Cutting Blade Sharpness Affects Appearance and Other Quality Attributes of Fresh-cut Cantaloupe Melon

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ABSTRACT: Cantaloupe melon pieces (1.8 cm dia × 3.5 to 4.0 cm cylinders) were prepared using stainless steel borers with sharp or blunt blades, and stored for 12 d in air at 5°C. Pieces prepared with the sharp borer maintained marketable visual quality for at least 6 d, while those prepared with the blunt borer were unacceptable by d 6 due to surface translucency and color changes. Borer sharpness did not affect changes in decay, firmness, sugar content, or aroma, but blunt-cut pieces had increased ethanol concentrations, off-odor scores, and electrolyte leakage compared to sharp-cut pieces. Respiration rates at 5°C were similar for both cutting treatments, but ethylene production rates were sometimes higher in pieces cut with the blunt blade.

Keywords: minimal processing, translucency, color, firmness, electrolyte leakage, respiration, ethylene production

Introduction

ProducIng Fresh-cut or Minimally Processed products involves substantial mechanical injury due to peeling, slicing, dicing, shredding, or chopping. Thus, the physiology of minimally processed fruits and vegetables is essential to the physiology of wounded tissue (Brecht 1995; Saltveit 1997). The main physiological manifestations of wounding include increased respiration and ethylene production, membrane degradation leading to cellular disruption and decompartmentalization of enzymes and substrates, and accumulation of secondary metabolites (McGlasson and Pratt 1964; Rolle and Chism 1987; Rosen and Kader 1989; Watada and others 1990; Dunlap and Robacker 1994; Varoquaux and Wiley 1994; Watada and others 1996). Associated increases occur in rates of biochemical reactions responsible for changes in quality characteristics, such as texture, color, flavor, and nutritional value (Cantwell 1992).

Many factors affect the intensity of the wound response in fresh-cut tissues. They include species and cultivar, stage of physiological maturity, temperature, O2 and CO2 concentrations, water vapor pressure, various inhibitors, and severity of wounding (Cantwell 1992; Brecht 1995). Saltveit (1997) considered that very sharp cutting tools should limit the number of injured cells, while blunt cutting instruments could induce injury to cells many layers removed from the actual cut. Bolin and others (1977) showed that the visual appearance and shelf life of shredded lettuce at 2°C was significantly reduced by using a dull rather than a sharp blade, or by chopping rather than slicing. Carrot slices prepared with a sharp blade had reduced microbial loads and off-odor development, higher microscopic cellular integrity, and an extended shelf life at 8°C, compared to slices prepared with blunt blades (Barry-Ryan and O’Beirne 1998). Increased injury at preparation may directly affect visual appearance of fresh-cut products, but may also have longer-term effects on physiology and composition.

A common defect of commercial fresh-cut melon is a translucent appearance, and we hypothesized that severity of wounding affects the development of this defect. Our objective was to evaluate the consequences of blade sharpness, and thereby the degree of wounding, on translucency and other quality attributes and the physiology of fresh-cut cantaloupe melon.

Materials and Methods

Fruit

For Experiment (Expt) 1, cantaloupe melon (Cucumis melo L. var. reticulatus Naud.) fruits (Mission, Ranger, and Hy Mark cultivars) were harvested at commercial maturity (½ to ¾ slip) on July 17, 1997, from a research station at 5 Points, Calif., U.S.A. Fruit of Hy Mark and Corona cultivars were obtained at commercial maturity from growers in Los Banos, Calif., U.S.A., for Expt 2 and 3 (August 27, 1997, and August 10, 1998). Fruits were transported to the laboratory in an air-conditioned vehicle and stored overnight at 2.5°C.

Fruit processing and storage

The equipment used for processing and storage was sanitized by immersion in 1000 ppm NaOCl for 30 min. Twelve to 15 melons of each cultivar were used for Expt 1, 20 melons for Expt 2, and 50 for Expt 3. Fruits were washed with a 1000 ppm (v/v) NaOCl solution, drained, and processed at room temperature (22°C). The blossom and stem-ends of each fruit were removed with a sharp knife leaving a 3.5- to 4.0-cm-wide ring that was dipped into 50 ppm NaOCl (pH 7, 13°C) for 30 s and drained. From each ring 6 longitudinal cylinders were cut using an 18-mm-dia stainless steel borer with a sharpened blade and another 6 cylinders were cut with a blunt borer (0.5-mm wall, unsharpened). Both cutting methods produced pieces that would be acceptable as a commercial product. In Expt 1, pieces prepared with each borer from fruit of each cultivar were randomly distributed into 9 (3 storage periods × 3 replications) 250-mL glass jars (10 pieces/jar). In the second and third experiments, the cylinders from each melon and borer were sequentially placed into the jars to ensure that cylinders from all melons were present in both cutting treatments and all storage periods. The jars were covered with cheesecloth, and placed in containers under a flow of humidified air at 5°C. Separate sam-

