Suppression of Ripening and Softening of 'Galia' Melons by 1-Methylcyclopropene Applied at Preripe or Ripe Stages of Development

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Abstract. **'Galia'** (*Cucumis melo* var. *reticulatus* L. Naud. 'Galia') **melons exhibit relatively short postharvest longevity, limited in large part by the rapid softening of this high quality melon. The present study was performed to characterize the physiological responses of 'Galia' fruit harvested at green (preripe) and yellow (advanced ripening) stages and treated with 1-methylcyclopropene (1-MCP) before storage at 20 °C. Treatment with 1.5 $\mu L \cdot L^{-1}$ 1-MCP before storage delayed the climacteric peaks of respiration and ethylene production of green fruit by 11 and 6 d, respectively, and also significantly suppressed respiration and ethylene production maxima. Softening of both green and yellow fruit was significantly delayed by 1-MCP. During the first 5 d at 20 °C, the firmness of green control fruit declined 66% while 1-MCP-treated fruit declined 46%. By day 11, firmness of control and 1-MCP-treated green fruit had declined about 90% and 75%, respectively. The firmness of control yellow fruit stored at 20 °C declined 70% within 5 d while 1-MCP-treated fruit declined 30%. The 1-MCP-induced firmness retention was accompanied by significant suppression of electrolyte leakage of mesocarp tissue, providing evidence that membrane dysfunction might contribute to softening of 'Galia' melons. The mesocarp of fruit harvested green and treated with 1-MCP eventually ripened to acceptable quality; however, under the treatment conditions (1.5 $\mu L \cdot L^{-1}$ 1-MCP, 24 h) used in this study, irreversible suppression of surface color development was noted. The disparity in ripening recovery between mesocarp versus epidermal tissue was considerably less evident for fruit harvested and treated with 1-MCP at an advanced stage of development. The commercial use of 1-MCP with 'Galia'-type melons should prove of immense benefit in long-term storage and/or export situations, and allow for retention of quality and handling tolerance for fruit harvested at more advanced stages of ripening.**

The 'Galia' (*Cucumis melo* var. *reticulatus* L. Naud. 'Galia') melon is a climacteric fruit in which ripening is highly coordinated by ethylene (Seymour and McGlasson, 1993). 'Galia' are premium melons with excellent flavor and intense aroma; however, the storage life of the fruit harvested preripe is 2 to 3 weeks even at low temperatures (5 to 6 °C) (Aharoni et al., 1993; Fallik et al., 2001).

Ethylene is known to regulate or coordinate fruit ripening and softening in climacteric fruit (Lelievre et al., 1997). Exposure to ethylene of either endogenous or external sources can reduce the postharvest life of climacteric and other fruit and vegetables by accelerating ripening or senescence processes (Reid, 1985),

and recent studies have shown that ultra low levels of ethylene (5 $nL \cdot L^{-1}$) can influence the time to ripen of climacteric fruit (Wills et al., 2001). The induction of ethylene responses and attendant changes in gene expression can be effectively delayed or reduced by inhibitors of ethylene action including silver thiosulphate (STS), and the cyclic olefins 2-5 norbornadiene, diazocyclopentadiene, and 1-methylcyclopropene (1-MCP) (Sisler and Serek, 1997, 1999). To date, 1-MCP seems to be the most practical ethylene action inhibitor due to its stability, effectiveness at low concentrations, short treatment durations, and nontoxic properties. The compound has been used successfully to prevent ethylene effects in a wide variety of fruit and vegetables (Blankenship and Dole, 2003). The effectiveness of 1-MCP at extending the postharvest life of a number of fruit has resulted in the adoption of this ethylene antagonist for commercial use with apples (Saftner et al., 2003). Furthermore, studies have confirmed that 1-MCP treatment can be effective when applied after the initiation of ripening (Hoeberichts et al., 2002; Mir et al., 2003; Wills and Ku, 2002), providing possibilities for permitting fruit to reach more advanced ripening before detachment. The

present study was performed to characterize the physiological responses of 'Galia' melons to 1-MCP when applied at either preripe or advanced stages of ripening.

Materials and Methods

Plant material. 'Galia' plants were grown in Greenhouse Facilities at the University of Florida Horticultural Farm near Gainesville, Fla., using the production practices established by Shaw et al. (2001). Temperatures were recorded every 15 min at several locations in the greenhouse using thermocouples and a data logger (CR-10 Campbell Scientific, Inc., N. Logan, Utah). Fruit were harvested at two stages of maturity; green (GRN, color stage 2), a preripe phase, and yellow (YLW, color stages 4 to 5), an advanced ripening phase. Fruit color was judged based on comparison with a color chart (1 = dark green; 2 = green; 3 = light yellow with green; 4 = light yellow; 5 = yellow; 6 = dark yellow to orange) for 'Galia' fruit used by Fallik et al. (2001). The fruit were transferred immediately following harvest to the Postharvest Horticulture Laboratory at Gainesville. Fruit were selected on the basis of uniformity of size and freedom from defects, and then washed with tap water, dipped in 200 $\mu L \cdot L^{-1}$ chlorinated water for 1 min, and air-dried.

