

Improving Postharvest Quality of Glasshouse Tomatoes Treated with 1-MCP at Ripeness Stage

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Abstract: Glasshouse tomatoes (*Lycopersicon esculentum* Mill) 'Falcato' harvested at light red stage were treated with 1-methylcyclopropene (1-MCP) in the concentration range 0.45-1.8 $\mu\text{l l}^{-1}$ for 24 h at 20°C and stored in 30 μm thick polyethylene bags at 20°C. Ripening of tomato held at 20°C delayed by exposure to 1-MCP and related to the concentration of 1-MCP. 1-MCP treatment delayed softening and extended shelf life in association with suppression of respiration. 1-MCP treated fruit at 0.9-1.8 $\mu\text{l l}^{-1}$ showed a reduced loss of titratable acid, soluble solid content, fruit firmness and color changes. 1-MCP applied to ripe tomatoes for 24 h at 0.9-1.8 $\mu\text{l l}^{-1}$ resulted in an increase in postharvest shelf life based on fruit appearance, with exposure to 1.8 $\mu\text{l l}^{-1}$ giving a 3 fold more (18 days) increase in shelf life, compared to control none-treated tomatoes (6 days). These results indicated that 1-MCP is an effective tool for quality improvement and extension of shelf life in glasshouse tomatoes and fruit might be harvested in stage 5 (light red) of ripening at which the most desirable organoleptic attributes had been developed on fruits.

Key words: Shelf life • 1-methylcyclopropene • *Lycopersicon esculentum* • firmness

INTRODUCTION

In climacteric fruit such as tomato the ethylene burst is required for normal fruit ripening, as illustrated by the slowing down or inhibition of ripening in ethylene-suppressed transgenic plants [1]. Non-climacteric fruits do not show a dramatic respiration or ethylene burst, nor do they continue to develop after harvest. Instead they undergo senescence process which is parallel some of the same process occurring in ripening fruit [2]. However, slowing the process of ripening and senescence extends the storage and shelf-life of fresh fruit and vegetables. This is achieved mainly by holding the commodity in a low temperature, altering the gas composition around the commodity. On the other hand, premature softening, induced by ethylene, as a serious commercial problem limiting the shipping, storage and shelf life of fruits includes tomato. However, recently a new tool, 1-methylcyclopropene (1-MCP), has been added to the methods used for extending shelf-life and quality of plant tissue. 1-methylcyclopropene has been successfully used in fruits in which it temporarily delays normal

ripening events due to interferes with ethylene link to its binding site represents a new and powerful tool for postharvest management of climacteric fruits [3]. It has been demonstrated that the inhibition of the ethylene action delays ripening and senescence in several species of fruits [3-5]. The success of the 1-MCP treatment depends on the method of application, duration and concentration as well as commodity factors such as maturity stage, cultivar and atmosphere [6]. Different concentrations and exposure times are effective at physiological such as; color turning and softening, increase in ethylene and respiration [7, 8]. 1-MCP extends the shelf life of conventional tomato cultivars at all stages of maturity [4, 9]. The shelf life of long life tomatoes is considerable extended compared with conventional tomato cultivars [10].

It is not clear if 1-MCP will benefit for glasshouse cultivar (Falcato) that widely grown during winter in Iran. Therefore, the purpose of this work was to evaluate the effects of 1-MCP concentration on "Falcato" a glasshouse tomato cultivar to extend postharvest shelf life.

MATERIALS AND METHODS

Tomato (*Lycopersicon esculentum* L.) cultivar "Falcato" (glasshouse tomato) were harvested during morning hours from a commercial field near Isfahan (central Iran) in 2004 and 2005. Fruits were immediately taken to the laboratory for experimentation. Fruits were sort for color, uniform size and freedom from defects and blemishes and stored overnight at 8°C. The next day, light red (stage 5) tomato fruit were identified and used for the study to provide three replicates of 40 fruit for each treatment. A sample of 20 fruits was analyzed to determine initial firmness, color, soluble solid content, respiration and titrable acid content.