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Sensory evaluations were performed at d 0, 6, 9 (Expt 3), and 12 and included subjective—overall visual quality (OVQ), decay, translucency, aroma, and off-odor—and objective—color, firmness, soluble solids, sugars, fermentative volatiles—measurements, 1 h after removing samples from the cold room. In Expts 2 and 3, respiration and ethylene production rates, volatile concentrations, and electrolyte leakage were also determined.

Subjective measurements were done by a trained evaluator (first author) using hedonic scales: OVQ was scored on a scale of 9 to 1, where 9 = excellent, 7 = good, 5 = fair, 3 = poor, and 1 = unusable. A score of 6 was considered the limit of marketability. The main reasons for the decrease in OVQ were development of decay and translucency. Macroscopic decay, translucency, and off-odor were scored on a scale of 1 to 5, where 1 = none, 3 = moderate, and 5 = severe. Aroma was evaluated on a scale of 5 to 1, where 5 = full, characteristic, 3 = moderate, and 1 = absence of characteristic aroma. Aroma and off odor were evaluated immediately after cutting the melon pieces in half with a knife.

Color values (L* a* b*) were determined on the ends and longitudinal sides of 10 pieces per treatment, using a Minolta Chroma Meter CR-200 (Minolta Corp., Instrument Systems Division, Ramsey, N.J., U.S.A.). Chroma (C) and hue angle (H) were calculated as (a* 2 + b* 2)1/2 and tan 1 (b*/a*), respectively. Color differences (ΔL*, ΔC, ΔH = difference in L*, C, and H, respectively) between d 6, 9, or 12 and d 0 were also determined. For the determination of ethanol, acetaldehyde, and ethyl acetate (Expt 2), 0.5 g of finely cut tissue was placed in test tubes, sealed with serum stoppers and stored at -20 °C. Subsequently, the tissue was thawed at 0 °C and incubated for 1 h in a 60 °C water bath. Headspace gases (0.5 mL) were injected into a gas chromatograph (model 5700A; Hewlett-Packard, Wilmington, Del., U.S.A.), equipped with a packed glass column (0.63 × 183 cm) containing 5% Carbowax 20M on 60/80 Carbopack as stationary phase (85 °C) and a flame ionization detector (250 °C). Ethanol, acetaldehyde, and ethyl acetate were identified by co-chromatography with standards, and quantified by a range of concentrations of the standards in 5 mL of water.

Microbiological evaluations (Expt 3) were performed on d 0, 6, and 12. Serial dilutions were prepared using 50 g of tissue, plated on Standard Methods Agar and Nutrient Yeast Dextrose Agar + 150 μL mL-1 streptomycin sulfate and incubated at 29 °C for total aerobic plate counts and yeast counts, respectively.

Statistical analysis

Data were tested by analysis of variance (Minitab for Windows, Minitab Inc., State College, Pa., U.S.A.) with mean separation by Fisher's method at P < 0.05. Trend analysis was used to determine the pattern of the parameters evaluated with time of storage.

Results and Discussion

Changes in sensory quality of melon pieces

Melon pieces of both cutting treatments had excellent overall visual quality at d 0 (data not shown). OVQ decreased linearly with storage time mainly due to the development of macroscopic decay—usually caused by fungi and yeast—and translucent, water-soaked areas. After 6 d, pieces prepared with the sharp borer had good or very good OVQ scores,
Table 1—Effect of sharpness of the borer used for cutting on sensory attributes of fresh-cut melon of 3 cultivars stored in air at 5 °C

