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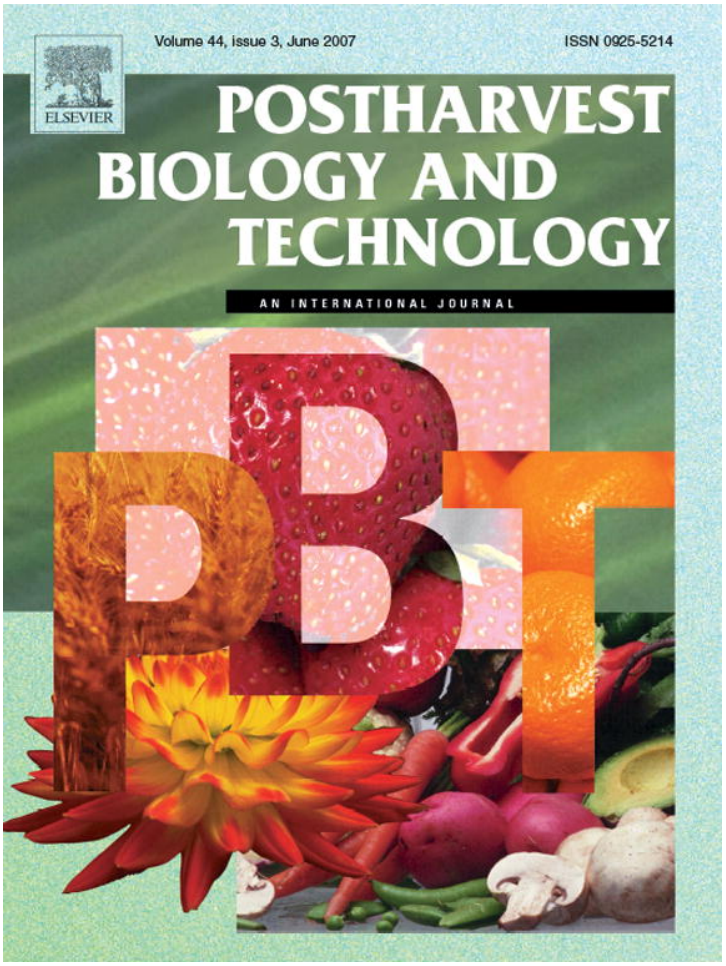

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Physiology of fresh-cut 'Galia' (*Cucumis melo* var. *reticulatus*) from ripe fruit treated with 1-methylcyclopropene

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Abstract

'Galia' (*Cucumis melo* var. *reticulatus* L. Naud. cv. Galia) fruit were harvested at the three-quarter slip stage and treated with 1 μL L^{-1} 1-methylcyclopropene (1-MCP) at 20 °C for 24 h. The fruit were processed and stored as fresh-cut cubes and intact fruit for 10 d at 5 °C. Ethylene production of fresh-cut cubes was approximately 4–5-fold higher than intact fruit at day 1. Afterward, the ethylene production of fresh-cut cubes declined significantly whereas that of intact fruit remained relatively constant at about 0.69–1.04 ng kg^{-1} s^{-1}. 1-MCP delayed mesocarp softening in both fresh-cut and intact fruit and the symptoms of watersoaking in fresh-cut fruit. Continuously stored fresh-cut cubes and cubes derived from intact fruit not treated with the ethylene antagonist softened 27% and 25.6%, respectively, during 10 d storage at 5 °C while cubes derived from 1-MCP-treated fruit softened 9% and 17%, respectively. Fresh-cut tissue from 1-MCP-treated fruit exhibited slightly reduced populations of both total aerobic organisms and Enterobacterium, although the differences did not appear to be sufficient to explain the differences in keeping quality between 1-MCP-treated and control fruit. Based primarily on firmness retention and reduced watersoaking, 1-MCP treatment deferred loss of physical deterioration of fresh-cut 'Galia' cubes at 5 °C by 2–3 d compared with controls.
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Keywords: *Cucumis melo*; Ethylene; Fresh-cut; Microbial growth; Ripening; Softening; Watersoaking

1. Introduction

The sales of fresh-cut fruits and vegetables in the United States alone have increased from $ 5 billion in 1994 to $ 12 billion in 2004 (International Fresh-cut Produce Association, 2004). The increase in consumer demand for fresh-cut produce has prompted increased research toward designing and implementing methods for improving and prolonging the quality of these highly perishable products (Soliva-Fortuny and Martin-Belloso, 2003).

