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Impact of Dipping Cherry Tomato Fruits in Different Concentrations of 1-Methylcyclopropane in Relation to Storability

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ABSTRACT

The research was carried out at the Horticulture Research Institute, Agriculture Research Center, Giza, Egypt, between 2020 and 2021. Tomato fruits (*Lycopersicon esculentum* L.) harvested at the Breaker stage from a local field in Sakha, Kafr El-Sheikh, Governorate, were chosen to investigate the effect of 1-methylcyclopropane (1-MCP) concentration on the ripening phase of tomato fruits (*Solanum lycopersicon* L.) and quality preservation. Tomato fruits were thoroughly soaked in aqueous 1-MCP at 50, 100 and 150µgL^{-1} for 10 minutes, then promptly dried and stored at 12°C. The results showed that 1-MCP treatment preserved the quality of tomato fruit firmness when compared to the control, which had a high concentration.

1. INTRODUCTION

Cherry tomatoes (*Solanum lycopersicum* L.) are nutritious and healthy, mainly because they contain large amounts of the lycopene, ascorbic acid, phenolic compounds and other bioactive compounds **(Souza *et al.*, 2020)**. In addition to containing all the nutrients of ordinary tomatoes, cherry tomatoes have 1.7 times the vitamin content of ordinary tomatoes **(Liang *et al.*, 2018; Mustapha *et al.*, 2020; Suwanaruang, 2016)**. Cherry tomatoes are typical climacteric fruits. The tomato crop is an important vegetable crop in Egypt. The average area planted with tomatoes is about 469 thousand feddans (8.625 million tons) **(FAO 2021)**, which represents 32% of the total vegetable area in Egypt. Tomatoes are also classified as export crops, making them a valuable source of foreign revenue. As an ethylene inhibitor, 1-Methylcyclopropene (1-MCP) can effectively delay fruit ripening and senescence **(Wang *et al.*, 2020b; Yu *et al.*, 2017)**. **Wang *et al.* (2020a)** also supplied that 1-MCP could maintain fruit quality and reducing chilling injury in peach fruit during the cold storage. However, studies showed that the effect of fruit preservation by only using 1-MCP is unsatisfactory **(*Meijun et al.*, 2020)**. The combined treatment was more beneficial for the maintenance of postharvest fruit quality and the inhibition of microbial enzymes than the single 1-MCP treatment **(Lum *et al.*, 2017)**. In a wide spectrum of fruits, vegetables, and floriculture crops, 1-MCP reduces ethylene effects. The effective concentrations are minimal, ranging from 2.5 μl^{-1} to 1 μl^{-1}. Because concentration and temperature interact, low quantities of 1-MCP applied over prolonged periods of time may be as beneficial as high amounts. 1-MCP is most typically employed at temperatures between 20 and 25˚C; however, it can also be utilized at lower temperatures in specific commodities. In most cases, treatment times of 12-24 hours were adequate to elicit a complete response. When utilizing 1-MCP, a number of parameters must be addressed, including cultivar, developmental stage, time from harvest to treatment, and numerous administrations.1-MCP can affect respiration, ethylene generation, volatile production, chlorophyll degradation, and other color changes, protein and membrane modifications, softening, illnesses and diseases, acidity, and sugars, depending on the species being treated. The goal of this study was to see how varying concentrations of aqueous 1-MCP, as well as immersion time and solution lifespan, affected tomato fruit ripening and quality.

2. MATERIALS AND METHODS

2.1 Plant material

Tomato (*Lycopersicon esculentum*) GUIDO RZ F1 (74-108), were obtained from a local field in Sakha, Kafr El-Sheikh Governorate. After being picked fruits were transferred to the postharvest laboratory in the institute of horticulture research (A.R.C). Fruits were kept for 16 days at 12˚C and 90-95% RH, at which time the majority of fruit had reached the breaker stage. Fruits were selected for uniformity of developmental stage and size. Fruits were packed in carton boxes (20×30 ×10 cm) and immediately transported to the department of vegetable crops handling research, horticulture research institute, agriculture research center, Giza, Egypt. The transportation period was 2-3 hours at 18-20˚C. In the laboratory, the fruits were divided into four treatments as follows:

1- First, treatment fruits were washed, air-dried, immersed in distilled water for10minutes, dried again, and kept for 16 days at 12˚C (control).