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Cutting treatment</th>
<th>OVQ1</th>
<th>Translucency2</th>
<th>Decay2</th>
<th>Aroma3</th>
<th>Off odor2</th>
<th>Firmness4 (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Day 6</td>
<td>Day 12</td>
<td>Day 6</td>
<td>Day 12</td>
<td>Day 6</td>
<td>Day 12</td>
</tr>
<tr>
<td>Hy Mark</td>
<td>Sharp</td>
<td>7.5 a5</td>
<td>4.3 a</td>
<td>1.3 a</td>
<td>1.8 a</td>
<td>1.0 a</td>
<td>3.0 b</td>
</tr>
<tr>
<td></td>
<td>Blunt</td>
<td>3.3 b</td>
<td>3.7 a</td>
<td>3.3 b</td>
<td>3.8 b</td>
<td>1.0 a</td>
<td>1.3 a</td>
</tr>
<tr>
<td>Mission</td>
<td>Sharp</td>
<td>7.7 a</td>
<td>3.0 a</td>
<td>1.1 a</td>
<td>2.3 a</td>
<td>1.0 a</td>
<td>3.3 a</td>
</tr>
<tr>
<td></td>
<td>Blunt</td>
<td>5.3 b</td>
<td>3.0 a</td>
<td>3.5 b</td>
<td>5.0 b</td>
<td>1.0 a</td>
<td>2.2 a</td>
</tr>
<tr>
<td>Ranger</td>
<td>Sharp</td>
<td>8.0 a</td>
<td>6.3 a</td>
<td>1.0 a</td>
<td>1.0 a</td>
<td>1.0 a</td>
<td>1.7 a</td>
</tr>
<tr>
<td></td>
<td>Blunt</td>
<td>6.4 b</td>
<td>4.7 b</td>
<td>2.2 b</td>
<td>3.5 b</td>
<td>1.0 a</td>
<td>2.0 a</td>
</tr>
</tbody>
</table>

1 Overall visual quality (OVQ) was scored on a scale of 9 to 1, where 9 = excellent, 7 = good, 5 = fair, 3 = poor and 1 = unusable. Development of decay and translucency were the main reasons for decrease in OVQ. A score of 6 was the limit of marketability.
2 Translucency, decay, and off odor were scored on a scale of 1 to 5, where 1 = none, 3 = moderate, and 5 = severe.
3 Aroma was evaluated on a scale of 5 to 1, where 5 = full, characteristic, 3 = moderate, and 1 = absence of characteristic aroma.
4 Firmness was measured on the end of each cylinder with a manual firmness tester equipped with a flat-tipped cylindrical 6-mm-dia probe.
5 Different letters within variety and d of storage indicate significant differences at the 5% level.

Table 2—Firmness of fresh-cut melon of 3 cultivars stored in air at 5 °C.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Initial firmness (N)</th>
<th>Day 6</th>
<th>Day 12</th>
<th>Day 6</th>
<th>Day 12</th>
<th>Day 6</th>
<th>Day 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hy Mark</td>
<td>6.3</td>
<td>4.7</td>
<td>2.2</td>
<td>3.5</td>
<td>1.0</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Mission</td>
<td>5.3</td>
<td>3.0</td>
<td>3.5</td>
<td>5.0</td>
<td>1.0</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>Ranger</td>
<td>8.0</td>
<td>6.3</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.7</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1—Firmness, expressed as rupture force, and distance to rupture of fresh-cut melon (cv. Corona) prepared with a sharp or blunt borer and stored in air at 5 °C.
the observed development of the translucent, water-soaked aspect of the pieces. The fact that these color changes were not only observed on the longitudinal sides (cut with the borer) but also progressively on the flat ends (cut with a sharp knife) of the blunt-cut pieces indicates that undesirable color changes and translucency were propagated through the melon piece during storage.

### Sugar composition

After 12 d, total sugar concentrations decreased 4%, 21%, and 13% for cultivars Hy Mark, Mission, and Ranger, respectively (Table 3). Total sugar concentrations decreased similarly in both cutting treatments for cultivars Mission and Ranger, but decreased more in blunt-cut pieces than in sharp-cut pieces for cultivar Hy Mark. In Expt 2, decreases in total and individual sugar concentrations during storage were not different between cutting treatments (data not shown).

### Respiration and ethylene production rates

The respiration rates of all melon pieces decreased significantly with time in storage, fitting linear and quadratic response models (Figure 2A). Respiration rates of blunt-cut pieces stored at 10°C increased after 5 d, and this was associated with pathological breakdown. Respiration rates of pieces stored at 10°C were 1.5 to 3.0 times higher than rates at 5°C. The cutting treatment did not affect the respiration rate of pieces stored at 5°C; at 10°C, blunt-cut pieces had higher respiration rates than sharp-cut pieces immediately after preparation and after 7 d of storage. In Expt 2, respiration rates of blunt-cut pieces were 20% higher than rates of sharp-cut pieces during the initial 4 d at 5°C, but were similar after this period.