The physical injury occurring in response to fruit processing initiates a series of events including increased respiration and ethylene production (Rolle and Chism, 1987; King and Bolin, 1989), and increased activities of a number of cell-wall hydrolases (Karakurt and Huber, 2003) and membrane lipases (Karakurt and Huber, 2003; Lamikanra and Watson, 2004). The storage life of fresh-cut commodities is also compromised by the proliferation of various microorganisms (Nguyen-the and Carlin, 1994; Palekar et al., 2004; Lu et al., 2005).

Low temperatures employed in the handling and storage of fresh-cut fruits suppress many biological processes; however, tissue softening, deterioration, and accumulation of hydrolytic enzymes can continue at relatively high rates (Lamikanra et al., 2000; Karakurt and Huber, 2003; Lamikanra and Watson, 2004). Applications of dilute hypochlorite (Ayhan et al., 1998), calcium salt dips (Luna-Guzman et al., 1999; Luna-Guzman and Barrett, 2000; Saftner et al., 2003), controlled or modified atmospheres (Qi et al., 1998; Bai et al., 2003), edible films and coatings (Hoa et al., 2002), and irradiation (Palekar et al., 2004) have proven to be of benefit in extending the shelf-life of fresh-cut tissues.

A commonly observed response to fresh-cut processing is enhanced ethylene production (Soliva-Fortuny and Martin-Belloso, 2003), though the role of ethylene in the deterioration and reduced shelf-life of fresh-cut fruits is not fully understood. Many studies have demonstrated that ethylene binding inhibitors, in particular 1-methylcyclopropene (1-MCP) (Sisler and Serek, 1997), can significantly delay ripening, softening, and other changes in climacteric fruits (reviewed in Blankenship and Dole, 2003). Noteworthy is that 1-MCP has been shown to

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extend the storage potential of a number of fruits when applied at advanced stages of ripening (Hoeberichts et al., 2002; Jiang and Joyce, 2002; Wills and Ku, 2002). This observation is of particular relevance for fresh-cut tissues as they are of necessity derived from ripe or nearly ripe fruit.

In a previous study, we reported that ripe (3/4-slip) 'Galia' melon fruit treated with 1-MCP and stored at 20 °C retained mesocarp firmness and other quality indices compared with air-treated fruit (Ergun et al., 2005). The purpose of the present study was to determine if the benefits of 1-MCP treatment of ripe 'Galia' fruit persisted in fresh-cut tissue stored at 5 °C.

2. Materials and methods

2.1. Plant materials

'Galia' (*Cucumis melo* var. *reticulatus* L. Naud. cv. Galia) plants were grown following the production practices established by Shaw et al. (2001) in greenhouse facilities at the University of Florida Horticultural Farm near Gainesville, FL. Fruit were harvested at the 3/4-slip stage and transferred to the postharvest facilities at the University of Florida in Gainesville. The fruit were selected for abscission properties (3/4-slip), uniformity of size (approximately 1250 ± 50 g), external color (uniform light yellow), and netting development. Soluble solids in freshly harvested fruit ranged from 11% to 12%. Within 24 h after harvest, the fruit were washed with tap water, immersed in 200 μL L^{-1} chlorinated water for 1 min, and air-dried before transferring to 20 °C for 1-MCP application.

2.2. 1-MCP treatment

1-MCP treatment of ripe 'Galia' melons was carried out as described in detail in Ergun et al. (2005) using a 0.14% powdered formulation of *SmartFresh*® (AgroFresh Inc., Philadelphia, PA). The only modification was that 1-MCP was applied at 1 μL L^{-1} for 24 h at 20 °C.

2.3. Preparation of fresh-cut 'Galia', and treatment design

Following treatment with 1-MCP or air (control), the fruit were transferred immediately to a 5 °C cold room, the surfaces of which had been sanitized (200 μL L^{-1} chlorinated water) prior to fruit processing. After several h at 5 °C to allow temperature equilibration, the blossom and pedicel ends of each fruit were removed with a sterile knife, and the fruit longitudinally cut into 2.5-cm thick slices (from the pedicel end to the stem end). The two outermost slices were peeled, and cut using a commercial bread slicer into cubes with approximate dimensions of 2.5 cm^3 and weighing 15–16 g. Nine cubes were derived from each fruit The cubes were placed in single layers in 1.7-L vented plastic containers (nine cubes per container) (*FridgeSmart*® Model 3991A-4, Tupperware Inc., Orlando, FL) with molded grids on the lower surface to facilitate uniform air circulation. Relative humidity in the containers was in the range of 94–97%. Seventy containers (35 each for fresh-cut tissue derived from control and 1-MCP-treated fruit) were used in this experiment, and 10 of these (5 for each treatment) were removed at intervals of 2 d for evaluation. Additionally, 80 intact fruit (40 each of control and 1-MCP-treated) were stored along with the fresh-cut tissue at 5 °C. With the exception of ethylene measurements, which were determined using both intact and fresh-cut tissue, all other parameters for intact fruit were determined using fresh-cut cubes prepared from intact fruit at each measurement interval using the protocol described above.