2- Second, the third, and the fourth treatments fruits were washed, air-dried, and immersion in an aqueous solution of 1-MCP (50, 100 and 150μgL^{-1}), respectively, for 10 min., dried again, and kept for 16 days at 12˚C. Fruit samples for each treatment were examined 4 days intervals to determine the physical and chemical changes in tomato fruits at 16 days intervals during a cold period. Physical and chemical properties were determined including weight loss percentage, decayed fruits (pathological), fruit peel colour, fruit firmness, total soluble solids (TSS) and titratable acidity, expressed as anhydrous citric acid, total soluble solids/acid ratio and ascorbic acid content (vitamin c). Each treatment comprised 6 carton boxes and every box containing 120 fruits was divided into 3 replicates each of 20 fruits to determine the physical and chemical characteristics.

2.2 MCP treatments

Three groups of 240 fruits each were treated with aqueous 1-MCP prepared from a commercial powdered formulation (Smart Fresh TM Rohm and Hass Inc., USA) by adding distilled water, according to the manufacturer's instructions. Solutions were prepared with 1-MCP powder at 50, 100 and 150$\mu g.L^{-1}$ (active ingredient). Quantities of powder containing the desired levels of active ingredient were suspended in 10 L of distilled water in 20 L plastic buckets and swirled gently with a plastic spatula for 10 min. The solutions were used no sooner than 10 min and no later than 45 min after preparation, and all immersion treatments were completed within 100–150min. The fruits were immersed (20 fruit per immersion cycle) into the solutions and covered with a weighted, plastic perforated plate to ensure complete coverage of the fruit during the immersion period. After removal, the fruits were quickly drained and wiped dry with a paper towel. The fruits were then placed on plastic trays and transferred to storage at 12°C. Half of the fruit (120) from each treatment were used to determination of whole-fruit firmness and surface hue. To investigate the effects of immersion duration, a 1-MCP solution was prepared at a concentration of 50 µl/l^{-1}, 20°C. Twenty minutes after preparation, tomato fruits at the breaker stage were immersed (60 fruit per immersion duration) for 10 min. Fruit not immersed in 1-MCP were used as controls. Fruit firmness and surface color were measured as described below. Longevity of 1-MCP solutions was tested using 10 L of aqueous 1-MCP at 100 µl^{-1} held in an open 20 L plastic container at 12°C. At intervals from 20 min through 24 h after preparation, fruits were immersed (60 fruit per immersion duration) in the 1-MCP for 1 min, dried, and surface color and firmness were monitored as described below.

2.3 Methods of determining physical properties

2.3.1 Fruit weight loss percentage

Fruits (of each replicate) to be assessed at the considered dates were weighted at the beginning of the experiment and that specified date. The fruit loss percentage was calculated by the following equation:

Fruit loss = initial fruit weight – fruit weight at the specified period/initial fruit weight ×100

2.3.2 Fruit firmness

Fruit firmness was determined using (a penetrometer). Firmness was measured using a 0.05 N load cell and a 7.5mm diameter stainless steel probe. After establishing zero-force contact between the probe and the fruit, the fruit was compressed 2.5mm at 2 equidistant points along the equatorial region of each fruit. The maximum force (N) generated during probe travel was used for data analysis, and the peak of resistance was recorded in six fruits, two from each replicate on the two opposite fruit sides, the fruit firmness was measured as Newton.

2.3.3 Fruit external colour measurement

Fruit surface color (hue angle) was determined on 20 individual fruit per treatment using a Minolta CR-400 colorimeter (Minolta Camera Co. Ltd., Japan) with a standard C illuminate. For the estimation of (L, C and H) values and to evaluate colour values as hue angle, according to **Poyesh *et al.*, (2017)**.