Ethylene production rates also decreased during storage. In Expt 3, ethylene production rates of pieces at 10°C were 2 to 6 times higher than rates at 5°C (Figure 2B). The cutting treatment only affected ethylene production after 4 d at 10°C, when rates of sharp-cut pieces continued to decrease, while those cut with the blunt borer were maintained. In Expt 2, ethylene production rates of blunt-cut pieces were consistently higher (10% on d 0 increasing to > 30% by d 6) than those of sharp-cut pieces at 5°C.

Several studies have compared the physiological behavior of cut and intact fruit (McGlasson and Pratt 1964; Rosen and Kader 1989; Watada and others 1990; Watada and others 1996). Few, however, have evaluated the response of plant tissues to increasing levels of wounding caused by cutting. The amount of damage imparted to the tissue depends on piece size (McGlasson 1969; Meigh and others 1960), sharpness of the blades used for cutting (Bolin and others 1977; Barry-Ryan and O’Beirne 1998), and even direction of the cut (Abe and others 1992; Zhou and others 1992). Our results show that cantaloupe pieces that had been more severely wounded by a blunt borer produced slightly more ethylene.
than those cut with a sharp blade. Increasing the amount of injury by reducing piece size in green bananas (McGlasson 1969) and ripe tomatoes (Meigh and others 1960) significantly increased ethylene production.

Wounding is also often accompanied by increases in respiration, and probably wound ethylene plays a role in the induction of increased respiration in tissue slices (Yang and Pratt 1978). However, the respiration rates of cantaloupe, Crenshaw, and honeydew pieces were similar to those of the intact fruit at 0, 5, and 10 °C, and only higher at 20 °C (Madrid and Cantwell 1993; Watada and others 1996). In our study, an increased level of wounding resulted in only a temporary increase in respiration rate at 10 °C. At 5 °C, the low storage temperature generally minimized differences between the cutting treatments.

## Table 3—Concentration of sugars in fresh-cut melon of 3 varieties prepared with a sharp or blunt borer and stored for 12 d in air at 5 °C

<table>
<thead>
<tr>
<th>Cutting Blade</th>
<th>Day of Storage</th>
<th>Total Sucrose (mg g⁻¹ fresh wt)</th>
<th>Glucose (mg g⁻¹ fresh wt)</th>
<th>Fructose (mg g⁻¹ fresh wt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hy Mark</td>
<td>Initial</td>
<td>0</td>
<td>76.8 a</td>
<td>39.2 a</td>
</tr>
<tr>
<td></td>
<td>Sharp</td>
<td>12</td>
<td>79.5 a</td>
<td>45.5 a</td>
</tr>
<tr>
<td></td>
<td>Blunt</td>
<td>12</td>
<td>68.3 b</td>
<td>31.3 b</td>
</tr>
<tr>
<td>Mission</td>
<td>Initial</td>
<td>0</td>
<td>80.4 a</td>
<td>39.7 a</td>
</tr>
<tr>
<td></td>
<td>Sharp</td>
<td>12</td>
<td>67.0 b</td>
<td>31.0 b</td>
</tr>
<tr>
<td></td>
<td>Blunt</td>
<td>12</td>
<td>59.7 b</td>
<td>30.1 b</td>
</tr>
<tr>
<td>Ranger</td>
<td>Initial</td>
<td>0</td>
<td>70.6 a</td>
<td>33.8 a</td>
</tr>
<tr>
<td></td>
<td>Sharp</td>
<td>12</td>
<td>64.8 a</td>
<td>28.6 a</td>
</tr>
<tr>
<td></td>
<td>Blunt</td>
<td>12</td>
<td>57.7 a</td>
<td>27.5 a</td>
</tr>
</tbody>
</table>

1 Different letters for a given parameter between cutting treatment and d of storage indicate significant differences at the 5% level.

Electrolyte leakage

The loss of solutes was greater in pieces cut with the blunt borer than in those cut with the sharp borer immediately after preparation (Figure 3). Electrolyte leakage remained high throughout the 12 d of storage in the blunt-cut pieces but increased linearly with time in the sharp-cut pieces to reach similar final values. The same pattern was shown in a separate experiment, although the difference in initial values was larger (25% and 35% electrolyte leakage for the sharp-cut and blunt-cut pieces, respectively).

Electrolyte leakage is an estimate of membrane permeability and integrity (Marangoni and others 1996). Membrane permeability was also higher in carrot slices cut with a blunt blade compared to slices cut with a sharp blade and stored at 8 °C (Barr-Ryan and O’Beirne 1998). Increased membrane permeability results in loss of cellular components and accumulation of liquid in intercellular spaces (Saltveit 1997). This was supported by the observation that the more severely wounded tissue discs (prepared with the blunt borer) sank in the bathing solution used for electrolyte leakage determination while those cut with the sharp borer floated.

