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 essentially 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, O_2 and CO_2 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 samples were prepared for measuring respiration and ethylene production rates.

Evaluations

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 computed (Anonymous 1994).

Firmness was determined using a manual firmness tester (Expt 1) or a TA-HD texture analyzer (Texture Technologies Corp., Scarsdale, N.Y., U.S.A.) (Expt 2 and 3), equipped with a flat-tipped cylindrical 6-mm-dia probe to determine maximum rupture force at a velocity of 1 mm sec^{-1} to a final depth of 6 mm. One reading was recorded from the end of each of 10 cylinders per replication.

Soluble solids were determined from melon juice extracted from 6 or 7 half- cylinders per replication and tested with a digital refractometer (Palette 100, Atago Co., Ltd., Tokyo, Japan).

Individual sugars (Expt 1 and 2) were determined as described by Klann and others (1993) with slight modifications. Cylinders were frozen at -20 °C, sugars were extracted from 1 g of tissue from the middle section of 3 cylinders by homogenizing 1 min in 3 mL of 95% ethanol (Ultra-Turrax® T25; Janke & Kunkel, Staufen, Germany), and boiled for 20 min in a water bath. After centrifugation (12,000 × g, 15 min), the supernatant was transferred, the residue re-extracted, and the supernatants were taken to a volume of 5 ml with 95% ethanol. A 0.5-ml aliquot was evaporated under vacuum to dryness (SpeedVac SVC 100, Savant Instruments Inc., Holbrook, N.Y., U.S.A.) and the residue was dissolved in 300 μL of Nanopure water (16.7 megohm-cm resistance) produced by a Nanopure II deionizer (Barnstead/Thermolyne Corp., Dubuque, Iowa, U.S.A.). This aqueous fraction was extracted twice with chloroform:isoamyl alcohol (24:1, v/v) and filtered through a 0.45-μm microfuge spin filter (Gelman, Ann Arbor, Mich., U.S.A.) before high performance liquid chromatography (HPLC) analysis. Sugars were separated by chromatography on a Supelcogel Ca column (300 × 7.8 mm) (Supelco, Inc., Bellefonte, Pa., U.S.A.) at 80 °C with Nanopure water as the eluant (0.6 mL min^{-1}), and detected with a differential refractometer (model 1770; Bio-Rad Laboratories, Richmond, Calif., U.S.A.). Sugars were identified by co-chromatography with standard solutions and concentrations were calculated from peak heights using these same standards.

For respiration and ethylene production rates (Expt 2 and 3), 10 melon cylinders per replication were weighed and stored in gas-tight containers with inlet ports connected to a continuous flow of humidified air at 5 and 10 °C. The air-flow rates were selected so that CO_2 accumulation did not exceed 0.2%. CO_2 and ethylene concentrations were measured daily by taking 1-mL gas samples from the outlet ports and injecting them into an infrared gas analyzer (model PIR-2000; Horiba, Ltd., Kyoto, Japan) and a gas chromatograph (model 8000; Carle Instruments Inc., Fullerton, Calif., U.S.A.), equipped with a modified alumina F1 (mesh size 60/80) column and a flame ionization detector, respectively. Standards of 0.5 % CO_2 and 1.1 μL L^{-1} ethylene were used for calibration. Electrolyte leakage determinations (Expt 2 and 3) were done on 6 discs (18 mm dia × 2 mm), prepared from the middle portion of the melon cylinders, cut in half, and incubated in 25 mL of 0.35 M mannitol solution at room temperature (22 °C). Electrolyte leakage into the disk bathing solution was measured after 1 h using a digital conductivity meter (Curtin Matheson Scientific Inc., Houston, Texas, U.S.A.). Total electrolytes were determined after freezing at –20 °C, thawing and rewarming to room temperature. Leakage data are expressed as a percentage of the conductivity of total tissue electrolytes (Lester and Stein 1993).

For the determination of ethanol, acetaldehyde, and ethyl acetate (Expt 2), 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 5730A; 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 μg 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

