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Influence of storage period and temperature on the postharvest characteristics of six melon (*Cucumis melo* L., Inodorus Group) cultivars

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Abstract

Six inodorus melon cultivars (*Cucumis melo* L., Inodorus Group, Naud., cv. Amarelo, Golden Casaba, Honeydew, Honey Loupe, Juan Canary, and Paceco) were harvested at horticultural maturity and evaluated for quality traits during three weeks of storage at 7, 12 and 15°C plus three days at 20°C. The soluble solids content did not change significantly during storage. Firmness of the pulp tissue declined during storage for all cultivars, but there were no significant differences among storage temperatures within a cultivar. Carbon dioxide production decreased during storage for all cultivars. Ethylene increased during storage, but at different rates for each cultivar. Weight loss was under 3% after three weeks of storage at 7 or 12°C, but it was around 4% for melons stored at 15°C. Storage temperature had no significant effect on the external appearance of 'Honeydew' and 'Golden Casaba', but other cultivars developed symptoms of chilling injury either during storage or during the subsequent three days at 20°C. Pitting and increased decay appeared first in susceptible fruit stored at 7°C and later for fruit stored at 12 and 15°C.

Keywords: Melon; Casaba; Cantaloupe; Chilling injury; Ethylene; Carbon dioxide

1. Introduction

Melon cultivars have varied developmental, maturation and ripening behavior; differing in such characteristics as external color, flesh color, firmness, seed cavity tissue, soluble solids content, flavor, aroma, and patterns of carbon dioxide and ethylene production during ripening. Comparatively few postharvest physiological studies have been done on inodorus melon (*Cucumis melo* L.) fruit, perhaps

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because members of this group are of relatively low commercial value. Of this group, fruit growth, development and ripening, and the production of ethylene and carbon dioxide during ripening has been extensively studied only in 'Honeydew' (Bianco and Pratt, 1977; Pratt et al., 1977). We recently reported on changes in 11 morphological and physiological characteristics during the growth, development, maturation and ripening on the plant of seven inodorus melon cultivars (cv. Amarelo, Golden Casaba, Honeydew, Honey Loupe, Juan Canary, Paceco, and Santa Claus Casaba) (Miccolis and Saltveit, 1991).

There are few published reports on the effect of storage temperature on the postharvest characteristics of these melons. In this paper we continue our study of inodorus melons (Miccolis and Saltveit, 1991) by describing the postharvest behavior of six cultivars of fruit during storage at chilling and non-chilling temperatures.

2. Materials and methods

Growth and selection of fruit

Six inodorus melon cultivars (cv. Amarelo, Golden Casaba, Honeydew, Honey Loupe, Juan Canary, and Paceco) were grown during the late summer at the University of California Department of Vegetable Crop farm at Davis under standard cultural practices. The replicate plots were arranged in a completely randomized pattern. When the first two leaves were well formed, plants were thinned to a spacing of 70 cm in rows and 150 cm apart. Pistillate flowers were tagged at anthesis and fruit set was determined seven days later as described by McGlasson and Pratt (1963). Horticultural maturity was determined from periodic measurements of the characteristic peel and pulp color, soluble solids content and firmness of pulp, and production of carbon dioxide and internal ethylene concentration from a few representative fruit. These measurements were taken as previously documented by Miccolis and Saltveit (1991). The time to reach horticultural maturity differed with each cultivar and occurred first for 'Juan Canary', two days later for 'Paceco', three days later for 'Honey Loupe', seven days later for 'Amarelo', eight days later for 'Golden Casaba', and eleven days later for 'Honeydew'. Melons were harvested in the morning of the day after they had been determined to be horticulturally mature and when the flesh temperature was about 20°C. Harvested melons were washed in 5% (v/v) commercial bleach, air dried and weighed. Fruit were selected for study that were uniform, true to type, and free of visual defects.