1-MCP application. 1-MCP was produced by adding 3 g of powder (0.14% formulation, SmartFresh, AgroFresh, Inc. Philadelphia, Pa.) to 50 mL deionized water in a 136-mL vial that was immediately sealed. 1-MCP concentration in the vial headspace was measured using a gas chromatograph (GC) (Hewlett Packard 5890 II GC; Avondale, Pa.) equipped with a 80- to 100-mesh Chromosorb PAW stainless steel column (1.8 m × 3.18 mm i.d.; Supelco, Bellefonte, Pa.). Injector, oven, and detector (FID) were set at 150, 70, and 200 °C, respectively. Isobutylene, which has a response factor similar to that of 1-MCP (Jiang et al., 1999), was used as a standard. About 10 mL of vial headspace gas were injected into a sealed 179-L metal chamber yielding an approximate 1-MCP concentration of 1.5 $\mu L \cdot L^{-1}$. Fruit were held for 24 h at 20 °C.

The effects of 1-MCP concentration were investigated in an experiment employing GRN fruit treated with 1-MCP at concentrations of 0 (air control), 0.09, 0.9, and 9 $\mu L \cdot L^{-1}$ for 24 h at 20 °C and subsequently stored at 15 °C.

Respiration and ethylene production. Fruit (five fruit per treatment) were sealed individually in 3.6-L plastic containers for 1 h at 20 °C. For CO_2 determination, 0.5 mL of headspace gas was analyzed on a gas chromatograph (series 580; Gow-Mac, Bridgewater, N.J.) equipped with a thermal conductivity detector (TCD). The carrier gas (helium) flow rate was 30 $mL \cdot min^{-1}$. The oven was set at 40 °C and the detector and injector were operated under ambient conditions (23 to 24 °C). For C_2H_4, 1 mL of headspace gas was analyzed using a gas chromatograph (HP 5890; Hewlett Packard, Avondale, Pa.) equipped with a FID. Injector, oven, and detector were operated at 200, 70, and 250 °C, respectively.

Firmness. Fruit firmness was measured at two equidistant, equatorial points on pared fruit using an Instron Universal Testing Instrument (model 441-C8009; Canton, Mass.) and a 20-kg load cell. The probe (convex, 11 mm diameter) was positioned at zero force contact with the pared fruit surface and driven to a depth of 10 mm with a crosshead speed of 50 mm·min⁻¹. Data are presented as the maximum force (N) attained during penetration.

Electrolyte leakage. Mesocarp cylinders (five cylinders per fruit) 8 mm in diameter were removed from the equatorial position of a fruit using a corkborer. The cylinders were trimmed to produce 8-mm-thick disks using the centermost region of each cylinder. Disks (five per fruit) were rinsed briefly with deionized water and blotted on a slightly moistened Whatman filter paper and then incubated in 15 mL of 500 mM mannitol for 6 h in a capped polypropylene tube (50 mL). Conductivity was measured immediately after addition of the disks to the 500 mM mannitol solution and following the 6 h incubation period with a conductivity bridge (YSI-31A; Yellow Springs, Ohio) equipped with a conductivity cell (model 3403; Yellow Springs, Ohio). For total electrolyte determination, the disks and bathing solution after 6 h were stored at –20 °C for at least 24 h, thawed, heated in a boiling water bath for 30 min, cooled to room temperature, and conductivity measured. Electrolyte leakage was expressed as a percentage of mesocarp total electrolyte content.

Soluble solids concentration, pH, and titratable acidity determination. At selected intervals during storage, fruit were peeled, diced, placed in polyethylene bags, and stored at –20 °C until analyzed. Partially thawed mesocarp tissue (80 g) was macerated with a mortar and pestle and centrifuged at 10,000 g for 10 min at 20 °C. The supernatant was used for measurement of soluble solids concentration (SSC) and pH. SSC and pH were determined using a digital refractometer (Abbe Mark-10480, Buffalo, N.Y.) and a digital pH meter (model 340; Corning, N.Y.) respectively. For titratable acidity (TA), 6 mL of the supernatant were titrated (Fisher 395 Dispenser, Pittsburg, Pa.) with 0.1 N NaOH to an end point of pH 8.2, and TA was expressed as percent malic acid equivalents.

Statistical and informal sensory analyses. General linear model program of SAS (SAS institute, Carey, N.C.) and Duncan's multiple range test were performed for Completely Randomized Design (CRD). Informal sensory analysis was performed by untrained personnel of the postharvest research group at the University of Florida. Assessments of fruit quality and marketability were based on fruit surface and flesh appearance, odor, flavor, and texture.

