

Effect of 1-MCP concentration, exposure time and storage temperature on post-harvest quality of mango fruit cv. Alphonso

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Abstract

Present research work was undertaken to study the effect of 1-Methyl Cyclopropene (1-MCP) on quality and shelf life of the mango fruits (Cv. Alphonso). The freshly harvested matured mango fruits were treated with fungicide at 0.5 $\mu\text{L/L}$ concentration for 10 mins followed by washing and cleaning. The fruits were then exposed to different concentrations of 1-MCP viz. 0.5, 1.0, 1.5 and 2 $\mu\text{L/L}$ at 20°C for 12 and 24 hrs respectively along with control fruits in an airtight chamber. The results obtained after conducting the above experiments indicated that the ripening was delayed by 1-MCP at early stages and shelf life of the fruit increases as the concentration of 1-MCP increased. Various physico-chemical changes such as physiological loss in weight (PLW), total soluble solids, surface colour, titrable acidity, ascorbic acid content and firmness of fruit was majorly influenced by 1-MCP which showed lower physiological loss in weight (11.6%), gradual increase in TSS from 9.7 to 22.1°Brix and colour from -3.63 to 2.59, considerable decrease was observed in titrable acidity from 1.34 to 0.14%, Ascorbic acid content from 81.18 to 25.2 mg/100 g and texture decreased from 312 to 66 gf respectively as compared to rest of the treatments and control fruits.

1. Introduction

Among all the fruits the Mango fruit is considered to be one of the best fruit in the world market because of its excellent flavour, attractive fragrance, beautiful colour, delicious taste and nutraceutical properties (Sakhale *et al.*, 2017). The Mango known by its scientific name *Mangifera indica* L. is the most important fruit crop in tropical and non-temperate regions of the world. Due to consumer's increasing desire for high quality and nutritional foods it has now become essential to prolong the season of this fruit. This is especially true for fruits which provide plenty of vitamins and minerals. The optimum quality of fruits is generally attained through ripening. Loss of fruit quality and wastage of fruits occurs due to the highly perishable nature of the fruits and damage during their transportation (Nakhasi *et al.*, 1991). Ripening of the climacteric fruits and other horticultural commodities is highly dependent upon ethylene (Lelièvre *et al.*, 1997; Czarny *et al.*, 2006).

Nowadays ethylene inhibitors are marking their presence by delaying the ripening is becoming common practice (Kebenei *et al.*, 2003; Sisler, 2006). Due to its approved feasible commercial use, easy application, and high efficacy with a large number of horticultural crops,

the novel chemical 1-methylcyclopropene (1-MCP) nowadays has been researched and is used as an ethylene inhibitor (Blankenship and Dole, 2003). Exposure of 1-MCP to the fruits is carried out in the form of gas in sealed containers (Serek *et al.*, 1994). Therefore, the competitiveness of mango fruits on the global market has been influenced by this non-sophisticated technology to extend the shelf life of mango at ambient and low temperature storage conditions with minimal impacts on the environment. The present investigation was therefore undertaken to study the effects of 1-MCP on concentration, exposure time, storage temperature post-harvest quality of mango fruit.

2. Materials and methods

The mango fruits of Cv. Alphonso were harvested manually at the proper stage of maturity from well-managed mango orchard near the Aurangabad city. The uniformly matured hard green fruits were brought to Food Technology Laboratory of the university department with utmost care. The fruits were washed with clean water and then graded on the basis of specific gravity by using 'Float and Sink method'. The graded fruits were then treated with a fungicide (Benomyl) at 500 ppm concentration in order to control the incidence

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of stem-end rot (SER) and anthracnose.

