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# Effect of 1-Methylcyclopropene on 'Le-Conte' Pear Storability

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**Abstract:** This investigation was carried out during 2009 and 2010 seasons to evaluate the effect of 1-MCP (1-Methylcyclopropene) on Le-Conte pear fruits storability and shelf life. 1-MCP was used in two concentrations; 1 and 2ppm applied to mature green fruits before storage at 0°C, 90-95 % relative humidity for 3 months followed by storage at 20°C, 90-95 % relative humidity for 12 days. Storability of pear cv. 'Le-Conte' was maintained by using 1-MCP compared with the control. 1ppm 1-MCP treatment suppressed the increase in decay, weight loss percentage and respiration rate. Firmness, T.S.S/Acid ratio and carotenoids content were affected significantly in treated fruits throughout storage and shelf life. These results indicated that 1ppm 1-MCP treatment maintained fruit quality during storage and shelf life as it slowed down physical and chemical changes occurred at ripening and deterioration.

**Key words:** Pear · Le-Conte cultivar · 1-MCP · Fruit quality · Storage · Shelf life

## INTRODUCTION

Pear fruit is one of the favorite fruits of temperate zone and is considered the third of deciduous fruits and the fourth among all fruits in its global distribution [1]. Le-Conte is the main pear cultivar grown in Egypt, resulted as a hybrid between *Pyrus communis* x *Pyrus serotina*, it is important to extend its storability and shelf life. Ethylene is known to coordinate fruit ripening and softening in climacteric fruits [2]. 1-Methylcyclopropene (1-MCP) is an inhibitor of ethylene binding that can prevent ethylene-dependent responses in many fruits [3, 4]. However, a fruit with many cultivars, each with unique ripening rates, susceptibility to physiological and pathological disorders and storage potential. De Wild *et al.* [5] suggested that, short-term controlled atmosphere storage might be replaced by 1-MCP treatment. Kim *et al.* [6] reported that, the storage periods of 'Wonhwang' pear was prolonged about 5-7 days in the case of 1-MCP treatment under the room temperature conditions. Both preharvest and postharvest 1-MCP treatments substantially reduced the incidence and severity of senescent scald, core breakdown and storage rots [7]. The objective of this research was to evaluate the effect of 1-MCP on Le-Conte pear fruits storability and shelf life.

## MATERIALS AND METHODS

This study was carried out during 2009 and 2010 seasons in the Experimental Research Station of the Faculty of Agriculture, Cairo University at Giza, Egypt. Pear fruits cv. 'Le-Conte' were harvested at the commercial mature stage according to Kilany [8]; the harvested fruits were selected uniform in size and skin colour and free of obvious mechanical damage and pathological defects, selected fruits were randomly divided into three groups; the first was control, the second group was treated by 1ppm 1-MCP (0.14% formulation, SmartFresh, AgroFresh, Inc.) for 24 hr and the third group was treated by 2 ppm 1-MCP for 24 hr. Then all treatments were stored at 0°C and 90-95 % relative humidity for 3 months followed by storage at 20°C for 12 days as shelf life period. Three fruits from each replicate were taken to determine the effect of the applied treatments on some physical and chemical parameters compared with the control fruits. Decay percentage was calculated on the bases of number of discarded fruits / total number of fruits × 100.

Fruit weight loss percentage was calculated using the following equation; (Fruit initial weight – Fruit weight at each sampling date) / Fruit initial weight × 100.

Fruit firmness was measured according to Mitcham *et al.* [9], data were presented in Ib/ inch$^2$. Instrumental peel colour was measured on two paired cheeks of each fruit objectively using a Minolta CR-200 chromameter (Minolta, Osaka, Japan) using the Commission International de l'Eclairage (CIE). Total sugars were determined according to Malik and Singh [10]. Respiration rate was measured by analyzing carbon dioxide by gas chromatography [11].

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Total phenols were determined colourmetrically using Folin Denis reaction methods according to Swain and Hillis [12]. Carotenoids were calculated according to the equation described by Norani [13]. A completely randomized block design was followed; the treatment means were compared using the methods of LSD at the 5% level of significance [14].

## RESULTS AND DISCUSSION

**Decay Percentage:** There was a positive relationship between decay percentage and periods of storage in all treatments in both seasons and it was significantly different, as shown in Tables 1 and 2 revealed that, control fruits showed the highest values. On the other hand 1ppm 1-MCP recorded 5.56 and 2.8% in the first and the second season respectively during storage at 0°C, whereas 2ppm 1-MCP recorded 25 and 17.44% in the first and the second season respectively during storage at 20°C.