The treatments included fresh-cut cubes derived from intact fruit treated with air (fresh-cut control, FCC) or 1.0 μL L^{-1} 1-MCP (fresh-cut cubes from 1-MCP-treated fruit, FCM), and fruit pre-treated with air (intact control, IC) or 1-MCP (1-MCP-treated intact fruit, IM). At intervals during storage at 5 °C, firmness, electrolyte leakage, watersoaking and sensory ratings, and microbial growth were measured for both continuously stored fresh-cut cubes (FCC, FCM) and intact fruit processed into cubes at the times of measurement (IC, IM).

2.4. Ethylene production

Ethylene production was measured every other day starting at day 1 by enclosing fresh-cut tissue and intact fruit in 0.9 and 3.6 L airtight containers (*Modular Mate*® series, Tupperware Inc., Orlando, FL), respectively, for 2 h at 5 °C. The same fresh-cut tissue and intact fruit were used throughout the experiment. Ethylene measurement of fresh-cut tissue was performed on five containers per treatment, each container with nine tissue cubes. Ethylene production in intact fruit was determined using three individual fruit for each treatment. After sealing for 2 h, 0.5 mL headspace samples were removed and ethylene determined using a gas chromatograph (Hewlett Packard, 5890, Avondale, PA) equipped with an activated alumina SS column (80/100, 1.83 m long, 3.2 mm wide) and flame ionization detector. The flow velocity of carrier gas (nitrogen) was 0.5 mL s^{-1}. Detector, oven (column) and injector were operated at 250, 70, 200 °C, respectively. After removing the headspace samples, the containers were again vented until the next measurement.

2.5. Firmness assessment

Firmness of the mesocarp cubes was measured with an Instron Universal Testing Instrument (Model 4411, Canton, MA) fitted with an 8-mm convex probe and 5-kg load cell. On the days for each firmness determination, samples of intact fruit were processed into fresh-cut cubes as described above. Firmness measurements were performed at 20 °C on five cubes from each treatment (one cube from each container or fruit). The convex probe was placed at zero force contact with the centermost section of the surface of each cube, and penetrated to a depth of 10-mm at a crosshead speed of 0.83 mm s^{-1}. Data are reported as the maximum force (N) generated during penetration of the cubes.

2.6. Electrolyte leakage

Fruit cylinders were removed from freshly prepared cubes (five cubes from each treatment, one cube from each container

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or fruit) of stored intact fruit and continuously stored fresh-cut cubes using an 8-mm steel cork borer. The cylinders were trimmed to produce 8-mm thick disks using the centermost region of each cylinder. The disks (five per cube) were rinsed briefly with water and blotted on a slightly moistened filter paper (Whatman). The disks (five samples of five disks per treatment) were transferred to 15 mL of 500 mM mannitol and placed on an oscillating shaker at room temperature for 4 h, followed by a conductivity measurement of the bathing solution. The aliquot removed for the conductivity measurement was returned to the bathing solution. Conductivity was measured using a conductivity bridge (Y-31A, Yellow Springs, OH) equipped with a conductivity cell (model 3403, Yellow Springs, OH). Afterward, the bathing solution and disks were transferred to −20 °C for at least 24 h, thawed and placed into a boiling water bath for 30 min, cooled to room temperature, and conductivity of the bathing solution again measured. Electrolyte leakage was expressed as percentage of total tissue electrolytes, estimated from the frozen/heated samples.

2.7. Sensory evaluation

Watersoaking (translucency) on the upright surface of fresh-cut cubes was expressed as the percentage of watersoaked area of a cube estimated visually to the nearest 5% increment. Cubes derived from fruit stored intact were prepared on each measurement day and evaluated similarly. Informal descriptive analysis was used to assess the quality of either continuously stored fresh-cut cubes or cubes derived from intact fruit with emphasis on overall appearance, odor, texture, and flavor (O'Connor-Shaw et al., 1994) according to the following hedonic scale: 1, poor; 2, poor-fair; 3, good; 4, good-excellent; and 5, excellent. The informal descriptive analyses were performed by postharvest personnel under evaluation lights (mixture of 60 W Plant Gro N Show incandescent bulbs and 40 W Blue P40B fluorescent fixtures; Sylvania, Danvers, MA), using three replicates of six cubes for each treatment.

