EFFECT OF 1- METHYL CYCLOPROPENE ON POST HARVEST QUALITY AND SHELF LIFE OF TOMATO FRUITS TREATED WITH EXOGENOUS ETHYLENE

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ABSTRACT

The present investigation was undertaken to study the effect of 1-Methyl Cyclopropene (1-MCP), on postharvest quality and shelf life of tomato, pre-treated with ethephon. The freshly harvested matured tomato fruits were selected and treated, with fungicide of 500 µL for 10 min followed by 500 µL ethephon treatment. The fruits were exposed to different concentrations of 1-methylcyclopropene viz. 0.5, 1.0, 1.5 and 2.0 µL at 20°C for 12 and 24 hrs (hr), respectively, in an airtight chamber. The effect of 1-MCP on the physicochemical quality of fruits was studied in detail. The study revealed that the fruits treated with 2 µL concentrations exposed for 24 hr at 20°C storage temperature recorded higher shelf life of 27 days with better physico-chemical quality characteristics, like physiological weight loss, total soluble solids, Colour, titrable acidity and ascorbic acid content.

KEYWORDS: *The Freshly Harvested, Physicochemical Quality & Ascorbic acid Content*

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INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is a major horticultural crop, with an estimated global production of over 223 million metric tons (FAO, 2010). It is one of the most important vegetable crops, cultivated all over the world, for its fleshy fruits. Salad tomatoes must have flavour, colour and texture, that satisfy the consumer's preference. Tomato, being a climacteric fruit, the start of ripening is accompanied by a rapid rise in respiration rate, called 'respiratory climacteric' during which, oxidative breakdown of complex substrates occur, ageing follows, leading to product deterioration. Also, tomatoes being fleshy fruits continue to lose water after harvest. This results in a wilted, dull appearance that reduces the eye appeal and freshness and eventually becomes unmarketable.

Increasing desire of consumers for high quality and nutritional foods has created a need for longer market season for both domestic as well as export markets. In domestic markets external application of ethylene is done for faster ripening to make the fruits ready for early marketing because, Optimum quality is attained through ripening, but, ripe fruits are highly perishable, having shortest shelf life and very labile to shipping damage which consequently leads to loss of quality and waste (Nakhasi et al., 1991). Hence, a non-sophisticated technology to extend shelf life of Tomato at ambient and low temperature storage conditions with minimal impacts to the environment is needed to increase the competitiveness of Tomato fruits on the global market. 1-methylcyclopropene (1-MCP) is increasingly being used to improve storage potential and maintain quality of fruit and vegetables. 1-MCP is registered for use on a number of crops (Watkins, 2008). Softening of fresh-cut

kiwifruit slices was delayed and ethylene production decreased by 1-MCP whether it was applied before or after processing. (Vilas-Baos and Kader, 2007). 1-methylcyclopropene (1-MCP) has been intensively researched and used as ethylene inhibitor (Blankenship and Dole, 2003; Huber, 2008) due to its approved feasible commercial use, easy application, and high efficacy with a large number of horticultural crops. 1-MCP exposure is treated in the form of gas in sealed containers (Serek et al., 1994).

However, there is not much available literature about the effectiveness of 1-MCP in relation to the stage of ripening at harvest and storage conditions. The present investigation was therefore undertaken to study effectiveness of 1-MCP in exogenously ethylene pre-treated fruits of tomato.

MATERIALS AND METHODS

The tomato fruits were harvested manually at the proper stage of maturity from well managed tomato farm near the Aurangabad city. The uniformly matured fruits were brought to the Food Technology Laboratory with utmost care. The fresh tomato fruits were harvested and divided into different stage of physiological maturity i.e. green to pink. Fruits, at the proper stage of physiological maturity (green and pink stage) were selected from well managed commercial farms, and then the fruits were washed thoroughly with clean water and then prepared for the treatments. 1-MCP solution was prepared from 4% active ingredient, Feiming Chemicals Ltd., China by personal communication and the graded tomato fruits were then treated with gaseous 1-methylcyclopropene (1-MCP).