2.1 1-MCP treatment

Mango fruits (Cv. Alphonso) were treated with gaseous 1-methylcyclopropene (1-MCP). 1-MCP solution was prepared by diluting 25 mg of 1-MCP powder in 1 L to obtain at the concentration of 1 mg/L solution from (4% active ingredient, Feiming Chemicals Ltd., China) and different concentrations of 1-MCP such as 0.5, 1, 1.5, and 2 $\mu\text{L/L}$ were prepared in same manner. The solution was used within 10 mins of preparation and all treatments were completed within 10 to 15 mins. The matured and graded mango fruits were subdivided into five groups containing 50 mangoes in each group and then subjected to 1-methylcyclopropene (1-MCP) treatments as shown in Table 1 at 0.5, 1, 1.5, and 2 $\mu\text{L/L}$ concentrations respectively while untreated fruits were considered as control (T_0). The fruits were packed in airtight containers along with a cup containing known concentrations of 1-MCP solution prepared in lukewarm water. The fruits were exposed to 1-MCP for the different period of exposure time i.e. 12 and 24 hrs and then stored at different temperature *viz.* at ambient temperature (25 to 28°C) and at 20°C. The fruits were then evaluated for various physico-chemical characteristics like titrable acidity, Ascorbic acid content, Percent physiological loss in weight of fruit (PLW), Colour, Total soluble solids, Texture (firmness) and shelf life of fruit.

2.1.1 Physiological loss in weight (%)

Physiological loss in weight of mango fruits of Cv.

Alphonso was calculated by using analytical weighing balance to determine the degree of maturity during the storage of 1-MCP treated and control fruit samples (Nunes, 2008).

2.1.2 Surface colour measurement

Colour value (A) and (B) was determined using a Minolta Colorimeter (Model-CR- 10, Konica, Japan) with a standard CIE illuminant by calculating the hue angle (h°) using formula $\tan^{-1}(B/A)$ (AOAC, 1990).

2.2.3 Total soluble solids (TSS)

The total soluble solids (%) in the mango recorded by digital Pocket Refractometer (PAL-3, Atago, Japan) and expressed in °Brix (AOAC, 1990).

2.2.4 Titrable acidity

The titrable acidity was determined by titrating known volume of mango pulp with 0.1 N solution of sodium hydroxide. The percentage of titrable acidity was expressed in terms of citric acid (Ranganna, 2002).

2.2.5 Total ascorbic acid content

Total ascorbic acid content was determined by 2, 6 dichlorophenol-indophenol visual titration method in which the dye which 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).

Table 1. Treatment details of 1-MCP concentration, exposure time and storage temperature of mango fruits (Cv. Alphonso)

Treatment	Treatment details
T_0	Control Fruits (Mango Cv. Alphonso)
T_1	1-MCP at 0.5 $\mu\text{L/L}$ +24 hrs exposure time + 20°C storage temperature
T_2	1-MCP at 1 $\mu\text{L/L}$ +24 hrs exposure time + 20°C storage temperature
T_3	1-MCP at 1.5 $\mu\text{L/L}$ +24 hrs exposure time + 20°C storage temperature
T_4	1-MCP at 2 $\mu\text{L/L}$ +24 hrs exposure time + 20°C storage temperature
T_5	1-MCP at 0.5 $\mu\text{L/L}$ + 24 hrs exposure time + Room temperature
T_6	1-MCP at 1 $\mu\text{L/L}$ +24 hrs exposure time + Room temperature
T_7	1-MCP at 1.5 $\mu\text{L/L}$ +24 hrs exposure time + Room temperature
T_8	1-MCP at 2 $\mu\text{L/L}$ +24 hrs exposure time + Room temperature
T_9	1-MCP at 0.5 $\mu\text{L/L}$ + 12 hrs exposure time + 20°C storage temperature
T_{10}	1-MCP at 1 $\mu\text{L/L}$ +12 hrs exposure time+ 20°C storage temperature
T_{11}	1-MCP at 1.5 $\mu\text{L/L}$ +12 hrs exposure time + 20°C storage temperature
T_{12}	1-MCP at 2 $\mu\text{L/L}$ +12 hrs exposure time + 20°C storage temperature
T_{13}	1-MCP at 0.5 $\mu\text{L/L}$ + 12 hrs exposure time + Room temperature
T_{14}	1-MCP at 1 $\mu\text{L/L}$ +12 hrs exposure time + Room temperature
T_{15}	1-MCP at 1.5 $\mu\text{L/L}$ +12 hrs exposure time + Room temperature
T_{16}	1-MCP at 2 $\mu\text{L/L}$ +12 hrs exposure time + Room temperature

*All fruits were treated with fungicide (500 ppm) for ten minutes.