1-MCP gas concentrations were 0.45, 0.9 and 1.8 $\mu\text{l l}^{-1}$, based on free container volume. Untreated control and 1-MCP-treated fruit were held in hermetic 28-l polyethylene containers. Ethylblock powder has 0.14% active ingredient and is distributed by Floralife. The compound was weighted (according to the manufacture procedure) and placed in a 2-ml Eppendorf tube. To release the 1-MCP gas, appropriate distilled water at 20°C was added to the Eppendorf tubes. After shaking for 45 sec, the Eppendorf tubes were placed inside the containers and the tube cap opened. The container lid was immediately sealed and the container was stored at $20\pm 1^\circ\text{C}$ for 24 h. Concentrations were referred to the free volume of the container (about 61% of the total volume).

After treatment with 1-MCP, the containers were ventilated for 1 h in air and the fruit were randomly divided into bags of 30 fruit each. The three replicates per treatment and inspection day used for quality analysis were obtained by sampling five fruit from three different bags. Fruit were sealed in 30 μm thick, polyethylene bags (O_2 transmission $6800 \text{ ml/m}^2/24 \text{ h/atm}$ and CO_2 transmission $3500 \text{ ml/m}^2/24 \text{ h/atm}$ at 20°C). Bags were stored at $20\pm 1^\circ\text{C}$ in a gas-tight container with a continuous 95% RH.

Quality parameters and senescence were evaluated at 20°C at harvest and on the 3rd, 6th, 9th, 12th, 15th and 18th day after harvest. Senescence was evaluated visually and by measuring fruit softening. Color was measured using a color meter (Minolta CR-200 colorimeter, Japan) calibrated with a white reference plate ($Y = 94.3$, $x = 0.3142$ and $y = 0.3211$). Fruit firmness was evaluated on three points of the fruit equator with a fruit pressure tester with a 9 mm probe tip. Juice squeezed and pH was measured using a pH meter. Soluble solid content (SSC) were measured with a hand refractometer. Titratable acidity was measured by titration of 5-ml samples with

0.1 mol NaOH to an endpoint of pH = 8.1. Respiration was measured by placing each treatment and replication of 12 fruit in 4 l glass jar hermitically sealed with a rubber stopper for 1 h. CO_2 evaluation in samples taken from the exit flow from each jar, using infrared CO_2 detection, following storage the fruits at 20°C after 0, 9 and 18 days of 1-MCP treatment.

All statistical procedures were performed using Mstat. Data were subject to ANOVA. Least significant differences (LSDs) were determined at $p < 0.05$ to compare means. The values presented in the fingers were means of three replications. SE indicates standard error and experiment replicated three times.

RESULTS

Flesh firmness is probably the best predictor of tomato shelf life. Control glasshouse tomatoes cultivar "Falcato" placed at 20°C after harvest reached their minimum flesh firmness after 18 days (Fig. 1). Application of 0.9 $\mu\text{l l}^{-1}$ 1-MCP was sufficient to delay tomato softening (Fig. 1). Fruit treated with 1.8 $\mu\text{l l}^{-1}$ 1-MCP showed higher firmness value than fruit treated with 0.9 $\mu\text{l l}^{-1}$ 1-MCP between days 6 to 15 but no significant difference was detected at the end of the experiment period. However, there was no significant difference in firmness between fruit treated with 0.45 $\mu\text{l l}^{-1}$ 1-MCP and control non-treated fruits. Control fruit were considered verly soft ($< 0.6 \text{ kg}$) after 6 d of storage, but fruit treated with 0.9 or 1.8 $\mu\text{l l}^{-1}$ 1-MCP were firmer and had greater than 0.6 kg fruit firmness even after 18 d at 20°C.

1-MCP treated fruit effectively reduced loss of titratable acidity after 18 days storing at 20°C (Fig. 2). Fruits treated with 1-MCP (0.9 $\mu\text{l l}^{-1}$) was showed that has higher than control fruit titratable acidity until 15 days storing at 20°C and the differences was highly significant and the effect was more pronounced at the higher concentration used (Fig. 2).