MCP Treatment

The solution of different concentrations of 1-MCP viz. 0.5, 1, 1.5 and 2 μ l/L was prepared. The solution was used within two minutes of preparation and all treatments were completed within five minutes. The treatments of the standardized concentrations of 1-MCP were a batch of 30 fruits, in each treatment. The fruits were then placed in ventilated corrugated fibre boxes (CFB) in the airtight, cool chamber and exposed to 1-MCP treatment for 12 and 24 hr at 20 °C temperature, followed by storage at room temperature and low temperature (20 °C), respectively, along with absolute control fruits. The fruits were then evaluated for various physico-chemical quality characteristics like, Percent physiological loss in weight (PLW), Surface colour, Total soluble solids, Titrable acidity, Ascorbic acid content and shelf life of fruits. The treatment details are presented in Table 1.

Physico-Chemical Analysis

Various physico-chemical analyses of the control and treated tomato fruits were carried out in order to determine the effect of treatments of 1-MCP on quality and shelf life extension of tomato fruits. The observations were recorded at frequent intervals of time during storage period.

Percent physiological loss in weight of tomato fruits of was obtained by calculating the difference in weights of fruits recorded by using analytical weighing balance to determine the degree of wholesomeness during the storage of 1-MCP treated fruits and control fruit samples (Nunes, 2008; Pauziah et. al., 2014). The colour value (A) and (B) was determined using a Minolta Colorimeter (Konica, Japan) with a standard CIE illuminant, by calculating the hue angle using formula $\tan^{-1} (B/A)$ (Pauziah et. al., 2014). The total soluble solids in the tomato fruits were measured by hand held digital pocket refractometer (Atago, Japan) and expressed in °Brix (A.O.A.C., 1990). Titrable acidity was determined by titration method and the percent titratable acidity was expressed, in terms of standard ascorbic acid. (Ranganna, 2002; Pauziah et.

al., 2014)

Moreover, the Total ascorbic acid content was determined by 2, 6 dichlorophenol-indophenol visual titration method, in which dye is blue in alkaline solution and red in acid solution, is reduced by ascorbic acid to colourless form. The reaction is quantitative and practically specific for ascorbic acid solution in pH range 1.0-3.5 (Ranganna, 2002). The data generated during the experiment, was statistically analyzed. The results are the average of three determinations and are expressed as Mean $\pm$ SD (Das and Giri, 1988).

RESULTS AND DISCUSSIONS

The postharvest application of 1-MCP at different concentrations viz. 0.5, 1.0, 1.5, and 2.0 μ l/L slowed down the ripening process of tomato fruits and improved shelf life significantly with increase in 1-MCP concentration. The rate of percent physiological loss in weight (% PLW) of tomato fruits was decreased with increase in 1-MCP concentrations, whereas Total soluble Solids (TSS) content was increased with increase in 1-MCP concentration. The rate of change in colour in terms of hue angle of fruits was improved with increase in the exposure time and 1-MCP concentration. However the rate of reduction in the ascorbic acid content and titrable acidity of fruits was observed at 20°C to increase in 1-MCP concentration and exposure time, respectively.

Effect of Different Concentration of 1-MCP on Quality of Tomato Fruits

The effect of various concentrations of 1-MCP treatment at different exposure time and storage temperatures was investigated in detail along with physicochemical quality and shelf life of fruits.

Physiological Loss in Weight (% PLW)

The percent PLW is directly related to the Shelf life of the fruits, higher the losses, lesser the shelf life and vice-versa. Therefore, it was having a significant impact on the marketability of the fruits. The results obtained with respect to the changes in physiological loss in weight (PLW) of fruits due to exposure of 1-MCP at varying concentration and different storage temperatures are presented in Table 2. The study revealed that the Tomato fruits treated with 1-MCP at 2.0 μ l/L concentration, exposed for 24 hr and then stored at 20°C (T_4) exhibited gradual increase in % PLW (upto 11.1%) during 27 days of shelf life as compared to control fruits (up to 11.3 %) during 12 days of shelf life and over rest of the treatments. The results are in close proximity as reported by (Aguayo et al., 2006; Vilas et al., 2006; Mao et al. 2007).

Surface Colour

Surface Colour plays major role in giving idea about the ripening index as well as stage of maturity of tomato fruits. The results with respect to the effect of 1-MCP treatment on surface colour during the storage are presented in Table 3. The changes in surface colour of the fruits are also shown in photographs as given in Figure 1. The study revealed that the tomato fruits exposed to 1-MCP at 2.0 μ l/L concentration for 24 hr and stored at 20°C (T_4) observed least development in surface colour from dark green to pale green and from pale green to yellow ranging -2.85 to 3.6 hue during 27 days of its storage period as compared to control fruits (-3.45 to 1.19 hue) during 12 days of its storage period and over rest of the treatments. The similar results reported in apple fruit by Bai et al. (2004).

