Forced-Air Cooling Reduces 1-MCP Application Duration on Plums (*Prunus salicina* Lindl.) without Reducing Effectiveness

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Abstract

A new application technology of applying 1-MCP during forced-air cooling (FAC) was tested in plums. The application time for 1-MCP was reduced from 24 h to 6 h without affecting treatment performance. 1-MCP–FAC treatment followed by storage at 10°C showed promise as a new methodology to avoid chilling temperatures and provide considerable energy savings without reducing postharvest life and consumer quality. This new 1-MCP application system is compatible with current postharvest handling, rendering it easy to adopt by the tree fruit industry. Our results encourage testing of this new technology at the commercial scale to accurately quantify energy savings and consumer reactions for specific operations and markets.

INTRODUCTION

Japanese plum (*Prunus salicina* L.) is a highly perishable temperate fruit and cold storage at 0°C is recommended to extend fruit postharvest life and maintain quality (Thompson et al., 2008). Most plum cultivars are susceptible to postharvest disorders such as chilling injury (CI) symptoms after prolonged cold storage and express CI symptoms during ripening at room temperature (Manganaris et al., 2008). The onset of these symptoms determines postharvest storage/shipping potential because CI development reduces consumer acceptance. Susceptibility of fruit to CI mainly varies according to genetic background and storage temperature (Crisosto et al., 1999; Crisosto et al., 2008).

Plum storage or transport at temperatures higher than 7.5°C to avoid CI has been tested in several cultivars and provided successful control of cold storage disorders, but fruit over-ripening, senescence, and softening overcame the benefits (Crisosto and Garner, 2008). 1-Methylcyclopropene (1-MCP) inhibits ethylene and prevents ethylene-dependent responses such as softening and senescence of vegetative and fruit tissues (Sisler and Serek, 1997). Its ability to inhibit plum ripening is well demonstrated (Abdi et al., 1998; Martinez-Romero et al., 2003; Candan et al., 2006), making it a promising approach for plum storage above chilling temperatures without undesired softening. The recommended application for stone fruit is 0.5 µl L^{-1} for 24 h in a sealed room or tent at 0°C. The 24-h application period recommended for stone fruits, which delays storage and packaging, is a potential barrier for use of 1-MCP. Postharvest forced-air cooling (FAC) is a commercial practice used worldwide on stone fruits to reduce disease development, softening, and weight loss of fresh fruit (Thomson et al., 2008). Forced-air cooling is a powerful tool that allows perishable produce to be marketed over long distances because it can cool produce quickly after harvest. It is the primary cooling method used for fresh fruits and vegetables in California prior to placing them in longer term cold storage (Thomson et al., 2008). This study attempted to avoid development of cold storage disorders during plum fruit storage by applying 1-MCP during forced-air cooling (~6 to 9 h). This method could eliminate the currently required 24 h application time and would not alter current plum postharvest operations and thus should be easily adopted by the stone fruit industry.

MATERIALS AND METHODS

Mid-season 'Fortune' (red) plums were commercially harvested, packed and delivered on the same day to the Gordon Mitchell Postharvest Lab at UC Kearney, Parlier, CA. Immediately after arrival, five replications of five fruits were used to measure fruit quality at harvest. Fruit were randomized and divided into three treatments: 1) untreated (control); 2) treated with 0.5 µl L^{-1} 1-MCP for 24 h at 0°C in sealed, 330-L aluminum tanks; and 3) treated with 0.5 µl L^{-1} 1-MCP for 6 h at 0°C in a forced-air cooler (1 L $s^{-1}kg^{-1}$) fitted in a sealed, 4000-L tent. Immediately after treatment, fruit from each treatment were split into two groups and stored at: 1) 0°C or 2) 10°C for up to 10 d. After storage at 0 or 10°C, five replicates of five fruits per treatment were transferred to room temperature (20°C, RH 90%) to evaluate fruit condition.

Ethylene production, respiration rate, tissue firmness, soluble solids content (SSC), titratable acidity (TA), and skin and flesh color of fruit were monitored during ripening at 20°C after removal from storage. Ethylene production and respiration rate were measured on five fruits sampled from each treatment using a gas chromatograph (model Carle AGC-211, EG&G Chandler Engineering, Tulsa, OK, USA). Respiration rate was calculated by carbon dioxide concentration in the gas phase of storage jars, measured by an infrared gas analyzer (Horiba PIR-2000R, Horiba Instruments Inc., Irvine, CA, USA). Fruit firmness was measured at the two opposite cheeks of each fruit after removal of peel (1 mm thick) using a UC Firmness Tester with a 8-mm probe. Five replicates of five fruits were used to analyze soluble solids content (SSC) and acidity (TA). Fruit skin and flesh color was measured with a portable colorimeter (Minolta CR-200, Minolta, Osaka, Japan) according to previous published protocols (Crisosto et al., 1997).

