Propionic acid 0.45%		1.421	C	1.389	B
	0	1.000	C	1.000	C
	7	1.000	C	1.000	C
	14	1.000	C	1.000	C
	21	1.000	C	1.000	C
	28	1.733	B	1.933	B
	35	2.400	A	2.600	A

Values followed by the same letter (s) are not significantly different at 5 %

Table 3: Effect of propionic acid treatments on general appearance (score) of cherry tomatoes during cold storage

Treatments	Days of storage	First season		Second season	
Control	0	9.000	a	9.000	a
	7	9.000	a	9.000	a
	14	9.000	a	9.000	a
	21	7.000	b	7.000	cd
	28	5.667	cd	5.667	ef
	35	4.333	e	4.333	g
Propionic acid 0.15%	0	9.000	a	9.000	a
	7	9.000	a	9.000	a
	14	9.000	a	9.000	a
	21	8.333	a	9.000	a
	28	6.333	bc	6.333	de
	35	5.000	de	5.000	fg
Propionic acid 0.25%	0	9.000	a	9.000	a
	7	9.000	a	9.000	a
	14	9.000	a	9.000	a
	21	8.333	a	9.000	a
	28	8.333	a	7.667	bc
	35	7.000	b	7.000	cd
Propionic acid 0.35%	0	9.000	a	9.000	a
	7	9.000	a	9.000	a
	14	9.000	a	9.000	a
	21	9.000	a	9.000	a
	28	9.000	a	9.000	a
	35	8.333	a	8.333	ab
Propionic acid 0.45%	0	9.000	a	9.000	a
	7	9.000	a	9.000	a
	14	9.000	a	9.000	a
	21	8.333	a	8.333	ab
	28	6.333	bc	6.333	de
	35	5.667	cd	5.667	ef
Control		7.333	C	7.333	D
Propionic acid 0.15%		7.778	BC	7.889	C
Propionic acid 0.25%		8.444	A	8.444	B
Propionic acid 0.35%		8.889	A	8.889	A
Propionic acid 0.45%		7.889	B	7.889	C
	0	9.000	A	9.000	A
	7	9.000	A	9.000	A
	14	9.000	A	9.000	A
	21	8.200	B	8.467	B
	28	7.133	C	7.000	C
	35	6.067	D	6.067	D

Values followed by the same letter (s) are not significantly different at 5 %

the prolonging of the storage period in both seasons, where the minimum values occurred at the end of the storage period. The decrease in general appearance during the storage period might be due to shriveling, color change and decay [19]. Similar results were obtained by Abdullah and Ibrahim [16] on cherry tomatoes and Ibrahim and Abdullah [15], on tomato and sweet pepper.

Concerning using propionic acid concentrations significantly affected visual quality deterioration Table 3. Cherry tomatoes fruits 4 treated with propionic acid 0.35% were rated the highest in overall quality, followed by using Propionic acid 0.25% Concentrations and the lowest value recorded by control. The quality of general appearance was improved by using propionic acid attributed to the effect of propionic acid on the reduction of weight loss and decay of cherry tomato fruits.

Table 4: Effect of propionic acid treatments on total soluble solids (TSS) percentage of cherry tomatoes during cold storage

Treatments	Days of storage	First season		Second season	
Control	0	7.000	a	8.000	a
	7	6.000	cd	7.333	bc
	14	5.667	de	7.000	cd
	21	5.000	f	6.667	de
	28	4.333	g	6.000	f
	35	4.000	g	5.333	g
Propionic acid 0.15%	0	7.000	a	8.000	a
	7	7.000	a	8.000	a
	14	5.333	ef	7.667	ab
	21	5.000	f	7.000	cd
	28	5.000	f	6.333	ef
	35	4.333	g	6.000	f
Propionic acid 0.25%	0	7.000	a	8.000	a
	7	7.000	a	8.000	a
	14	6.333	bc	8.000	a
	21	6.000	cd	8.000	a
	28	5.667	de	7.000	cd
	35	5.333	ef	6.667	de
Propionic acid 0.35%	0	7.000	a	8.000	a
	7	7.000	a	8.000	a
	14	7.000	a	8.000	a
	21	6.667	ab	8.000	a
	28	6.333	bc	7.667	ab
	35	6.000	cd	7.000	cd
Propionic acid 0.45%	0	7.000	a	8.000	a
	7	6.667	ab	7.667	ab
	14	6.333	bc	7.333	bc
	21	6.000	cd	7.000	cd
	28	5.333	ef	6.667	de
	35	5.000	f	6.000	f
Control		5.333	D	6.722	C
Propionic acid 0.15%		5.611	C	7.167	B
Propionic acid 0.25%		6.222	B	7.611	A
Propionic acid 0.35%		6.667	A	7.778	A
Propionic acid 0.45%		6.056	B	7.111	B
	0	7.000	A	8.000	A
	7	6.733	A	7.800	AB
	14	6.133	B	7.600	B
	21	5.733	C	7.333	C
	28	5.333	D	6.733	D
	35	4.933	E	6.200	E