2.8. Microbial counts

On days 0, 5, and 10, three tissue samples (each approximately 5 g) derived from three cubes (from three containers or three intact fruit) were removed with a steel, flame-sterilized cork borer (21.5 mm diameter) and a flame-sterilized knife on sterilized aluminum foil in a microbial transfer hood. Tissue was obtained by inserting the cork borer through the original 2.5 cm^3 mesocarp cubes. The 5 g samples were then incubated in 45 mL sterile phosphate buffered saline (PBS), pH 7. Cubes derived from intact fruit processed as for cubes at the start of the experiment were prepared in a similar fashion. The PBS and fruit tissue were vortexed at high speed for 1 min using a Fisher-Genie 2 Vortex (Scientific Industries Inc., Bohemia, NY), followed by 10-fold dilutions using sterile PBS as needed. Total aerobic, Enterobacteriaceae, yeasts and molds, total coliforms, and lactic acid bacteria counts were made using 1 mL of the PBS extract. The plates and incubation conditions for each count were: total aerobic count, 3M Petrifilm aerobic count plate (3M Microbiology Products, St. Paul, MN), 3 d at 30 °C; Enterobacteriaceae, 3M Petrifilm Enterobacteriaceae count plate, 1 d at 30 °C; yeasts and molds, 3M Petrifilm yeast and molds count plate, 5 d at 25 °C; total coliforms, 3M Petrifilm coliform count plate, 1 d at 30 °C; and lactic acid bacteria, 3M Petrifilm aerobic count plate, incubation for 2 d at 30 °C in a 1.9-L airtight plastic container with a Gas Pak anaerobic system envelope (Becton Dickinson and Co., Cockeysville, MD). The plates were prepared in a laminar-flow hood at day 0 (immediately after slicing) and after 5 and 10 d storage at 5 °C. Microbial counts were reported as log colony forming units kg^{-1} on a fresh weight basis.

2.9. Experimental design and statistics

General linear model program (PROC GLM) of SAS (SAS institute, Carry, NC) and Duncan's multiple range test ($P \leq 0.05$) were performed for randomized complete block design in which treatments were blocks and containers and intact fruits as replications.

3. Results and discussion

At day 1 after treating fruit with air or 1-MCP, ethylene-production rates (measured at 5 °C) of fresh-cut tissue from fruit treated with or without 1-MCP (FCC, 3.59 ± 0.04 ng kg^{-1} s^{-1}; FCM, 2.95 ± 0.15 ng kg^{-1} s^{-1}) were 4–5-fold higher than those of intact fruit (IC, 0.65 ± 0.06 ng kg^{-1} s^{-1}; IM, 0.55 ± 0.11 ng kg^{-1} s^{-1}) (Fig. 1). The higher ethylene production in the continuously stored fresh-cut tissue persisted throughout the experiment but production rates declined steadily during storage. Ethylene production of intact fruit measured at 5 °C remained below 0.69 ng kg^{-1} s^{-1}. The decline in ethylene production in fresh-cut 'Galia' fruit is in agreement with the findings of Luna-Guzman et al. (1999) for fresh-cut muskmelon (*C. melo* L. var. *reticulatus*). These authors reported that ethylene production of fresh-cut ripe muskmelon fruit declined during the first 7 d of storage at 5 °C, although this decline was followed

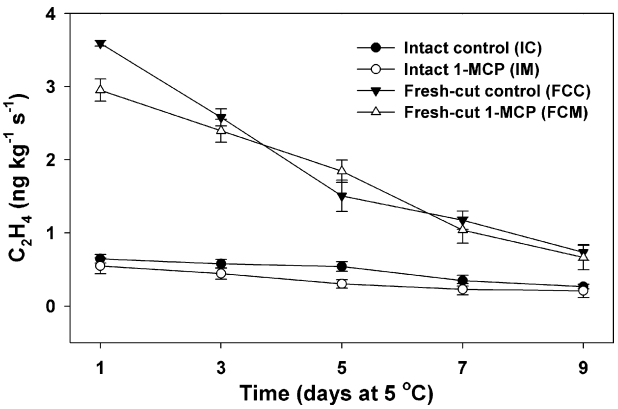

Fig. 1. Ethylene production in ripe 'Galia' fruit or fresh-cut tissue during storage at 5 °C. Intact fruit treated with (IM, open circle) or without 1-MCP (IC, closed circle) and continuously stored fresh-cut cubes derived from ripe fruit treated with (FCM, open triangle) and without 1-MCP (FCC, closed triangle). Vertical bars represent standard error of the means (mesocarp cubes, $n = 5$; intact fruit, $n = 3$).