**Weight Loss (%):** Tables 3 and 4 showed that, weight loss increased continuously during the storage period in both seasons, 1ppm 1-MCP treatment showed the lowest values; 7.98 and 16.36% in 2009 season during storage period and shelf life respectively. While control showed the highest values in both seasons.

**Instrumental Colour:** a* peel value increased by time as shown in Tables 5 and 6 in both seasons. The differences between treatments were non-significant in the first season. While 2ppm 1-MCP treatment showed the lowest values in the second season during storage and shelf life by -14.4 and -13.4 respectively.

Table 1: Decay (%) during storage at 0°C as affected by 1-MCP treatments in 2009 and 2010 seasons

| | Days of storage (B) | | | | Days of storage (B) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment (A) | Initial | 30 | 60 | 90 | Initial | 30 | 60 | 90 |
| | | 2009 season | | | | 2010 season | | |
| Control | 0.00 | 0.00 | 2.78 | 8.33 | 0.00 | 0.00 | 2.92 | 8.67 |
| 1ppm | 0.00 | 0.00 | 0.00 | 5.56 | 0.00 | 0.00 | 0.00 | 2.80 |
| 2ppm | 0.00 | 0.00 | 0.00 | 8.13 | 0.00 | 0.00 | 0.00 | 7.94 |
| L.S.D $^{0.05}$ | (A × B) = 0.80 | | | | (A × B) = 0.72 | | | |

Table 2: Effect of 1-MCP treatments on decay (%) during storage at 20°C in 2009 and 2010 seasons

| | Days of shelf life (B) | | | | Days of shelf life (B) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment (A) | Initial | 4 | 8 | 12 | Initial | 4 | 8 | 12 |
| | | 2009 season | | | | 2010 season | | |
| Control | 8.33 | 22.48 | 36.07 | 55.27 | 8.67 | 19.44 | 36.07 | 52.78 |
| 1ppm | 5.56 | 11.14 | 21.48 | 27.78 | 2.80 | 7.15 | 13.93 | 22.22 |
| 2ppm | 8.13 | 11.14 | 19.44 | 25.00 | 7.94 | 8.89 | 11.11 | 17.44 |
| L.S.D $^{0.05}$ | (A × B) = 0.66 | | | | (A × B) = 0.80 | | | |

Table 3: Weight loss (%) during storage at 0°C as affected by 1-MCP treatments in 2009 and 2010 seasons

| | Days of storage (B) | | | | Days of storage (B) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment (A) | Initial | 30 | 60 | 90 | Initial | 30 | 60 | 90 |
| | | 2009 season | | | | 2010 season | | |
| Control | 0.00 | 5.63 | 7.38 | 14.93 | 0.00 | 5.43 | 8.70 | 10.03 |
| 1ppm | 0.00 | 6.43 | 7.25 | 7.98 | 0.00 | 5.41 | 8.97 | 10.53 |
| 2ppm | 0.00 | 6.39 | 8.01 | 10.97 | 0.00 | 4.60 | 9.96 | 11.29 |
| L.S.D $^{0.05}$ | (A × B) = 1.27 | | | | (A × B) = 0.60 | | | |

Table 4: Effect of 1-MCP treatments on weight loss (%) during storage at 20°C in 2009 and 2010 seasons

| | Days of shelf life (B) | | | | Days of shelf life (B) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment (A) | Initial | 4 | 8 | 12 | Initial | 4 | 8 | 12 |
| | | 2009 season | | | | 2010 season | | |
| Control | 14.93 | 19.55 | 19.65 | 21.68 | 10.03 | 12.34 | 16.08 | 20.90 |
| 1ppm | 7.98 | 8.25 | 10.95 | 16.36 | 10.53 | 13.21 | 16.96 | 20.45 |
| 2ppm | 10.97 | 13.42 | 15.66 | 18.45 | 11.29 | 13.99 | 17.63 | 20.83 |
| L.S.D $^{0.05}$ | (A × B) = 1.34 | | | | (A × B) = 0.76 | | | |