Cultivar	Cutting treatment	OVQ[1] Day 6	OVQ[1] Day 12	Translucency[2] Day 6	Translucency[2] Day 12	Decay[2] Day 6	Decay[2] Day 12	Aroma[3] Day 6	Aroma[3] Day 12	Off odor[2] Day 6	Off odor[2] Day 12	Firmness[4] (N) Day 6	Firmness[4] (N) Day 12
Hy Mark	Sharp	7.5 a[5]	4.3 a	1.3 a	1.8 a	1.0 a	3.0 b	3.7 a	3.7 a	1.0 a	1.0 a	11.1 a	9.8 b
	Blunt	3.3 b	3.7 a	3.3 b	3.8 b	1.0 a	1.3 a	3.1 a	3.3 a	2.7 b	1.7 a	12.9 a	12.0 a
Mission	Sharp	7.7 a	3.0 a	1.1 a	2.3 a	1.0 a	3.3 a	2.7 a	3.5 a	1.3 a	1.0 a	12.0 a	8.9 b
	Blunt	5.3 b	3.0 a	3.5 b	5.0 b	1.0 a	2.2 a	3.2 a	3.5 a	2.7 b	2.7 b	13.3 a	13.8 a
Ranger	Sharp	8.0 a	6.3 a	1.0 a	1.0 a	1.0 a	1.7 a	4.0 a	3.7 a	1.0 a	1.3 a	8.5 b	8.9 b
	Blunt	6.4 b	4.7 b	2.2 b	3.5 b	1.0 a	2.0 a	3.8 a	3.7 a	1.0 a	1.0 a	10.2 a	12.0 a

[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

while those prepared with the blunt borer were on or below the limit of marketability due to translucency (Table 1). After 12 d, sharp-cut pieces from cultivar Ranger had higher OVQ scores than those prepared with the blunt borer, but there was no difference between cutting treatments for the other 2 cultivars. All melon pieces were free of decay at d 6 of storage. By d 12, sharp-cut pieces from cultivar Hy Mark had more decay than those prepared with the blunt borer, while there were no differences in decay between cutting treatments for the other 2 cultivars (Table 1). In Expt 2 and 3, development of decay was generally similar for pieces prepared with the sharp and blunt borers (data not shown).

Cantaloupe aroma was full and characteristic at d 0 and decreased within the first few d after cylinder preparation. By d 6, the aroma of melon pieces was usually described as moderate. The sharpness of the borer did not affect the loss of aroma, but pieces of cultivars Mission and Hy Mark cut with the blunt borer had higher off-odor scores than pieces cut with the sharp borer (Table 1).

The changes in visual appearance and aroma observed in the sharp-cut pieces were similar to those reported in other studies on fresh-cut cantaloupe (Madrid and Cantwell 1993; Portela and others 1997).

Texture

Initial firmness (rupture force) of the pieces was significantly different among the experiments (15.1 to 17.2, 9.3, and 6.3 N for Expt 1, 2 and 3, respectively); however, in all cases, firmness decreased significantly with time of storage. In Expt 1, blunt-cut pieces had higher firmness values after 12 d than those prepared with the sharp borer (Table 1). The decrease in firmness during storage was not affected by the sharpness of the borer in Expt 2 and 3 (data not shown; Figure 1). Potential differences between cutting treatments could have been minimized due to the lower initial firmness values. Rupture distance is another useful parameter to characterize texture (Jackman and Stanley 1995). In Expt 3, the distance to rupture was higher in the blunt-cut pieces than in the sharp-cut pieces by d 12. This was accompanied by a slight increase in rupture force and indicates spongier tissue.

Color and translucency

The most notable differences between cutting treatments were reflected in color and appearance changes. Representative color data corresponding to cultivar Hy Mark (Expt 2) are presented here, but trends were also similar in Expt 1 and 3. Immediately after preparation, the longitudinal side of the blunt-cut pieces had lower hue (more orange), lower L* (darker) and similar chroma (intensity) values, compared to pieces prepared with the sharp borer (72.6 compared with 75.9, 50.2 compared with 61.7, and 16.7 compared with 17.7, for hue, L*, and chroma, respectively). During storage, there was a greater decrease in L* and chroma values in blunt-cut than sharp-cut pieces (Table 2). Hue angles increased similarly in both cutting treatments during storage.

On the ends of the sharp-cut cylinders, changes in L* and chroma were minimal during storage (Table 2). However, for blunt-cut pieces, there were significant progressive changes during storage. Hue angle values did not change during storage in pieces from either cutting treatment.

Color is an important component of visual appearance (Clydesdale 1991). Although initially the pieces prepared with the blunt borer appeared more attractive due to the darker orange color, this was an early symptom of what later became undesirable translucency. The significant decrease in lightness (L*) and chroma of blunt-cut melon pieces reflects