Storage of fruit

Five fruit were evaluated within 5 h of harvest and 18 groups of five fruit each were stored at 7, 12, and 15°C for one, two, or three weeks before holding at 20°C for three additional days. All experiments were performed in the UCD Mann Laboratory in walk-in cold-rooms at 7, 12, 15 or 20°C and ≈90% relative humidity.

Evaluation of fruit

Fruit were visually examined for external color, surface discoloration and decay, and symptoms of chilling injury upon removal from storage and after subsequent holding for three days at 20°C. A subjective scale was used where 1 = no spots or surface blemishes; 2 = slight, 0–10% of surface affected; 3 = moderate, 10–30%; 4 = severe, 30–50%; 5 = extreme, >50%. Individual melons were then placed in 10-l respirometer jars that were purged with a 2 l min⁻¹ flow of humidified, ethylene-free air at 20°C. After 5 h, the fruit had warmed to 20°C and the rate of carbon dioxide production had stabilized. One-ml gas samples of the inlet and outlet flows were taken and analyzed for carbon dioxide concentration in an infrared gas analyzer (Saltveit and Strike, 1989). The melons were then removed from the jars and the internal ethylene concentrations determined by withdrawing gas samples from the seed cavity as described by Miccolis and Saltveit (1991) and analyzing them by gas chromatography (Saltveit and Yang, 1987).

Firmness was measured in 5 cm thick equatorial slices, without the rind, with a 24 × 8-mm diameter cylindrical plunger attached to a Hunter Spring Pressure Tester (Model L-10N). Measurements of the percent soluble solids were made with a ABBE-36 Bausch and Lomb refractometer on juice squeezed from two undamaged pieces of tissue cut from the equatorial slice. These observations were made initially and after one, two, and three weeks of storage at 7, 10 and 12°C, and after an additional three days at 20°C.

All experiments were repeated at least twice with similar results. Data were subjected to ANOVA and LSD values at $P = 0.05$ were calculated. No consistent statistically significant differences were detected among the treatments between the experiments, so means presented in this paper are the combined averages.

3. Results and discussion

Soluble solids content

Differences in the percent soluble solids among the cultivars at harvest persisted during storage. At harvest, 'Honeydew' had the highest percentage soluble solid content (16.2%), while 'Golden Casaba' had the lowest (11.2%). All the other cultivars had soluble solids contents which ranged from 13.0 to 14.8%. After three weeks of storage 'Amarelo' and 'Honeydew' had the highest percent soluble solids which averaged 15.5 and 15.1%, respectively, while 'Honey Loupe', 'Juan Canary', and 'Paceco' averaged 14.4, 14.3, and 13.5%, respectively. 'Golden Casaba' still had the lowest percent soluble solids which averaged 11.3%. The soluble solids values were not significantly changed by three additional days of storage at 20°C after one, two or three weeks of storage at the various temperatures.

Surprisingly, there was no significant change in the percent soluble solids among any of the cultivars during the three weeks of storage or during the three additional days at 20°C. There was also no significant effect of temperature during storage on the soluble solids content of any of the cultivars. Cohen and Hicks (1986) had the same results with 'Gold Star', 'Superstar' and 'Saticoy' cantaloupe varieties (*C. melo*, Reticulatus Group) stored at 5 or 12°C for two to nine days and at 20°C for

an additional two to five days. Their results also confirmed those of Evensen (1983) who studied six cantaloupe-type cultivars harvested at three stages of maturity and stored at 0 and 4.5°C.

Firmness

Firmness of the pericarp tissue declined after harvest in all six cultivars with little difference among storage temperature and shelf life (Table 1). At harvest, the firmest fruit were 'Juan Canary' and 'Paceco', while the softest were 'Honeydew' and 'Golden Casaba'. As would be expected, the melons held at 15°C were usually softer than fruit held at 7°C. However, differences were sometimes not significant or were actually reversed. For example, 'Paceco' fruit stored at 15°C were firmer than fruit stored at 7°C for all samplings immediately after storage. Holding the fruit for three days at 20°C usually reduced firmness, but again this was only consistent among the cultivars after three weeks of storage.