Results

1-MCP concentration and efficacy. In initial trials, 'Galia' melons harvested green (GRN), before the onset of ripening, were treated with 1-MCP at concentrations of 0, 0.09, 0.9, and 9 µL·L⁻¹ at 20 °C and subsequently stored at
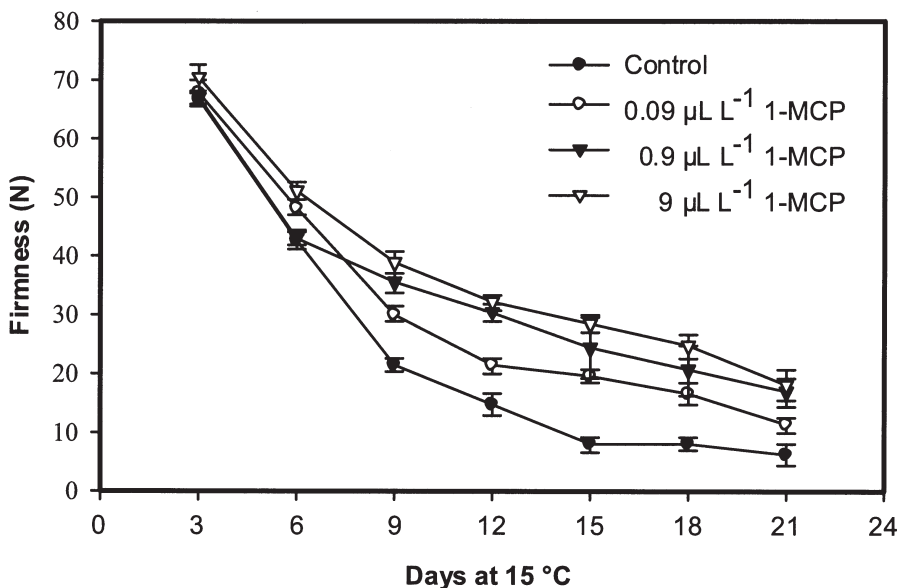

Fig. 1. Firmness of green 'Galia' fruit treated with air (control) or 1-MCP at 0.09, 0.9, and 9 µL·L⁻¹ (24 h, 20 °C) and subsequently stored at 20 °C. Vertical bars are standard deviations of means (n = 5).

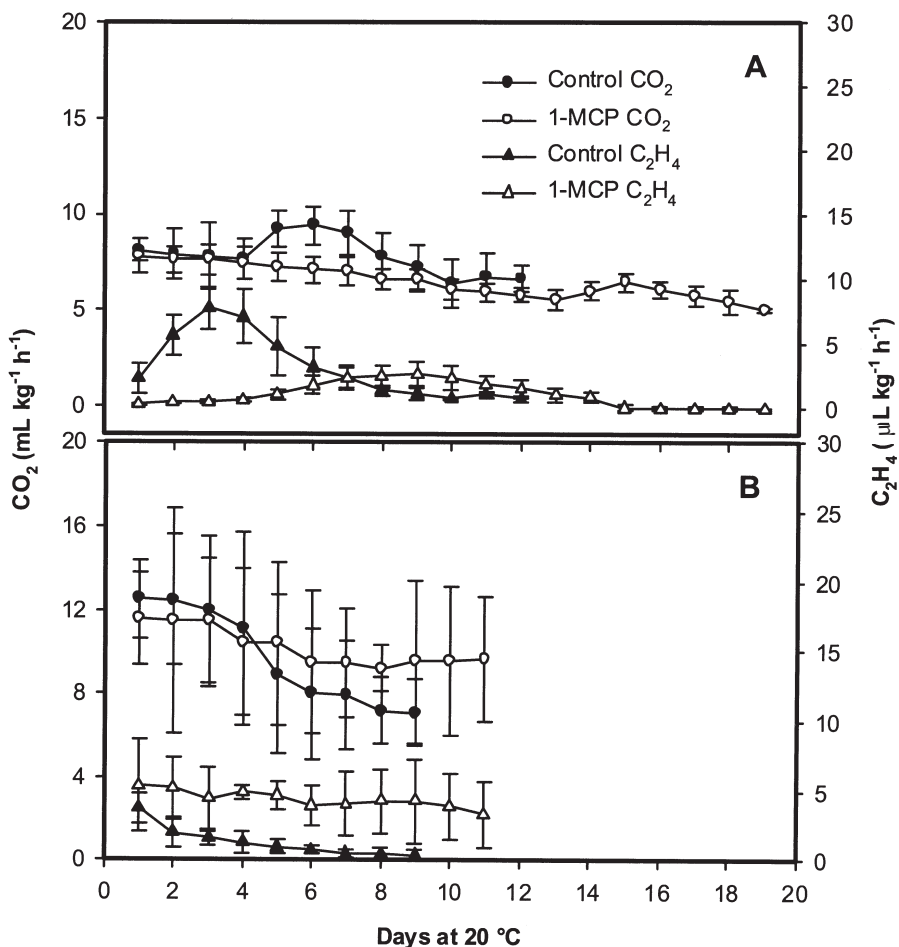Fig. 2. Respiration and ethylene production of green (**A**) and yellow (**B**) 'Galia' melons treated with air or 1.5 µL·L⁻¹ 1-MCP and stored at 20 °C. Vertical bars represent standard deviation of the means (n = 5).