Total Soluble Solids (TSS)

Total soluble solids content (TSS) is one of the most important quality parameters of the fruits and gives an idea

about the degree of ripening of fruits. The gradual change in the TSS indicated the controlled development in the ripening of fruits which is regulated by the action of 1-MCP. The changes in TSS content are directly proportional to the concentration of 1-MCP, exposure time and storage temperatures and the results obtained are presented in Table 4. The study revealed that the tomato fruits exposed to 2.0 μL of 1-MCP concentration for 24 hr and stored at 20°C (T_4) showed gradual increase in TSS from 1.1 to 3.7 ^{outbreaks} during 27 days of its storage period as compared to control (1.4 to 3.3 ^{approx}) during 12 days of its storage period and over rest of the treatments. The result was found in close approximation, with results given in tomato by Santos (2004).

Titration Acidity

Titration acidity is one of the most important factors responsible for the fruit quality determination. The results with respect to the change in titration acidity, in terms of citric acid were determined and the results obtained are presented in Table 5. The study revealed that the tomato fruits exposed to 1-MCP at 2.0 μL concentration for 24 hr and stored at 20 °C (T_4) exhibited a gradual decrease in titration acidity from 0.40 to 0.11%, during the 27 days of its storage period, as compared to control (0.49 to 0.17%), during 12 days of storage period and over the rest of the treatments. Results are in close confirmation with Gergoff Grozeff *et.al.* 2017.

Ascorbic Acid Content

Change in ascorbic acid content is a significant parameter in determining the wholesomeness of fruits at any stage. The investigation deals with the effect of 1-MCP concentrations, exposure time and storage temperature on the ascorbic acid content of Tomato fruits. The results obtained are presented in Table 6. The study revealed that the fruits exposed to 1-MCP at 2.0 μL concentration exposed for 24 hr and stored at 20 °C (T_4) showed a gradual decrease in ascorbic acid content from 73.45 to 20.8 mg/100g during the 27 days of its storage period as compared to control fruits (74.1 to 20.34 mg/100gm) during the 12 days of its storage period and rest of the treatments. Similar observations are reported in banana fruits by Sisler and Serek (1997).

CONCLUSION

The postharvest quality and shelf life of tomato fruits were having a strong association with 1-MCP concentration and its exposure time. Shelf life of tomato fruits increased, with increase in concentration of 1-MCP and its exposure time; and also the physico-chemical properties viz. Percent physiological loss in weight of fruit, surface colour, total soluble solids (TSS), titration acidity and ascorbic acid content was significantly influenced by 1-MCP concentration and its exposure time. Fruits treated with 2.0 μL 1-MCP concentration for 24 h exposure time and stored at 20 °C storage temperature found the best results, in terms of physicochemical quality with highest shelf life 27 days. It can be concluded that, 1-MCP has great potential in delaying the ripening, along with improvement in overall quality of the fruits due to its ethylene antagonistic action. It has also found techno-economically feasible.

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Control fruits

0th Day 6th day 12th day

Fruits Exposed to Ethylene (500 ppm)+1-MCP at 2μl/L+24 hrET+ 20 °C Storage Temperature

0th Day 12th Day 24th Day

Figure 1: Effect of 1-MCP Treatment on Colour of Tomato Fruits

Table 1: Treatment Details of 1-MCP Concentrations, Exposure Time and Storage Temperature of Tomato Fruits