2.3 Texture measurement

Textural characteristics of fruit in terms of firmness was determined by using a texture analyzer (FTC, USA) incorporating a 5 mm diameter probe with 1mm/s test speed and 0.5 N trigger force was inserted into the surface of mango fruits at 10 mm distance. The maximum force generated during the probe's travel was measured in gram force (gf). Firmness was measured on the side along the equatorial region of the fruits. Minimum 10 fruits were measured from each treatment for determination of texture and the results obtained in terms of firmness are expressed in gf (Sisler *et al.*, 2006).

2.4 Statistical analysis

The statistical analysis was carried out with single factor two-way with replication by using Analysis of Variance (ANOVA) with the help of Excel spreadsheets of MS Office 2007 software package and Genstat 12 edition (Das and Giri, 1988).

3. Results and discussion

The freshly harvested Mango fruits (Cv. Alphanso) after their pretreatments were treated with gaseous 1-methylecyclopropene (1-MCP) at different concentrations viz. 0.5, 1.0, 1.5 and 2.0 $\mu\text{L/L}$ respectively. The results obtained for various parameters are discussed under suitable headings. The rate of physiological loss in weight of fruit was decreased with increase in 1-MCP concentration, Total soluble solids increased slowly with increase in 1-MCP concentration, the rate of change in colour of mango fruit was improved with the increase in the exposure time and concentration of 1-MCP. The rate of reduction in the ascorbic acid content and titrable acidity of fruit was decreased and the firmness was slowly decreased with increase in the exposure time and concentration of 1-MCP (Dong *et al.*, 2002).

3.1 Effect of different concentrations of 1-MCP on quality of Mango (Cv. Alphanso)

The effect of the application of 1-MCP treatment at different concentrations, exposure time and storage temperatures on quality of mango fruits (Cv. Alphanso) were investigated in detail. The results obtained with respect to appearance of fruits are shown in Figure 1 and the data of various parameters presented in respective tables.

Table 2 indicates that the mango fruits treated with 1-MCP at 2.0 $\mu\text{L/L}$ concentration and exposed for 24 hrs and stored at 20°C (T_4) showed gradual increase in PLW from (11.66%) during 33 days of storage period as compared to control (15.6%) during 12 days of its storage period and rest of the treatments. Statistically, 1-MCP has shown a significant effect on % PLW of mango fruit ($P < 0.05$). Reduction in a weight loss of 1-MCP treated fruits may be attributed to slow respiration rate and maintenance of tissue rigidity of the fruits (Dong *et al.*, 2002).

It revealed from the data presented in Table 3 that the mango fruits treated with 1-MCP at 2.0 $\mu\text{L/L}$ concentration exposed for 24 hrs and stored at 20°C (T_4) showed significant decrease in colour from -3.63 to 2.59 during 27 days of its storage period as compared to control fruits (-3.96 to 5.9) during 12 days of its storage period and over rest of the treatments. 1-MCP significantly decreased the surface colour of Alphanso mangoes ($P < 0.05$) delayed decrease in colour maybe because the ethylene is produced by both, endogenously as well as exogenously and accelerates the degradation of chlorophyll and the appearance of red, yellow and orange pigments, which are involved in the expression of gene coding for the synthesis of carotenoids (Rodrigo *et al.*, 2007).

