



Environmentally Friendly and
Safe Technologies for Quality
of Fruits and Vegetables

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The papers contained in this book report some of the peer reviewed Proceedings of the International Conference “Environmentally friendly and safe technologies for quality of fruit and vegetables”, but also other papers related with the subject were included. The manuscripts were reviewed by the Editor and Editorial Board, and only those papers judged suitable for publication were accepted. The Editor wish to thank to all the reviewers and authors for their contribution.

Authors are responsible for content and accuracy of their papers.

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SECTION 5. NEW APPROACHES TO ENHANCE SAFETY
AND QUALITY OF MINIMALLY PROCESSED FRUITS AND
VEGETABLES

31. VOLATILE AND QUALITY CHANGES IN FRESH-CUT CANTALOUPE AND HONEYDEW MELONS STORED IN MODIFIED ATMOSPHERE PACKAGING

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Abstract

Modified atmosphere packaging (MAP) in fresh-cut melons has been reported to preserve the visual quality during storage, yet its effect upon aroma and firmness is cultivar-dependent. The main objective of this research was to compare the properties of fresh-cut from a fast senescing cantaloupe with a slow senescing honeydew melon, regarding changes in quality and volatiles, when stored in passive MAP. Fresh-cut cubes of cantaloupe and honeydew melons were packaged in polypropylene trays, over-wrapped with a microperforated film and stored for 14 days at 5 °C. Three replicate packages of each cultivar were assayed at day 0, 4, 7, 11 and 14 for color, firmness, soluble solid content (SSC), respiration rate and volatile retention, and the experiment was repeated. Volatile compounds were extracted using a relatively recent technique, Stir Bar Sorptive Extraction (SBSE), and quantified via GC-MS. Color and SSC remained constant throughout storage. During the first 4 days of storage, the cantaloupe cubes softened at a higher rate (2.0 N day⁻¹) than honeydew cubes (0.9 N day⁻¹), but firmness remained relatively unchanged thereafter until the end of the storage period. Fresh-cut cantaloupe cubes exhibited a higher respiration rate (17.5–43.4 mL CO₂ kg⁻¹ h⁻¹) than fresh-cut honeydew cubes (7.7–30.0 mL CO₂ kg⁻¹ h⁻¹), throughout the entire storage period. Esters and aldehydes were the major volatile compounds present in the samples of both cultivars, but cantaloupe yielded higher concentrations of esters and aldehydes, and lower concentrations of alcohols than honeydew. Esters increased their levels during storage, whereas alcohols and aldehydes decreased.

Keywords: *Cucumis melo*, firmness, minimally processed, quality

Introduction

Fresh-cut processing induces a physiological response to tissue due to rupturing, and wounding enhances respiration rate and ethylene production. Color, sweetness and texture, perceived as important quality attributes of fresh-cut melons (Portela & Cantwell 1998) change as well as aroma compounds that are often only released upon cell disruption (Buttery 1993). The understanding of the processes leading to these changes is essential to develop better approaches to improve quality perceived by the consumer and shelf-life (Rico *et al.* 2007; Toivonen & Brummell 2008).

Cantaloupe and honeydew melons are commonly used as fresh-cut fruit. Cantaloupe melons are climacteric, exhibit higher respiration and ethylene production rates, show faster softening and shorter shelf-life than the non-climacteric honeydew melons. In climacteric melon fruits, ethylene regulates rind degreening, aroma formation and abscission, and partly regulates flesh softening (Bauchot *et al.* 1998; Flores *et al.* 2001, 2002). Although the role of ethylene in regulating the expression of genes involved in aroma volatile synthesis has been demonstrated in climacteric fruits such as melons and apple (Defilippi *et al.* 2005; El-Sharkawy *et al.* 2005; Manriquez *et al.* 2006), little is known about the regulation of aroma formation in non-climacteric fruits.

Aroma of fresh-cut melon is made up of a complex mixture of volatile compounds, such as aldehydes, acetate and nonacetate esters, alcohols and sulphur-containing compounds. Our goal was to assess the effect of minimal processing upon the physicochemical quality and aroma volatiles of cantaloupe and honeydew melons.