Over the three weeks of storage, 'Honeydew', 'Amarelo', 'Juan Canary' and 'Golden Casaba' declined in firmness by an average of 67, 63, 60 and 54%, respectively, while 'Paceco' and 'Honey Loupe' only declined by 40 and 32%,

Table 1

Firmness in Newtons of six inodorus melon cultivars at harvest and after storage at 7, 12, and 15°C for one, two, or three weeks followed by three days of storage at 20°C. Each mean represents 10 fruit. Means within each cultivar and storage period followed by the same letter are not statistically different at the 5% level

Cultivar	Storage temper- ature (°C)	Firmness (N)							LSD 5%
		At harvest	1 week	+ 3 days	2 weeks	+ 3 days	3 weeks	+ 3 days	
Amarelo	7	29.4	24.5 b	15.0 b	16.7 b	18.6 a	13.8 a	7.5 a	3.6
	12		26.7 a	20.6 a	18.6 a	16.7 b	10.8 b	7.1 a	5.2
	15		26.5 a	21.5 a	16.7 b	11.8 c	7.9 c	5.7 b	4.9
Golden Casaba	7	26.5	22.5 a	21.6 a	18.6 a	14.7	12.3	11.5	2.3
	12		20.6 b	18.7 b	17.8 a	13.8	12.7	11.8	2.4
	15		21.4 ab	18.5 b	15.7 b	14.7	11.8	11.7	2.1
Honeydew	7	27.4	22.5 a	14.7 b	18.6 a	9.7 a	13.8 a	9.7 a	4.1
	12		20.6 b	17.6 a	14.7 b	7.5 b	6.9 b	7.4 b	3.8
	15		19.6 b	18.6 a	13.6 b	7.2 b	6.3 b	6.8 b	4.5
Honey Loupe	7	35.3	31.4 a	25.6 b	27.4 ab	26.7	26.5 a	15.6	5.5
	12		27.4 b	27.4 a	28.4 a	28.3	23.4 b	14.7	4.9
	15		27.7 b	27.8 a	26.7 b	27.8	22.3 b	14.5	5.0
Juan Canary	7	57.8	29.4 a	23.4 b	23.4 b	23.4 b	23.4 b	19.5 b	5.8
	12		25.6 b	21.6 b	24.5 b	25.6 ab	26.4 a	24.5 a	6.4
	15		26.5 b	28.4 a	28.4 a	26.7 a	19.6 c	19.6 b	5.5
Paceco	7	46.0	33.3 b	33.3 b	28.4 c	30.4 b	26.7 b	16.7 b	7.4
	12		34.4 ab	35.3 ab	31.4 b	34.5 a	24.5 b	17.8 ab	7.8
	15		35.6 a	36.4 a	34.3 a	31.5 ab	32.3 a	18.6 a	7.7

respectively. These large differences in the rate of softening did not markedly affect the ordering of the fruit by firmness. After three weeks, the order of the cultivars was almost identical to that after one week of storage, while they were within one rank of their initial firmness at harvest.

The six cultivars separated into two distinct groups on the basis of their ability to retain firmness when held for three days at 20°C after three weeks of storage. 'Golden Casaba', 'Honeydew' and 'Juan Canary' retained around 93% of their firmness, while 'Amarelo', 'Honey Loupe' and 'Paceco' retained only around 64% of their firmness. This grouping was related to the firmness of the fruit, since two of the three firmest fruit, 'Paceco' and 'Honey Loupe', retained around 63% of their firmness, while two of the three softest fruit, 'Honeydew' and 'Golden Casaba', retained 95% of their firmness.

