Use of Mild Heat Pre-treatment for Quality Retention of Fresh-cut Cantaloupe Melon

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ABSTRACT: The effect on sensory attributes and shelf life of fresh-cut cantaloupe melon subjected to pre-cut heat treatment at 50 °C for 60 min, followed by storage at 4 °C prior to cutting, and then storage at 10 °C for 8 d was determined. Heat treatment reduced the rate of respiration and moisture loss during storage of the cut fruit. The treatment also reduced total microbial count during the 1st storage d and prevented growth of lactic acid bacteria that occurred in untreated fruit after 8 d in storage. Sensory evaluations indicate that heat treatment increased intensities of desirable attributes such as fruity melon and sweet aromatic flavors, and reduced undesirable flavors such as musty, sour, bitter, chemical and fermented. The study suggests that heat treatment would be useful in improving shelf life of fresh-cut fruit.

Keywords: Mild heat pre-treatments, Postharvest, Minimal processing, Sensory evaluation, Cucumis melo L., Fruit

Introduction

Heat treatment has been used for many years to control fungal spores and insect infestations in fruits and vegetables (Seo and others 1997; Lurie 1998). Mild heat treatment of a number of horticultural crops has been reported to improve product quality and shelf life. The beneficial effect of heat treatment has been attributed to the synthesis of heat shock proteins (HSPs; Wang and others 2001). Heat treatment inhibits ethylene synthesis, tissue response to ethylene, and cell wall degradation associated with hydrolytic enzymes (Lurie 1998). Heat also allows demethylation of pectin by pectin methyl esterase to form anionic carboxyl groups with which calcium can form salt bridge links thereby strengthening cell walls (Alonso and others 1997). This could make cell walls less accessible to the enzymes that cause softening (Sams and others 1993). Wang and others (2001) demonstrated that heat treatment of apples increases HSPs content and reduce ethylene production. Cell wall degrading enzymes and production of ethylene production are frequently disrupted and are sometimes not produced or delayed following heating (Paull and Chen 2000). Heated strawberries were firmer and stored better than unheated fruit (Vicente and others 2002).

Most of the efforts to improve the sensory quality and shelf life of fresh-cut fruits have been limited to post-cut treatments. The reduced shelf life of cut fruit, relative to that of intact fruit, is associated with physiological and biochemical changes typical of the senescence process such as increased respiration and ethylene production, and loss of membrane integrity (Toivonen and DeEll 2002). The objective of this project was to determine the effect of mild heat treatment on sensory quality and shelf life of fresh-cut cantaloupe melon.

Materials and Methods

Fruit preparation

Cantaloupe melon (Cucumis melo L. var. reticulatus), supplied by Del Monte Fresh Produce Co. (Coral Gables, Fla., U.S.A.), was received at 4 °C. Heat treatment was conducted by immersing fruit into a water bath at 50 °C, for a period of 60 min. The treated fruit was then stored for 24 h at 4 °C before processing by cutting longitudinally into 2 halves, removing seeds, and then cutting into 8 equal parts. The skin was removed and cubes, approximately 2 to 3 cm × 2.5 cm, were prepared in pie-like wedges cut from the 2.5-cm-wide slices. Good manufacturing practices and best possible sanitary conditions were strictly adhered to during processing and all subsequent handling stages. Approximately 300 g of cubes from each melon were placed into 24-ounce (about 1 liter) low-profile Juice Catcher containers (SRW-24-JC; Winkler Forming Inc., Carrollton, Tex., U.S.A.), and stored at 10 °C. For sensory evaluations, 12 cantaloupe melons, 6 heat-treated and 6 controls (untreated), were processed. Each melon yielded samples for 2 panelists allowing a panelist to observe the sensory differences of a single melon throughout the course of the experiment. Sensory samples were comprised of 6 melon cubes stored in 5 cm fruit cups (nr 381200; Rock-Tenn Co., Norcross, Ga., U.S.A.) labeled with the panelist’s name and a 3-digit random number. Samples were evaluated after 1, 5 and 8 d in storage, with the exception of taste determination that was conducted after 1 and 5 d storage period.