Material & Methods

Orange fleshed cantaloupes ('Sol Real') and green fleshed honeydews (unknown cultivar) were received and kept overnight at 5 °C, prior to processing. Fruits were washed in cold water, dipped in 100 ppm of sodium hypochloride solution, and allowed to drain. The skin was removed using a CP-44 Melon Peller (Muro Co.), the blossom and stem ends were discarded, placental tissue and seeds were removed and cubes were prepared (ca. 2.5×2.5 cm). The cubes (ca. 175 g) were placed immediately in 250 g polypropylene MAP trays (Green-Tek, USA), and overwrapped with a microperforated film with an O₂ transmission rate of 5200 cm³m⁻¹ dia⁻¹ atm⁻¹ (Amcor Flexibles, Europe). Samples were stored for 14 days (d) at 5 °C, and analyzed at days 0, 4, 7, 11 and 14.

Color was measured in the CIE L*C*h color space, with a colorimeter CR-400 (Konica Minolta, Japan), using the illuminant D65. Pulp color of melon cubes was measured twice in each of three cubes samples, from three replicated packages of each cultivar. Mesocarp tissue firmness was measured with an 8 mm-probe hand-held penetrometer (McCormick, FT327, Italy) on three cubes from each replicate. Soluble solids content (SSC, °Brix) was determined on the juice obtained from three cubes using a hand-held refractometer (Atago PAL-1, Japan). In order to monitor the package headspace, a small piece of adhesive rubber strip was attached to the MAP film, and the sampling needle of the gas analyzer (Mocon Pac Check Model 650 Dual Head Space Analyzer, USA) was inserted in each package. The respiration rate was calculated from measurements of CO₂ released to the headspace of a closed system for 2 h. CO₂ was measured with a gas analyzer. For volatile analyses, samples were juiced with a Braun MP80 Juicer (Germany) and the stir bar sorptive extraction (SBSE) technique was used. Stir bars with 10 mm length, manufactured by Gerstel (Muelheim an der Ruhr, Germany), were conditioned at 300 °C for 1 h, and properly re-conditioned between samplings. The stir bars were placed in 10 mL vials containing 1 mL of juice, from each replicated sample, 4 mL of 62.5 % saturated salt solution and 2-methylbutyl 3-methylbutanoate as internal standard, and sealed with a steel cap fitted with a teflon/silicon septum. Extraction was then performed for 1 h at 38.5 °C and 850 rpm, via Variomag Multipoint HP15 stir plate. After said extraction, the volatile compounds were quantified via GC-MS (Agilent 5973 MSD, USA) using a DB5 capillary column (30 m×0.25 mm×0.25 μm, Agilent).

Results

Color and SSC remained relatively constant throughout storage for both melon cultivars (data not shown). SSC ranged between 9.6%±0.2 and 9.5%±0.2 for cantaloupe, and 11.3%±0.5 and 11.5%±0.4 for honeydew.

Initial firmness values were 30.1 N ± 3.6 for cantaloupe and 21.5 N±2.7 for honeydew cubes. Firmness of both fresh-cut cultivars decreased during the first 4 d at 5 °C, and remained relatively unchanged for the remaining storage period. During the first 4 d of storage, cantaloupe cubes softened at a higher rate (2.0 N day⁻¹) than honeydew cubes (0.9 N day⁻¹), and by the end of the 14 d of storage, firmness values were 18.9 N±2.3 for cantaloupe cubes and 15.9 N±2.1 for honeydew cubes (Fig 1).

O₂ levels inside the packages gradually decreased to 11.1% for cantaloupe and 14.2% for honeydew, while CO₂ increased to 11.3% and 7.9% for cantaloupe and honeydew, respectively (data not shown). Fresh-cut cantaloupe cubes exhibited a higher respiration rate (17.5-43.4 mL CO₂ kg⁻¹ h⁻¹) than fresh-cut honeydew cubes (7.7-30.0 mL CO₂ kg⁻¹ h⁻¹), throughout the entire storage period (Fig 2).