15 °C. Firmness of GRN control fruit declined from about 67 to 6.3 N over a 21-d period at 15 °C, while that of fruit treated with 1-MCP decreased to average values of 11.3 N (0.09 µL·L⁻¹ 1-MCP), 17 N (0.9 µL·L⁻¹ 1-MCP), and 18.1 N (9 µL·L⁻¹ 1-MCP) during the 21 d period

(Fig. 1). The firmness of fruit treated with 9 µL·L⁻¹ 1-MCP did not differ significantly from that of fruit treated with 0.9 µL·L⁻¹ 1-MCP, indicating that the maximum firmness retention for 1-MCP-treated (24 h, 20 °C) 'Galia' fruit was attained at concentrations of about

1.0 μL·L^{−1}. All subsequent experiments with 'Galia' fruit were performed using 1-MCP at 1.5 μL·L^{−1} (24 h, 20 °C).

Respiration and ethylene production. The respiratory drifts and ethylene production rates of 'Galia' fruit harvested at green (GRN) and yellow (YLW) stages provide physiological evidence for the developmental differences anticipated in these fruit based on external color at harvest. The respiration of both control and 1-MCP-treated GRN fruit decreased initially during storage at 20 °C (Fig. 2A). The respiration of control and 1-MCP-treated GRN fruit reached values of 9.4 mL·kg^{−1}·h^{−1} at day 6 and 6 mL·kg^{−1}·h^{−1} at day 15, respectively, representing a 36% reduction and 9-d delay in peak respiration values. Ethylene production of GRN control fruit increased rapidly during storage, reaching a peak value (7.8 μL·kg^{−1}·h^{−1}) at day 3, whereas that of 1-MCP-treated GRN fruit increased initially at day 3 and reached a peak (2.7 μL·kg^{−1}·h^{−1}) at day 9, representing a 65% reduction and 6-d delay in peak climacteric ethylene production (Fig. 2A).

The respiration of fruit harvested at an advanced stage of ripening (YLW, color stage 4 to 5) decreased gradually during storage at 20 °C, with no statistical differences between the treatments (Fig. 2B). Ethylene production in both control and 1-MCP-treated YLW fruit also declined steadily during storage. Ethylene production of control fruit declined nearly 90%, from 3.8 to 0.4 μL·kg·h^{−1}, over 9 d of storage whereas that of 1-MCP-treated fruit declined about 20%, from about 5.0 to 4.0 μL·kg·h^{−1}, during 11 d of storage at 20 °C. Although the magnitude of ethylene production and respiratory rates of YLW fruit were comparable to those observed for fruit harvested GRN (Fig. 2A and B), the respiratory and ethylene production drifts of the YLW fruit were clearly postclimacteric in nature.

Firmness. As shown in Fig. 3 A, control and 1-MCP-treated fruit exhibited slight but consistent differences in firmness upon removal from the 1-MCP treatment, indicating a rapid response of these fruit to the ethylene antagonist. During subsequent storage at 20 °C, both control and 1-MCP-treated GRN fruit softened significantly and rapidly (Fig. 3A). During the initial 5 d of storage, control GRN fruit softened at a rapid and constant rate, losing 66% of their initial firmness, compared with a 46% decline in 1-MCP-treated fruit. At the final day of storage of control fruit (day 13), firmness had declined nearly 95% compared with values at the start of the experiment. The firmness of 1-MCP-treated GRN fruit through 13 d of storage fruit had declined 80%. 1-MCP-treated fruit softened relatively slowly over the remaining 8 d of storage, eventually reaching values about 10% of those at the start of the experiment.

Firmness of control and 1-MCP-treated YLW fruit did not differ immediately following 1-MCP treatment (see day 1, Fig. 3B). Thereafter, firmness of fruit of both treatments declined although at a significantly lower rate in 1-MCP-treated fruit. Over the initial 5 d of storage, firmness declined about 27% and 75% in 1-MCP-treated and control fruit,

respectively. The firmness of 1-MCP-treated YLW fruit remained unchanged from 5 to 9 d, but declined sharply over the final 3 d of storage. At the final measurements day for both treatments, firmness of control (day 9) and 1-MCP-treated fruit (day 11) had declined about 70% and 55%, respectively.

