

Short communication

Quality changes of minimally processed honeydew melons stored in air or controlled atmosphere

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Abstract

Pieces (18 × 35 mm cylinders) were prepared from sanitized fruits of four honeydew melon varieties (Green Flesh, Morning Ice, Rico, RML 2704) harvested at typical commercial maturity. Pieces were stored in air or controlled atmosphere (CA = air + 15% CO₂) at 5°C and evaluated for sensory quality, firmness, color and soluble solids concentration (SSC) after 0, 6 and 12 days. Significant variation was found among varieties in SSC (9.9–12.2%), firmness (14.0–19.9 N), and chroma (10.4–19.0), hue angle (115–113) and L* (63.7–66.8) color values of pieces on day 0. Pieces from the four varieties averaged 10 N firmness loss from day 0 to 12 and CA reduced loss significantly in only one variety. During air storage color saturation decreased only in pieces from varieties with high initial chroma (C) values. Average ΔC between days 0 and 12 was –3.7 for air-stored vs –1.0 for CA-stored pieces. Average ΔL* was –5.8 and –1.4 for the same conditions, respectively. SSC were maintained during storage in air or CA. Pieces stored in 15% CO₂ had higher visual quality scores than those stored in air. In addition, CA storage greatly reduced development of macroscopic decay, translucency and off-odors. © 1998 Elsevier Science B.V. All rights reserved.

Keywords: *Cucumis melo* L. var. *inodorus* Naud.; Color; Firmness; Soluble solids; Visual quality; Decay; Aroma

1. Introduction

Color, sweetness and texture are important quality attributes of muskmelons (*Cucumis melo*)

(Pratt, 1971; Seymour and McGlasson, 1993). Postharvest changes in pigment and sugar concentrations are small, and harvest at the appropriate stage of maturity is crucial to good eating quality (Pratt et al., 1977; Lester and Shellie, 1992).

The determination of harvest maturity is particularly difficult in honeydew melons since the ab-

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scission zone, useful harvest criteria for cantaloupes, does not form until the fruit are overripe (Pratt et al., 1977). Various subtle changes in external color (green to white), peel texture (hairy to smooth), aroma at the blossom end (none to detectable), and fruit density (low to high) are used in commercial production to assess harvest maturity. Harvest typically occurs at the beginning of fruit ripening and the pulp should have a minimum of 10% soluble solids concentration (SSC) (Bianco and Pratt, 1977). Ripening in honeydew melons is associated with increased respiration and ethylene production rates, softening, and aroma development (Pratt et al., 1977).

Honeydew melons are generally stored at 7–10°C while 2–4°C is considered ideal for cantaloupes (Hardenburg et al., 1986). For minimally processed pieces, however, temperatures near 0°C are considered ideal (Madrid and Cantwell, 1993; O'Connor-Shaw et al., 1994). Controlled atmospheres (CA) with high CO₂ concentrations are effective supplements when storage is >0°C. CA helps maintain visual quality and reduce microbial growth on fresh-cut cantaloupe, but its effect on firmness, color, and sugar concentration has varied (Madrid and Cantwell, 1993; Portela et al., 1997; Portela, 1998).

Most research on minimally processed melon has focused on cantaloupe, but honeydew melons are a common component of fresh-cut fruit products. In this work we evaluated changes in sensory quality, SSC, firmness and color of minimally

processed honeydew melon prepared from four varieties and stored in air or CA. Our objective was to compare the magnitude of the changes in fresh-cut honeydew pieces with those previously reported for fresh-cut cantaloupe.

2. Materials and methods

2.1. Fruit

Seeds of honeydew melon (*Cucumis melo* L. var. *inodorus* Naud.) of varieties Rico, Morning Ice, Green Flesh and RML 2704 were sown on March 14, 1997 at Five Points, CA and standard cultural practices were followed (Mayberry et al., 1996). Medium to large fruit (2–3 kg) were harvested at commercial maturity (Class 1 to Class 2, Pratt et al., 1977) on the morning of June 27. Class 1 fruit are considered minimum maturity, with a greenish–white external color and a firm, crisp pulp; Class 2 fruits have a mainly white external color with a smooth surface and firm crisp pulp. The fruit were transported to the laboratory and stored overnight at 10°C prior to processing.

2.2. Fruit processing and storage

Fruit were selected for uniformity based mainly on flesh crispness when cut. External color and aroma varied among varieties (Table 1). Six to

Table 1
General characteristics of the four honeydew melon varieties used in this study

Variety and seed source	External color	Aroma of intact fruit	Crispness when cut	Average % soluble solids	Ripeness class ^a
Green Flesh (Rogers)	Greenish with considerable fuzz	None	Crisp; pulp splits	12.2	1–1.5
Morning Ice (Harris Moran)	White with trace of green	Barely detectable	Crisp; pulp splits	10.7	1.5
Rico (Sunseeds)	White, trace of green; slight fuzz	Slight	Crisp; pulp splits	9.9	1.5
RML 2704 (Rogers)	White and very waxy	Slight	Crisp; pulp splits	10.7	1.5–2
L.S.D. _{.0.05}	–	–	–	0.6	–

Fruit were selected based on external appearance and crispness of the pulp when cut with a knife.