For both cantaloupe and honeydew melons, the total volatile abundance increased during the 14 d of storage. This increase was mostly due to the increase in acetate (Fig 3) and non-acetate esters (Fig 4). Cantaloupe yielded higher concentrations of esters and aldehydes (Fig 5), and lower concentrations of alcohols than honeydew (Fig 6), and sulfur-containing compounds were found to be low in both cultivars (data not shown).

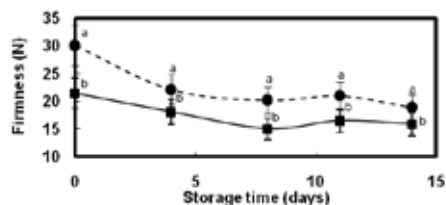


Fig 1. Firmness of fresh-cut cantaloupe (●) and fresh-cut honeydew (■), stored for 14 d at 5 °C. Data points are the average of 18 replicates. Statistical analysis comparing differences between cultivars. Values followed by the same letter are not significantly different ($p \leq 0.05$), by the non parametric Kruskal-Wallis H test.

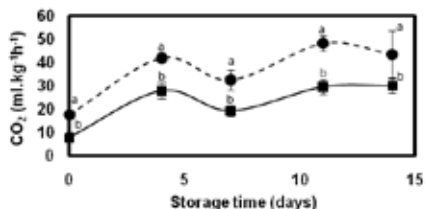


Fig 2. Respiration rate of fresh-cut cantaloupe (●) and fresh-cut honeydew (■), stored for 14 d at 5 °C. Points are the average of 6 replicates. Statistical analysis comparing differences between cultivars. Values followed by the same letter are not significantly different ($p \leq 0.05$), by the non parametric Kruskal-Wallis H test.

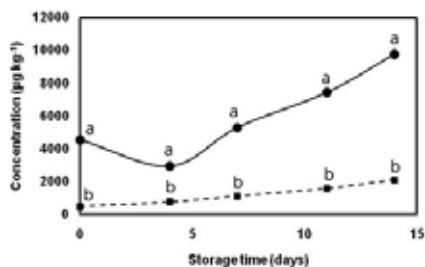


Fig 3. Total concentration of acetate esters in fresh-cut cantaloupe (●) and fresh-cut honeydew (■), stored for 14 d at 5 °C. Points are the sum of different compounds. Statistical analysis comparing differences between cultivars. Values followed by the same letter are not significantly different ($p \leq 0.05$), by one way ANOVA.

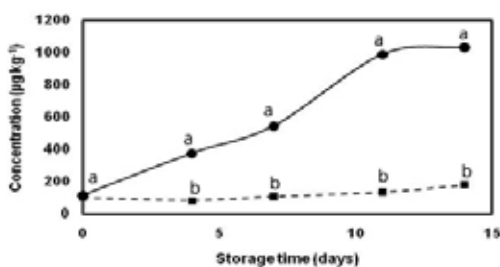


Fig 4. Total concentration of non-acetate esters in fresh-cut cantaloupe (●) and fresh-cut honeydew (■), stored for 14 d at 5 °C. Points are the sum of different compounds. Statistical analysis comparing differences between cultivars. Values followed by the same letter are not significantly different ($p \leq 0.05$), by one way ANOVA.

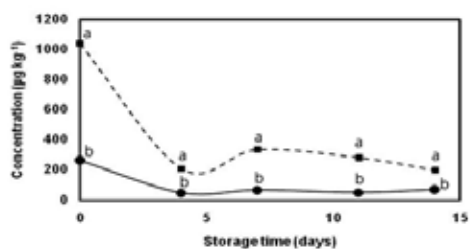


Fig 5. Total concentration of alcohols in fresh-cut cantaloupe (●) and fresh-cut honeydew (■), stored for 14 d at 5 °C. Points are the sum of different compounds. Statistical analysis comparing differences between cultivars. Values followed by the same letter are not significantly different ($p \leq 0.05$), by one way ANOVA.