Electrolyte leakage. Electrolyte leakage of 'Galia' mesocarp increased during storage at 20 °C for all treatments and for both GRN and YLW fruit (Fig. 4). In preripe fruit (GRN), leakage diverged significantly throughout storage, with control fruit increasing nearly linearly to about 35% during the 13 d of storage. In contrast, leakage of 1-MCP-treated GRN fruit remained relatively constant at about 20% through 5 d of storage, increasing thereafter but never exceeding values of 27%. Interestingly, after reaching maximum leakage values of 27%, values for 1-MCP-treated GRN fruit remained nearly constant during the remaining period of storage. Electrolyte leakage of YLW control fruit increased significantly and sharply (from 25% to 36%) during the initial 7 d of storage, whereas that of 1-MCP-treated fruit increased from initial values of 21.5% to about 23% over the same time period (Fig. 4B).

Soluble solids concentration, pH, and

titratable acidity. Soluble solids concentration (SSC) of GRN control and YLW fruit averaged about 8.5% and 11%, respectively, and showed no significant differences between treatments (data not shown). The mesocarp pH of both GRN control and 1-MCP-treated fruit changed little during storage, ranging between 5.9 and 6.4 (data not shown). In YLW fruit, the mesocarp pH decreased very slightly (control, from 6.7 to 6.6; 1-MCP-treated from 6.6 to 6.3) during storage. For all treatments and for both stages of development (GRN, YLW), the magnitude of changes and differences in pH were statistically insignificant. Titratable acidity (TA) of GRN control fruit increased slightly from 0.097 to 0.12% during storage whereas that of 1-MCP-treated fruit remained unchanged, averaging about 0.093% throughout storage (data not shown). The TA of YLW fruit increased during storage (control from 0.045% to 0.055%; 1-MCP from 0.056% to 0.11%).

Informal quality analysis. Surface color changes were assessed on the basis of the rating scale of Fallik et al. (2001). The color of GRN control fruit had developed a uniformly yellow (color stage 5) appearance by day 9, and had developed a full orange (color stage
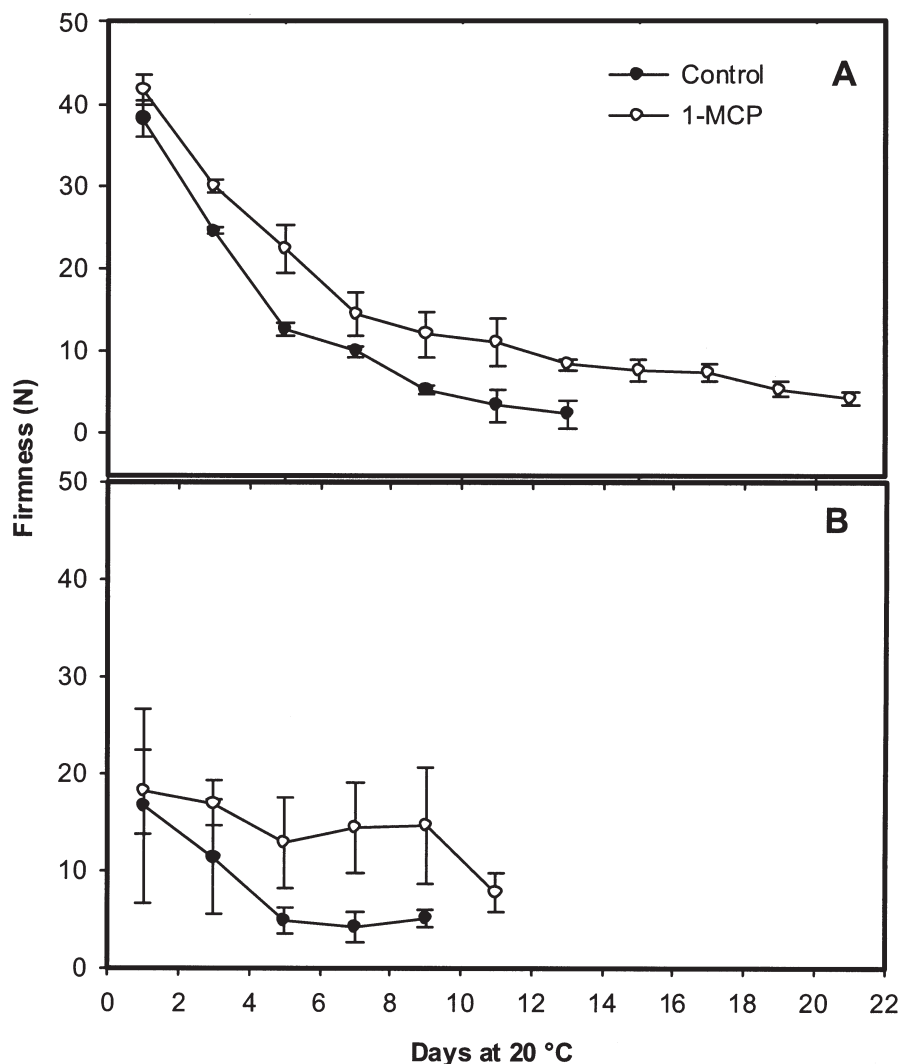