2.3.4 Fruit decay

Where the measurement of the proportion of diseases through the periodic examination every four days and so was examined five times using the following assessment:

Decay score (1 = none, 2 = slight, 3 = moderate, 4 = moderately severe and 5 = severe), according to **(Ahmed *et al.*, 2018)**.

2.3.5 Fruit visual appearance

Where it was measured with the quality of the external appearance of fruits by periodic inspection every four days and so was examined five times using the following evaluation:

Visual quality score (9 = excellent, 7 = good, 5 = fair, 3 = poor, 1 = unusable), according to **(Ahmed *et al.*, 2018)**.

2.4 Chemical properties

2.4.1 Fruit total soluble solids (TSS)

The TSS content was measured by a graduated hand- held refractometer (Atago Co., Ltd, Japan; model PAL- 1) using the homogenized sample. Five cherry tomatoes were consumed each time and repeated three times. It was necessary to gently wipe the endoscope with lens paper and zero the refractometer before each experiment. The unit of TSS content was expressed by Brix, %. The titratable acidity (TA) was measured using the method devised by **Chen *et al.* (2020)**.

2.4.2 Fruit Ascorbic acid content

The content of ascorbic acid in cherry tomatoes was determined and calculated in accordance with the titration method with 2, 6-dichlorophenol indophenols (DCPIP) in

Muley and Singhal (2020), and the unit was expressed in $mg \cdot kg^{-1}$.

2.4.3 Titratable acidity percentage

Titratable acidity was determined as citric acid by titration against sodium hydroxide (0.1N), using phenolphthalein as an indicator. Acidity was calculated as grams of malic acid per 100 ml of juice according to **A.O.A.C. (2007)**.

2.4.4 Statistical analysis

The effects of 1-MCP treatments, shelf-life periods and their interactions on different characteristics were analysed statistically by analysis of variance (ANOVA) using the COSTAT software and mean comparison by LSD at 0.05 p.

3. RESULTS AND DISCUSSION

The influence of 1-Methylcyclopropene (1-MCP) treatments was investigated on tomato (*Lycopersicon esculentum* L.) GUINDO RZ F1 (74-108) during five storage periods (after zero, 4, 8, 12 and 16 days). The studied characteristic divided into physical and chemical traits. The physical characteristics have included fruit weight, weight loss percentage, firmness, external color measurement (L and C), decay, and visual appearance. Moreover, the chemical attributes were total soluble solids percentage, ascorbic acid content, and titratable acidity. The results are outlined in analysis of variances and mean performance, as follows:

Analysis of variances:

Analysis of variance in seasons 2020 and 2021 for the physical and chemical characteristics is presented in Tables 1 and 2. Mean squares of storage periods, 1-MCP treatments, and interaction between periods and treatments differed significantly ($p<0.05$) for all studied characteristics, except for treatments in season 2020, the interaction between periods and treatments for the two seasons and in season 2021. These results reveal that there were sufficient differences among the used storage periods and 1-MCP treatments. Moreover, the significance of the interaction between storage periods and treatments reflect the different action of the studied treatments under the different storage periods.

Mean performance:

3.A Physical characteristics

3.A.1 Fruit weight loss percentage

The main reason for the weight lessens of fruits during storage is the presence of water molecules. The fruits gradually deteriorate in quality with the loss of water **(Tsuchida *et al.*, 2004)**. Data in Table 1 showed that weight loss percentages generally increase with prolonging the storage period in both seasons, for fruit treated with 50 and 100 µgL^{-1} were nearly mid-way between control fruit and those treated with 150 µgL^{-1} from about 4 to 16 days, season 2020.

In addition, control fruit and fruit treated at all concentrations had similar weight loss percentages and slowly increased until 8 days of storage then the rate of loss percentage increased faster to maxima with concentrations of control, 50, 100 and 150 µgL^{-1} of 1-MCP treatments in season 2021. These results agree those of **(Ahmed *et al.*, 2018)** and **(El–Sheikh, 1998)**. This increase in weight the loss might be attributed to respiration and other senescence related to metabolic processes during storage, the 1-MCP treatments might reduce the respiration rate of the fruit and inhibited ripening processes which diminished the weight loss of fruit during storage **(Watkins, 2002)** and thereby extend the storage life of tomato fruits **(Blankenship and Dole, 2003)**. Previous studies have shown that 1-MCP can inhibit the increase in the respiration rate of fruits **(Toivonen and Lu, 2005)**.