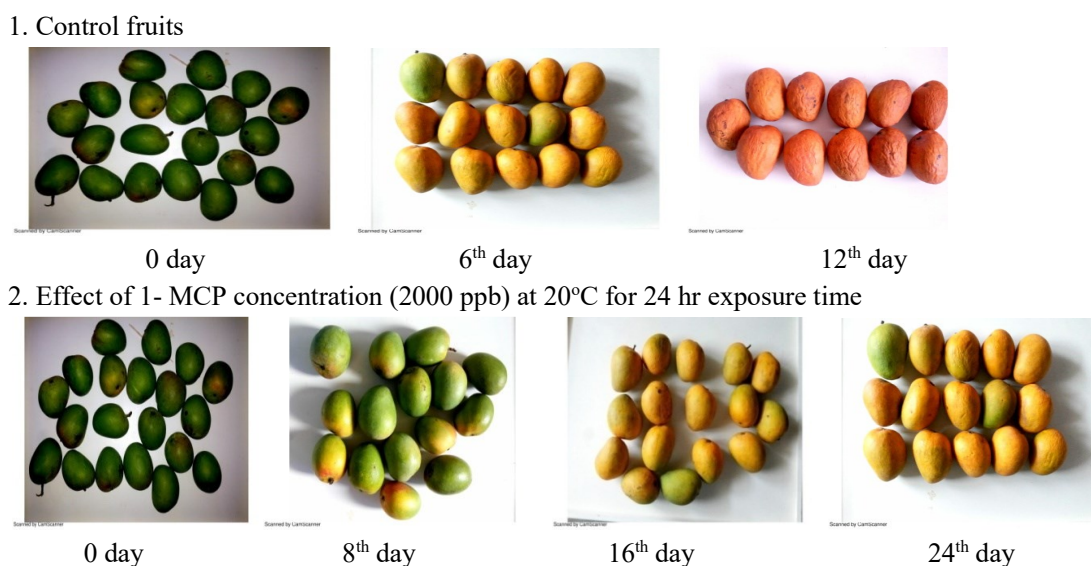


Figure 1. Effect of 1-MCP on Alphanso mangoes during storage

Table 2. Effect of 1-MCP concentrations, exposure time and storage temperature on PLW (%) of Mango fruits (Cv. Alphonso)

Treatments	Storage Period (Days)									
	0	3	6	9	12	15	18	21	24	27
T ₀	0	4.7	8.6	11.5	15.6	*	*	*	*	*
T ₁	0	4.2	7.5	9.3	11.4	13.2	*	*	*	*
T ₂	0	3.7	7.3	8.8	10.3	11.9	12.8	*	*	*
T ₃	0	3	5.3	7.8	9.3	9.9	10.2	11.7	12.3	*
T ₄	0	2.4	3.9	5.8	7.9	8.4	10.3	10.7	11	11.6
T ₅	0	4.7	8.2	10.3	13.7	*	*	*	*	*
T ₆	0	4.3	7.7	9.3	11.3	12.7	*	*	*	*
T ₇	0	3.5	5.7	8.4	9.3	10.5	11.8		*	*
T ₈	0	3.2	4.8	7.4	9.3	10.5	12.7	13.4	*	*
T ₉	0	4.2	8.7	10.73	13.67	*	*	*	*	*
T ₁₀	0	3.25	7.74	9.83	11.55	11.9	13.29	*	*	*
T ₁₁	0	3	6.57	9.55	10.17	12.1	12.59	13	*	*
T ₁₂	0	2.79	3.67	6.37	8.91	10	11.39	12.2	*	*
T ₁₃	0	5.7	10.4	11.8	13.5	*	*	*	*	*
T ₁₄	0	4.7	7.69	10.3	13.2	*	*	*	*	*
T ₁₅	0	3.9	6.6	9.51	11.3	12.8		*	*	*
T ₁₆	0	3.09	5.5	7.9	9.5	11.8	12.4	*	*	*

Each value is the average of three determinations. T₀ - Control, T₁ to T₁₆-1-MCP Treatment. *Fruits discarded due to spoilage

Table 3. Effect of 1-MCP concentrations, exposure time and storage temperature on colour of Mango fruits (Cv. Alphonso)

Treatments	Storage Period (Days)									
	0	3	6	9	12	15	18	21	24	27
T ₀	3.96	-4	3.5	5.2	5.9	*	*	*	*	*
T ₁	4.14	-4.1	1.6	2.6	5.3	6.7	*	*	*	*
T ₂	3.7	-3.8	0.6	1.1	1.8	1.9	2.05	2.1	*	*
T ₃	3.99	-4	-1.6	-3	3.92	3.8	4.1	4.12	4.27	*
T ₄	3.63	-3.6	-3	-2.8	2.1	2.1	2.34	2.4	2.45	2.59
T ₅	-4.4	2.4	2.9	3.7	4.7		*	*	*	*
T ₆	-4.1	1.9	2.1	3	3.3	3.9	*	*	*	*
T ₇	-3.7	1.4	1.99	4.2	4.6	4.9	5.2	*	*	*
T ₈	-5.5	1.1	1.6	2.1	2.22	2.6	3.1	3.3	3.7	*
T ₉	-4.1	1.14	2.79	3.41	3.91	*	*	*	*	*
T ₁₀	-4.2	1.78	1.56	2.81	3.49	3.94	4.21	*	*	*
T ₁₁	5.24	1.93	1.29	1.92	2.3	2.71	3.01	3.71	*	*
T ₁₂	-5.5	2.71	-1.1	1.18	1.83	2.3	2.8	3.6	*	*
T ₁₃	-1.9	2.01	3.4	4.19	4.81	*	*	*	*	*
T ₁₄	-3.4	0.101	2.71	3.34	4.01	*	*	*	*	*
T ₁₅	-4.7	-2.5	1.91	2.76	3.01	3.89		*	*	*
T ₁₆	-4.4	-2.6	2	2.7	3.01	3.6	4.21	*	*	*