Determination of respiration

Immediately after cutting, cut fruit (50 g) was placed into Mason jars (0.5 L) fitted with air-tight lids equipped with rubber septums and stored at 10 °C. At the designated sampling time, a needle syringe attached to Mocon Pack Check 650 analyzer (MOCON\Modern Controls, Inc., Minneapolis, Minn., U.S.A.) was inserted into the rubber septum of the respective jar and sample gas (8 cm³) from the headspace was analyzed for CO₂ and O₂ gas respectively. Differences in respiration rate between samples during storage were assessed from the gas composition.

Moisture loss determination

Initial fruit weight was determined immediately after fruit processing. On each sampling date, fruit stored in low-profile Juice Catchers was transferred into new containers that had been maintained at the storage temperature, and moisture loss of the fruit was assessed immediately after the transfer.
Mild heat pre-treatment of cantaloupe...

was estimated as the difference in the weight of fruit on the sampling date from weight of fruit when freshly processed.

Microbial assays were performed by Silliker, Inc. (Grand Prairie, Tex., U.S.A.). On each sampling day, 2 sets of fruit (50 g) for each treatment in 5 cm fruit cups were cooled down to 4 °C, placed on ice packs in Styrofoam containers previously cooled down to the same temperature and shipped overnight. Fruit pieces were homogenized with sterile water, serially diluted, and overlaid onto Aerobic Count Petrifilm plates, Petrifilm Coliform plates, and Yeast and Mold Petrifilm plates. The coliform counts were done after 24 h of incubation at 35 °C while yeast and mold counts were taken at 120 h. The total aerobic plate counts were done after incubation for 48 h at 35 °C. For lactic acid bacteria determination, the fruit was initially blended with 0.1% peptone, serially diluted, and overlaid onto deMan Rogosa Sharpe (MRS) plates. Plates were then incubated at 30 °C for 120 h before colonies were counted.

Descriptive sensory analysis

Eleven panelists, having from 1 to 10 y experience in descriptive sensory analysis of cantaloupe melon (Meilgaard and others 1999), participated in the sensory evaluation. They evaluated 12 aroma, 18 flavor, and 6 texture attributes. Sensory descriptors reported were fruity/melon, cucurbits, citrus, floral, green/grassy, woody, chemical rancid/painty, waterlike, sweet aromatic, musty, fermented (aroma/flavor); metallic, bitter, salty, sweet, sour, astringent (flavor); surface wetness, hardness, cohesiveness, crispness, juiciness and moisture release (texture) (Bett 2002). During evaluations, panelists vented the lids to allow the headspace to enter the nose. Intensities of the various aromas emitted from the samples were assessed. After aroma evaluations, panelists performed flavor and texture analysis by mouth. Intensity was rated on a 0 to 15-point anchored scale with 0 being not detectable and 15 being more intense than most foods (Meilgaard and others 1999). If a flavor/textural descriptor was observed with a different flavor/textural intensity in 2 different cubes, then an estimated average was recorded by the panelist. Panelists used filtered water and unsalted crackers between samples to cleanse their palates. Sensory analysis was conducted under red lights to discourage preconceptions associated with food coloration. A warm-up sample was presented 1st to reduce the 1st sample position bias. Thereafter, the experimental samples were presented monadically in random order at 10 min intervals within a session. All panelists received the samples in the same order. All treatments for a given storage day were replicated within the same melon and presented at 1 session.

Statistical analysis

Standard error of mean values was determined from standard deviation and sample size using GraphPad Prism (San Diego, Calif., U.S.A.) software. The unpaired t test with Welch correction was performed for comparison of means using GraphPad Instat software. Difference between mean values is considered significant when \( P < 0.1 \).