Carbon dioxide production and ethylene concentration

The initial rate of carbon dioxide production was fairly consistent among the cultivars; averaging between 14 and 18 ml kg⁻¹ h⁻¹ for five of the six cultivars (Fig. 1). In contrast, 'Honey Loupe' had an initial respiration rate around 30 ml carbon dioxide kg⁻¹ h⁻¹. These rates of production are slightly lower than those previously reported for these cultivars (Miccolis and Saltveit, 1991). Generally, carbon dioxide production was strongly influenced by temperature, with the highest rate at 15°C and the lowest rate at 7°C. However, 'Golden Casaba' had higher rates of carbon dioxide production from fruit stored at 12°C than at 15°C after two and three weeks of storage. Carbon dioxide production was fairly consistent and averaged around 4 ml kg⁻¹ h⁻¹ among all cultivars over one, two and three weeks of storage. Production from fruit increased in variability over the storage periods at 12 and 15°C.

While the production of carbon dioxide showed slight increases in some of the cultivars and temperatures after harvest, except for 'Honeydew' fruit stored at 15°C for three weeks, the rate of carbon dioxide production during three weeks of storage never exceeded the initial rate at harvest (Fig. 1). The lack of a well defined respiratory climacteric from these fruit was unexpected since harvested melons have been reported to be climacteric (Pratt et al., 1977). However, we previously reported that a climacteric was not observed in freshly harvested inodorus melon fruit (Miccolis and Saltveit, 1991), nor in netted muskmelon fruit ripened on the vine (Shellie and Saltveit, 1993). Unlike the fruit in our previous study (Miccolis and Saltveit, 1991), which were periodically harvested during their maturation and ripening, the fruit in the present study were horticulturally mature when harvested and their handling conformed to that used by Pratt et al. (1977).

The internal concentration of ethylene varied over a much wider range than did carbon dioxide production (Fig. 1). Ethylene concentration usually increased by week 2 and 3 of storage. Only in 'Amarelo' and 'Honey Loupe' was a decline seen, and then only in 'Honey Loupe' did the concentration not increase to its original or higher concentration. The maximum concentration during storage at all temperatures barely exceeded 0.4 nl l⁻¹ for 'Amarelo' and 'Paceco', was close to 4 nl l⁻¹ for 'Golden Casaba' and 'Honey Loupe', and exceeded 12 nl l⁻¹ for 'Honeydew'