Treatment	Treatment Details
T ₀	Control Fruits (Tomato)
T ₁	Ethylene (500 ppm)+1-MCP at 0.5µl/L+24 hr exposure time + 20 °C storage temperature
T ₂	Ethylene (500 ppm)+1-MCP at 1µl/L+24 hr exposure time + 20 °C storage temperature
T ₃	Ethylene (500 ppm)+1-MCP at 1.5µl/L+24 hr exposure time + 20 °C storage temperature
T ₄	Ethylene (500 ppm)+1-MCP at 2µl/L+24 hr exposure time + 20 °C storage temperature
T ₅	Ethylene (500 ppm) +1-MCP at 0.5µl/L+24 hr exposure time+ Room temperature
T ₆	Ethylene (500 ppm) + 1-MCP at 1µl/L+ 24 hr exposure time + Room temperature
T ₇	Ethylene (500 ppm) + 1-MCP at 1.5µl/L+ 24 hr exposure time+ Room temperature
T ₈	Ethylene (500 ppm) + 1-MCP at 2µl/L+ 24 hr exposure time+ Room temperature
T ₉	Ethylene (500 ppm) + 1-MCP at 0.5µl/L +12 hr exposure time + 20 °C storage temperature
T ₁₀	Ethylene (500 ppm) +1-MCP at 1µl/L+12 hr exposure time + 20 °C storage temperature
T ₁₁	Ethylene (500 ppm) + 1-MCP at 1.5µl/L +12 hr exposure time + 20 °C storage temperature
T ₁₂	Ethylene (500 ppm) +1-MCP at 2µl/L+12 hr exposure time + 20 °C storage temperature
T ₁₃	Ethylene (500 ppm) + 1-MCP at 0.5µl/L +12 hr exposure time +Room temperature
T ₁₄	Ethylene (500 ppm) +1-MCP at 1µl/L+12 hr exposure time +Room temperature
T ₁₅	Ethylene (500 ppm) +1-MCP at 1.5µl/L +12 hr exposure time +Room temperature
T ₁₆	Ethylene (500 ppm) +1-MCP at 2µl/L+12 hr exposure time +Room temperature

*ET- Exposure Time

RT- Room Temperature

ST- Storage Temperature

Table 2: Effect of 1-MCP Concentrations, Exposure Time and Storage Temperature on PLW (%) of Tomato Fruits

Treatments	Storage Period (Days)									
	0	3	6	9	12	15	18	21	24	27
T ₀	0	3.8 ±.44	5.7± 0.9	7.9± 0.89	11.3±1.19	*	*	*	*	*
T ₁	0	3.5±.44	5.2± 0.13	7.4±0.84	9.9± 1.93	11.1± 1.92	13.8±1.20	*	*	*
T ₂	0	3.1±.40	4.9± 0.33	6.6± 1.47	8.7± 1.53	9.9± 1.89	11.4±	12± 1.64	*	*
T ₃	0	2.5±.41	3.7± 0.88	5.6± 1.33	8.2± 1.90	9.9± 1.44	11.3±1.37	11.7± 1.42	12.3±1.29	*
T ₄	0	2.1±.42	3± 0.12	4.5± 0.99	6.7± 1.72	8.1± 1.20	8.7± 1.50	9.1± 1.99	9± 1.77	11.1±1.99
T ₅	0	3.9±.44	5.7± 0.66	8.4±0.44	10.7±1.33	*	*	*	*	*
T ₆	0	3.4±.48	5± 0.34	7.8±1.55	9.9± 1.48	11.8± 1.39	*	*	*	*
T ₇	0	3±.45	5.5± 0.55	7.8± 0.59	9.9±2.02	10.4±1.29	12.7±1.38	*	*	*
T ₈	0	2.5±.44	3.7± 0.79	6.3±0.77	8.4± 1.26	9.9± 1.30	12.1±1.29	*	*	*
T ₉	0	4.1±.38	6.7± 0.18	9.9± 1.40	12.8±1.94	*	*	*	*	*
T ₁₀	0	3.7±.50	6.2± 0.39	8.9±1.66	10.1±1.29	11.4± 1.99	12.7±1.12	*	*	*
T ₁₁	0	3±.29	5.8± 0.29	6.9± 0.59	8.9± 1.49	9.6± 1.33	10.6±1.92	11.1± 1.30	12.4±1.70	*
T ₁₂	0	2.99±.28	3.7± 0.17	4.9± 0.59	6.3± 1.39	7.9± 1.79	9.87±1.27	11.4± 1.47	12.2±1.80	*
T ₁₃	0	3.7±.50	7.9± 0.64	11.3± 0.8	*	*	*	*	*	*
T ₁₄	0	4.2±.45	7.4± 0.65	9.3± 0.11	12.4±1.99	*	*	*	*	*
T ₁₅	0	3.4± 1.3	7± 0.66	9.1± 0.25	10.8±1.00	11.7± 1.20	*	*	*	*
T ₁₆	0	3.1±.50	5.9± 0.8	8.3± 0.37	10.1±1.22	11.4± 1.90	12.5±1.88	*	*	*

Each value is the average of three determinations and expressed as Mean±SD.