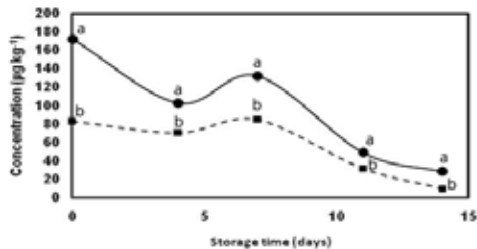


Fig 6. Total concentration of aldehydes in fresh-cut cantaloupe (●) and fresh-cut honeydew (■), stored for 14 d at 5 °C. Points are the sum of different compounds. Statistical analysis comparing differences between cultivars. Values followed by the same letter are not significantly different ($p \leq 0.05$), by one way ANOVA.

Discussion

Quality attributes differed between cantaloupe and honeydew cubes. Color parameters (L^* , C and h) did not change significantly during storage, and visual differences were only due to the characteristic flesh color of the cultivar. Similarly, little color change was reported in previous studies (Boynton *et al.* 2005; Beaulieu & Lea 2007).

Soluble solid content was higher in honeydew than in cantaloupe cubes (data not shown). Similar results were reported by Saftner *et al.* (2006) with no consistent pattern of change in SSC among any of the genotypes being observed during storage.

Cantaloupe, as expected from its climacteric behaviour, exhibited higher softening rates than honeydew cubes, as previously reported (Saftner *et al.* 2006). Throughout the entire storage period there were significant differences in firmness between cultivars, with fresh-cut cantaloupe exhibiting higher firmness than fresh-cut honeydew.

The respiration rate of fresh-cut cantaloupe was higher than that of fresh-cut honeydew, as previously reported (Saftner *et al.* 2006). Both cultivars showed an increase of CO_2 production between days 0 and 4, unlike the results in cantaloupe by Luna-Guzmán *et al.* (1999) and Aguayo *et al.* (2003), and in honeydew by Saftner *et al.* (2003), according to which the respiration rate of fresh-cut melons decreased in the first two days of storage. An increase in CO_2 production was observed between days 7 and 11. This increase may have been induced by microbial growth, as reported by Aguayo *et al.* (2003), Bai *et al.* (2003) and Saftner *et al.* (2003), although visual microbes were not observed. Levels of O_2 and CO_2 inside the cantaloupe and honeydew packages were similar to those found in cantaloupe by Bay *et al.* (2001) and Aguayo *et al.* (2003) and in honeydew by Bai *et al.* (2003) in which levels of O_2 and CO_2 inside the packages did not reach equilibrium during MAP storage and were not sufficient to inhibit microbial growth.

Preliminary volatile data analysis indicated that volatile compounds discriminate cantaloupe from honeydew melons. There were distinct qualitative and quantitative differences in the aromatic volatiles studied between cultivars (data not shown). The total volatile concentration in fresh-cut cantaloupe was 3-fold that in fresh-cut honeydew. While Saftner *et al.* (2006) reported an increase of total volatile abundance of fresh-cut melons only in the first 2 d of storage under MAP, in this study such an increase was observed throughout the entire storage period. Esters were the major volatiles identified in both cultivars. Among them, butyl acetate, 2-methylbutyl acetate, benzyl acetate and hexyl acetate were the most abundant (Wang *et al.* 1996; Wyllie *et al.* 1996; Bauchot *et al.* 1998; Bai *et al.* 2003; Saftner *et al.* 2003; Aubert & Bouger 2004; Beaulieu 2006b). There was a continuous change in ester balance during fresh-cut storage. Saftner *et al.* (2003) indicated a decrease of acetate esters during fresh-cut melon storage under MAP, and Beaulieu (2006a,b) demonstrated an acetate decrease with concomitant non-acetate ester increase in fresh-cut stored in clamshell containers, however, in this study an increase of both acetate and nonacetate esters levels was observed. Total esters concentration was 67% higher in cantaloupe than in honeydew. Alcohols and aldehydes decreased during storage. Alcohols were more abundant in honeydew than in cantaloupe due to the higher level of (*Z*)-6-nonenol, a flavour-related compound in honeydew melons (Buttery *et al.* 1982). Similar to results generated by Bauchot *et al.* (1998), sulphur-containing compounds, which were believed to have an important role in the overall aroma profile of melon (Kemp *et al.* 1972; Wyllie & Leach 1992), were detected in very small amounts in both cultivars.