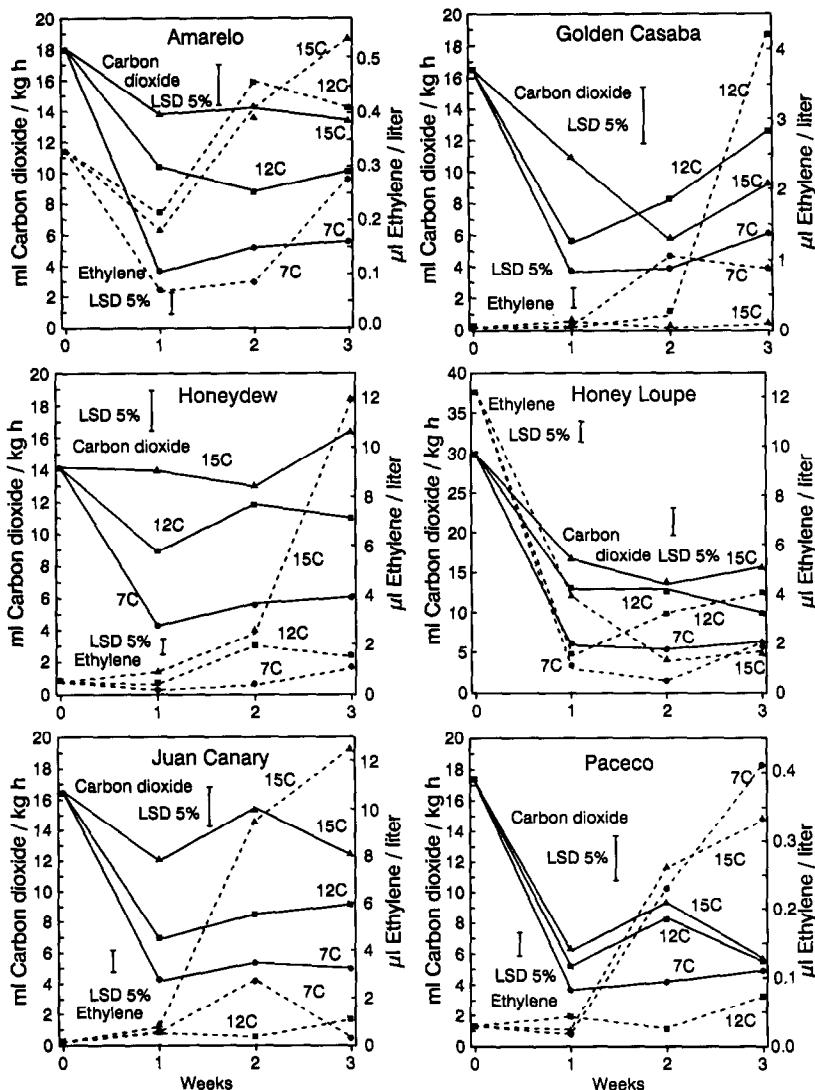


Fig. 1. Carbon dioxide production in $\text{ml kg}^{-1} \text{h}^{-1}$ and internal ethylene concentration in $\mu\text{l l}^{-1}$ in six inodorus melon cultivars at harvest and after storage at 7, 12 and 15°C for one, two and three weeks. The vertical bar is the calculated LSD 5% value for each measurement for each cultivar.

and 'Juan Canary'. These vastly different ethylene concentrations were not mirrored by similar large differences in carbon dioxide production. Also, large increases in ethylene concentration over time, were usually not reflected by large increases in carbon dioxide production. The two cultivars with the highest maximum ethylene concentrations had similar low concentration at 7 and 12°C for most of the storage period, while fruit stored at 15°C showed a large increase at the end of storage

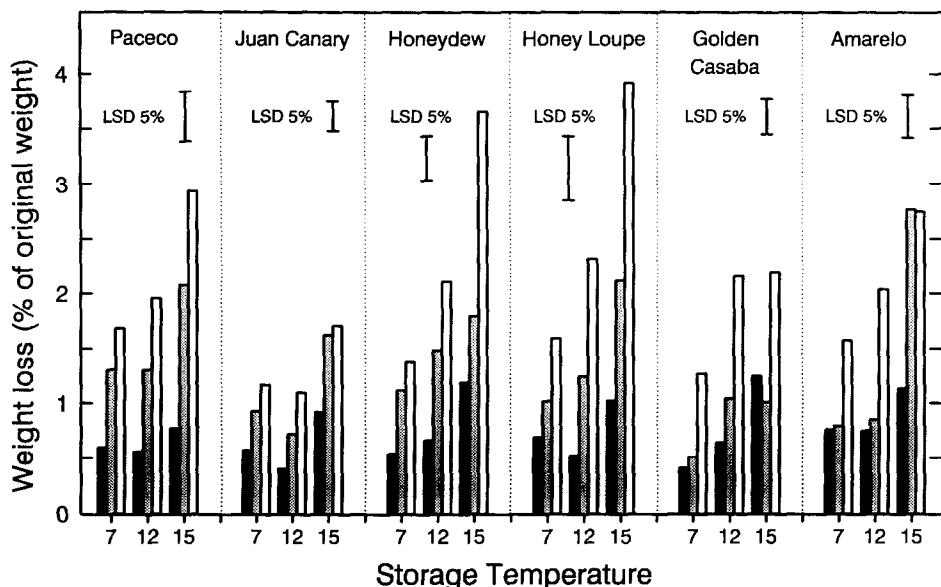


Fig. 2. Weight loss in percent of original weight of six inodorus melon cultivars at harvest and after storage at 7, 12 and 15°C for one, two and three weeks. The vertical bar is the calculated LSD 5% value for each cultivar.

which may have been due to senescence of the fruit. Concentrations in the other cultivars were variable and may reflect conflicting responses of senescence, aging and chilling injury.