Mean percent of soluble solids content was greater in 1-MCP-treated fruit than untreated fruit from day 3 to day 18 after 1-MCP treatment (Fig. 3). In control fruits, SSC decreased from 4.1% (day 0) to reached a minimum of 3.4% (day 18). In fruit treated with 0.45 $\mu\text{l l}^{-1}$ 1-MCP, SSC remained low (3.5%) after 18 days fruits stored at 20°C. The increase of SSC in fruit treated with 1-MCP underwent future retardation (Fig. 3).

In contrast, visible changes in tomato skin color do not so much occur after treating fruits with 1-MCP. However, a decrease in hue angle (H°) values became apparent in tomato during storing fruits at 20°C (Fig. 4).

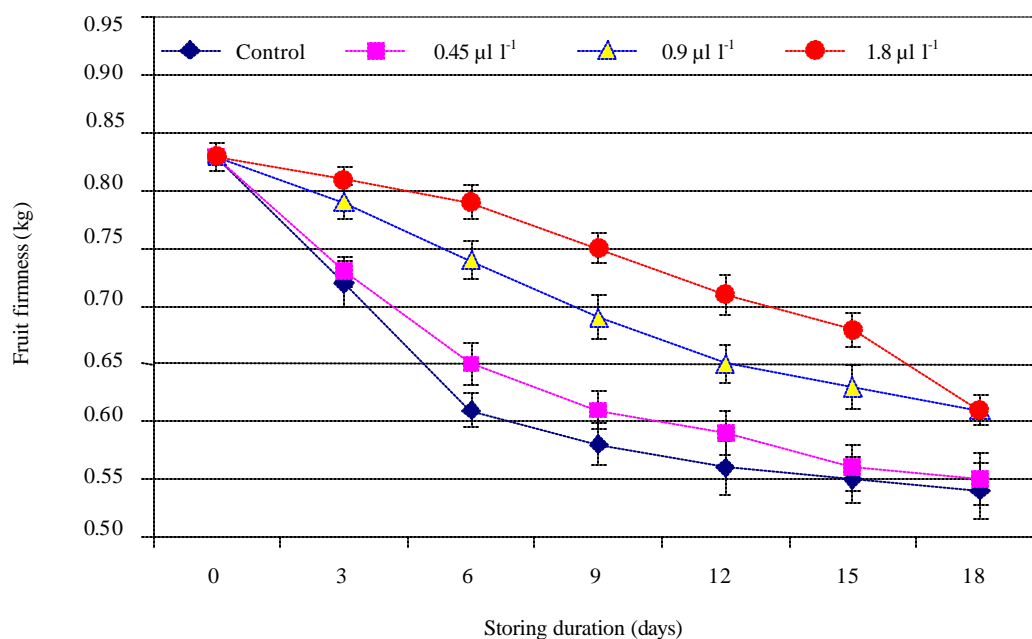


Fig. 1: Firmness of ripe glasshouse tomato "Falcato" treated at harvest with 1-MCP for 24 h and stored for 18 days at ambient air temperatures (20°C). Vertical bars represent S.E. of mean