Fig. 3. Firmness of green (**A**) and yellow (**B**) 'Galia' melons treated with air (control) or 1.5 μL·L^{−1} 1-MCP and stored at 20 °C. Vertical bars represent standard deviation of the means (n = 5).

Fig. 4. Electrolyte leakage of green (**A**) and yellow (**B**) 'Galia' melons treated with air (control) or 1.5 µL·L^{-1} 1-MCP and stored at 20 °C. Vertical bars represent standard deviation of the means (n = 5).

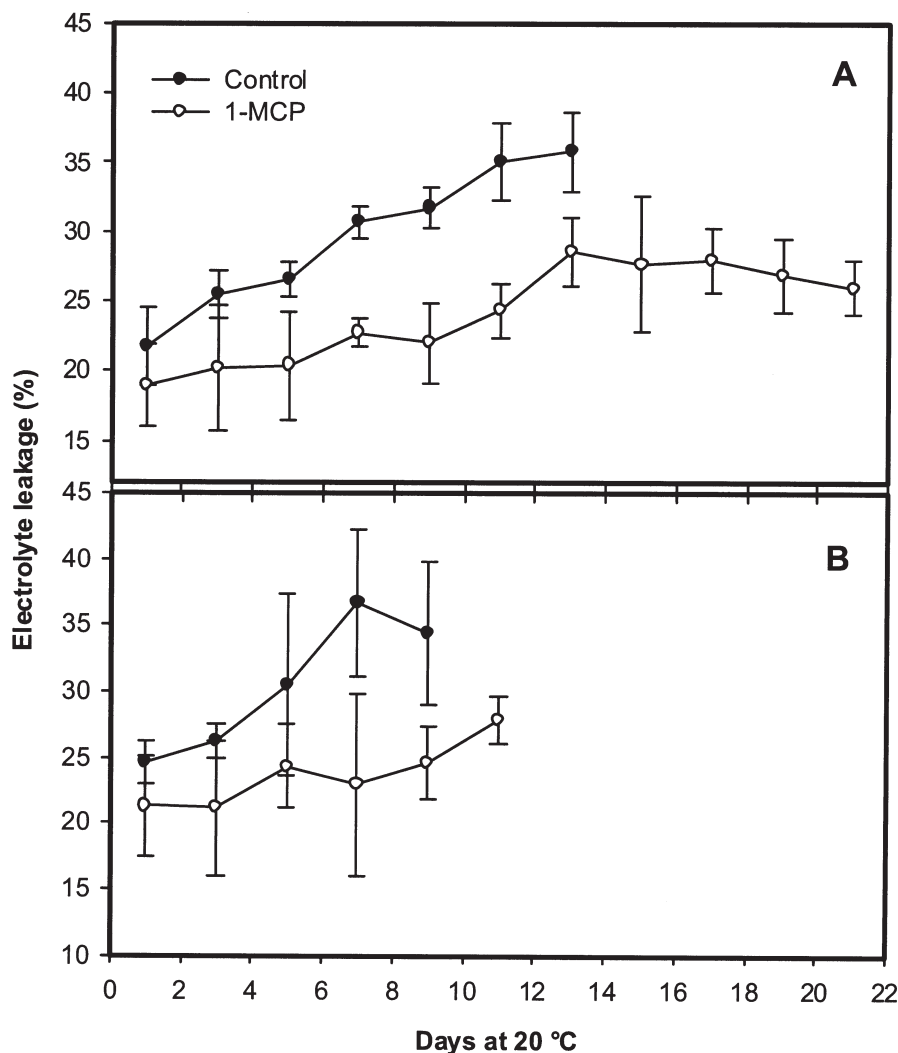6) appearance after day 13. In contrast, the surface color of 1-MCP-treated GRN fruit never exceeded color scores of 3 (light yellow to green) to 4 (light yellow). YLW control fruit had developed an orange surface (color stage 6) after day 5 while 1-MCP-treated YLW fruit maintained a yellow appearance (color stage 5) through 6 d of storage 20 °C, developing a nearly uniform orange appearance (color stage 6) after d 10. Based on informal sensory analysis, the table ripe (edible stage) condition for fruit harvested GRN was maintained from days 5 through 9 for control fruit and from days 13 through 19 for 1-MCP-treated fruit, amounting to a 4-d delay in reaching an edible stage (40% extension in consumable shelf-life). The edibility of YLW fruit persisted through day 5 (control) or day 9 (1-MCP-treated), representing an 80% extension in consumable shelf life. The incidence of external and internal decay symptoms was minimal in all treatments and showed no differences related to stage of maturation at harvest or 1-MCP treatment.