Each value is the average of three determinations. T₀ - Control, T₁ to T₁₆-1-MCP Treatment. *Fruits discarded due to spoilage

The mango fruits treated with 1-MCP at 2.0 µL/L concentration exposed for 24 hrs and stored at 20°C (T₄) exhibited gradual decrease in texture in terms of firmness from 312 to 66 gf during 33 days of storage period as compared to control (448 to 48 gf) during 12 days of storage period and over rest of the treatments as shown in Table 4. The 1-MCP significantly decreased firmness of Alphonso mangoes (P<0.05). This reduction in firmness may be due to action of hydrolase enzyme which is induced by ethylene during ripening, enzymes such as polygalacturonase (PG), pectin methylesterase (PME), β-galactosidase and pectate lyase (PL) degrade the polymeric carbon hydrates, especially those of pectic and hemicellulosic substances through which the cell walls and the tensile force, which hold the cells together,

are weakened and the softening of the fruit is accelerated (Goulao *et al.*, 2007; Sañudo *et al.*, 2008).

Table 5 shows that the mango fruits exposed to 1-MCP at 2.0 µL/L concentration for 24 hrs and stored at 20°C (T₄) exhibited gradual decrease in titrable acidity from 1.34 to 0.14% during 27 days of its storage period as compared to control fruits (1.3 to 0.32%) during 12 days of storage period and over rest of the treatments. 1-MCP significantly decreased the titrable acidity of Alphonso mangoes (P<0.05). The decrease in titratable acids during storage may be attributed to a marked increase in malic acid utilization during ripening (AOAC, 1990; Sakhale *et al.*, 2017).

Table 4. Effect of 1-MCP concentrations, exposure time and storage temperature on Texture in terms of firmness (gf) of Mango fruits (Cv. Alphonso)

Treatments	Storage Period (Days)									
	0	3	6	9	12	15	18	21	24	27
T ₀	448	291	165	104	48	*	*	*	*	*
T ₁	361	223	163	102	89	49	*	*	*	*
T ₂	363	291	178	138	102	88	50	*	*	*
T ₃	382	288	209	161	146	100	64	48	*	*
T ₄	312	290	220	162	137	98	89	78	73	66
T ₅	388	216	153	107	76	50	*	*	*	*
T ₆	297	215	167	106	74	44	*	*	*	*
T ₇	333	230	186	113	95	83	55	*	*	*
T ₈	370	227	202	170	145	113	96	69		*
T ₉	494	236	136	77	73	44	*	*	*	*
T ₁₀	484	213	127	76	70	67	*	*	*	*
T ₁₁	490	445	262	130	96	70	50	36		*
T ₁₂	522	459	439	411	282	136	96	70		*
T ₁₃	388	216	153	107	50	*	*	*	*	*
T ₁₄	297	215	167	106	44	*	*	*	*	*
T ₁₅	333	230	186	113	95	55	*	*	*	*
T ₁₆	370	227	202	170	145	113	65			*

Each value is the average of three determinations. T₀ - Control, T₁ to T₁₆-1-MCP Treatment. *Fruits discarded due to spoilage

Table 5. Effect of 1-MCP concentrations, exposure time and storage temperature on titrable acidity (%) of Mango fruits (Cv. Alphonso)