Table 5: a*Peel value during storage at 0°C as affected by 1-MCP treatments in 2009 and 2010 seasons

| | Days of storage (B) | | | | Days of storage (B) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment (A) | Initial | 30 | 60 | 90 | Initial | 30 | 60 | 90 |
| | | 2009 season | | | | 2010 season | | |
| Control | -14.5 | -13.2 | -12.4 | -11.8 | -15.2 | -14.4 | -14.1 | -13.2 |
| 1ppm | -14.5 | -13.8 | -13.3 | -12.6 | -15.2 | -15.1 | -14.5 | -13.9 |
| 2ppm | -14.5 | -13.1 | -12.3 | -12.0 | -15.2 | -14.8 | -14.6 | -14.4 |
| L.S.D $^{0.05}$ | (A × B) = 1.9 | | | | (A × B) = 1.5 | | | |

Table 6: Effect of 1-MCP treatments on a*Peel value during storage at 20°C in 2009 and 2010 seasons

| | Days of shelf life (B) | | | | Days of shelf life (B) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment (A) | Initial | 4 | 8 | 12 | Initial | 4 | 8 | 12 |
| | | 2009 season | | | | 2010 season | | |
| Control | -11.8 | -11.7 | -11.2 | -10.5 | -13.2 | -12.9 | -11.4 | -10.3 |
| 1ppm | -12.6 | -12.2 | -11.1 | -10.7 | -13.9 | -13.6 | -12.9 | -12.4 |
| 2ppm | -12.0 | -11.5 | -10.9 | -10.8 | -14.4 | -14.3 | -14.1 | -13.4 |
| L.S.D $^{0.05}$ | (A × B) = 2.6 | | | | (A × B) = 2.3 | | | |

**Firmness:** Data in Tables 7 and 8 showed the effect of 1-MCP treatments on firmness in both seasons. Firmness decreased continuously with storage time during both seasons. The differences between treatments were non-significant in both seasons during storage. Whereas 1ppm 1-MCP treatment maintained the highest significant levels after 12 days during storage at 20°C in both seasons which reached 17.78 and 15.67 Ib/ inch$^2$ respectively.

**T.S.S/Acid Ratio:** Tables 9 and 10 showed the effect of 1-MCP treatments on T.S.S/Acid ratio during storage and shelf life in both seasons, 1ppm 1-MCP recorded the highest significant levels as it reached 97.46 and 98.19 in the first and the second season respectively.

**Respiration Rate:** Data in Tables 11 and 12 showed that, 1-MCP treatments were the lowest significant rates during 2009 and 2010 seasons compared with the control which reached 11.19 and 11.47 in the first and the second season respectively.

**Total Sugars:** Total sugars increased gradually during storage. On the other hand, the differences between treatments were non-significant in both seasons (data are not shown).

**Total Phenols:** Total Phenols decreased continuously during the storage (Tables 13 and 14), phenols decreased significantly in control, while 1-MCP treatments showed higher significant values during 2010 season.

**Carotenoids:** Tables 15 and 16 presented the effect of 1-MCP treatments on fruits content of carotenoids which showed lower values in both seasons compared with the control which reached 0.81 and 0.97 mg /100 gm in the first and the second season respectively.

The present study revealed that 1-MCP treatments maintained fruit quality including physical and chemical parameters as it slowed down changes occurred during ripening and deterioration. This data are similar to this found by Kim *et al.* [6] who reported that, the storage periods of 'Wonhwang' pear were prolonged about 5-7 days in the case of 1-MCP treatment under room temperature conditions and found that MCP slowed down respiration compared with control.

Calvo [15] showed that, 1-MCP treatment slowed loss of firmness, titratable acidity, colour change, decreased ripening and prevented development of several physiological disorders in 'Williams' pears, also trend of data was similar to this which was obtained by Robert *et al.* [16].

Also Zhi and Wang [7] found that, 1-MCP was very effective in decreasing decay as 1-MCP treatments substantially reduced the incidence and severity of senescent scald, core breakdown and storage rots. 1-MCP has the potential to slow softening and to prevent disorders of fruits [17, 11, 6]. The mechanism of action of 1-MCP involves it tightly binding to the ethylene receptor in plants and thereby blocking the effects of ethylene [18-20]. Watkins *et al.* [4] showed that, 1-MCP reduced superficial scald incidence and accumulations of $\alpha$-farnesene and conjugated trienols during storage. These results indicate that, 1ppm 1-MCP treatment maintains fruit quality as it delays physical and chemical changes attendant with deterioration.