Fruits discarded due to spoilage

Table 3: Effect of 1-MCP Concentrations, Exposure Time and Storage Temperature on Colour (Hue) of Tomato Fruits

Treatments	Storage Period (Days)									
	0	3	6	9	12	15	18	21	24	27
T ₀	-3.45±1.8	0.54±0.2	1.12±0.7	1.12±1.3	1.19±1.1	*	*	*	*	*
T ₁	-5.1±1.1	0.52±1.9	0.52±1.6	1.2±1.3	1.65±1.8	2.15±1.3	0.52±1.0	*	*	*
T ₂	-3.27±2.0	0.94±1.4	0.94±2.1	2.46±1.7	2.56±0.1	2.8±0.5	3.02±0.9	3.12±1.3	*	*
T ₃	-2.99±1.1	1.89±1.0	1.89±0.4	2.1±0.8	2.42±0.3	2.47±0.1	2.6±1.1	2.61±1.9	3.46±0.9	*
T ₄	-2.85±0.91	2.83±2.0	2.83±1.1	3.19±1.4	3.37±1.9	3.4±1.4	3.45±1.3	3.68±1.1	3.57±1.0	3.6±1.1
T ₅	-3.1±0.5	1.7±0.9	2.72±0.1	3.19±1.9	3.6±1.4	*	*	*	*	*
T ₆	-2.29±0.9	1.65±1.1	2.4±1.7	3.57±2.1	3.79±1.0	3.84±0.5	*	*	*	*
T ₇	-2.99±1.4	1.52±1.8	1.66±1.1	2.6±1.3	3.12±1.3	3.49±1.1	3.6±1.0	*	*	*
T ₈	-2.56±1.1	2.31±1.9	2.65±1.4	3.48±1.0	3.6±1.1	3.63±1.4	3.93±0.7	*	*	*
T ₉	-3.87±1.5	1.96±1.9	2.63±0.7	2.91±1.0	3.23±0.5	*	*	*	*	*
T ₁₀	-6.73±1.1	0.93±1.8	1.89±1.4	2.58±1.0	3.19±1.1	3.28±1.1	3.37±1.4	*	*	*
T ₁₁	-3.28±1.9	-1.93±1.1	0.79±0.5	1.68±1.9	2.17±1.8	2.69±1.1	2.917±0.4	3.13±0.9	3.29±1.1	*
T ₁₂	-4.58±0.8	-1.47±1.0	0.23±1.1	0.79±0.1	1.69±1.3	2.16±0.9	2.59±0.7	2.91±1.0	3.28±0.4	*
T ₁₃	-3.84±0.4	1.89±0.8	2.83±0.1	3.29±1.1	*	*	*	*	*	*
T ₁₄	-2.98±0.9	1.77±0.3	2.78±0.7	3.01±1.0	3.36±0.1	*	*	*	*	*
T ₁₅	-3.78±0.7	-1.48±0.1	1.93±1.1	2.57±1.0	2.9±0.8	3.24±0.3	*	*	*	*
T ₁₆	-4.26±0.7	-1.98±0.4	1.48±1.1	2.1±1.9	2.62±1.1	2.9±0.6	3.28±0.1	*	*	*

Each value is the average of three determinations and expressed as Mean±SD.

Fruits discarded due to spoilage

Table 4: Effect of 1-Mcp Concentrations, Exposure Time and Storage Temperature on Tss (°brix) of Tomato Fruits