Treatments	Storage Period (Days)									
	0	3	6	9	12	15	18	21	24	27
T ₀	1.3	0.9	0.8	0.4	0.32	*	*	*	*	*
T ₁	1.4	0.9	0.7	0.61	0.4	0.21	*	*	*	*
T ₂	1.31	1.24	1.11	0.9	0.71	0.53	0.32	*	*	*
T ₃	1.47	1.35	1.24	1	0.89	0.62	0.41	0.29	0.17	*
T ₄	1.34	1.27	1.19	1	0.94	0.73	0.52	0.36	0.24	0.14
T ₅	1.29	1.01	0.84	0.66	0.13	*	*	*	*	*
T ₆	1.38	1	0.7	0.5	0.3	*	*	*	*	*
T ₇	1.3	1.1	1	0.8	0.4	0.31	*	*	*	*
T ₈	1.4	1.1	0.8	0.6	0.2	0.17	0.1	*	*	*
T ₉	1.2	1.1	1	0.7	0.2		*	*	*	*
T ₁₀	1.35	1.29	1.2	1.6	1.2	0.7	0.1	*	*	*
T ₁₁	1.41	1.3	1.2	1.11	1	0.8	0.4	0.14	*	*
T ₁₂	1.3	1.23	1.9	1.7	1.35	1.29	0.79	0.16	*	*
T ₁₃	1.37	1.25	1.19	0.18	0.11	*	*	*	*	*
T ₁₄	1.25	1.18	1.11	0.55	0.14	*	*	*	*	*
T ₁₅	1.3	1.25	1.1	1	0.57	0.18	*	*	*	*
T ₁₆	1.35	1.31	1.26	1.1	1	0.8	0.15	*	*	*

Each value is the average of three determinations. T₀ - Control, T₁ to T₁₆-1-MCP Treatment. *Fruits discarded due to spoilage

The data pertaining to TSS in Table 6 showed that the mango fruits exposed to 1-MCP at 2.0 $\mu\text{L/L}$ concentration for 24 hrs and stored at 20°C (T₄) exhibited gradual increase in TSS from 9.7 to 22.1°Brix during 27 days of its storage period as compared to control (8.6 to 22.1°Brix) during 12 days of its storage period and over rest of the treatments. 1-MCP showed a significant effect on total soluble solids of Alphonso mangoes ($P < 0.05$). Increase in TSS and sugars during storage maybe due to the breakdown of complex organic metabolites into simple molecules. Further, it may be attributed to hydrolysis of starch into sugars, on

complete hydrolysis of starch no further increase in sugars occurred and subsequently, a decline in these parameters is evident as they along with other organic acids are the primary substrate for respiration (Serek *et al.*, 1994)

As indicated in Table 7, the Alphonso mango exposed to 1-MCP at 2.0 $\mu\text{L/L}$ concentration for 24 hrs and stored at 20°C (T₄) exhibited gradual decrease in ascorbic acid content (81.18 to 25.2 mg/100 g) during 27 days of its storage period as compared to control fruits (82.44 to 22.7 mg/100 g) during 12 days of its storage life and rest of the treatments. The ascorbic acid content

Table 6. Effect of 1-MCP concentrations, exposure time and storage temperature on TSS (°Brix) of Mango fruits (Cv. Alphonso)

Treatments	Storage Period (Days)									
	0	3	6	9	12	15	18	21	24	27
T ₀	8.6	12.8	17.6	19.4	22.1	*	*	*	*	*
T ₁	10.3	15.7	18.7	20.2	21.7	22.4	*	*	*	*
T ₂	13.7	15.5	17.2	19.9	20.1	20.8	21.5	*	*	*
T ₃	12.3	14.4	16.6	18.5	19.3	20.5	21.2	21.9	22.5	*
T ₄	9.7	14.2	17.5	18.2	19.7	20.2	20.9	21.5	21.8	22.1
T ₅	9.6	19.3	20.2	20.7	21.6	*	*	*	*	*
T ₆	16.2	18.3	19	20.4	21.8	22.7	*	*	*	*
T ₇	15.5	18.4	20.3	20.8	21.5	22.1	23.2	*	*	*
T ₈	15.8	18.2	19.1	19.6	20	21.8	21.9	22.5	*	*
T ₉	12.5	15.8	17.9	19.6	23.5	*	*	*	*	*
T ₁₀	11.8	14.65	17.55	19.8	20.4	22.3	24	*	*	*
T ₁₁	12.5	13.9	16.87	18.4	21.7	23.1	23.6	24	*	*
T ₁₂	10	12.5	14.7	17.4	19.3	21.6	23.1	20.2	*	*
T ₁₃	14.7	17.5	20.8	21.6	23.2	*	*	*	*	*
T ₁₄	12.5	16.7	18.9	21.4	23.5	*	*	*	*	*
T ₁₅	13.7	15.3	18.2	20.4	21.6	22.5	*	*	*	*
T ₁₆	11.6	13.1	17.4	19.3	21.8	22.2	23.2	*	*	*