3.A.2 Fruit firmness

The research proposed that 1-MCP could inhibit fruit softening **(Pelayo *et al.*, 2003)** and our experiments yielded similar results. Data presented in Table 2 showed that firmness values were observed to be significantly decreased corresponding to the continuous storage period in seasons 2020 and 2021, respectively. On the other hand, tomato fruit's firmness values were observed to be increased with the increase of 1-MCP concentrations during the first and the second seasons, respectively. Similar results were reported by **(Ahmed *et al.*, 2018)** and **El-Sheikh *et al.* (1998)**. The decline in fruit firmness may be due to the gradual breakdown of proto pectin to lower molecular weight fractions which are more soluble in water and this was directly correlated with the rate of softening of the fruit **(Wills *et al.*, 1981)**, all over the storage period, however, fruits treated with 1-MCP at 100 and 150 μgL^{-1} was the most effective treatment. These results were in agreement with those obtained by according to **Ahmed *et al.* (2018)** and **Celso *et al.* (2001)**, who found that tomato fruits treated with 1-MCP showed a delay in ripening and senescence and reduce softening of fruits.

3.A.3 Fruit external color measurement (L values)

Results in Table 3 showed that, L values of tomatoes increased with the storage period extended, L values of tomatoes were strongly affected by 1-MCP concentration and all concentrations (50, 100 and 150 μgL^{-1}) had near magnitude and remain fixed or little declined until 12 days then slowly increased from 12 to 16 days. Color L values sharply declined within 4-8 days of storage in control fruit, then slowly increased until 16 days. In general, maximum delay in color L values decline was obtained with the 150 μgL^{-1} of 1-MCP, these results agree with those of **(Ahmed *et al.*, 2018 ; Poyesh *et al.*, 2017)**.

3.A.4 Fruit external color measurement (C values)

Data in Table 4 indicated that, C values of tomato fruit color increased with prolonging storage period, the initiated C values of tomato fruit color did not differ significantly in the first and second seasons, respectively for the used 1-MCP concentrations at the beginning of storage. The C values in an average tomato fruit eternal color were noticed to be significantly increased until 16 days under control followed by significantly declined under 50 μgL^{-1} of 1-MCP concentration, then significantly increased under 100μgL^{-1} concentration, after that significantly decreased under 150 μgL^{-1} concentration in the first and second seasons, respectively, these results agree those of (**Ahmed *et al.*, 2018)** and **Cantwell (2010)**.

3.A.5 Fruit external color measurement (H values)

External (h* value) color of cherry tomato fruits showed increasing with the advance in storage period (Table 5). Results in Table 5 clear that H values of tomato color were strongly affected by 1-MCP concentrations and all concentrations and control had very near magnitude and acutely increased until 4 days than control sharply decreased until 8 days followed slowly increased, while 50, 100 and 150 μgL^{-1} concentrations little declined until 12 days then slowly increased from 12 to 16 days. The concentration of 150 μgL^{-1} was the lowest treatment affected by prolonging the storage periods, these results agree with those of (**Ahmed *et al.*, 2018; Poyesh *et al.*, 2017; Sabir *et al.*, 2014)**.

3.A.6 Fruit decay

Results presented in Table 6 showed that, the decay score increased with extending the storage period. The tomato fruit decay average values were not changed until 4 days and then significantly increased at 16 days in the two seasons. On the other hand, tomato fruits decay values were decreased with the increase of 1-MCP concentrations, these results agree with those of **(Ahmed *et al.*, 2018; Guill´en *et al.*, 2006; Castillo *et al.*, 2006; Meng *et al.*, 2009; Zhang *et al.*, 2012; Amoateng *et al.*, 2018)**. Moreover, there was a significant interaction between 1-MCP concentrations and storage periods; the lowest fruit decay was noticed within fruits treated with 150 μgL^{-1} of 1-MCP. While the highest fruit decay was noticed within untreated fruits in the two seasons.