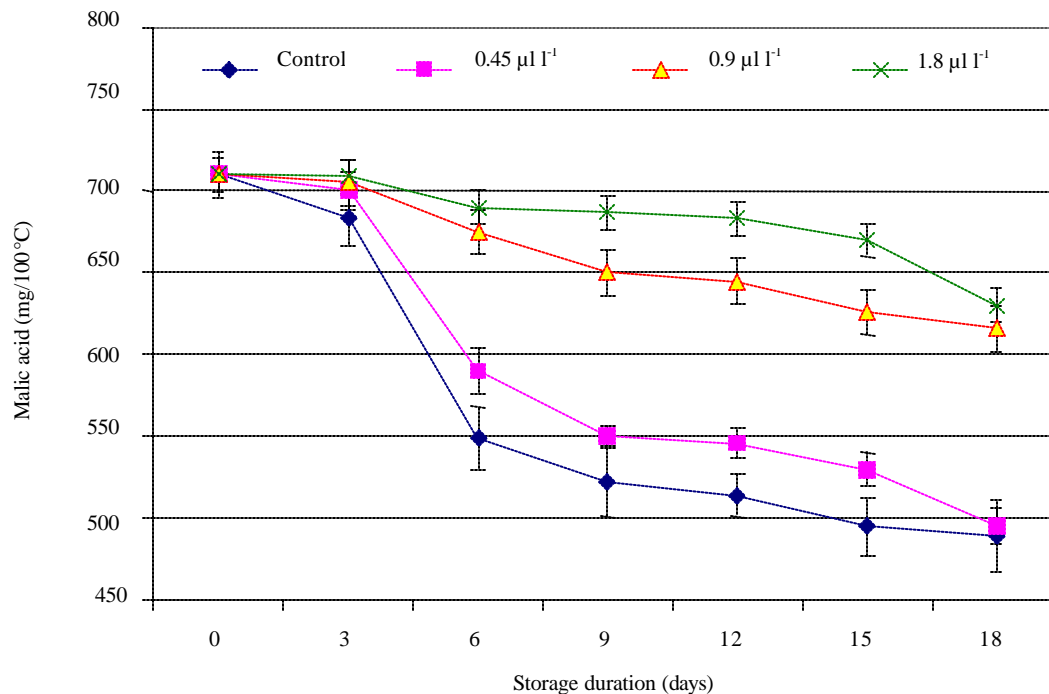


Fig. 2: Changes in malic acid content of ripe glasshouse tomato "Falcato" and treated at harvest with 1-MCP for 24 h at 20°C and stored at ambient air temperatures of 20°C. Vertical bars represent S.E. of mean

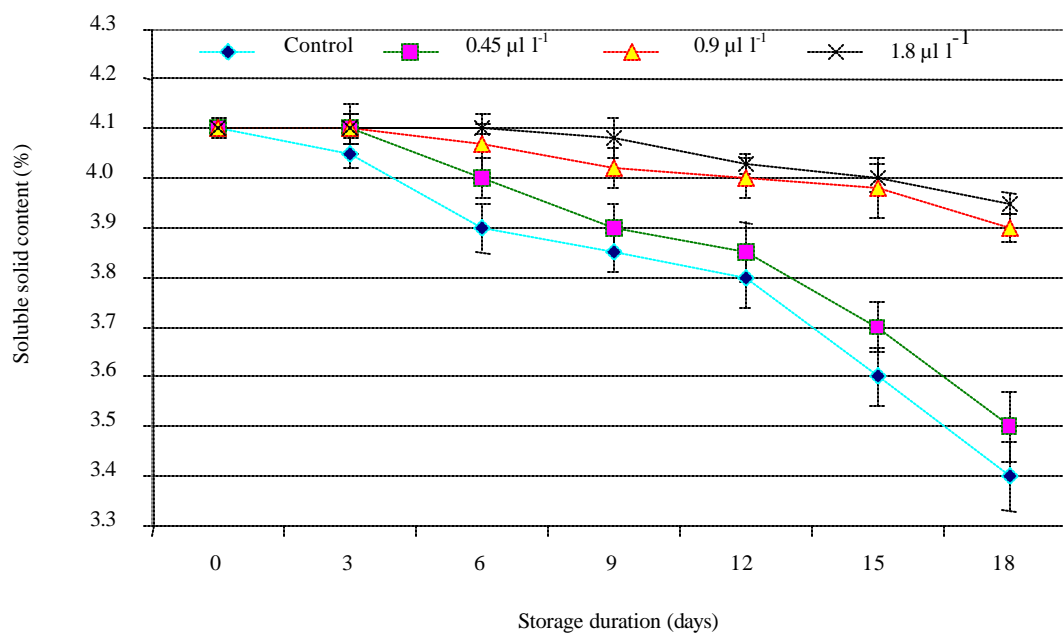


Fig. 3: Changes in Soluble Solid Content of ripe glasshouse tomato "Falcato" and treated at harvest with 1-MCP for 24 h at 20°C and stored at ambient air temperatures of 20°C. Vertical bars represent S.E. of mean