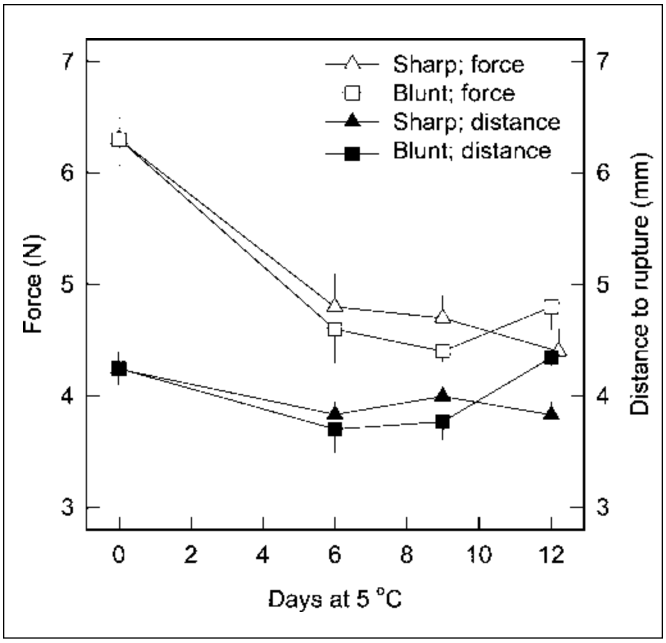

Figure 1—Firmness, expressed as rupture force, and distance to rupture of fresh-cut melon (cv. Corona) prepared with a sharp or blunt borer and stored in air at 5 °C.

Table 2—Effect of sharpness of the borer used for cutting on color changes of fresh-cut melon (cv. Hy Mark) stored in air at 5 °C

Position of the measurement[1]	Cutting treatment	ΔL*[2] Day 6	ΔL*[2] Day 12	ΔC[2] Day 6	ΔC[2] Day 12	ΔH[2] Day 6	ΔH[2] Day 12
Longitudinal side	Sharp	-1.35 a[3]	-1.57 a	0.94 a	-0.37 c	0.26 a	0.59 b
	Blunt	-2.01 b	-3.30 b	-1.17 b	-2.51 d	0.29 a	0.45 b
Flat ends	Sharp	-0.05 a	-0.18 a	-0.04 a	-1.06 c	0.29 a	0.44 a
	Blunt	-4.33 b	-5.52 b	-2.06 b	-3.31 d	0.18 a	0.26 a

[1] Longitudinal side = side of the cylinder cut with the sharp or blunt borer; flat ends = ends of the cylinder cut with a sharp knife in both treatments.
[2] ΔL*, ΔC, ΔH = difference in L*, chroma and hue values, respectively, between d 6 or 12 and d 0.
[3] Different letters for a given parameter and position of measurement indicate significant differences at the 5% level.

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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