Discussion

In terms of fruit softening, 1-MCP delayed ripening of 'Galia' melon fruit harvested at a preripe stage of development (GRN) at all concentrations tested (Fig. 1). Firmness retention in GRN fruit treated with 0.9 µL·L^{-1} 1-MCP was much greater compared with that of GRN fruit treated with 1-MCP at 0.09 µL·L^{-1}, but 1-MCP in excess of 9 µL·L^{-1} showed no further suppression of ripening or softening. Softening of GRN 'Galia' fruit was strongly delayed by 1-MCP, consistent with findings for other fruit including apple (Fan et al., 1999), banana (Jiang et al., 1999), avocado (Jeong et al., 2002), and tomato (Wills and Ku, 2002). 'Galia' fruit at an advanced stage of ripening (YLW), which at the time of harvest were nearly 55% softer compared with fruit harvested GRN, also showed a significant disruption in the kinetics of postharvest softening in response to 1-MCP. Other fruit, including apple (Jiang and Joyce, 2002; Mir et al., 2001) and tomato (Hoeberichts et al., 2002), showed reduced rates of softening in response to application of 1-MCP following the initiation of ripening, although the disruption was much less dramatic than noted for 'Galia' melons.

The 1-MCP-induced disruption in the continuation of softening would be anticipated in cases where the synthesis of candidate enzymes is dependent on competent and continuous

ethylene responsiveness. Nonetheless, in a number of fruits, including preripe avocado (Jeong et al., 2002) and, as shown in the present study, GRN 'Galia' melons, rates of softening were relatively normal in the short term following 1-MCP treatment but diverged significantly in softening kinetics with time in storage. Explanations for this pattern include the accumulation of specific wall enzymes before 1-MCP treatment and ripening, followed by rapid turnover of ethylene-responsive cell wall enzymes upon 1-MCP-induced attenuation of ethylene reception. In tomato fruit at early stages (mature-green, breaker) of ripening (Hoeberichts et al., 2002), 1-MCP completely inhibited softening in the short term (through 6 d), indicating that mechanisms contributing to softening might involve different degrees of ethylene responsiveness in different fruit. The effect of 1-MCP in disrupting the kinetics of softening of 'Galia' fruit at advanced ripening (YLW) implies that the enzymes responsible are subject to rapid turnover or that individual cell-wall enzymes are capable of limited catalytic half-lifes, due to turnover, physical entrapment, or other constraints imposed within the cell wall (Huber et al., 2001, 2003). 1-MCP applied to full-ripe tomato fruit was not consistently effective at interrupting softening (Hoeberichts et al., 2002). The rather dramatic influence of suppressing ethylene action in 'Galia' melon at advanced stages of ripening might have significant benefits in the fresh-cut industry, which relies on the use of nearly fully ripe fruit.

The maximum ethylene production rates of both GRN and YLW 'Galia' fruit were at or below 5 µL·kg^{-1}·h^{-1} during postharvest ripening (Fig. 2A and B), within the range observed in a number of melon cultigens including 'Galia' (Zheng and Wolf, 2000). 1-MCP significantly delayed the onset of climacteric ethylene production and respiration in GRN 'Galia' fruit during storage at 20 °C (Fig. 2A). Ethylene production and respiration rates did not fully recover in GRN fruit treated with 1-MCP, with maxima remaining 65% and 36% lower, respectively, than those of control fruit. These effects of 1-MCP on stored, preclimacteric 'Galia' melon are similar to data for preclimacteric 'Charentais' muskmelon, which during storage at 14 °C following exposure to 1-MCP (1 µL·L^{-1}, 24 h, 14 °C) exhibited a 4 d delay in peak ethylene production relative to control fruit (Chatenet et al., 2000). The trends of delayed and suppressed climacteric drifts noted for 'Galia' and 'Charentais' melon treated with 1-MCP have been reported for other fruit including avocado (Jeong et al., 2002) and climacteric stone fruit (Abdi et al., 1998; Fan et al., 2000) The effects of 1-MCP at suppressing ethylene biosynthesis are not universal, with significantly enhanced ethylene production in response to the ethylene antagonist having been reported for mature-green banana (Golding et al., 1998) and mature-green tomato fruit (Sisler and Blankenship 1993).