Each value is the average of three determinations. T₀ - Control , T₁ to T₁₆-1-MCP Treatment. *Fruits discarded due to spoilage

Table 7. Effect of 1-MCP concentrations, exposure time and storage temperature on Ascorbic acid content (mg/100g) of Mango fruits (Cv. Alphonso)

Treatments	Storage Period (Days)									
	0	3	6	9	12	15	18	21	24	27
T ₀	82.44	64.8	54.18	41.4	22.7	*	*	*	*	*
T ₁	78.66	59.4	54.2	45.2	39.7	33.6	27.54	*	*	*
T ₂	80.28	72.36	67.7	63.1	55.8	52.02	30.24	21.49	*	*
T ₃	80.1	74.16	71.7	67.8	62.9	59.04	34.74	29.6	24.3	*
T ₄	81.18	74.88	72.5	69.7	66.6	60.3	54.7	44.5	37.8	25.2
T ₅	78.84	68.58	62.28	43.74	23.7	*	*	*	*	*
T ₆	80.1	71.1	63.54	55.98	48.78	23.76	*	*	*	*
T ₇	80.82	72.36	66.24	59.58	44.3	26.28	22.1	*	*	*
T ₈	81.36	74.88	69.12	64.62	56.16	44.67	33.89	23.98		*
T ₉	82.01	68.91	39.99	31.76	23.71	*	*	*	*	*
T ₁₀	83	71.63	59.5	41.8	30.2	26.1	21		*	*
T ₁₁	80.57	73.8	68.74	60.4	54.67	34.24	26.5	21.98	*	*
T ₁₂	83.55	74.5	60.58	54.98	49.48	38.77	31	23.54	*	*
T ₁₃	80	58.55	36.78	30.1	24.1	*	*	*	*	*
T ₁₄	83.19	61.77	39.15	30.5	22.45	*	*	*	*	*
T ₁₅	84	63.5	41.59	36.78	29.55	21.67	*	*	*	*
T ₁₆	82	67.19	45.83	35.8	31.98	27.91	20.5	*	*	*

Each value is the average of three determinations. T₀ - Control , T₁ to T₁₆-1-MCP Treatment. *Fruits discarded due to spoilage

of 1-MCP treated fruit reduced slowly and delayed the ripening process due to unavailability of active sites for ethylene which were blocked by 1-MCP in order to delay the ripening process and hence not allowing the sudden decrease in the concentration of ascorbic acid. 1-MCP showed a significant effect on ascorbic acid content of Alphonso mangoes (P<0.05). This is because 1-MCP might be affecting the metabolism of carbohydrates because organic acids are respiratory substrates (Rodrigo *et al.*, 2007).

4. Conclusion

The research work which was carried out intensively

for Alphonso mango fruit has led to the conclusion that the concentration 1-MCP and its exposure time has its strong influence on postharvest quality and shelf life of the mango fruits. As the concentration of the chemical 1-MCP and its exposure time raised, then the Shelf life of mango (Cv. Alphonso) also found increased. 1-MCP concentration and its exposure time also had shown its significant impact on various physicochemical properties such as physiological loss in weight of fruit, colour, total soluble solids, Acidity, ascorbic acid and Texture (Firmness) of the fruits. However, the fruits which were exposed for 24 hrs at 2.0 µL/L 1-MCP concentration and stored at 20°C storage temperature found the highest

shelf life of 27 days with best results in terms of physicochemical quality.

Conflict of Interest

The authors declare no conflict of interest.