Data were subjected to analysis of variance and least significant differences (LSD) at the 5% level were used for comparing means using SPSS 17.0 for Windows (SPSS, Chicago, IL, USA).

RESULTS

The standard 1-MCP treatment (applied for 24 h at 0°C) and the novel methodology of applying 1-MCP during FAC (applied for 6 h at 0°C), both delayed ripening changes at both storage temperatures in 'Fortune' plums (Fig. 1). The efficacy of 1-MCP applied during FAC was similar to the standard 24 h application in both temperatures tested. Additionally, 1-MCP treated fruit stored at both temperatures showed reduced and delayed respiration rates compared to untreated fruit (Data non shown). Both 1-MCP application approaches (24-h standard and 6-h FAC) were significantly effective at protecting fruit from rapid softening during ripening after 10 d storage at 0 or 10°C. It must be emphasized that the reduced duration of 1-MCP application during FAC combined with storage at 10°C was very effective at inhibiting softening of 'Fortune plums', which exhibited better firmness retention than untreated, cold-stored (0°C) fruit during ripening after 10 d storage. In general, both 1-MCP application protocols extended fruit shelf life (days to reach 'ready to eat' ≤13 N firmness) four to six days beyond untreated fruit stored for 10 d at 0 or 10°C. Thus the alternate treatment strategy during FAC appeared to be very promising and this technology should be able to be adopted easily by growers because of the reduced time required by not adding an extra step to the current postharvest handling of plums.

CONCLUSIONS

1-MCP application during forced-air cooling reduced treatment application time without affecting performance and postharvest handling operations. Thus, this novel 1-MCP-FAC application system can replace the current, 24 h application, making it easy to adopt by the tree fruit industry.

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Figures

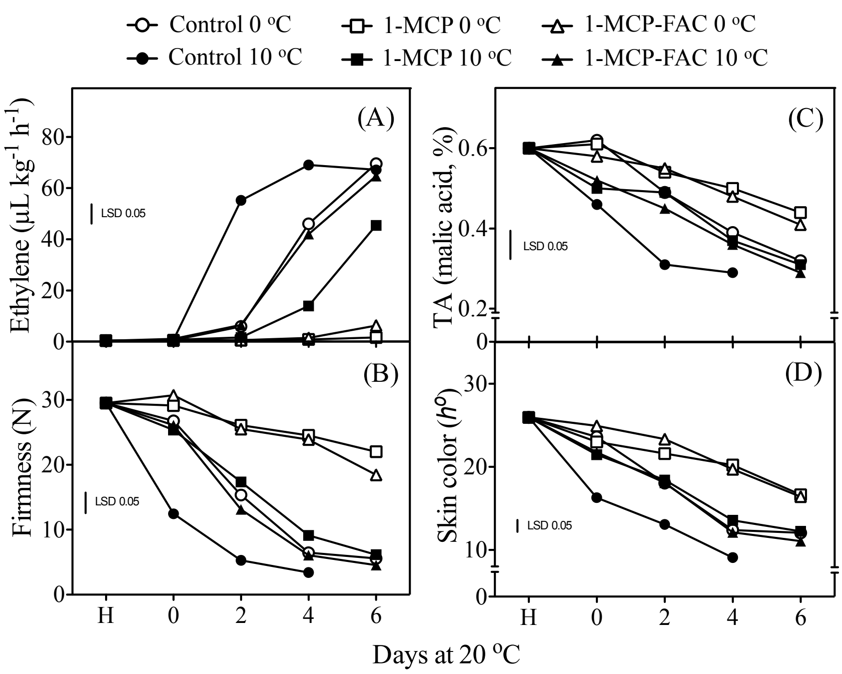

Fig 1. Postharvest changes in ethylene production (A), tissue firmness (B), titratable acidity (TA) (C) and skin color (D) of 'Fortune' plums measured during ripening at 20°C after 10 days of storage at 0 or 10°C, of fruit treated or not treated with 0.5 μl L^{-1} 1-MCP before storage for 24 h (1-MCP) or 6 h (1-MCP-FAC). Bars in each particular figure represent standard errors (LSD; *P=0.05*).