Ethanol, acetaldehyde, and ethyl acetate concentrations

The concentrations of acetaldehyde and ethyl acetate in the melon pieces prepared with the sharp or blunt borers were similar (data not shown). Average acetaldehyde concentrations were 2.3 and 2.0 μmoles g⁻¹ fresh weight at d 6 and 12, respectively. The average concentrations of ethyl acetate increased during the same period from 0.5 to 1.2 μmoles g⁻¹ fresh weight. Ethanol concentrations did not change between d 6 and 12 of storage, but were significantly higher in pieces prepared with the blunt borer than in pieces prepared with the sharp borer (8.0 and 11.0 μmoles g⁻¹ fresh weight for sharp and blunt borers, respectively).

Accumulation of liquid in the intercellular spaces as a consequence of membrane rupture can reduce gas diffusion and induce anaerobic respiration (Saltveit 1997). However, the difference in ethanol concentration between sharp-cut and blunt-cut pieces was small, and ethanol levels in pieces from both cutting treatments were similar to those measured in other cantaloupe pieces stored in air (Portela and others 1997).

Microbiological quality

Total aerobic microbial load of pieces prepared with the sharp and blunt borers were similar at all times of evaluation (Table 4). Yeasts were not detected until d 12 of storage, when pieces of both cutting treatments showed similar counts.

Fluids released from damaged cells during cutting are rich in sugars and proteins and provide a nutritive substrate for microbial growth (Rolle and Chism 1987; Saltveit 1997). Barry-Ryan and O’Beirne (1998) compared the effects of slicing carrots with a razor blade, a sharp machine blade, and a blunt machine blade and found that microbial loads were reduced in the less damaging slicing treatments. In our study, however, the differences in cutting had no effect on microbial counts. Decay scores of sharp and blunt melon pieces were also similar for pieces of 2 of 3 cultivars (Table 1). Very careful sanitation during preparation of the pieces may have minimized potential differences between cutting treatments. Some samples prepared with the blunt borer had less decay than those prepared with the sharp borer (Table 1). This may have been due to surface moisture evaporating and/or being

![Figure 3—Efflux of electrolytes into 0.35 M mannitol solution from melon discs (cv. Corona) prepared with a sharp or blunt borer and stored in air at 5 °C. Data are averages of 3 determinations ± standard deviation.](image-url)
taken up by the tissue soon after preparation leading to a dry, rough surface that may have limited the subsequent growth of microorganisms. This surface characteristic was not observed in pieces cut with the sharp borer, in which a moist bright appearance was maintained throughout storage.

**Conclusions**

Cutting cantaloupe melon pieces with a sharp borer resulted in longer shelf life at 5°C than cutting with a blunt borer. The most notable difference between the blunt and sharp-cut pieces was in color. Blunt-cut pieces had a darker orange color (lower hue and L* values) after preparation, and L* and chroma values decreased significantly after storage. These color changes were associated with the progressive appearance of translucency, a common visual defect in commercial fresh-cut melon. Respiration and ethylene production rates were affected only slightly by cutting treatment. However, blunt-cut pieces had higher ethanol concentrations, off-odor scores, and electrolyte leakage than sharp-cut pieces. It is apparent that minimizing mechanical injury is conducive to maintaining quality attributes of fresh-cut melon, and that the translucency defect in particular can be significantly reduced by using very sharp cutting blades.

**References**


**Table 4—Microbial counts of fresh-cut melon (cv. Corona) prepared with a sharp or blunt borer and stored in air at 5°C**

<table>
<thead>
<tr>
<th>Cutting treatment</th>
<th>Days</th>
<th>Aerobic plate count (CFU/g)</th>
<th>Yeast count (CFU/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sharp borer</td>
<td>0</td>
<td>3.7 × 10^2 a1</td>
<td>&lt; 1 × 10^2</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>3.0 × 10^2 a3</td>
<td>&lt; 1 × 10^2</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>3.5 × 10^3 a6</td>
<td>&lt; 1 × 10^2</td>
</tr>
<tr>
<td>Blunt borer</td>
<td>0</td>
<td>4.3 × 10^2 a2</td>
<td>&lt; 1 × 10^2</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>1.5 × 10^3 a4</td>
<td>&lt; 1 × 10^2</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>1.5 × 10^4 a7</td>
<td>&lt; 1 × 10^2</td>
</tr>
</tbody>
</table>

1 Different letters within d of storage indicate significant differences at the 5% level.