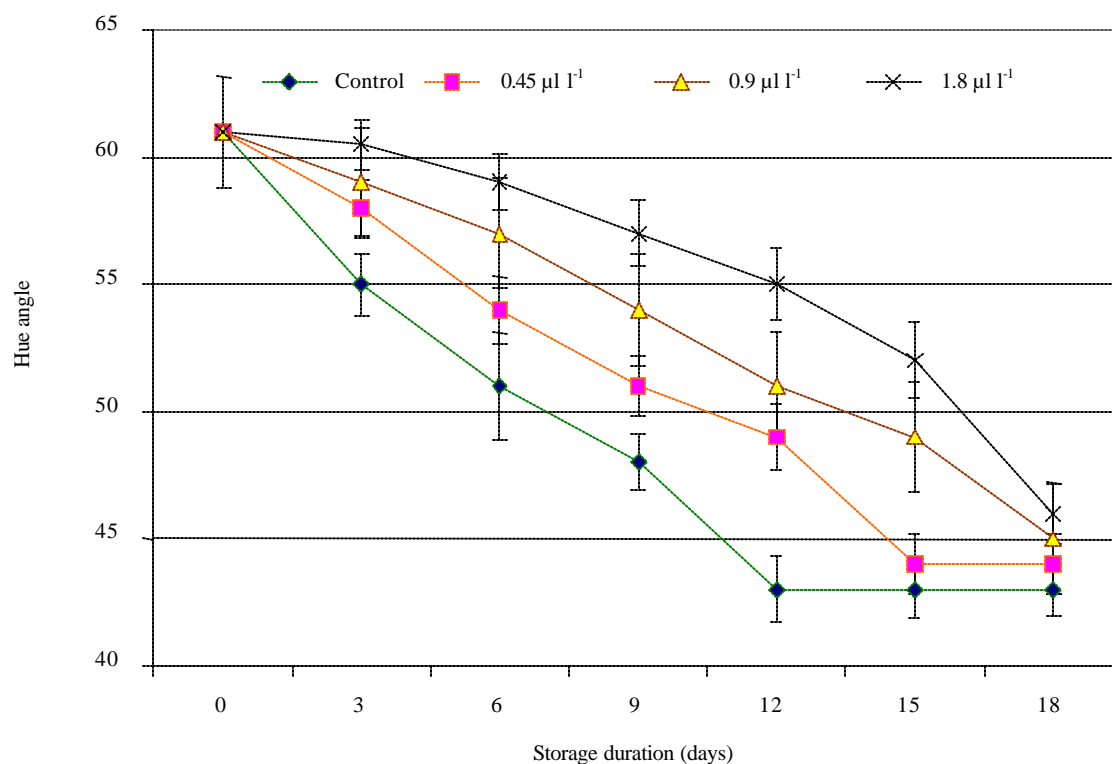


Fig. 4: Color (as hue angle) of glasshouse tomato (Falcato) stored at 20°C following 1-MCP treatment. Vertical bars represent S.E. of mean

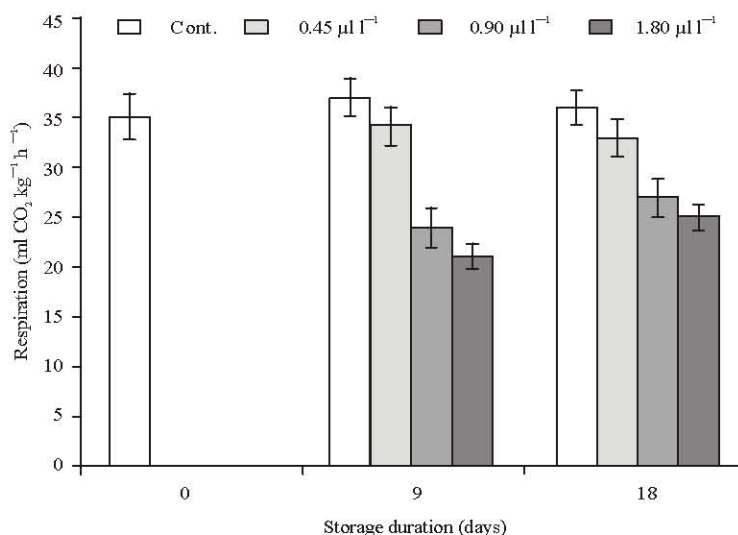


Fig. 5: Respiration of glasshouse tomato (Falcato) stored at 20°C following 1-MCP treatment. Vertical bars represent SE of mean