Values followed by the same letter (s) are not significantly different at 5 %

The interaction between propionic acid concentrations and the storage period showed that the concentration of 0.35% propionic acid recorded the highest visual quality score throughout the whole storage period and ended with an 8.33 (excellent score) score after 35 days of storage, followed by fruits treated with propionic acid treated with 0.25% and lowest visual quality score were recorded with control treatments.

Table 5: Effect of propionic acid treatments on firmness (kg/cm^2) of cherry tomatoes during cold storage

Treatments	Days of storage	First season		Second season	
Control	0	6.120	a	5.940	a
	7	5.823	f	5.603	f
	14	5.413	k	5.057	l
	21	5.020	o	4.610	r
	28	4.207	u	4.027	u
	35	3.810	x	3.827	v
Propionic acid 0.15%	0	6.120	a	5.940	a
	7	5.933	d	5.620	f
	14	5.563	i	5.213	j
	21	5.150	n	4.913	n
	28	4.420	s	4.637	q
	35	3.957	w	4.033	u
Propionic acid 0.25%	0	6.120	a	5.940	a
	7	6.007	b	5.750	c
	14	5.750	g	5.407	g
	21	5.310	l	5.150	k
	28	4.740	q	4.840	o
	35	4.203	u	4.330	s
Propionic acid 0.35%	0	6.120	a	5.940	a
	7	6.013	b	5.817	b
	14	5.873	e	5.650	e
	21	5.477	j	5.313	h
	28	4.920	p	5.020	m
	35	4.333	t	4.717	p
Propionic acid 0.45%	0	6.120	a	5.940	a
	7	5.973	c	5.683	d
	14	5.703	h	5.283	i
	21	5.203	m	5.057	l
	28	4.520	r	4.703	p
	35	4.067	v	4.210	t
Control		5.066	E	4.844	E
Propionic acid 0.15%		5.191	D	5.059	D
Propionic acid 0.25%		5.355	B	5.236	B
Propionic acid 0.35%		5.456	A	5.409	A
Propionic acid 0.45%		5.264	C	5.146	C
	0	6.120	A	5.940	A
	7	5.950	B	5.695	B
	14	5.661	C	5.322	C
	21	5.232	D	5.009	D
	28	4.561	E	4.645	E
	35	4.074	F	4.223	F

Values followed by the same letter (s) are not significantly different at 5 %

Total Soluble Solids (TSS) Percentage: Analysis from Table 4, demonstrated a significant decrease in the total soluble solids (TSS) percentage of cherry tomato fruits over time in two seasons. These findings align with the studies conducted by Abdullah and Ibrahim [16].

Regarding treatments, results in Table 4. Show that the TSS percentage of cherry tomato fruits was significant by different tested materials as compared with the control treatment during the storage period. Cherry tomato fruits which were treated with propionic acid at 0.35% were the most effective treatments in preserving TSS percentage, followed by propionic acid at 0.45% or 0.25% with no significant difference between them, while the other treatments had less effect in this concern.

Concerning the interaction between the storage period and propionic acid treatments, data in Table 4, showed that the rate of decrease in TSS % was low when using propionic acid after 35 days of storage at 10°C.

Firmness (kg/cm^2): Data illustrated in Table 5, highlighted significant variances in the firmness of cherry tomato fruits among different postharvest treatments during cold storage. Typically, the firmness of cherry tomatoes decreased progressively over time. The prolonged storage leads to decreased fruit firmness due to the degradation of soluble pectin by the enzyme endopolygalacturonase, resulting in tissue softening [20]. Furthermore, Bico *et al.* [21] observed that a slower rate of firmness loss is associated with reduced transpiration and respiration rates, which subsequently help delay the ripening and senescence of fruits.

According to Tigist *et al.* [14], the increase in hydrolytic enzymatic activities and changes in hydrostatic pressure of tomato fruit progressively lower the fruit firmness.