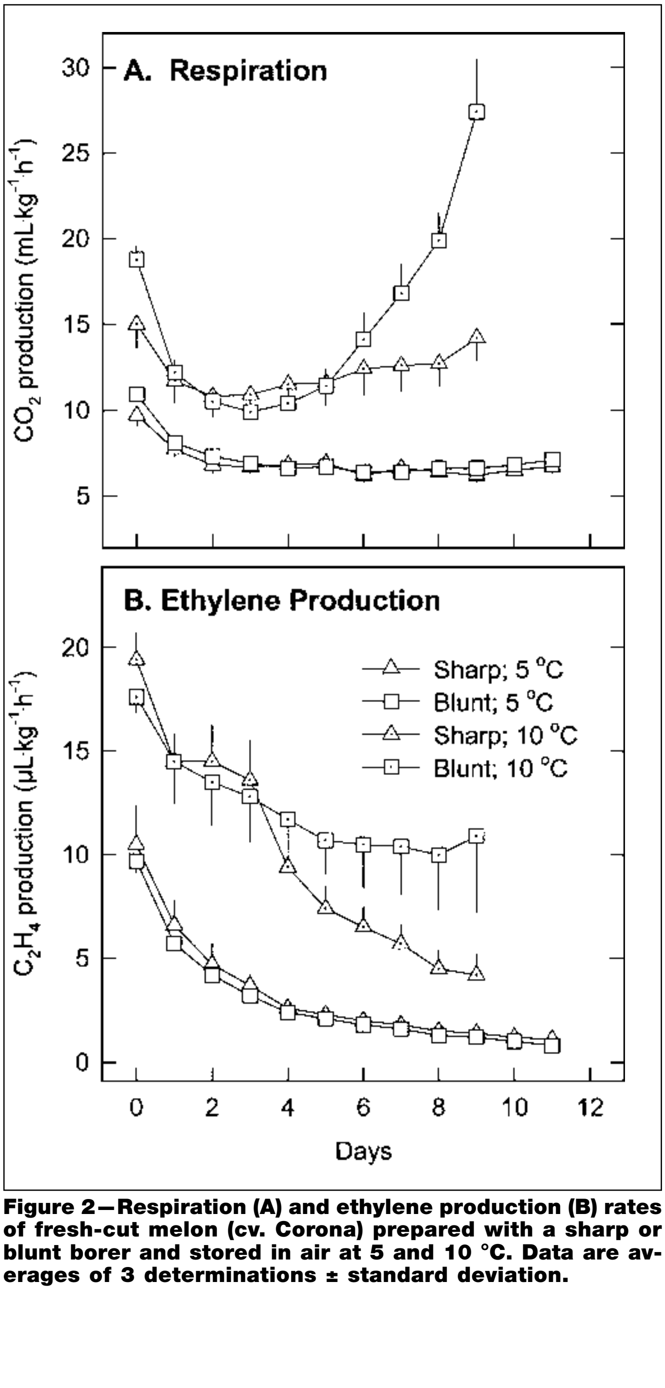

Figure 2—Respiration (A) and ethylene production (B) rates of fresh-cut melon (cv. Corona) prepared with a sharp or blunt borer and stored in air at 5 and 10 °C. Data are averages of 3 determinations ± standard deviation.

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

Cultivar	Cutting treatment	Day of storage	Total	Sucrose	Glucose	Fructose
			(mg g^{-1} fresh wt)			
Hy Mark	Initial	0	76.8 a[1]	39.2 a	17.6 a	20.0 a
	Sharp	12	79.5 a	45.5 a	14.2 b	19.8 a
	Blunt	12	68.3 b	31.3 b	17.1 a	20.0 a
Mission	Initial	0	80.4 a	39.7 a	18.5 a	22.2 a
	Sharp	12	67.0 b	31.0 b	15.3 ab	20.7 a
	Blunt	12	59.7 b	30.1 b	13.3 b	16.4 b
Ranger	Initial	0	70.6 a	33.8 a	17.1 a	19.7 a
	Sharp	12	64.8 a	28.6 a	15.6 a	20.6 a
	Blunt	12	57.7 a	27.5 a	13.9 a	16.4 b

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

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.

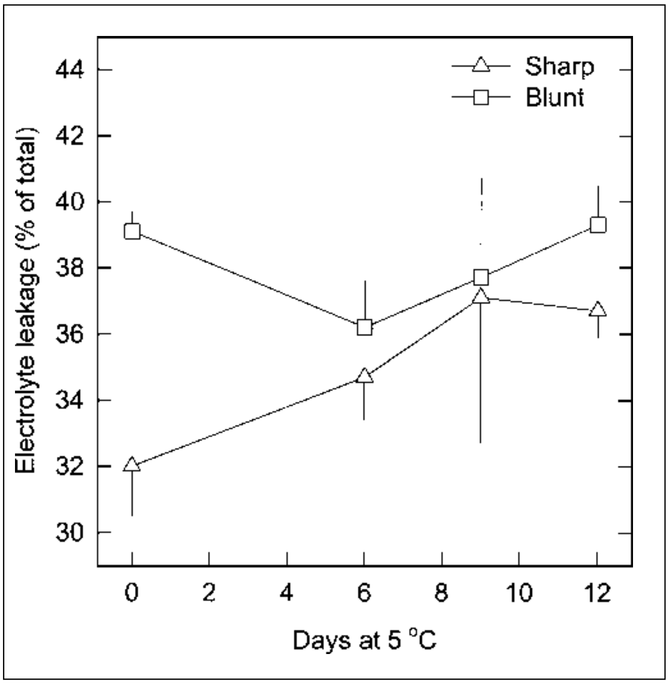

Figure 3—Efflux of electrolytes into 0.35 M mannitol solution from melon discs (cv. Corona) prepared with a sharp or blunt borer and stored in air at 5 °C. Data are averages of 3 determinations ± standard deviation.

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 (Barry-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

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

	Days		
Cutting treatment	0	6	12
	Aerobic plate count (CFU/g)		
Sharp borer	3.7×10^2 a[1]	3.0×10^3 a	3.5×10^8 a
Blunt borer	4.3×10^2 a	1.5×10^3 a	1.5×10^8 a
	Yeast count (CFU/g)		
Sharp borer	$< 1 \times 10^2$	$< 1 \times 10^2$	1.8×10^3 a
Blunt borer	$< 1 \times 10^2$	$< 1 \times 10^2$	2.5×10^3 a

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

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

Abe K, Yoshimura K, Zhou YF, and Iwata T. 1992. Studies on physiological and chemical changes of partially processed sweet pepper fruit (Part II). Change of chemical compounds in cut surface of sweet pepper in relation to difference of storability by shredding direction. J Jpn Soc Cold Preservation Food 17(4):146-151.