Table 7: Firmness (Ib/ inch$^2$) during storage at 0°C as affected by 1-MCP treatments in 2009 and 2010 seasons

| | Days of storage (B) | | | | Days of storage (B) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment (A) | Initial | 30 | 60 | 90 | Initial | 30 | 60 | 90 |
| | 2009 season | | | | 2010 season | | | |
| Control | 20.78 | 20.12 | 19.04 | 14.58 | 24.88 | 22.37 | 19.40 | 17.07 |
| 1ppm | 20.78 | 20.54 | 19.11 | 18.71 | 24.88 | 23.40 | 22.04 | 20.13 |
| 2ppm | 20.78 | 19.47 | 18.96 | 18.48 | 24.88 | 22.36 | 21.94 | 18.75 |
| L.S.D $^{0.05}$ | (A × B) = 5.52 | | | | (A × B) = 4.68 | | | |

Table 8: Effect of 1-MCP treatments on firmness (Ib/ inch$^2$) during storage at 20°C in 2009 and 2010 seasons

| | Days of shelf life (B) | | | | Days of shelf life (B) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment (A) | Initial | 4 | 8 | 12 | Initial | 4 | 8 | 12 |
| | 2009 season | | | | 2010 season | | | |
| Control | 14.58 | 11.29 | 10.51 | 9.00 | 17.07 | 15.77 | 14.82 | 7.92 |
| 1ppm | 18.71 | 18.35 | 17.92 | 17.78 | 20.13 | 16.90 | 16.67 | 15.67 |
| 2ppm | 18.48 | 18.17 | 17.60 | 17.45 | 18.75 | 16.93 | 16.50 | 15.51 |
| L.S.D $^{0.05}$ | (A × B) = 3.74 | | | | (A × B) = 0.85 | | | |

Table 9: T.S.S/ Acid ratio during storage at 0°C as affected by 1-MCP treatments in 2009 and 2010 seasons

| | Days of storage (B) | | | | Days of storage (B) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment (A) | Initial | 30 | 60 | 90 | Initial | 30 | 60 | 90 |
| | 2009 season | | | | 2010 season | | | |
| Control | 16.91 | 22.31 | 34.17 | 36.02 | 23.28 | 29.74 | 52.70 | 58.44 |
| 1ppm | 16.91 | 23.52 | 36.05 | 39.71 | 23.28 | 30.95 | 51.77 | 61.33 |
| 2ppm | 16.91 | 24.27 | 33.51 | 43.56 | 23.28 | 31.79 | 49.39 | 59.26 |
| L.S.D $^{0.05}$ | (A × B) = 4.42 | | | | (A × B) = 6.79 | | | |

Table 10: Effect of 1-MCP treatments on T.S.S/ Acid ratio during storage at 20°C in 2009 and 2010 seasons

| | Days of shelf life (B) | | | | Days of shelf life (B) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment (A) | Initial | 4 | 8 | 12 | Initial | 4 | 8 | 12 |
| | 2009 season | | | | 2010 season | | | |
| Control | 36.02 | 36.87 | 40.23 | 57.58 | 58.44 | 64.73 | 73.18 | 81.04 |
| 1ppm | 39.71 | 44.31 | 49.13 | 97.46 | 61.33 | 75.62 | 87.56 | 98.19 |
| 2ppm | 43.56 | 38.55 | 44.13 | 95.74 | 59.26 | 69.48 | 83.71 | 92.43 |
| L.S.D $^{0.05}$ | (A × B) = 16.52 | | | | (A × B) = 14.85 | | | |

Table 11: Respiration rate (ml $CO_2$ / kg fruit / hr) during storage at 0°C as affected by 1-MCP treatments in 2009 and 2010 seasons

| | Days of storage (B) | | | | Days of storage (B) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment (A) | Initial | 30 | 60 | 90 | Initial | 30 | 60 | 90 |
| | 2009 season | | | | 2010 season | | | |
| Control | 4.32 | 3.58 | 4.00 | 4.40 | 3.75 | 1.97 | 2.30 | 3.65 |
| 1ppm | 4.32 | 2.33 | 2.56 | 2.89 | 3.75 | 2.16 | 2.30 | 2.75 |
| 2ppm | 4.32 | 2.34 | 2.76 | 3.01 | 3.75 | 1.63 | 2.05 | 2.54 |
| L.S.D $^{0.05}$ | (A × B) = 0.57 | | | | (A × B) = 0.46 | | | |