Table 1: Effect of methylcyclopropane concentrations of weight loss (%) during cold storage of cherry tomatoes

MCP Concentrations	Season 1 Storage period (days)					Mean	Season 2 Storage period (days)					Mean
	0	4	8	12	16		0	4	8	12	16	
50 µgL^{-1}	00.00	8.17	8.09	8.03	6.1	7.6	00.00	8.26	8.24	6.32	6.23	7.26
100 µgL^{-1}	00.00	4.21	4.03	3.22	2.14	3.4	00.00	4.24	4.21	3.21	2.27	3.48
150 µgL^{-1}	00.00	1.11	0.01	0.01	0.02	0.29	00.00	1.26	0.014	0.01	0.032	0.33
Cont.	00.00	13.97	12.09	11.95	10.09	12.03	00.00	14.31	12.25	12.21	10.36	12.28
Mean	00.00	6.86	6.05	5.80	4.58	5.83	00.00	7.01	6.17	5.43	4.72	5.84
LSD 0.05			0.16						1.88			

Table 2: Effect of methylcyclopropane concentrations of firmness during cold storage of cherry tomatoes

MCP Concentrations	Season 1 Storage period (days)					Mean	Season 2 Storage period (days)					Mean
	0	4	8	12	16		0	4	8	12	16	
50 µgL^{-1}	9.03	6.03	6	5.27	5.03	6.27	9.14	6.19	6.18	5.33	5.12	6.39
100 µgL^{-1}	9	8	7.04	7.02	7	7.61b	9.3	8.22	7.38	7.19	7.18	7.85
150 µgL^{-1}	9.05	9.00	9.00	9.00	8.05	8.82	9.28	9.21	9.17	9.11	8.33	9.02
Cont.	9.04	3b	3	2a	2	3.81	9.14	3.22	3.1	2.13	2.11	3.94
Mean	9.03	6.51	6.26	5.82	5.52	6.63	9.22	6.17	6.46	5.94	5.69	6.80
LSD 0.05			0.16						0.31			

Table 3: Effect of methylcyclopropane concentrations of fruit external color measurement (L values) during cold storage of cherry tomatoes

MCP Concentrations	Season 1					Mean	Season 2					Mean
	Storage period (days)						Storage period (days)					
	0	4	8	12	16		0	4	8	12	16	
50 μgL^{-1}	67.6	72.72	74.22	77.98	92.02	76.91	66.66	72	72.33	78	91.66	76.13
100 μgL^{-1}	64.29	68.14	76.85	83.72	83.76	75.41	67.33	68	75	83	84	75.47
150 μgL^{-1}	61.80	62.77	63.63	75.21	84.77	69.64	63	64	64.33	75.66	82.66	69.93
Cont.	63.65	94.77	103.08	105.27	110.28	95.41	65	94	104	108.66	111	96.53
Mean	64.34	74.6	79.45	85.55	92.71	79.34	65.5	74.5	78.92	86.33	92.33	79.52
LSD 0.05			1.844						2.203			

Table 4: Effect of methylcyclopropane concentrations of fruit external color measurement (C values) during cold storage of cherry tomatoes

MCP Concentrations	Season 1					Mean	Season 2					Mean
	Storage period (days)						Storage period (days)					
	0	4	8	12	16		0	4	8	12	16	
50 μgL^{-1}	25.18	26.63	28.74	30.86	31.18	28.52	26	28.4	30	31	31.5	29.38
100 μgL^{-1}	26.19	27.25	27.55	28.20	28.59	27.56	24.66	25.33	26	26.66	27	25.93
150 μgL^{-1}	23.23	23.54	25.26	26.47	26.89	25.08	22.92	22	23	25	25.09	23.6
Cont.	26.73	30.98	33.19	35.9	37.63	32.89	26	29	31.66	34	36	31.33
Mean	25.33	27.1	28.69	30.36	31.06	28.51	24.9	26.18	27.67	29.17	29.9	27.56
LSD 0.05			1.597						1.59			