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by significant increases in ethylene production that the authors speculated reflected increased microbial proliferation. Aguayo et al. (2004) reported significantly higher but steadily declining ethylene production in fresh-cut versus intact 'Galia' melons at 5 °C (no 1-MCP treatments employed), but less pronounced differences between processed versus whole fruit at 0 °C. The higher ethylene-production rates in fresh-cut 'Galia' compared with intact fruit at 5 °C is likely due to stress-induced ethylene production in damaged tissue (Rolle and Chism, 1987).

In sharp contrast to the ethylene-production characteristics of fresh-cut 'Galia' (Fig. 1) and muskmelon (Luna-Guzman et al., 1999) fruits, ethylene production in fresh-cut watermelon (*Citrullus lanatus* Thunb.) showed no wound enhancement and remained at extremely low to non-detectable levels throughout storage (Mao et al., 2005; Perkins-Veazie and Collins, 2005). ACC oxidase levels in fresh-cut watermelon from 1-MCP-treated fruit were also below detection (Mao et al., 2005). Interestingly, the effects of 1-MCP at preventing placental tissue softening of air-stored whole watermelon fruit (Mao et al., 2004) were not maintained in excised (fresh-cut) placental tissue (Mao et al., 2005), even though excised placental tissue does exhibit softening and watersoaking in response to exogenous ethylene (Huber et al., unpublished data). The morphological distinction between the edible tissues of 'Galia' and cantaloupe melons (mesocarp) or watermelon (primarily placental/endocarp) might explain the differences in response to 1-MCP. The low ethylene production (<0.03 ng kg^{-1} s^{-1}) of whole watermelon fruit (Mao et al., 2005) and largely undetectable production in placental tissue suggests that rind tissues (exocarp/mesocarp) constitute the primary sources of ethylene production. The inability of 1-MCP to influence the shelf-life of fresh-cut watermelon maintained in an ethylene-free environment (Mao et al., 2005) is consistent with this view.

Other than at day 1, ethylene production in fresh-cut 'Galia' at 5 °C was unaffected by 1-MCP. This observation is in contrast to reports for fresh-cut 'Golden Delicious' apple fruit treated with 1-MCP (1 or 10 μL L^{-1}). Jiang and Joyce (2002) reported that ethylene production in slices derived from 1-MCP-treated apple fruit remained suppressed after 5 and 10 d of storage at 4 °C (Jiang and Joyce, 2002). Fresh-cut slices derived from 1-MCP-treated 'Pacific Rose' apple fruit also showed reduced ethylene production compared to slices from control fruit (Perera et al., 2003).

The firmness of fresh-cut cubes derived from intact fruit was measured immediately following 1-MCP treatment and tissue processing (day 0) and at 2-d intervals thereafter. The initial divergence in firmness values of control and 1-MCP-treated fruit (day 0, Fig. 2) likely reflects the influence of 1-MCP at suppressing softening during the 24 h exposure period at 20 °C. Firmness of all treatments declined during subsequent storage at 5 °C, although the rate of decline was significantly reduced in tissues derived from 1-MCP-treated fruit, both in continuously stored cubes (FCM) and those prepared at each measurement interval (IM) (Fig. 2). Tissue derived from 1-MCP-treated fruit declined from an initial value of 12.8 ± 3.9 to about 11.6 ± 0.8 N during 10 d of storage compared with a decline to 10.6 ± 1.2 N for FCM. Tissue derived from intact control fruit declined from