Regarding treatments, it is clear from the results in Table 5, that using propionic acid 0.35% was the most effective treatment in maintaining firmness and had a significant effect on fruit firmness followed by using propionic acid 0.25% and the lowest values recorded on control treatment.

Concerning the effect of interaction between propionic acid treatments and the storage period, the same results showed significant effects in both seasons, the maximum values of fruit firmness at the end of the storage period (35 days) were noticed by the fruits which treated with 0.35% in the first and second seasons, respectively followed by propionic acid at 0.25%.

Titratable Acidity (mg. citric acid /100g FW): Analysis from Table 6, demonstrated a significant increase in titratable acidity in cherry tomato fruits as the storage period was extended from 0 to 35 days in both seasons.

As for the effect of treatments, data in Table 6 showed that control fruits had the highest value of titratable acidity compared with propionic acid treatments. Applying propionic acid had a significant effect on cherry tomato fruits and the lowest value of titratable acidity content was observed in fruits treated with propionic acid 0.35% and 0.25% with no significant differences between them in the first season and with propionic acid 0.35% in the second season.

Concerning the effect of the interaction among the treatments, propionic acid and storage period on the titratable acidity content, data showed that titratable acidity contents of cherry tomatoes, data showed that using propionic acid 0.35% gave the lowest value of propionic acid after 35 days of storage.

Table 6: Effect of propionic acid treatments on titratable acidity (mg. citric acid /100g FW) of cherry tomatoes during cold storage

Treatments	Days of storage	First season		Second season	
Control	0	0.360	h	0.340	g
	7	0.363	gh	0.347	ef
	14	0.367	fg	0.350	de
	21	0.370	ef	0.357	bc
	28	0.383	ab	0.360	ab
	35	0.387	a	0.363	a
Propionic acid 0.15%	0	0.360	h	0.340	g
	7	0.363	gh	0.347	ef
	14	0.363	gh	0.350	de
	21	0.370	ef	0.353	cd
	28	0.380	bc	0.357	bc
	35	0.383	ab	0.360	ab
Propionic acid 0.25%	0	0.360	h	0.340	g
	7	0.360	h	0.340	g
	14	0.360	h	0.347	ef
	21	0.370	ef	0.350	de
	28	0.373	de	0.350	de
	35	0.377	cd	0.353	cd
Propionic acid 0.35%	0	0.360	h	0.340	g
	7	0.360	h	0.340	g
	14	0.360	h	0.340	g
	21	0.367	fg	0.343	fg
	28	0.370	ef	0.343	fg
	35	0.370	ef	0.347	ef
Propionic acid 0.45%	0	0.360	h	0.340	g
	7	0.363	gh	0.340	g
	14	0.363	gh	0.347	ef
	21	0.370	ef	0.350	de
	28	0.377	cd	0.353	cd
	35	0.380	bc	0.360	ab
Control		0.372	A	0.353	A
Propionic acid 0.15%		0.370	AB	0.351	A
Propionic acid 0.25%		0.367	CD	0.347	B
Propionic acid 0.35%		0.364	D	0.342	C
Propionic acid 0.45%		0.369	BC	0.348	B
	0	0.360	C	0.340	D
	7	0.362	C	0.343	D
	14	0.363	C	0.347	C
	21	0.369	B	0.351	B
	28	0.377	A	0.353	B
	35	0.379	A	0.357	A

Values followed by the same letter (s) are not significantly different at 5 %

Table 7: Effect of propionic acid treatments on total sugars (mg /100g FW) of cherry tomatoes during cold storage

Treatments	Days of storage	First season		Second season	
Control	0	3.460	s	3.530	t
	7	3.803	m	3.983	m
	14	4.143	i	4.310	i
	21	4.433	g	4.653	g
	28	4.737	d	4.913	d
	35	5.137	a	5.313	a
Propionic acid 0.15%	0	3.460	s	3.530	t
	7	3.683	o	3.913	o
	14	3.953	k	4.127	k
	21	4.210	h	4.430	h
	28	4.580	f	4.733	f
	35	4.957	b	5.113	b
Propionic acid 0.25%	0	3.460	s	3.530	t
	7	3.557	q	3.703	r
	14	3.763	n	3.917	o
	21	3.950	k	4.113	k
	28	4.213	h	4.437	h
	35	4.657	e	4.827	e
Propionic acid 0.35%	0	3.460	s	3.530	t
	7	3.503	r	3.623	s
	14	3.670	o	3.737	q
	21	3.827	lm	3.953	n
	28	4.073	j	4.220	j
	35	4.420	g	4.630	g
Propionic acid 0.45%	0	3.460	s	3.530	t
	7	3.627	p	3.830	p
	14	3.840	l	4.043	l
	21	4.117	i	4.323	i
	28	4.447	g	4.633	g
	35	4.810	c	5.043	c
Control		4.286	A	4.451	A
Propionic acid 0.15%		4.141	B	4.308	B
Propionic acid 0.25%		3.933	D	4.088	D
Propionic acid 0.35%		3.826	E	3.949	E
Propionic acid 0.45%		4.050	C	4.234	C
	0	3.460	F	3.530	F
	7	3.635	E	3.811	E
	14	3.874	D	4.027	D
	21	4.107	C	4.295	C
	28	4.410	B	4.587	B
	35	4.796	A	4.985	A