Anonymous. 1994. Precise Color Communication. Ramsey, N.J.: Minolta Corp. Instrument Systems Division. 49 p.

Barry-Ryan C and O'Beirne D. 1998. Quality and shelf-life of fresh cut carrot slices as affected by slicing method. J Food Sci 63(5):851-856.

Bolin HR, Stafford AE, King Jr AD, and Huxsoll CC. 1977. Factors affecting the storage stability of shredded lettuce. J Food Sci 42(5):1319-1321.

Brecht JK. 1995. Physiology of lightly processed fruits and vegetables. HortScience 30(1):18-22.

Cantwell M. 1992. Postharvest handling systems: Minimally processed fruits and vegetables. In: Kader AA, editor. Postharvest technology of horticultural crops. 2nd ed. Oakland, Calif.: Univ. of California, Division of Agriculture and Natural Resources. Publ. 3311. p 277-281.

Clydesdale FM. 1991. Color perception and food quality. J Food Qual 14(1):61-74.

Dunlap JR and Robacker KM. 1994. Wound induced ethylene production from excised muskmelon fruit tissue. J Hort Sci 69(1):189-195.

Klann EM, Chetelat RT, and Bennett AB. 1993. Expression of acid invertase gene controls sugar composition in tomato (*Lycopersicon*) fruit. Plant Physiol 103(3):863-870.

Jackman RL and Stanley DW. 1995. Perspectives in the textural evaluation of plant foods. Trends Food Sci Technol 6(6): 187-194.

Lester G and Stein E. 1993. Plasma membrane physicochemical changes during maturation and postharvest storage of muskmelon fruit. J Amer Soc Hort Sci 118(2):223-227.

Madrid M and Cantwell M. 1993. Use of high CO_2 atmospheres to maintain quality of intact and fresh-cut melon. In: Proc. 6th Intl. Controlled Atmosphere Research Conf. NRAES-71; June 15-17, 1993, Ithaca, N.Y. Ithaca: Northeast Regional Agric. Engineering Service. p 736-745.

Marangoni AG, Palma T, and Stanley DW. 1996. Membrane effects in postharvest physiology. Postharvest Biol Technol 7(3):193-217.

McGlasson WB. 1969. Ethylene production by slices of green banana fruit and potato tuber tissue during the development of induced respiration. Australian J Biol Sci 22(3):489-491.

McGlasson WB. and Pratt HK. 1964. Effects of wounding on respiration and ethylene production by cantaloupe fruit tissue. Plant Physiol 39(1):128-132.

Meigh DF, Norris KH, Craft CC, and Lieberman M. 1960. Ethylene production by tomato and apple fruits. Nature 186(2):902-903.

Portela S, Nie X, Suslow T, and Cantwell M. 1997. Changes in sensory quality and fermentative volatile concentrations of minimally processed cantaloupe stored in controlled atmospheres. In: Gorny JR, editor. Proc 7th Intl Controlled Atmosphere Research Conf. July 13-18, 1997. Davis, Calif. Postharvest Outreach Program, Univ of California, Davis, Calif. Postharvest Hort. Series No. 19. Vol 5. p 123-129.

Rolle RS and Chism GW. 1987. Physiological consequences of minimally processed fruits and vegetables. J Food Qual 10(2):157-177.

Rosen JC and Kader AA. 1989. Postharvest physiology and quality maintenance of sliced pear and strawberry fruits. J Food Sci 54(3):656-659.

Saltveit ME. 1997. Physical and physiological changes in minimally processed fruits and vegetables. In: Tomás-Barberán FA and Robins RJ, editors. Phytochemistry of fruits and vegetables. Oxford, UK: Clarendon Press. p 205-220.

Varoquaux P and Wiley RC. 1994. Biological and biochemical changes in minimally processed refrigerated fruits and vegetables. In: Wiley RC, editor. Minimally processed refrigerated fruits and vegetables. New York: Chapman and Hall. p 226-268.

Watada AE, Abe K, and Yamuchi N. 1990. Physiological activities of partially processed fruits and vegetables. Food Technol 44(5):116-122.

Watada AE, Ko NP, and Minott DA. 1996. Factors affecting quality of fresh-cut horticultural products. Postharvest Biol Technol 9(2):115-125.

Yang SF and Pratt HK. 1978. The physiology of ethylene in wounded plant tissues. In: Kahl G, editor. Biochemistry of wounded plant tissues. Berlin, Germany: Walter de Gruyter. p 595-622.

Zhou Y-F, Abe K, and Iwata T. 1992. Effect of shredding modes on the deterioration of the quality of partially processed pepper fruits. Nippon Shokuhin Kogyo Gakkaishi 39(2):161-166.

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