Table 5: Effect of methylcyclopropane concentrations of fruit external color measurement (h* value) during cold storage of cherry tomatoes

MCP Concentrations	Season 1 Storage period (days)					Mean	Season 2 Storage period (days)					Mean
	0	4	8	12	16		0	4	8	12	16	
50 μgL^{-1}	93.99	98	100	102	105	99.8	95.05	97	101.96	103	104.17	100.24
100 μgL^{-1}	95	97	99	100	101	98.4	94.09	96.07	98	100.21	101.4	97.95
150 μgL^{-1}	92.04	92.59	93.05	95.03	96.1	93.76	90.44	91	93.66	95.65	96.66	93.48
Cont.	93.08	95	99.96	110	120	103.61	91.04	96	100.18	112	121.33	104.1
Mean	93.53	95.65	98	101.76	105.53	98.89	92.66	95.02	98.45	102.72	105.89	98.94
LSD 0.05			0.23						1.918			

Table 6: Effect of methylcyclopropane concentrations on decay score during cold storage of cherry tomatoes

MCP Concentrations	Season 1 Storage period (days)					Mean	Season 2 Storage period (days)					Mean
	0	4	8	12	16		0	4	8	12	16	
50 μgL^{-1}	1.01	1.75	2.02	2.03	2.05	1.77	1.02	1.78	2.1	2.12	2.18	1.84
100 μgL^{-1}	1.2	1.3	1.3	1.4	1.54	1.36	1.22	1.33	1.34	1.41	1.56	1.37
150 μgL^{-1}	1	1.02	1.04	1.08	1.1	1.05	1.14	1.16	1.19	1.20	1.21	1.18
Cont.	1	3.02	3.5	3.92	5.03	3.29	1	3.11	3.57	4.03	5.17	3.38
Mean	1.05	1.77	1.97	2.11	2.43	1.84	1.1	1.85	2.05	2.17	2.53	1.94
LSD 0.05			0.08						0.157			

3.A.7 Fruit visual appearance

Data in Table 7 indicate that general appearance of tomato fruits was deteriorated during storage and the visual quality score dropped from excellent to good, and fair or poor after 16 days at 12°C. The tomato fruit's visual appearance means in Table 7 did not change until 4 days and then significantly decreased at 16 days in the two seasons. On the other hand, tomato fruit's visual appearance means were increased with the increase of 1-MCP during the two seasons, these results agree with those of **(Ahmed *et al.*, 2018 ; Meng *et al.*, 2008)**. The fruit's visual appearance was maintained at a 9 value until 16, 12, 8 days by 150 µgL^{-1} and 4 days by the control in the two seasons (Table 7).

3.B Chemical characteristics

3.B.1 Total soluble solids T.S.S

Results in Table 8 showed that total soluble solids decreased with prolonging storage period, the data in Table 8 illustrate that the total soluble solids percentage showed in the first and second seasons, respectively under all 1-MCP concentrations in the zero date during the two seasons. The means of total soluble solids percentages in tomato fruit were observed to be significantly increased as affected by the extent of storage periods after 16 days in seasons 2020 and 2021, respectively. On the other hand, the means of these percentages were observed to be decreased as the reflection of the increasing of 1-MCP concentrations after zero dates and after 16 days during the first and the second seasons, respectively. These results agree with those of **(Ahmed *et al.*, 2018; Wills *et al.*, 1981; Guill´en *et al.*, 2006; Castillo *et al.*, 2006; Meng *et al.*, 2008; Sabir *et al.*, 2014; Amoateng *et al.*, 2018)**. Moreover, there was a significant interaction between 1-MCP concentrations and storage periods, the less fruit total soluble solids percentages were obtained within fruits treated with 150 µgL^{-1} of 1-MCP, while the lowest fruit ones were noticed within untreated fruits in the two seasons. The highest total soluble solids percentages were under control after 16 days, while the lowest percentages were 4.03 after 16 days as affected by150 µgL^{-1} concentration in the first and second seasons, respectively.