Results and Discussion

Among the possible consequences of mechanical injury to produce is increased respiration rate (Toivonen and DeEll 2002). The increased respiration results in reduced product shelf life, and treatments that reduce respiration rates would generally increase the shelf life of cut produce. Respiration rate, as indicated by \( CO_2 \) emission, was lower during storage of cut cantaloupe melon from treated fruit relative to unheated controls (Figure 1). The oxygen consumption pattern was essentially the reverse of the emission rate, with the heated fruit consuming the least amount of \( O_2 \) (data not shown). Post-cut hot water dipping of cantaloupe melon was reported by Luna-Guzman and others (1999) to have no effect on either respiration rate or ethylene production during storage. The different observation in this study is indicative of differences in the effect of heat on metabolic and physiological changes that occur when whole fruit is heat-treated relative to the post-cut product treatment. This is also evidenced by a 30% reduction in level of ethylene that occurs in uncut cantaloupe melon immediately after heating or removal of the heat-treated fruit after refrigerated storage (Dunlap and others 1990). Postharvest heat treatments of uncut fruit typically lead to alterations of gene expression (Paull and Chen 2000), which apparently does not occur in post cut treated fruit. Wang and others (2001) stated that a complete explanation for the protective effect of heat treatments in uncut fruit is elusive, but indicated that the protection appears to be related to the induced formation of HSPs. Kim and others (1993) also reported reduced respiration for some apple cultivars as a result of heat treatment and that respiration rate decreased with storage time at 2 °C.

Moisture loss in fruit pieces obtained from heated fruit was con-
Mild heat pre-treatment of cantaloupe . . .

considerably less than fruit from the unheated control during storage (Figure 2). Heat treatment increases protoplasmic viscosity and loss of membrane permeability as a result of protoplasmic streaming (Paull and Chen 2000) and this might have contributed to the moisture retention in treated fruit pieces. Heat-induced enzymatic alteration in pectin and cell walls might also be a factor in the observed effect (Alonso and others 1997). A similar moisture retention effect was reported for heat-treated Valencia oranges (Williams and others 1994). Results from microbiological testing indicated that the total plate count (Log CFU/g) after 24 h of storage was less than 1.00, while that of the control was 3.98 (Table 1). After 5 d in storage, total plate counts were higher and comparable for both the treated and control fruit. Yeast, mold, and coliform counts in treated and untreated fruit were minimal and there was no significant difference as a result of fruit treatment (data not shown). The difference in microbial counts after 8 d of storage was the sudden and rapid growth of lactic acid bacteria in the control (4.23 Log CFU/g) unlike the treated fruit that had minimal lactic acid bacteria growth (< 1.00 Log CFU/g). Previous studies (Lamikanra and others 2000) have indicated the prevalence of bacterial growth during storage of fresh-cut cantaloupe relative to mold and yeast. The presence of significant quantities of lactic acid bacteria in cut fruit was suggested as a potential marker for temperature abuse during storage because low temperatures favored the growth of Gram-negative stained rods, while at abuse temperatures (above 10°C) Gram positive mesophilic bacteria tend to dominate. Lactic acid bacteria growth in this study was not observed in samples analyzed before the 8th d unlike the rapid growth of the bacteria that occurred after 1 d in storage at 20°C (Lamikanra and others 2000).

Sensory descriptors and definitions of melon flavor and texture used were previously published (Bett 2002). Fruit quality deterioration during storage of fresh-cut cantaloupe melon is indicated by the decrease in desirable aroma intensities such as fruity/melon and sweet aromatic, and increases in woody, musty, chemical, rancid/painty, and fermented aromas that are undesirable (Figure 3). Loss of fruity character during storage of cut cantaloupe melon has been ascribed to reduction in the concentration of esters (Lamikanra and Richard 2002). The most significant change in aroma in the unheated fruit was the increase between d 1 and d 5 in the fermented aroma that increased more than 13 fold. Heat-treated fruit had higher intensities of the fruity/melon aroma after the 1st storage d (P = 0.048), and although intensity decreased during storage, they were consistently rated higher than the corresponding untreated fruit. After 8 d in storage, the fruity melon aroma intensity was higher (P = 0.080) while musty (P = 0.002), rancid/painty (P = 0.007), and fermented (P = 0.081) aroma intensities were lower.