Values followed by the same letter (s) are not significantly different at 5 %

Total Sugars (mg /100g FW): Analysis from Table 7 demonstrated a significant increase in the total sugars of cherry tomato fruits over two seasons. These findings align with the studies conducted by Abdullah and Ibrahim [16].

As for the effect of propionic acid concentrations, it's clear from the results in Table 7 that control fruits had the highest value of total sugars compared with propionic acid treatments. The lowest value of total sugars was observed in fruits treated with propionic acid 0.35 % in both seasons. This result may be attributed to the role of propionic acid in reducing weight loss percentage and delaying ripening.

Regarding the effect of the interaction among treatments, propionic acid concentrations and storage period, data in Table 7 showed that fruits treated with propionic acid 0.35% had the lowest value of total sugar after 35 days of storage.

Ascorbic Acid Content (mg /100g FW): Further findings in Table 8 showed a significant reduction in ascorbic acid content over 35 days of storage at 10°C, corroborating results by Abdullah and Ibrahim [16] and Raafat *et al.* [22] on cherry tomato, Ibrahim and Abdullah [15] on tomato and sweet pepper and Mohammed *et al.* [23] on cherry tomato.

Paradis *et al.* [24] found that the reduction in ascorbic acid content during the storage period might have been due to the higher rate of sugar loss through respiration than water loss through transpiration.

The impact of postharvest treatments on ascorbic acid levels was significant, as detailed in Table 8. Treatments with propionic acid succeeded in preserving higher levels of ascorbic acid compared to the lowest levels observed in the untreated control.

Lycopene Content (mg/100 g FW): Results in Table 9 show that lycopene content gradually increased as the storage time increased. The increase in lycopene content with the elapse of the storage period may be due to that, the production of lycopene content is directly correlated with ripening and the formation of lycopene depends on the temperature range and rate of respiration during storage [25]. These observations align with previous findings by Ali *et al.* [26] On tomatoes and Abdullah and Ibrahim [16] on cherry tomatoes.

Further examination in Table 9 highlighted substantial differences in lycopene between various postharvest treatments and the untreated control across both seasons. Treating cherry tomato fruits with all tested materials significantly decreased the lycopene content of tomato fruits as compared to the control treatment which significantly increased lycopene content in both seasons of study. The superior treatment for decreasing lycopene content, propionic acid 0.35% was the most effective treatment with significant differences. The early increase in lycopene content in untreated fruits might be due to the faster ripening of fruits than in the fruits treated with other material, while, propionic acid treatments have beneficial effects on fruit physiology such as delaying the ripening of fruits.

Table 8: Effect of propionic acid treatments on ascorbic acid (mg /100g FW) of cherry tomatoes during cold storage

Treatments	Days of storage	First season		Second season	
Control	0	36.150	a	37.330	a
	7	35.813	f	36.707	ef
	14	35.290	j	36.113	j
	21	34.863	o	35.547	l
	28	34.313	t	34.813	pq
	35	33.823	w	34.420	r
Propionic acid 0.15%	0	36.150	a	37.330	a
	7	35.877	e	36.740	de
	14	35.213	k	36.320	h
	21	34.907	n	35.813	k
	28	34.547	r	35.307	n
	35	34.053	v	34.720	q
Propionic acid 0.25%	0	36.150	a	37.330	a
	7	35.930	c	37.033	c
	14	35.633	g	36.620	f
	21	35.310	j	36.220	i
	28	35.007	m	35.813	k
	35	34.513	s	35.210	o
Propionic acid 0.35%	0	36.150	a	37.330	a
	7	36.013	b	37.133	b
	14	35.807	f	36.813	d
	21	35.513	h	36.457	g
	28	35.210	k	36.043	j
	35	34.813	p	35.420	m
Propionic acid 0.45%	0	36.150	a	37.330	a
	7	35.903	d	36.830	d
	14	35.407	i	36.420	g
	21	35.113	l	36.027	j
	28	34.770	q	35.343	mn
	35	34.263	u	34.903	p
Control		35.042	E	35.822	E
Propionic acid 0.15%		35.124	D	36.038	D
Propionic acid 0.25%		35.424	B	36.371	B
Propionic acid 0.35%		35.584	A	36.533	A
Propionic acid 0.45%		35.268	C	36.142	C
	0	36.150	A	37.330	A
	7	35.907	B	36.889	B
	14	35.470	C	36.457	C
	21	35.141	D	36.013	D
	28	34.769	E	35.464	E
	35	34.293	F	34.935	F