Weight loss

The percent weight loss increased both with temperature and with duration of storage (Fig. 2). In general, weight loss was below 3% at the end of three weeks storage. Two cultivars, 'Honeydew' and 'Honey Loupe', however, had weight losses close to 4% after three weeks storage at 15°C.

Changes in external appearance

The external color and flesh color did not markedly change with storage (data not shown), however, spots and external discoloration did appear on four of the six cultivars during storage (Fig. 3). The spots that appeared on fruit stored at 7°C resembled chilling induced pitting while the spots on fruit stored at 12 or 15°C more closely resembled senescent blemishes. There was a progressive increase in the subjective surface evaluation score with time in storage and with holding at 20°C for 'Amarelo', 'Juan Canary' and 'Paceco' fruit stored at 7°C. We felt this reflected chilling-induced injury. In contrast, fruit stored at 12 or 15°C either showed an abrupt increase in the score at two and/or at three weeks and the scores were relatively constant for the next evaluation. Both 'Honey Loupe' and 'Paceco' retained much better appearance when stored at 15°C than at 12 or 7°C, and only

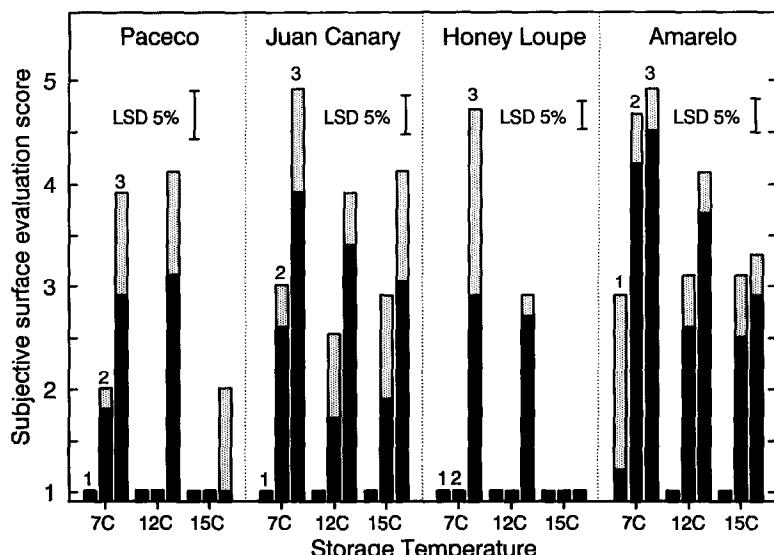


Fig. 3. Subjective surface evaluation scores for six inodorus melon cultivars at harvest and after storage at 7, 12 and 15°C for one, two and three weeks. A subjective scale was used where 1 = no spots or surface blemishes; 2 = slight, 0–10% of surface affected; 3 = moderate, 10–30%; 4 = severe, 30–50%; 5 = extreme, >50%. The vertical bar is the calculated LSD 5% value for each cultivar.

showed pronounced deterioration in appearance after three weeks. The decline in the surface appearance of 'Amarelo' and 'Juan Canary' did not appear to be influenced by storage temperature since a similar decline occurred at all storage temperatures and was severe after only two weeks of storage.

Summary

These six inodorus melon cultivars exhibited quite variable postharvest behavior under our storage conditions. Harvested fruit showed change in firmness, carbon dioxide and ethylene production, surface appearance and weight loss, but the soluble solids content, external color and flesh color remained almost constant during the three weeks of storage.

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