Treatments	Storage Period (Days)									
	0	3	6	9	12	15	18	21	24	27
T ₀	1.4±0.3	1.6±0.1	1.8±0.1	2.9±0.1	3.3±0.1	*	*	*	*	*
T ₁	1.4±0.1	1.7±0.4	1.9±0.8	1.9±0.1	2.3±0.2	2.5±0.1	3.1±0.7	*0.1	*	*
T ₂	1.3±0.8	1.4±0.4	1.3±0.1	1.4±0.9	1.7±0.7	2.3±0.5	2.3±0.9	3.6±0.6	*	*
T ₃	1.3±0.3	1.5±0.1	1.4±0.8	1.5±0.2	1.8±0.3	1.7±0.4	2.1±0.2	2.1±0.2	3.4±0.5	*
T ₄	1.1±0.5	1.3±0.3	1.5±0.1	1.5±0.8	1.8±0.7	1.9±0.3	2.1±0.7	2.2±0.5	2.5±0.4	3.7±0.5
T ₅	1.1±0.4	1.4±0.8	1.7±0.1	2.1±0.3	3.7±0.9	*	*	*	*	*
T ₆	1.3±0.3	1.4±0.2	1.6±0.4	1.9±0.7	2.2±0.4	3.1±0.2	*	*	*	*
T ₇	1.3±0.1	1.5±0.9	1.7±0.6	2.2±0.3	2.2±0.8	3.3±0.9	3.6±0.1	*	*	*
T ₈	1.4±0.4	1.7±0.4	2.1±0.1	2.4±0.7	2.5±0.7	2.9±0.5	3.5±0.7	*	*	*
T ₉	1.6±0.7	1.8±0.3	2.4±0.1	2.7±0.9	3.1±0.9	*	*	*	*	*
T ₁₀	1.3±0.2	1.2±0.7	1.5±0.1	1.9±0.9	2.1±0.4	2.4±0.1	3.5±0.1	*	*	*
T ₁₁	1.4±0.6	1.5±0.3	1.6±0.5	1.9±0.4	2±0.8	2.2±0.7	2.5±0.7	2.7±0.2	3.2±0.3	*
T ₁₂	1.3±0.2	1.4±0.4	1.7±0.7	1.9±0.8	2.1±0.7	2.3±0.8	2.3±0.3	2.6±0.5	3.7±0.9	*
T ₁₃	1.4±0.9	1.7±0.8	2.1±0.2	3.3±0.3	*	*	*	*	*	*
T ₁₄	1.6±0.1	1.8±0.1	2.1±0.8	2.5±0.9	3±0.9	*	*	*	*	*
T ₁₅	1.3±0.2	1.8±0.4	2.1±0.3	2.3±0.1	2.6±0.3	3.2±0.8	*	*	*	*
T ₁₆	1.3±0.5	1.4±0.9	1.7±0.7	1.9±0.4	2.2±0.6	2.4±0.5	3.4±0.4	*	*	*

Each value is the average of three determinations and expressed as Mean±SD.

Fruits discarded due to spoilage

Table 5: Effect of 1-MCP Concentrations, Exposure Time and Storage Temperature on Titrable Acidity (%) of Tomato Fruits

Treatment	Storage Period (Days)									
	0	3	6	9	12	15	18	21	24	27
T ₀	0.49±0.01	0.26±0.02	0.13±0.000000.05	0.17±0.04	0.17±0.03	*	*	*	*	*
T ₁	0.39±0.01	0.33±0.05	0.24±0.06	0.21±0.07	0.17±0.02	0.14±0.04	0.12±0.04	*	*	*
T ₂	0.40±0.04	0.35±0.04	0.30±0.09	0.28±0.03	0.21±0.07	0.17±0.04	0.14±0.01	0.11±0.04	*	*
T ₃	0.40±0.02	0.35±0.03	0.33±0.06	0.32±0.04	0.22±0.06	0.19±0.02	0.17±0.04	0.14±0.05	0.12±0.01	*
T ₄	0.40±0.02	0.38±0.01	0.33±0.02	0.32±0.05	0.3±0.04	0.2±0.02	0.18±0.03	0.14±0.01	0.12±0.11	0.11±0.02
T ₅	0.37±0.02	0.29±0.01	0.23±0.05	0.21±0.05	0.12±0.06	*	*	*	*	*
T ₆	0.40±0.04	0.27±0.05	0.24±0.02	0.22±0.05	0.16±0.08	0.13±0.09	*	*	*	*
T ₇	0.39±0.02	0.31±0.03	0.28±0.05	0.26±0.07	0.23±0.05	0.21±0.01	0.12±0.03	*	*	*
T ₈	0.4±0.02	0.34±0.01	0.32±0.02	0.26±0.03	0.24±0.06	0.22±0.02	0.14±0.01	*	*	*
T ₉	0.35±0.09	0.31±0.08	0.21±0.07	0.19±0.06	0.10±0.01	*	*	*	*	*
T ₁₀	0.46±0.06	0.41±0.03	0.37±0.06	0.31±0.04	0.26±0.06	0.17±0.03	0.11±0.02	*	*	*
T ₁₁	0.44±0.02	0.42±0.07	0.39±0.04	0.35±0.03	0.28±0.01	0.21±0.03	0.18±0.03	0.136±0.04	0.11±0.05	*
T ₁₂	0.437±0.03	0.41±0.01	0.37±0.08	0.34±0.02	0.31±0.04	0.3±0.02	0.27±0.01	0.24±0.04	0.10±0.02	*
T ₁₃	0.40±0.03	0.29±0.06	0.17±0.09	0.14±0.02	*	*	*	*	*	*
T ₁₄	0.38±0.04	0.27±0.06	0.14±0.01	0.1±0.05	0.16±0.02	*	*	*	*	*
T ₁₅	0.49±0.03	0.34±0.06	0.27±0.09	0.25±0.01	0.21±0.33	0.17±0.04	*	*	*	*
T ₁₆	0.43±0.04	0.37±0.07	0.29±0.08	0.28±0.05	0.17±0.06	0.14±0.07	*	*	*	*