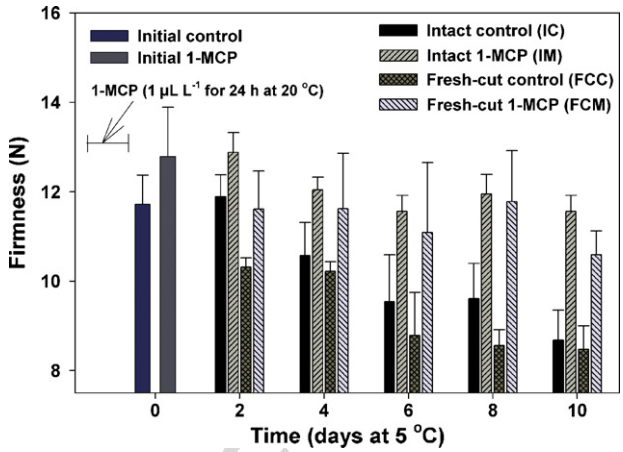

Fig. 2. Firmness of fresh-cut 'Galia' mesocarp during storage at 5 °C. Intact fruit were processed into fresh-cut cubes at each measurement interval. Twenty-four hours 1-MCP treatment terminated at day 0. (IC, IM) Cubes derived from intact control or 1-MCP-treated fruit at each measurement interval; (FCC, FCM) continuously stored cubes from control or 1-MCP-treated fruit. Vertical bars represent standard error of the means ($n = 5$ mesocarp cubes).

11.7 ± 1.1 to 8.7 ± 1.5 N for tissue processed at each measurement interval and 8.5 N for continuously stored cubes. The significant retention of mesocarp firmness of 1-MCP-treated 'Galia' fruit during storage at 5 °C is in agreement with our earlier report (Ergun et al., 2005) for intact 1-MCP-treated-'Galia' held at 20 °C. The firmness retention in ripe 'Galia' melon in response to 1-MCP indicates that the processes contributing to softening depend on continued ethylene action well into the ripening process, consistent with reports on the effects of 1-MCP on the softening of other fruits at advanced stages of ripening including tomato (Hoeberichts et al., 2002; Hurr et al., 2005), 'Galia' melon (Ergun et al., 2005), 'Golden Delicious' apple (Jiang and Joyce, 2002), and papaya (Ergun and Huber, 2004). Based largely on firmness retention, periods of extended shelf-life (2–3 d) noted for fresh-cut 'Galia' were also observed for fresh-cut tissues derived from 1-MCP-treated banana (*Musa acuminata* v. Cavendish Williams), kiwifruit (*Actinindia deliciosa*), and mango (*Mangifera indica* L.) fruits (Vilas-Boas and Kader, 2001).

Electrolyte leakage of tissues derived from fruit at each measurement interval (IC and IM) remained below 15% throughout storage (Fig. 3). The leakage values of tissue cubes derived from intact 'Galia' fruit are lower than those reported for tissue derived from 'Galia' fruit in an earlier report (Ergun et al., 2005) in which intact ripe fruit were stored at 20 °C compared with 5 °C in the present study. Leakage values were higher in continuously stored fresh-cut 'Galia' at the first measurement interval (2 d) compared with 0-d tissue and increased slightly through 10 d of storage. Leakage of 1-MCP-treated fresh-cut tissue (continuously stored) remained slightly lower than values for control tissue. Higher electrolyte leakage values for continuously stored fresh-cut tissue versus tissue derived from intact fruit at each measurement interval were also reported for tomato (Jeong et al., 2004). Jeong et al. (2004) also noted that electrolyte leakage in continuously stored tomato slices was not significantly reduced in response to 1-MCP.

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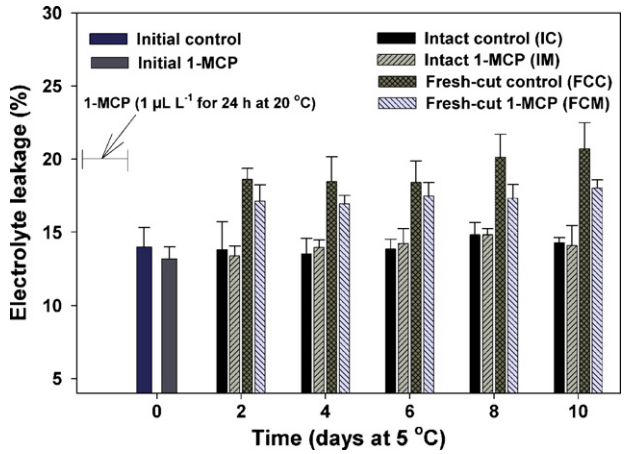

Fig. 3. Electrolyte leakage of fresh-cut 'Galia' mesocarp during storage at 5 °C. Intact fruit were processed into fresh-cut cubes at each measurement interval. Twenty-four hours 1-MCP treatment terminated at day 0. (IC, IM) Cubes derived from intact fruit at each measurement interval; (FCC, FCM) continuously stored cubes from control or 1-MCP-treated fruit. Vertical bars represent standard error of the means ($n = 5$ replicates, each with 5 disks).