Conclusion

For most quality parameters, the discrimination by climacteric and non-climacteric behaviour was better at processing than by the end of the storage period. Regarding aroma development, acetate esters that are often considered the most important flavour-related volatiles in several melon cultivars (Buttery *et al.* 1982; Beaulieu 2006b); increased while a decrease of alcohols and aldehydes was observed during fresh-cut cantaloupe and honeydew storage. In this experiment, MAP provided a mean to reduce respiration. Likely

due to high O₂ availability in MAP, there was an available pool of acetyl-CoA in both cultivars, even after 14 d of storage, which allowed acetate ester formation via alcohol esterification by alcohol acetyltransferase (AAT). Simultaneously, AAT esterified other acyl donors with available alcohols, to form non-acetate esters. These results suggest that MAP retarded the loss of volatile compounds in fresh-cut cantaloupe and honeydew melons, thus maintaining quality during storage.

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References

- Aguayo E, Allende A, Artés F. 2003. Keeping quality and safety of minimally fresh processed melon. *Eur Food Res Technol* 216:494-9
- Aubert C, Bouger N. 2004. Investigation of volatiles in Charentais cantaloupe melons (*Cucumis melo* Var. *cantaloupensis*). Characterization of aroma constituents in some cultivars. *J Agr Food Chem* 52:4522-8
- Bai J, Saftner RA, Watada AE, Lee YS. 2001. Modified atmosphere maintains quality of fresh-cut cantaloupe (*Cucumis melo* L.). *J Food Sci* 66:1207-11
- Bai J, Saftner RA, Watada AE. 2003. Characteristics of fresh-cut honeydew (*Cucumis melo* L.) available to processors in winter and summer and its quality maintenance by modified atmosphere packaging. *Postharvest Biol Technol* 28:349-59
- Bauchot AD, Mottram DS, Dodson AT, John P. 1998. Effect of aminocyclopropane-1-carboxyl acid oxidase antisense gene on the formation of volatile esters in Cantaloupe Charentais melon (cv. Védrandais). *J Agric Food Chem* 46:4787-92
- Beaulieu JC, Lea JM. 2003. Volatile and quality changes in fresh-cut mangos prepared from firm-ripe and soft-ripe fruit, stored in clamshell containers and passive MAP. *Postharvest Biol Technol* 30:15-28
- Beaulieu JC. 2006a. Effect of cutting and storage on acetate and nonacetate esters in convenient, ready-to-eat fresh-cut melons and apples. *HortScience* 41:65-73
- Beaulieu JC. 2006b. Volatile changes in cantaloupe during growth, maturation, and in stored fresh-cuts prepared from fruit harvested at various maturities. *J Am Soc Hort Sci* 131:127-39
- Beaulieu JC, Lea JM. 2007. Quality changes in cantaloupe during growth, maturation, and in stored minimally processed cubes prepared from fruit harvested at various maturities. *J Am Soc Hort Sci* 132:720-8
- Boynton BB, Welt BA, Sims CA, Brecht JK, Balaban MO, Marshall MR. 2005. Effects of low-dose electron beam irradiation on respiration, microbiology, color, and texture of fresh-cut cantaloupe. *HortScience* 15:802-7
- Buttery RG, Seifert RM, Ling LC, Soderstrom EL, Ogawa JM, Turnbaugh JG. 1982. Additional aroma components of honeydew melon. *J Agr Food Chem* 30:1208-11
- Buttery RG, Ling LC. 1993. Volatiles of tomato fruit and plant parts: relationship and biogenesis, pp:23-34. In: *Bioactive volatile compounds from plants*. Teranishi R, Buttery R, Sugisawa H (eds) ACS Books, Washington DC
- Defilippi BG, Dandekar AM, Kader AA. 2005. Relationship of ethylene biosynthesis to volatile production, related enzymes, and precursor availability in apple peel and flesh tissues. *J Agr Food Chem* 53:3133-41
- El-Sharkawy I, Manriquez D, Flores FB, Regad F, Bouzayen M, Latche A, Pech JC. 2005. Functional characterization of a melon alcohol acyl-transferase gene family involved in the biosynthesis of ester volatiles. Identification of the crucial role of a threonine residue for enzyme activity. *Plant Mol Biol* 59:345-62
- Flores F, Ben Amor M, Jones B, Pech JC, Bouzayen M, Latche A, Romojaro F. 2001. The use of ethylene-suppressed lines to assess differential sensitivity to ethylene of the various ripening pathways in Cantaloupe melons. *Physiol Plantarum* 113:128-33
- Flores F, el Yahyaoui F, de Billerbeck G, Romojaro F, Latche A, Bouzayen M, Pech JC, Ambid C. 2002. Role of ethylene in the biosynthetic pathway of aliphatic ester aroma volatiles in Charentais Cantaloupe melons. *J Exp Bot* 53:201-6
- Kemp TR, Stolz LP, Knavel DE. 1972. Volatile components of muskmelon fruit. *J Agr Food Chem* 20:196-8
- Luna-Guzmán I, Cantwell M, Barret DM. 1999. Fresh-cut cantaloupe: effects of CaCl₂ dips and heat treatments on firmness and metabolic activity. *Postharvest Biol Technol* 17:201-13
- Manriquez D, el-Sharkawy I, Flores FB, el-Yahyaoui F, Regad F, Bouzayen M, Latche A, Pech JC. 2006. Two highly divergent alcohol dehydrogenases of melon exhibit fruit ripening-specific expression and distinct biochemical characteristics. *Plant Mol Biol* 61:675-85