Table 12: Effect of 1-MCP treatments on respiration rate (ml $CO_2$ / kg fruit / hr) during storage at 20°C in 2009 and 2010 seasons

| | Days of shelf life (B) | | | | Days of shelf life (B) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment (A) | Initial | 4 | 8 | 12 | Initial | 4 | 8 | 12 |
| | 2009 season | | | | 2010 season | | | |
| Control | 4.40 | 4.48 | 5.23 | 11.19 | 3.65 | 4.76 | 5.37 | 11.47 |
| 1ppm | 2.89 | 3.39 | 4.94 | 8.08 | 2.75 | 3.68 | 5.89 | 8.40 |
| 2ppm | 3.01 | 3.13 | 4.74 | 8.29 | 2.54 | 3.98 | 5.97 | 8.77 |
| L.S.D $^{0.05}$ | (A × B) = 0.75 | | | | (A × B) = 0.36 | | | |

Table 13: Total phenols (%) during storage at 0°C as affected by 1-MCP treatments in 2009 and 2010 seasons

| | Days of storage (B) | | | | Days of storage (B) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment (A) | Initial | 30 | 60 | 90 | Initial | 30 | 60 | 90 |
| | 2009 season | | | | 2010 season | | | |
| Control | 1.10 | 1.03 | 0.83 | 0.77 | 1.71 | 1.41 | 1.03 | 0.92 |
| 1ppm | 1.10 | 0.92 | 0.70 | 0.54 | 1.71 | 1.42 | 1.34 | 1.16 |
| 2ppm | 1.10 | 0.72 | 0.62 | 0.59 | 1.71 | 1.40 | 1.17 | 1.07 |
| L.S.D $^{0.05}$ | (A × B) = 0.69 | | | | (A × B) = 0.59 | | | |

Table 14: Effect of 1-MCP treatments on total phenols (%) during storage at 20°C in 2009 and 2010 seasons

| | Days of shelf life (B) | | | | Days of shelf life (B) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment (A) | Initial | 4 | 8 | 12 | Initial | 4 | 8 | 12 |
| | 2009 season | | | | 2010 season | | | |
| Control | 0.77 | 0.75 | 0.41 | 0.38 | 0.92 | 0.90 | 0.88 | 0.25 |
| 1ppm | 0.54 | 0.46 | 0.24 | 0.23 | 1.16 | 0.86 | 0.84 | 0.28 |
| 2ppm | 0.59 | 0.53 | 0.34 | 0.32 | 1.07 | 0.83 | 0.50 | 0.41 |
| L.S.D $^{0.05}$ | (A × B) = 0.49 | | | | (A × B) = 0.35 | | | |

Table 15: Carotenoids (mg /100 gm) during storage at 0°C as affected by 1-MCP treatments in 2009 and 2010 seasons

| | Days of storage (B) | | | | Days of storage (B) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment (A) | Initial | 30 | 60 | 90 | Initial | 30 | 60 | 90 |
| Control | 0.115 | 0.136 | 0.433 | 0.564 | 0.213 | 0.555 | 0.683 | 0.752 |
| 1ppm | 0.115 | 0.225 | 0.325 | 0.421 | 0.213 | 0.449 | 0.466 | 0.508 |
| 2ppm | 0.115 | 0.263 | 0.334 | 0.514 | 0.213 | 0.477 | 0.566 | 0.604 |
| L.S.D $^{0.05}$ | (A × B) = 0.271 | | | | (A × B) = 0.227 | | | |

Table 16: Effect of 1-MCP treatments on carotenoids (mg /100 gm) during storage at 20°C in 2009 and 2010 seasons

| | Days of shelf life (B) | | | | Days of shelf life (B) | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment (A) | Initial | 4 | 8 | 12 | Initial | 4 | 8 | 12 |
| | 2009 season | | | | 2010 season | | | |
| Control | 0.564 | 0.618 | 0.791 | 0.810 | 0.752 | 0.759 | 0.811 | 0.970 |
| 1ppm | 0.421 | 0.430 | 0.618 | 0.633 | 0.508 | 0.569 | 0.583 | 0.616 |
| 2ppm | 0.514 | 0.526 | 0.526 | 0.571 | 0.604 | 0.616 | 0.676 | 0.677 |
| L.S.D $^{0.05}$ | (A × B) = 0.302 | | | | (A × B) = 0.107 | | | |

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