1-MCP slowed down these changes when utilized after treatment. H° value of 1-MCP treated fruit after 18 days of storing were similar to those of control none-treated fruit. Increasing the 1-MCP concentration from 0.9 to 1.8 µl l⁻¹ should fewer changes in H° between days 9 and 12 but no significant difference was measured at the end of the storage period.

The initial level of respiration rate for tomato at 20°C was 35 ml CO₂.kg⁻¹.h⁻¹ (Fig. 5). Respiration dropped sharply in fruits treated with 1-MCP during storing fruits at 20°C. Fruits treated with 1.8 µl l⁻¹ 1-MCP has significantly lower respiration for day 9, compared to the control none-treated fruits. Respiration in tomato fruits at the end of storage (18 days), slightly increased, but the final levels being significantly higher in control than in 1-MCP treated fruits, for both concentrations (0.9 and 1.8 µl l⁻¹).

DISCUSSION

Ripening and senescence process of climacteric fruits regulated by the plant hormone ethylene and once the autocatalytic ethylene production start a wide range of both physical and chemical changes occur, such as tissue softening, pigment degradation and biosynthesis of new ones, changes in sugar and organic acid content and respiration pattern [11, 12]. These effects lead to an acceleration of the senescence process and in turn short periods of shelf life [2, 13]. Emerging research is focused to the use of non-contaminants mean to prolong the fruit

storability and to extend their shelf life. In this sense, application of 1-MCP in 'Falcato' tomato showed beneficial effects in term of significant reduction in respiration rate, retention of fruits firmness and color pigment, soluble solid content and titratable acid (Figs. 1-5). These effects were dose dependent since high correlation were found between the analyzed parameters and the 1-MCP applied dose. Then, fruit quality parameters could be maintained and increased shelf life could be also obtained. These results support the observations of Menniti *et al.* [5] and Valero *et al.* [8] in plums, Eduardo *et al.* [14] in fresh-cut banana, Able *et al.* [15] in leafy Asian vegetable, Jiange *et al.* [16] in banana, Harima *et al.* [17] in persimmon and Wills and Ku [18] in green and ripe tomatoes.

For consumer, fruit firmness and color are much appreciated sensorial attributes and sometimes the factors determining their acquisition. During ripening, color degradation and tissue softening occur which are related to the reduced shelf life, especially at 20°C. 1-MCP was able to maintain fruit firmness and color during 18 days at 20°C, while in control tomato after 6 days the firmness level dropped sharply. This behavior seems to be a general effect of 1-MCP in most of the studied fruits [19-21]. The intensity of the maintenance of fruit firmness and color was dose-dependent (Figs. 1 & 4), as was respiratory rate.

The background work for the discovery of 1-MCP as an ethylene inhibitor came out from work of Sisler and Blankenship [22]. Given that 1-MCP blocks ethylene

perception Sisler and Serek [23], it has the potential to prevent or slow limiting factors and processes contributing to the loss of shelf life that are dependent upon ethylene. 1-MCP also, will protect plant products from both endogenous and exogenous sources of ethylene which is resulted to delay ripening and senescence [2].

In terms of shelf life, it could be established that in control tomato the maximum storage period with optimum quality parameters was 1 week at 20°C, while for 1-MCP treated tomatoes the storability was extended up to *ca.* 3 weeks at 20°C, the 1.8 $\mu\text{l l}^{-1}$ being the dose that let better quality property, in which the great deterioration of control tomato is clear compared with the 1-MCP treated ones. Therefore, the use of 1-MCP would seem to have commercial potential for growers and traders to delay senescence of ripe tomatoes.

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