Changes in flavor taste intensities were essentially similar to those of aroma (Figure 4). Heat treatment resulted in fruit with more intense fruity/melon taste on d 1 (P = 0.058) and d 5 (P = 0.023). Sweet (P = 0.023) and sweet aromatic (P = 0.004) flavors were more intense in cut heated fruit after 5 d in storage. Cut fruit from unheated cantaloupe melon was judged by panelists to be having a stronger bitter taste (P = 0.004) after 1 d in storage than those from the heated fruit. After 5 d, intensities of musty (P = 0.023), chemical (P = 0.003), bitter (P = 0.002), sour (P = 0.002), and fermented (P = 0.001) flavors were higher in the untreated fruit. The fermented flavor, as in fermented aroma, was detected by panelists to be slightly higher in the heated fruit after the 1st d in storage (P = 0.104), but the intensity of this off-flavor increased severalfold on d 5 in the nonheated relative to the heated fruit. The sour taste is a basic taste stimulated by acids (Bett 2002). In apples, the effect of heat treatment on sourness might be different from our

Table 1—Microbial growth (Log CFU/g) during storage of pre-cut heat treated (trtd) cantaloupe melon and unheated control (cntrl) at 10 °C

<table>
<thead>
<tr>
<th></th>
<th>Cntrl</th>
<th>Trtd</th>
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<tr>
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<td>3.9a</td>
<td>&lt; 1.0b</td>
<td>6.7cd</td>
<td>6.1c</td>
<td>7.2d</td>
<td>6.9cd</td>
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<td><strong>Day 8</strong></td>
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<td><strong>Total Plate Count</strong></td>
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<tr>
<td><strong>Coliform</strong></td>
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<td>&lt; 1.0a</td>
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<tr>
<td><strong>Lactic Acid</strong></td>
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<td>&lt; 1.0a</td>
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<td>&lt; 1.0a</td>
<td>4.2b</td>
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<tr>
<td><strong>Yeast</strong></td>
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<td>&lt; 1.0a</td>
<td>3.8b</td>
<td>3.7b</td>
<td>4.7c</td>
<td>3.4b</td>
</tr>
<tr>
<td><strong>Mold</strong></td>
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<td>&lt; 1.0a</td>
<td>&lt; 1.0a</td>
<td>&lt; 1.0a</td>
<td>&lt; 1.0a</td>
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*Numbers in each row without the same letter are significantly different

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results on cantaloupe melon. Kim and others (1993) and Laurie and Klein (1992) reported lower total acidity in heated apple slices than the nonheated fruit. The effect of heat treatment on acidity and sweetness varies depending on the fruit (Paull and Chen 2000).

Most studies report reduction of softening and increased firmness to be the main textural changes that result from postharvest heat treatment of fruit (Kim and others 1993; Paull and Chen 2000, Valero and others 2002; Abreu and others 2003). In heat-treated plums, increased cell wall-bound spermidine induced a greater cell wall stability and plum firmness (Valero and others 2002). Firmness was not one of the sensory attributes specifically evaluated in this study. The textural properties of treated and untreated fruit determined were not significantly different (Figure 5).

A temperature around 55 °C was indicated by Couey (1989) as the most severe treatment that is noninjurious in hot water treatments of cantaloupe melon. Our results on flavor and texture attributes indicate that the temperature used in this study (50 °C) had no apparent adverse effect, instead it improved product quality. Previous studies on cut melons (Lamikanra and Watson 2001, 2003, 2004) demonstrated that some enzymes such as peroxidase, lipase, and esterase are relatively unstable when incubated at temperatures above 60 °C for 20 min. Inactivation of these enzymes prior to cutting and/or the reduced ability to synthesize them as a result of pre-cut heat treatment could also contribute to cut fruit with improved sensory quality and prolonged storage life.

**Conclusions**

Hot water treatment of whole cantaloupe melon prior to cutting could be used to improve sensory quality and shelf life of the cut fruit. Fresh-cut melon from heat-treated fruit had lower respiration rates and improved moisture retention during storage. The microbial advantage of this treatment on fresh-cut cantaloupe melon, particularly at temperatures below 10 °C might be limited to an initial reduction of bacterial growth during the early stages of stor-
Mild heat pre-treatment of cantaloupe... age. Evaluation by a highly trained panel demonstrated improved sensory attributes during storage as a consequence of preheating fruit prior to cutting. Further research is needed to determine optimum temperatures and duration of heat treatment for improving the quality of fresh-cut fruit.

References