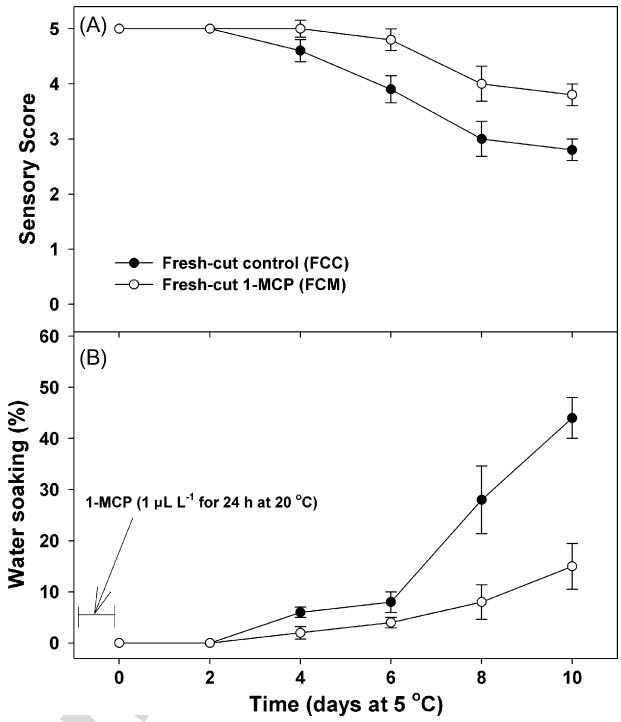

Fig. 4. Mesocarp sensory evaluation (A) and watersoaking percentage (B) for continuously stored fresh-cut 'Galia' tissue. Hedonic scale: 1, poor; 2, poor-fair; 3, good; 4, good-excellent; and 5, excellent. Twenty-four hours 1-MCP treatment terminated at day 0. (FCC, FCM) Continuously stored cubes from control or 1-MCP-treated fruit. Vertical bars represent standard error of the means ($n = 3$ replicates, 5–6 cubes per replicate).

Tissue watersoaking or translucency, and juice leakage are major factors limiting the longevity and quality of fresh-cut fruits including tomato (Hong and Gross, 2001; Jeong et al., 2004), watermelon (Mao et al., 2005), papaya (Ergun et al., 2006) and cantaloupe (*C. melo* L. (Reticulatus Group)) (Luna-Guzman et al., 1999). Although the causes of this condition remain largely unknown, watersoaking was reduced yet not prevented in fresh-cut tissue derived from 1-MCP-treated intact tomato (Jeong et al., 2004) and papaya (Ergun and Huber, 2004), indicating that ethylene contributes to the condition. In agreement with these findings, watersoaking symptoms in continuously stored fresh-cut 'Galia' tissue were significantly reduced or delayed in response to 1-MCP (Fig. 4A). The effects of 1-MCP became pronounced after 6 d, and after 10 d of storage watersoaking scores had increased to 45% for FCC and 15% for FCM. Watersoaking was not observed in tissues derived from intact fruit at each measurement interval (not shown), indicating that the condition was likely not a response to low-temperature. Also evident is that the incidence of watersoaking did not closely parallel changes in tissue firmness, the measurement of which involved penetration of tissue cubes to a depth of 10 mm. This is consistent with the findings of Jeong et al. (2004), who reported for fresh-cut tomato slices that firmness remained unchanged between days 4 and 8 at 5 °C, during which time watersoaking incidence more than doubled. Firmness measurements of fresh-cut 'Galia' were determined at the centermost region of the cubes whereas incipient watersoaking appeared at the corners of the cubes, regions bearing the highest ratio of cut surface to tissue volume. Aguayo et al. (2004) have suggested that increased surface to volume ratio results in more rapid deterioration of fresh-cut cantaloupe melon.