^a Pratt et al., 1977.

nine melons of each variety were washed with a 1000 ppm (v/v) sodium hypochlorite solution, drained and processed at room temperature (22°C) on a surface cleaned with 70% ethanol. The equipment used for processing and storage containers were sanitized by immersion in 1000 ppm sodium hypochlorite solution for 30 min. The blossom and stem-ends of each fruit were discarded leaving one or two 3.5–4.0 cm wide rings which were dipped into a 50 ppm sodium hypochlorite solution (pH 8, 13°C) for 30 s and then drained. Ten to 15 longitudinal cylinders were cut with a sharp 18-mm diameter stainless steel borer. Cylinders from all fruit of each variety were randomly distributed into 250-ml glass jars (10 pieces/jar = 1 replicate) which were placed in containers at 5°C under a continuous flow of humidified air or CA (15% CO₂ in air).

2.3. Evaluations

Sensory evaluations were performed at days 0, 6 and 12 and included subjective and objective measurements on three replicates per variety after equilibration to room temperature. Subjective measurements were done by the first author using hedonic scales: overall visual quality (OVQ) was scored on a 9 to 1 scale, where 9, excellent; 7, good; 5, fair; 3, poor and 1, unusable. A score of 6 was considered the limit of saleability. Macroscopic decay, translucency and off-odor were scored on a 1 to 5 scale, where 1, none; 3, moderate and 5, severe. Aroma, sweetness and typical flavor were scored on a 5 to 1 scale, where 5, full, characteristic; 3, moderate and 1, absence of characteristic aroma, flavor or sweetness. Aroma and off-odor were evaluated immediately after cutting the melon pieces.

Color was determined using a Minolta Chroma Meter (Minolta Corporation Instrument Systems Division, Ramsey, NJ). L*, a*, b* values were recorded from the ends of 10 cylinders per replication. Chroma (C), hue angle (H), and color differences (ΔL^* , ΔC , ΔH between day 6 or 12 and day 0) were calculated (Minolta Corp., 1994).

Firmness was determined using a manual firmness tester with a flat-tipped cylindrical 6-mm diameter probe. One reading was taken from the

end of 10 cylinders per replication. Soluble solids concentrations (SSC) were determined from melon juice squeezed from 6–7 half cylinders and tested with a digital refractometer (Palette 100, Atago Co., Ltd., Tokyo, Japan).

2.4. Statistical analyses

Data were tested by analysis of variance (Minitab for Windows, Minitab, Inc., State College, PA) with mean separation by Fisher's method at $P \leq 0.05$.

3. Results

Pieces stored in air and CA (air + 15% CO₂) had good to very good OVQ scores at day 6 (Fig. 1A,B). Decrease in OVQ was due to a lack of 'fresh appearance' with a slight drying of the surface. There was no macroscopic decay on pieces stored in air or CA after 6 days. At day 12 visual quality scores of air-stored pieces were below the limit of saleability due to decay and translucent areas. At day 12 pieces of all varieties stored in CA had good OVQ and no macroscopic decay.

At the time of preparation, pulp of all varieties was considered crisp based on a 'splitting' type separation and sound when the knife cut the fruits. Pulp firmness, however, varied significantly among varieties on day 0 (Fig. 1C,D). Average firmness decreased from 17.5 N at day 0 to 7.3 N in air-stored pieces at day 12. CA storage reduced firmness loss in only one variety (Green Flesh), and average firmness value for CA-stored pieces was 9.0 N.

Pulp color varied notably among the four varieties. Cv Rico had pale white–green flesh while the others had flesh with more green pigmentation, as indicated by the higher chroma scores (Table 2). Initial hue angle values varied from 115 in 'Green Flesh' pieces to 113 in 'Rico'. Initial L* values for 'Green Flesh' pieces were different from those of the other three varieties (Table 2). CA storage reduced loss of chroma in pieces of three varieties (not 'Rico') and decrease of L* in all varieties. Chroma values of the low pigmented