Values followed by the same letter (s) are not significantly different at 5 %

As for the effect of interaction between propionic acid treatments and storage period, results in Table 9 showed a significant effect on lycopene content in both seasons of study, the minimum values at the end of the storage period (35 days) were noticed by tomato fruits which treated with propionic acid that recorded 3.640 and 3.820 followed by propionic acid 0.25% which gave 4.147 and 4.133 in the first and second seasons, respectively.

Table 9: Effect of propionic acid treatments on lycopene (mg /100g FW) of cherry tomatoes during cold storage

Treatments	Days of storage	First season		Second season	
Control	0	0.450	t	0.410	v
	7	1.337	o	1.537	q
	14	2.420	j	2.433	m
	21	3.627	f	3.720	h
	28	4.943	b	5.313	c
	35	6.017	a	6.520	a
Propionic acid 0.15%	0	0.450	t	0.410	v
	7	1.117	p	1.343	r
	14	1.847	m	2.047	n
	21	2.533	i	3.240	i
	28	3.833	e	4.927	d
	35	4.933	b	5.427	b
Propionic acid 0.25%	0	0.450	t	0.410	v
	7	0.730	r	0.830	t
	14	1.353	o	1.347	r
	21	1.947	l	2.037	n
	28	3.113	h	2.920	j
	35	4.147	d	4.133	f
Propionic acid 0.35%	0	0.450	t	0.410	v
	7	0.487	s	0.630	u
	14	0.920	q	1.113	s
	21	1.617	n	1.847	o
	28	2.513	i	2.740	k
	35	3.640	f	3.820	g
Propionic acid 0.45%	0	0.450	t	0.410	v
	7	0.920	q	1.133	s
	14	1.617	n	1.743	p
	21	2.213	k	2.533	l
	28	3.537	g	3.727	h
	35	4.533	c	4.840	e
Control		3.132	A	3.322	A
Propionic acid 0.15%		2.452	B	2.899	B
Propionic acid 0.25%		1.957	D	1.946	D
Propionic acid 0.35%		1.604	E	1.760	E
Propionic acid 0.45%		2.212	C	2.398	C
	0	0.450	F	0.410	F
	7	0.918	E	1.095	E
	14	1.631	D	1.737	D
	21	2.387	C	2.675	C
	28	3.588	B	3.925	B
	35	4.654	A	4.948	A

Values followed by the same letter (s) are not significantly different at 5 %

REFERENCES

1. Economic, Affairs Sector, Ministry of Agriculture Egypt. 2020/2021.
2. D'Aquino, S., A. Mistriotis, D. Briassoulis, M.L. Di Lorenzo, M. Malinconico and A. Palma, 2016. Influence of modified atmosphere packaging on postharvest quality of cherry tomatoes held at 20°C. Postharvest Biol. Technol., 115: 103-112. Doi: 10.1016/j. postharvest. 2015.12.014.