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References

- AOAC. (1990). Official methods of analysis. Washington D.C., USA: Association of Official Agricultural Chemists.
- Blankenship, S.M. and Dole, J.M. (2003). 1-Methylcyclopropene: a review. *Postharvest Biology Technology*, 28(1), 1–25. [https://doi.org/10.1016/S0925-5214\(02\)00246-6](https://doi.org/10.1016/S0925-5214(02)00246-6)
- Czarny, J.C., Grichko, V.P. and Glick, B.R. (2006). Genetic modulation of ethylene biosynthesis and signalling in plants. *Biotechnology Advances*, 24(4), 410–419. <https://doi.org/10.1016/j.biotechadv.2006.01.003>
- Das, M.N. and Giri, N.C. (1988). Design and analysis of experiments, 2nded. New Delhi, India: Wiley Eastern Ltd.
- Dong, L., Lurie, S. and Zhou, H. (2002). Effect of 1-methylcyclopropene on ripening of ‘Canino’, apricots and ‘Royal Zee’ plums. *Postharvest Biology Technology*, 24(2), 135–145. [https://doi.org/10.1016/S0925-5214\(01\)00130-2](https://doi.org/10.1016/S0925-5214(01)00130-2)
- Goulao, L.F., Santos, J., de Sousa, L. and Oliveira, C.M. (2007). Patterns of enzymatic activity of cell wall-modifying enzymes during growth and ripening of apples. *Postharvest Biology Technology*, 43(3), 307–318. <https://doi.org/10.1016/j.postharvbio.2006.10.002>
- Kebenei, Z., Sisler, E.C., Winkelmann, T. and Serek, M. (2003). Efficacy of new inhibitors of ethylene perception in improvement of display life of kalanchoe (*Kalanchoe blossfeldiana* Poelln) flowers. *Postharvest Biology Technology*, 30(2), 169–176. <https://doi.org/10.1016/j.postharvbio.2006.10.002>
- Lelièvre, J.M., Latché, A., Jones, B., Bouzayeu, M. and Pech, J.C. (1997). Ethylene and fruit ripening. *Physiologia Plantarum*, 101(4), 727–739. <https://doi.org/10.1016/j.postharvbio.2006.10.002>
- Nunes, M.C.N. (2008). Colour Atlas of postharvest quality of fruits and vegetables, p. 239–243. UK: John Wiley and Sons, INC. <https://doi.org/10.1002/9780813802947>
- Ranganna, S. (2001). Hand Book of Analysis and Quality Control for Fruits and Vegetable Products. 7th ed., p. 594–625. New Delhi, India: Tata McGraw Hill Book Co.
- Rodrigo, M.J. and Zacarias, L. (2007). Effect of postharvest ethylene treatment on carotenoid accumulation and the expression of carotenoid biosynthesis genes in the flavedo of orange (*Citrus sinensis* L. Osbeck) fruit. *Postharvest Biology Technology*, 43(1), 14–22. <https://doi.org/10.1016/j.postharvbio.2006.07.008>
- Sakhale, B.K., Gaikwad, S.S. and Chavan, R.F. (2017). Effect of 1-Methylcyclopropene on Physicochemical Changes and Shelf Life of Mango fruit (Kesar). *Journal of Food Science and Technology*, 55(2), 776–781. <https://doi.org/10.1007/s13197-017-2990-0>
- Sañudo, J., Siller, J. Osuna, T., Muy Rangel, D., López, G. and Labavitch, J. (2008). Control de la maduración en frutos de papaya (*Carica papaya* L.) con 1-metilciclopropeno y ácido 2-cloroetil fosfónico. *Revista Fitotecnia Mexicana*, 31, 141–147.
- Serek, M., Sisler, E.C. and Reid, M.S. (1994). Novel gaseous ethylene binding inhibitor prevents ethylene effects in potted flowering plants. *Journal of the American Society for Horticultural Science*, 119(6), 1230–1233. <https://doi.org/10.21273/JASHS.119.6.1230>
- Sisler, E.C. (2006). The discovery and development of compounds counteracting ethylene at the receptor level. *Biotechnology*, 24(4), 357–367. <https://doi.org/10.1016/j.biotechadv.2006.01.002>