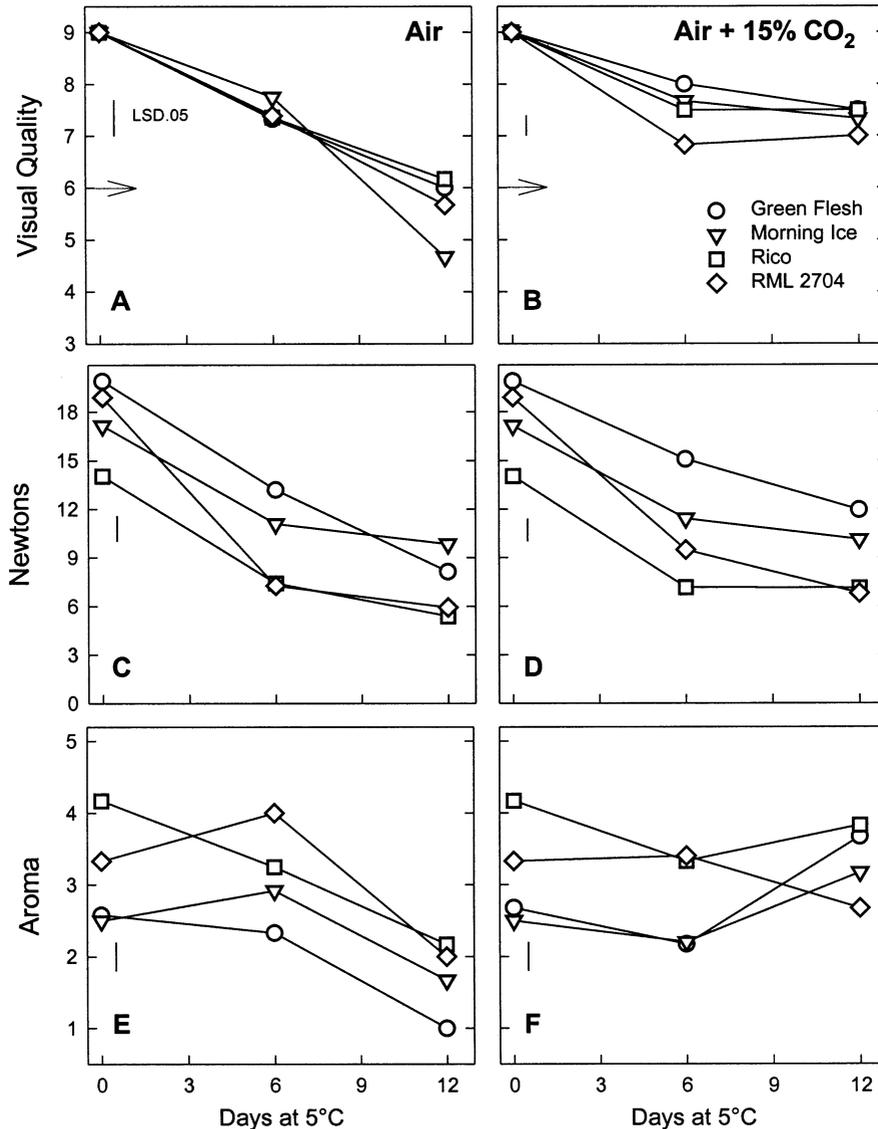


Fig. 1. Visual quality (A, B), firmness (C, D) and aroma (E, F) changes in honeydew melon pieces from four varieties stored in air (left) or CA (air + 15% CO₂) (right) at 5°C. After equilibration to room temperature, visual quality was scored on a 9 to 1 scale, where 9, excellent; 7, good; 5, fair; 3, poor and 1, unusable. The arrow (score of 6) indicates the limit of saleability. Pieces were measured for firmness with a 6-mm probe, and then cut in half for evaluation of aroma on a 5 to 1 scale, where 5, full, characteristic; 3, moderate and 1, absence of characteristic aroma. The vertical bars indicate L.S.D._{0.05} values.

'Rico' pieces did not change over 12 days in air or CA. Average hue angle values did not change in air storage, but increased 0.5 in CA storage.

Typical honeydew melon aroma generally decreased during storage. Aroma loss was higher in air-stored than CA-stored pieces (Fig. 1E,F). No

off-odors were detected in pieces stored in CA. Off-odors were not detected in air-stored pieces on day 6, but after 12 days, pieces had an average off-odor score of 3 (moderate), with no differences among varieties. Off-odors were associated with macroscopic decay.

SSC varied among varieties, with average concentrations of 12.2, 10.7, 9.9 and 10.7% for cv Green Flesh, Morning Ice, Rico, and RML 2704, respectively (Table 1). Pieces from the four varieties were rated by the first author as similar in sweetness and typical flavor on day 0 and day 6. For a given variety, SSC did not differ significantly with time in storage or between atmospheres (data not shown).