- Portela SI, Cantwell MI. 1998. Quality changes in minimally processed honeydew melons stored in air or controlled atmosphere. *Postharvest Biol Technol* 14:351-7
- Rico D, Martín-Diana AB, Barat JM, Barry-Ryan C. 2007. Extending and measuring the quality of fresh-cut fruit and vegetable: a review. *Trends Food Sci Technol* 18:373-86
- Saftner RA, Bai J, Abbott JA, Lee YS. 2003. Sanitary dips with calcium propionate, calcium chloride, or a calcium amino acid chelate maintain quality and shelf life stability of fresh-cut honeydew chunks. *Postharvest Biol Tec* 29:257-69
- Saftner RA, Abbott JA, Lester G, Vinyard B. 2006. Sensory and analytical comparison of orange-fleshed honeydew to cantaloupe and green-fleshed honeydew for fresh-cut chunks. *Postharvest Biol Technol* 42:150-60
- Toivonen PMA, Brummell DA. 2008. Biochemical bases of appearance and texture changes in fresh-cut fruit and vegetables. *Postharvest Biol Technol* 48:1-14
- Wang Y, Wyllie SG, Leach DN. 1996. Chemical changes during the development and ripening of the fruit *Cucumis melo* (cv. Makdimon). *J Agr Food Chem* 44:210-6
- Wyllie SG, Leach DN. 1992. Sulfur-containing compounds in the aroma volatiles of melons (*Cucumis melo*). *J Agr Food Chem* 40:253-6
- Wyllie SG, Leach DN, Wang Y. 1996. Development of flavor attributes in the fruit of *C. melo* during ripening and storage, pp:228-39. In: *Biotechnology for Improved Foods and Flavors*, Takeoka GR, Teranishi R, Williams PJ, Kobayashi A (eds). ACS Symposium Series 637. ACS Books. Washington, DC