3.B.2 Ascorbic acid content

Chen *et al.* (2020) proposed that the ascorbic acid was more stable in an acidic environment. Due to the high ascorbic acid content of fruits in the early stage of storage, we supplied that 1-MCP and TPC treatments had a positive effect on the holding of ascorbic acid content during 0 – 15 d. Data in Table 9 indicated that, ascorbic acid content for tomato fruits was decreased as the storage period extended. The average ascorbic acid contents in tomato fruit were significantly enhanced as a result of increased length of storage times after 16 days in the two seasons. On the contrary, the means of these contents were observed to be declined as a result of the increase of 1-MCP concentrations after zero dates and after 16 days in the two seasons, respectively. These results agree with those of **(Ahmed *et al.*, 2018; Meng *et al.*, 2008; Sabir *et al.*, 2014; Amoateng *et al.*, 2018)**. The general trend in Table 9 was that ascorbic acid contents were in steady increment with the increasing length of storage times under all studied treatments.

The control treatments showed an acute increase from zero to 8 days then little increase after that in the two seasons. The concentrations of 100 and 150 µgL^{-1} were between the control and 150 µgL^{-1} had near magnitude and the concentrations of 50 and 100 µgL^{-1} were between the control and 150 µgL^{-1}. It may be for the reason that ascorbic acid content was lower in the late storage period than in the early. But the ascorbic acid was prone to maintain the reduced state under the supply of hydrogen from phenolic hydroxyl groups of phenolic compounds **(Vinha *et al.*, 2013)**.

3.B.3 Titratable acidity

The means of the titratable acidity in tomato fruit were significantly decreased corresponding to the continuous storage days and after 16 days in the two seasons, respectively as indicated in Table 10. On the other hand, the means of tomato fruits contents of titratable acidity were observed to be significantly increased with the increasing of 1-MCP concentrations after zero and after 16 days during the two seasons, respectively. These results were in agreement with those obtained by **(Ahmed *et al.*, 2018; Kaynas and Sumeli 1995)** who found that titratable acidity reduced during storage at 4°C. The reduction in fruit acidity during storage might be attributed to the rapid rate of oxidation of pyruvic acid and other acids to carbon dioxide **(Wills *et al.*, 1981)**.

In summary, the 1-MCP treatment groups can better sustain the TA content of cherry tomatoes at a higher level after harvest. The suppression of ripening was concentration dependent, according to the earlier findings, when comparing fruit treated with the aqueous treatment of 1-MCP at 50, 100 and 150 μgL^{-1} to control fruit, maximal suppression in response for 10 min immersion occurred at doses of 100 and 150 μgL^{-1}. Climacteric ethylene peaks were delayed and respiration was significantly inhibited.

Table 7: Effect of methylcyclopropane concentrations on visual appearance during cold storage of cherry tomatoes

MCP Concentrations	Season 1					Mean	Season 2					Mean
	Storage period (days)						Storage period (days)					
	0	4	8	12	16		0	4	8	12	16	
50 µgL^{-1}	9.1	6.1	6	6	5.01	6.44	9.16	6.21	6.14	6.08	5.2	6.54
100 µgL^{-1}	9.03	8.03	8	7.1	7.1	7.85	9.44	8.20	8.18	7.27	7.26	8.07
150 µgL^{-1}	9.03	9.03	9.02	9.02	9.02	9.02	9.14	9.14	9.1	9.09	9.09	9.11
Control	9.00	5	3	2	1	4	9.1	5.21	3.16	2.20	1.11	4.15
Mean	9.04	7.04	6.5	6.03	5.53	6.82	9.21	7.19	7.395	6.16	5.66	7.1
LSD 0.05			0.088						0.263			

Table 8: Effect of methylcyclopropane concentrations on T.S.S percentage during cold storage of cherry tomatoes