Each value is the average of three determinations and expressed as Mean±SD.

Fruits discarded due to spoilage

Table 6: Effect of 1-MCP Concentrations, Exposure Time and Storage Temperature on Ascorbic Acid Content (Mg/100g) of Tomato Fruits

Treatments	Storage Period (Days)									
	0	3	6	9	12	15	18	21	24	27
T ₀	74.1±2.3	68.93±1.3	53.11±2.0	27.12±2.2	20.34±2.0	*	*	*	*	*
T ₁	68.93±1.1	61.02±1.7	55.37±2.1	47.46±2.0	40.68±1.5	27.12±1.0	18.08±1.1	*	*	*
T ₂	72.32±1.7	64.41±1.3	56.5±1.9	49.72±6	46.33±1.1	40.68±1.5	31.64±1.3	21.3±2.1	*	*
T ₃	71.19±1.8	63.28±2.8	54.24±1.7	47.46±1.1	44.07±1.0	40.68±1.9	35.03±2.4	28.5±1.0	23.1±1.1	*
T ₄	73.45±2.9	64.41±1.1	55.37±1.9	49.72±1.1	46.33±1.0	42.94±1.6	38.42±2.4	29.38±2.2	23.73±2.4	20.8±1.1
T ₅	71.19±2.1	47.2±2.1	34.7±1.0	31.45±1.0	26.67±1.7	*	*	*	*	*
T ₆	75.71±1.8	67.8±1.3	58.76±1.1	51.98±1.0	38.42±2.4	22.77±2.1	*	*	*	*
T ₇	72.32±1.9	64.41±1.3	55.37±1.8	48.59±1.4	45.2±1.8	35.1±1.1	23.7±1.9	*	*	*
T ₈	74.58±2.2	65.54±2.1	56.5±1.9	50.85±1.0	43.6±1.5	32.8±1.3	24.7±1.1	*	*	*
T ₉	70.7±2.1	61.4±2.0	47.3±1.5	31.7±1.1	22.5±1.6	*	*	*	*	*
T ₁₀	70.3±2.0	65.8±2.2	50.5±1.8	34.3±1.4	28.9±1.9	23.7±1.1	21.1±1.3	*	*	*
T ₁₁	69.5±2.1	62.7±2.9	54.3±1.8	46.2±1.1	38.7±1.0	31.5±1.3	26.4±1.0	23.6±1.2	20.3±0.9	*
T ₁₂	70.2±2.2	63.7±1.9	58.4±1.1	52.7±1.9	47.3±1.1	41.8±1.0	34.2±1.3	26.4±1.5	20.1±1.9	*
T ₁₃	68.7±1.5	50.7±1.9	37.4±1.3	21.7±1.7	*	*	*	*	*	*
T ₁₄	69.5±1.9	55.3±2.1	43.5±1.4	36.3±2.0	20.7±1.1	*	*	*	*	*
T ₁₅	70.3±2.1	57.9±2.0	46.2±1.9	34.8±1.1	27.1±1.0	19.5±2.6	*	*	*	*
T ₁₆	67.9±1.0	61.8±1.6	50.7±1.8	39.4±1.1	31.5±1.3	24.3±0	19.4±1.5	*	*	*

Each value is the average of three determinations and expressed as Mean±SD.

Fruits discarded due to spoilage