4. Discussion

Although we did not measure physiological parameters, Madrid (1993) studied respiration and ethylene production rates of honeydew pieces (18×40 mm cylinders) harvested at different stages of maturity. At 5°C pieces from maturity Class 1 and Class 2 fruits had similar respiration (5.0 and 5.4 $\text{mg CO}_2 \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$, respectively) and ethylene production rates (0.2 and 0.3 $\mu\text{l} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$, respectively). However, firmness values differed significantly between the two maturity classes (35.6 and 28.9 N, respectively, using an 11-mm probe) as did SSC (10.9 and 12.4% , respectively). In the present study, we classified melons into maturity classes based on external characteristics and flesh crispness. Depending on the quality attribute, the melons could be placed in either maturity Class 1 or Class 2. For example, fruits of cv Greenflesh had external and firmness characteristics typical of Class 1, but SSC were

more typical of Class 2 melons (Pratt et al., 1977). The relationships between external and internal characteristics to stage of maturity may differ among honeydew varieties (Lester and Shellie, 1992).

As reported previously for cantaloupe melon pieces (Madrid and Cantwell, 1993; Portela et al., 1997), a 15% CO_2 atmosphere benefited melon pieces by reducing decay and translucency development. This atmosphere did not result in any increase in fermentative volatiles in cantaloupe pieces (Portela et al., 1997). CA may also help maintain color in both cantaloupe and honeydew pieces. Color in green fleshed melons is attributed to the combination of low concentrations of carotenoids and chlorophylls in plastids (Seymour and McGlasson, 1993). High CO_2 atmospheres may help maintain pigment concentrations in melon pieces by reducing plastid senescence as in other fruits and vegetables (Kader, 1986). Firmness retention of fresh-cut honeydew at 5°C was not generally benefited by CA, a result similar to that reported for cantaloupe melon pieces (Madrid and Cantwell, 1993; Portela, 1998).

Initial firmness values of honeydew pieces (17.5 N) were much higher than those of cantaloupe pieces (12.5 N in Portela, 1998). This may be related to differences in physiological stage of ripeness, but also to the higher amount of cell wall polysaccharides in honeydew than cantaloupe pulp (Simandjuntak et al., 1996). In our study the rate of firmness loss was also much

Table 2

Chroma and L^* color values of honeydew melon pieces from four varieties stored at 5°C for 0 and 12 days in air or CA

Variety	Chroma ^a				L^*							
	0 days		6 days		0 days		6 days		12 days			
	Air	CA	Air	CA	Air	CA	Air	CA	Air	CA		
Green Flesh	19.0	18.4	18.5	15.1	19.1	63.7	62.5	62.3	58.0	61.1		
Morning Ice	17.7	15.9	15.3	12.6	15.2	66.7	65.4	64.6	60.6	65.5		
Rico	10.4	10.7	9.2	9.3	9.5	66.6	66.0	66.9	64.5	66.4		
RML 2704	19.0	17.4	17.6	14.4	18.1	66.8	64.2	66.4	57.6	65.6		
Average	16.5	15.6	15.2	12.8	15.5	66.0	64.5	65.0	60.2	64.6		
L.S.D. _{0.05}	1.4				1.7							

^aCalculated as $(a^*2 + b^*2)^{1/2}$.

higher in honeydew than cantaloupe pieces. This is consistent with results by Madrid (1993) in which firmness of honeydew pieces decreased 50% during air storage at 5°C for 8 days. By comparison, Portela (1998) reported an average firmness decrease of only 28% for cantaloupe pieces stored at 5°C for 12 days. Surprisingly, O'Connor-Shaw et al. (1994) reported that a sensory panel did not find significant changes in texture of honeydew pieces stored at 4° or 8.5°C over 8 days. The melons may have been immature, as indicated by the low flavor and texture sensory scores in their study. Madrid (1993) demonstrated that the less mature the fruit, the less was the decrease in firmness of honeydew pieces stored at 5°C. With pieces prepared from fruit at commercial maturity, our measurements clearly demonstrated a larger firmness decrease in honeydew than in cantaloupe pulp.

Typical honeydew aroma increased in pieces during 4 days at 15°C (Madrid, 1993), but to retard microbial growth temperatures > 5°C need to be avoided. Aroma of honeydew pieces declined at 5°C in the present study and in the study by Madrid (1993). The decline was similar to that of cantaloupe pieces stored in air or CA at 5°C (Portela et al., 1997). High CO₂ atmospheres probably helped reduce aroma loss by retarding the development of off-odors which were often associated with microbial growth.

5. Conclusions

Storage conditions reported to maintain the quality of cantaloupe melon pieces also apply well to fresh-cut honeydew. At 5°C atmospheres with 15% CO₂ significantly retarded decay development, but not firmness loss in pieces from both melon types. Firmness decrease was much greater in honeydew than cantaloupe pieces. SSC changed little during storage in pieces of both melon types. Chroma color values decreased significantly in air at 5°C, while CA reduced color changes in both cantaloupe and honeydew pieces.

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