Watersoaking or translucency symptoms likely reflect cellular damage including localized acidification of peripheral damaged cell layers, mobilization of cell-wall calcium, and activation of cell-wall hydrolases and other enzymes. Pectin oligomer efflux (an index of accelerated cell-wall degradation) from discs of ripe tomato pericarp was proportional to cut surface area (Huber and Lee, 1989), and pectin degradation was markedly enhanced in tomato fruit in response to tissue disruption (Brummell and Labavaitch, 1997; Huber et al., 2001). Enzymes including lipases and lipoxygenase (EC. 1.13.11.12) reported for fresh-cut watermelon (Karakurt and Huber, 2003) and cantaloupe (Lamikanra and Watson, 2004) are also likely candidates in contributing to watersoaking. The effects of calcium salts at inhibiting the development of translucency in cantaloupe (Luna-Guzman et al., 1999; Luna-Guzman and Barrett, 2000; Lamikanra and Watson, 2004) and firmness changes and electrolyte leakage in fresh-cut watermelon (Mao et al., 2005) are consistent with a role for both membrane (Picchioni et al., 1996) and cell-wall metabolism (Karakurt and Huber, 2003) in the development of watersoaking. Saftner et al. (2003) speculated that the reduction in translucency of honeydew (*C. melo* L. (Inodorus Group)) melon chunks in response to calcium dips was due to increased calcium binding at injured surfaces rather than throughout the tissue as a whole.

As assessed by sensory evaluation, the hedonic score for IC or IM remained at 5 (excellent) during the 10-d storage period at 5 °C (not shown), while the continuously stored fresh-cut cubes initiated a decline at day 4 (FCC) and day 8 (FCM). On days 4–8 the sensory scores for FCC fruit declined from about 4.7 (good-excellent to excellent) to 2.8 (poor-fair to good) at day 10. By contrast, FCM tissue remained above 4 (good-excellent

Table 1
Microbial counts (log CFU kg^{-1} fresh weight) for mesocarp tissue of intact or fresh-cut 'Galia' fruit stored at 5 °C

Treatment	Total aerobic count			Enterobacteriaceae			Yeasts		
	Day 0	Day 5	Day 10	Day 0	Day 5	Day 10	Day 0	Day 5	Day 10
IC	3.7 a	2.8 a	3.9 a	ND	ND	2.8 a	ND	ND	3.1 a
IM	ND	ND	4.1 a	ND	ND	3.7 a	ND	ND	3.3 a
FCC	3.8 a	3.3 a	6.3 b	ND	4.4	4.9 b	ND	3.5	6.0 b
FCM	3.8 a	4.2 b	6.2 b	ND	ND	4.7 b	ND	ND	6.0 b

(IM) 1-MCP- or air (IC)-treated fruit stored intact and processed on the days of measurement. (FCC and FCM) Continuously stored fresh-cut tissue derived from air or 1-MCP-treated fruit. Means ($n = 3$) followed by the same letter within a column are not significantly different according to Duncan's multiple range taste ($P \leq 0.05$). ND = non-detected.

to excellent) through day 8. In general, the declining sensory scores of the fresh-cut tissue paralleled the increased incidence of tissue watersoaking.

Microbial counts for fresh-cut 'Galia' cubes stored continuously or in tissue derived from intact fruit on days 5 and 10 are summarized in Table 1. Total coliform, lactic acid bacteria and mold counts remained negligible in all treatments throughout the 10-d storage period (data not shown). Total aerobic counts increased sharply between days 5 and 10 in both FCC and FCM, with FCC having slightly higher counts (log 6.3 CFU kg^{-1}) than FCM (log 6.2 CFU kg^{-1}) at day 10 (Table 1). Total aerobic population of tissue cubes derived from intact fruit remained negligible throughout storage (Table 1). Enterobacteriaceae in both FCC and FCM increased during storage, and FCC showed slightly higher counts (log 4.9 CFU kg^{-1}) than FCM (log 4.7 CFU kg^{-1}) at day 10 (Table 1). Enterobacteriaceae levels remained negligible in tissue derived from intact fruit (Table 1). Yeasts accumulated in both FCC (log 6.0 CFU kg^{-1}) and FCM (log 6.0 CFU kg^{-1}) on days 5–10, while the incidence of yeasts in both IC and IM was negligible. Significant increases in microbe populations of fresh-cut 'Galia' fruit occurred after day 5, but differences between 1-MCP and air-treated fruit were not significant.

4. Conclusions

Based on firmness and sensory evaluations 1-MCP treatment extended the storage life of fresh-cut 'Galia' by 2–3 d at 5 °C. The main limitation to storage duration of fresh-cut ripe 'Galia' melon was tissue watersoaking, which was significantly reduced or delayed in tissue from 1-MCP-treated fruit. The lack of significant differences in microbial loads between the control and 1-MCP-treated 'Galia' indicates that the difference in the rate of deterioration between the treatments under the storage conditions employed was largely a consequence of tissue rather than microbial metabolism. The different responses to 1-MCP noted for fresh-cut 'Galia' compared with fresh-cut watermelon are likely due to the derivation of the edible tissues (i.e., carpel versus placental) and their ethylene-production capacities.

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