MCP Concentration	Season 1					Mean	Season 2					Mean
	Storage period (days)						Storage period (days)					
	0	4	8	12	16		0	4	8	12	16	
50 µgL^{-1}	4.51	4.75	4.79	5.01	5.09	4.83	4.59	4.82	4.84	5.15	5.2	4.92
100 µgL^{-1}	4.2	4.24	4.3	4.4	4.51	4.33	4.26	4.3	4.34	4.46	4.56	4.38
150 µgL^{-1}	4	4	4.03	4.11	4.16	4.06	4.06	4.11	4.15	4.19	4.2	4.14
Cont.	4.53	5.54	6.14	6.24	6.99	5.89	4.57	5.59	6.15	6.27	6.91	5.9
Mean	4.31	4.63	4.82	4.94	5.19	4.78	4.37	4.71	4.87	5.02	5.22	4.84
LSD 0.05			0.071						0.136			

Table 9: Effect of methylcyclopropane concentrations on ascorbic acid content during cold storage of cherry tomatoes

MCP Concentrations	Season 1					Mean	Season 2					Mean
	Storage period (days)						Storage period (days)					
	0	4	8	12	16		0	4	8	12	16	
50 µgL^{-1}	1.34	1.37	1.42	1.42	1.46	1.4	1.37	1.37	1.41	1.44	1.44	1.41
100 µgL^{-1}	1.22	1.25	1.27	1.3	1.33	1.3	1.13	1.23	1.24	1.28	1.35	1.25
150 µgL^{-1}	1.06	1.12	1.13	1.15	1.18	1.13	1.15	1.18	1.19	1.19	1.2	1.18
Cont.	1.42	1.65	1.81	1.94	2.24	1.81	1.43	1.64	1.85	1.91	2.45	1.84
Mean	1.26	1.35	1.41	1.45	1.55	1.41	1.27	1.36	1.42	1.46	1.61	1.42
LSD 0.05			0.06						0.104			

Table 10: Effect of methylcyclopropane concentrations on titratable acidity during cold storage of cherry tomatoes

MCP Concentrations	Season 1					Mean	Season 2					Mean
	Storage period (days)						Storage period (days)					
	0	4	8	12	16		0	4	8	12	16	
50 µgL^{-1}	8.11	8.09	7.55	7.52	7.16	7.69	8.13	8.12	7.57	7.55	7.46	7.77
100 µgL^{-1}	8.45	8.39	8.28	8.17	7.79	8.22	8.24	8.15	8.09	8.03	7.80	8.06
150 µgL^{-1}	8.52	8.52	8.27	8.17	8.14	8.32	8.63	8.25	8.34	8.27	8.19	8.39
Cont.	8.84	7.11	6.55	6.19	5.08	6.75	8.63	7.10	6.71	6.13	5.51	6.82
Mean	8.48	8.03	7.66	7.51	7.04	7.65	8.17	8.41	7.68	8.03	7.24	7.76
LSD 0.05			0.11						0.24			

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تأثيرالغمس في تركيزات مختلفة من ميثيل سيكلوبروبان على جودة وتخزين ثمارالطماطم الشيرى

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الكلمات المفتاحية:
الطماطم الشيرى، ١- ميثيل سيكلوبروبان، الجودة، التخزين.

الملخص

أجريت هذه الدراسة اثناء عامي٢٠٢٠، ٢٠٢١بمعهد بحوث البساتين، مركز البحوث الزراعية ، مصر. حيث تم اخذ ثمار الطماطم الشيرى صنف جيندو من احدى الحقول فى قرية سخا،مركز كفر الشيخ ،محافظة كفرالشيخ وتم نقلها الى معهد بحوث البساتين وتم اختيار الثمار والبدء فى معاملتها بمادة ١- ميثيل سيكلوبروبين حيث تم غمر الطماطم كليا فى المحلول بتركيزات مختلفة (٠ و٥٠ ،١٠٠ ،١٥٠ميكروجرام / لتر) لمدةعشرة دقائق ثم تم تجفيف الثمار سريعا وتم التخزين على ١٢ درجة مئوية لمدة١٦يوم. وأوضحت النتائج أن المعاملة بمادة ١- ميثيل سيكلوبروبين أدت الي الحفاظ على جودة ثمار الطماطم مقارنة بنباتات الكنترول وكانت أفضل التركيزات في هذا الصدد هي التركيزات الأعلى (١٠٠ و ١٥٠ ميكروجرام/ لتر).