The respiratory and ethylene production drifts of 'Galia' fruit harvested at an advanced stage of ripening (YLW) were clearly indicative of postclimacteric behavior. Both ethylene

production and respiration declined throughout storage, with 1-MCP exhibiting slightly but consistently higher values throughout (ethylene) or after 4 d (respiration) of storage. This likely reflects the less advanced senescence of the 1-MCP-treated, postclimacteric fruit, compared with control fruit. Although the relevance of the transient increase in respiratory activity of harvested (versus attached) melon and other climacteric fruit has been questioned (Saltveit, 1993), and recently viewed as a possible response to the stress of detachment (Bower et al., 2002), it is clear that the postharvest respiratory patterns of 'Galia' melons are significantly influenced by ethylene responsiveness.

Electrolyte efflux of both 'Galia' mesocarp tissue increased during storage for all treatments. Increased electrolyte leakage has been reported for ripening muskmelon-type melons (Lacan and Baccou, 1996; Lester and Stein, 1993). The increased leakage of both GRN and YLW 'Galia' fruit was strongly suppressed by 1-MCP, indicating that membrane dysfunction is to some extent modulated by ethylene. Ethylene has been reported to enhance the activities of free-radical-producing enzymes (Paliyath and Droillard, 1992) and has been shown to increase transcript abundance and activities of a number of lipases and lipoxygenase in ethylene-treated watermelon (*Citrullus lanatus*) fruit (Karakurt and Huber, 2004). The enhanced activities of lipases and attendant increases in electrolyte leakage and placental tissue softening in ethylene-treated ripe watermelon were largely prevented in fruit treated with 1-MCP before ethylene exposure (Mao et al., 2004). In this respect, membrane dysfunction (as opposed to cell-wall localized events) might be of unrecognized importance in the overall softening of 'Galia' and other melon types.

SSC differed with developmental stage at harvest (average of 8.5% in GRN versus 11% in YLW), but levels changed minimally during storage and were unaffected by 1-MCP (data not shown). The effects of 1-MCP upon TA and pH were also statistically negligible. Slightly higher TA in YLW fruit were noted in 1-MCP-treated fruit. Higher TA has been noted for tomato fruit treated with 1-MCP at an advanced stage of ripening, although these data were in response to treatment with exceptionally high levels of 1-MCP (5 to 100 μL·L^{-1}) (Wills and Ku, 2002).

Subjective observation indicated that epidermal pigmentation changes of 'Galia' fruit were notably delayed by 1-MCP, particularly for fruit harvested GRN. Whereas fruit harvested YLW (color stages 4 to 5) eventually reached a orange surface color characteristic of ripe 'Galia' fruit (stage 6), fruit harvested GRN (stage 2) never exceeded light yellow (stage 4), and in a few specimens showed retention of green color (stage 3). The incomplete ability of 1-MCP-treated GRN 'Galia' to develop normal surface pigmentation belies the condition of the mesocarp, which in treated fruit eventually reached and retained firmness values quite suitable for consumption. This differential effect of ethylene responsiveness on pulp versus peel

ripening is consistent with the ripening patterns reported for transgenic 'Charentais' melons expressing antisense ACC oxidase (Flores et al., 2001). Differential effects of 1-MCP on the surface color of fruit in general might well depend on the multiplicity of pigment changes contributing to final fruit color (i.e., chlorophyll degradation, selective pigment synthesis, or both) and their relative dependency on ethylene responsiveness. The inability of 1-MCP-treated-fruit to fully express all ethylene-induced ripening parameters is consistent with reports that 1-MCP acts as a high affinity, noncompetitive inhibitor of ethylene action (Jiang and Fu, 2000). Exogenous ethylene treatment can induce selective recovery of some ripening parameters, including PG and EGase accumulation in 1-MCP-treated avocado fruit compared with 1-MCP-treated fruit not receiving ethylene (Jeong and Huber, 2004); however, other features of ripening, including softening and some pigmentation changes, appear to be more recalcitrant to the action of exogenous ethylene.

As noted in Fallik et al (2001), the commercial handling and exportation of 'Galia' melons are facilitated by harvesting at a green stage (stage 2), yet fruit harvested at this stage never express the flavor (volatiles, sugar levels) characteristics of fruit harvested when yellow (stage 5). Although fruit at a full yellow stage of development might not serve as candidates for long-term export operations, the strong influence of 1-MCP on the firmness retention of fruit harvested YLW, even during subsequent storage at 20 °C, suggests that the use of 1-MCP on 'Galia' harvested at intermediate to advanced stages of ripening might prove quite beneficial for fruit destined for long-term storage and export purposes and for use as fresh-cut products. Additionally, the fruit used in the present studies were stored under near-ambient conditions (20 °C), suggesting that the benefits derived from 1-MCP treatment might be even greater than those reported herein for fruit stored at low temperature following 1-MCP treatment.

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