3. Wu, S., M. Lu and S. Wang, 2016. Effect of oligosaccharides derived from Laminaria japonica incorporated pullulan coatings on preservation of cherry tomatoes. Food Chem., 199: 296-300. Doi: 10.1016/J. foodchem. 2015.12.029.
4. Gharezi, M., N. Joshi and E. Sadeghian, 2012. Effect of post-harvest treatment on stored cherry tomatoes. J. Nut. Food Sci., 2: 157.
5. Carrie, H. and B. Friedhelm, 1999. Efficacy of several organic acids against molds. The Journal of Applied Poultry Research, 8(4): 480-487.
6. Huyen, N.Th. and N.M. Duc, 2021. Effect of propionic acid and mixed wax (Bee-Carnaura wax) on total microorganism and quality of purple passion fruit at ambient temperature. Pak. J. Bio. Technol., 18(3-4): 63-68.
7. A.O.A.C., 200. Official methods of analysis of AOAC International. 2000. 17th edition. Gaithersburg, MD, USA, Association of Analytical Communities.
8. Nelson, N., 1974. A photometric adaptation of the Somogyi methods for determination of glucose. J. Biol. Chem., 195: 19-23.
9. Somogyi, M., 1952. Noted on sugar determination. J. Biol. Chem., 195: 19-23.
10. Sadasivam and Manickam, 2004. Biochemical methods, TNAU, New age international (P) Limited, Publishers, New Delhi.
11. Ito, H. and H. Horie, 2009. Proper Solvent Selection for Lycopene Extraction in Tomatoes and Application to a Rapid Determination. Bulletin of The National Institute of Vegetable and Tea Science, 8: 165-173.
12. Snedecor, C.W. and W.G. Cochran, 1982. Statistical Methods. 7th Ed.Thelowa state Univ. Press. Ames. Iowa, USA, pp: 325-330.
13. Mwendwa, R., O.W. Owino, J. Ambuko, M. Wawire and N. Nenguwo, 2016. Characterization of postharvest physiology attributes of six commercially grown tomato varieties in Kenya. African Journal of Food Agriculture Nutrition and Development, 16(1): 10613-10631.
14. Tigist, M., T.S. Workneh and K. Woldetsadik, 2013. Effects of variety on the quality of tomato stored under ambient conditions. Journal of Food Science and Technology, 50(3): 477-486.
15. Ibrahim, H.A. and M.A.A. Abdullah, 2018. Effects of 1-Methylcyclopropane on quality of tomato and sweet pepper fruits during mixed loads. Biosci. Res., 15(1): 270-279.
16. Abdullah, M.A.A. and H.A. Ibrahim, 2018. Effect of fumaric acid, β-aminobutyric acid and packaging materials treatments on quality and storability of cherry tomatoes. Middle East J. Agric. Res., 7(4): 1395-1410.
17. Sang, N. and L.H. Hai, 2021. Effect of propionic acid on fruit decay and postharvest quality of Vietnamese purple passion fruit during low temperature storage. Acta Hortic., 1312: 463-479.
18. Liu, T., L. Li, G. Zhan, T. Li, F. Zhang and Y. Wang, 2014. Postharvest propionic acid and hot water treatment for the control of black spot disease in Chinese ya pears. Advance Journal of Food Science and Technology, 6(2): 265-270.
19. Gonzalez-Aguilar, A., L.R. Granados, M. Baez and R. Saltveit, 1997. Hot water dips and film packaging extend the self-life of bell peppers. Post-Harvest Hort. Series-Dept. Pomol. Univ. California, 18: 66-72.
20. Kaur, K. and W.S. Dhillon, 2014. Influence of maturity and storage period on physical and biochemical characteristics of pear during post cold storage at ambient conditions. J Food Sci. Technol., 52(8): 5352-5356.
21. Bico, S.L.S., M.F.J. Raposo, R.M.S.C. Morais and A.M.M.B. Morais, 2009. Combined effect of chemical dip and / or carrageenan coating and / or Controlled Atmosphere on quality of fresh-cut banana. Food Control, 20: 508-514.
22. Raafat, S.M., M.I. Abou-Zaid, M.R. Tohamy and H.E. Arisha, 2016. Impact of some plant essential oil treatments on controlling cherry tomatoes spoilage, improvement shelf life and quality attributes during storage. Zagazig J. Agric. Res., 43(3): 785-813.
23. Mohammed, Omaima O., M.B. Azzazy and S.E.A. Badawe, 2021. Effect of some edible coating materials on quality and postharvest rots on cherry tomato fruits during cold storage. Zagazig J. Agric. Res., 48(1).
24. Paradis, C., F. Castaigne, T. Desrosiers and C. Willemot, 1995. Evaluation of vitamin C, B-carotene and chlorophyll content in broccoli heads and florets during storage in air. Sciences des Aliments, 15(2): 113-123.
25. Javanmardi, J. and C. Kubota, 2006. Variation of lycopene, antioxidant activity, total soluble solids and weight loss of tomato during postharvest storage. Postharvest Biol. and Technol., 41: 151-155.
26. Ali, A., M. Maqbool, P.G. Alderson and N. Zahid, 2013. Effect of gum arabic as an edible coating on antioxidant capacity of tomato (*Solanum lycopersicum* L.) fruit during storage. Postharvest Biol. and Technol., 76: 119-124.