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Seasonal variation in the development of chilling injury in 'O'Henry' peaches

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Abstract

Mealiness, a chilling injury symptom, is one of the most important quality limiting factors in peaches and nectarines exported from Chile. The development of mealiness was analyzed over 3 years to quantify the expression of this chilling injury (CI) symptom in different growth seasons. For such a purpose, 'O'Henry' peaches, considered a CI susceptible cultivar, were harvested and stored at 0 °C (non-CI inducing conditions) and 4 °C (CI inducing conditions) for 15, 21 and 30 days. Quantitative measurements of juice content in the fruits, an indicator of mealiness, showed that there was a significant variation in the expression of the disorder over the years, being higher in 2 years of evaluations. As expected, there was a reduction in juice content, or a higher incidence of mealiness, with longer cold-storage especially at 4 °C. There was no detectable correlation between juice content and quality attributes and physiological parameters, including skin color, flesh firmness, soluble solids content, respiration and ethylene production rates, suggesting factors other than those analyzed in this study, are involved in this disorder.

Keywords: Mealiness; Wooliness; Physiological disorders; Quality; Chilling injury; Nectarines

1. Introduction

The distance from Chile to its main fruit consumer markets poses the difficult challenge of supplying these markets with high quality produces. Prolonged storage of peaches, nectarines and other stone fruits can negatively effect fruit quality due to the development of physiological disorders, known as chilling injury (CI) or internal breakdown (Lill et al., 1989; Lurie and Crisosto, 2005). Susceptibility to these problems is modulated by a number of factors, of which the most decisive component is fruit cultivar (Kader, 1985; Von Mollendorf, 1987). Unfortunately many cultivars, including most of those exported by Chile to distant markets, are highly susceptible to CI problems (Retamales et al., 1992; Retamales et al., 2000).

CI in peaches and nectarines can induce a variety of different symptoms, including mealiness or lack of juice, flesh browning and impaired softening which is referred to as leatheriness. However, the most common CI problem reported under Chilean exporting conditions is mealiness. Mealiness is a major problem since mealy fruits lack juice and are unacceptable to consumers, and can lead to serious economical consequences for the stone fruit industry. For this reason, a Chilean governmental and industrial initiative has developed a biotechnology approach to understand the agronomical and molecular bases of mealiness, so that the magnitude, frequency and variability of mealiness may be correlated with other genetic and physiological features of the fruit (Meisel et al., 2005; www.genomavegetal.cl).

Among the many preharvest factors that have been evaluated for their participation in the development of mealiness, cultivar, crop load, fruit size and canopy position have been associated with this disorder (Lurie and Crisosto, 2005). The presence of a

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number of cultivars susceptible to CI problems may be because previous breeding and cultivar evaluation programs have been orientated towards seeking visible characteristics of attractiveness (size, color) and yield.

Analyzing different commercial cultivars of peaches and nectarines we have observed that the degree of mealiness in these fruits varies from year to year. Therefore, the main objective of this experiment was to quantify the expression of mealiness in different growth seasons over a 3-year time-span in the CI susceptible cultivar O'Henry.

2. Materials and methods

2.1. Plant material

Trials were carried out in the summer of 2003–2005 (years 1–3, respectively). Fruit were harvested from 8-year-old 'O'Henry' trees grown on Nemaguard rootstocks in a commercial orchard located in the Aconcagua Valley, Chile (34°17′W, 70°54′S). Change in fruit ground color was considered as a harvesting index, a parameter used by the fruit company's technical staff. In general, large to medium size fruits were selected and transported to a packing facility for cooling and preparation for marketing. Then, after sorting, sizing and packaging, the peaches were stored at 0 and 4 °C, for 15, 21 and 30 days, simulating Chilean exporting conditions.

2.2. Maturity and quality parameters

At harvest, packing, cold room storage and shelf-life conditions, fruit maturity and quality parameters were measured. A Minolta CR-300 Chromameter instrument was used to measure the ground color, recording the data in L^*, a^* and b^* parameters. Total soluble solids (TSS) was measured by a temperature-compensated refractometer and expressed as the percent of soluble solids in juice. Titratable acidity, expressed as malic acid, was performed by adding 0.2N NaOH until reaching pH 8.2. The firmness of the fruit was evaluated by using a penetrometer with a 8 mm plunger in two opposite sides of the fruit that had previously been peeled to remove the epidermis. The suture was avoided in these analyses.

2.3. Physiological parameters

Within each experiment ethylene production and respiration rates were determined during storage in individual fruits using a static system. Four fruits were weighed and placed in 0.5 L jars at 20 °C. The jars were sealed for 3 h to obtain gas samples. Carbon dioxide concentrations were measured by injecting 1 mL headspace sample in a Perkin-Elmer GC equipped with a TCD detector and a CTR-1 column. Ethylene was measured using a Shimadzu GC equipped with FID detector and alumina column.

2.4. Expression of mealiness and browning

Quantitative determination of mealiness as described by Crisosto and Labavitch (2002) was performed. Briefly, 40 g of fruit tissue was taken and placed in four layers of cheesecloth for juice extraction with the equipment. Juice obtained through pressing was centrifuged at $6000 \times g$ for 10 min and the supernatant was recovered and weighed in order to determine the percentage of juice relative to original weight of the sample. A criterion of considering fruits as mealy was established for those fruits that showed no more than 10% juice w/w after the quantitative measurement. Mealiness was evaluated when fruits reached a degree of softening equivalent to the ripening and eating stage, that reflects the maximum expression of the disorder (i.e. to soften to about 1 kg-force = 9.8 N). Thus, differences in juiciness are to be attributed to the incidence of mealiness, without significant distortions owing to lack of adequate ripeness.

All evaluations were performed at harvest (mature), followed by ripening the fruit at 20 °C between 2 and 6 days; immediately after cooling and processing at the packing plant followed by ripening at 20 °C; after storage at 0 °C for 15, 21 and 30 days followed by ripening at 20 °C; after storage at 4 °C for 15, 21 and 30 days followed by ripening at 20 °C.

2.5. Statistical analysis

There were at least 16 replicates (one fruit each) for all the evaluations. Data were subjected to analysis of variance and means were separated by Tukey's test at the 5% level of significance using Statgraphics Plus 5.

Table 1
Maturity and physiological parameters of O'Henry peaches at harvest and ripening (shelf-life at 20 °C)

Year	Firmness (N)	Color (Hue)	TSS (%)	TA (g L^{-1})	Respiration rate (mL CO_2 kg^{-1} h^{-1})	Ethylene production (μL C_2H_4 kg^{-1} h^{-1})
At harvest						
1	71.3 a[a]	97.7	12.8 a	8.9	15.3 b	1.7 a
2	62.4 b	94.1	11.0 b	7.2	24.2 b	3.2 a
3	55.9 b	78.4	10.0 b	5.8	17.0 b	2.1 a
After shelf-life at 20 °C (ripe)						
1	7.9 c	87.0	11.0 b	5.1	83.4 a	2.9 a
2	13.4 c	84.2	10.8 b	6.4	21.0 b	3.2 a
3	13.0 c	76.1	10.9 b	5.5	21.2 b	4.5 a

TSS: total soluble solids; TA: titratable acidity.
[a] Values (means) followed by different small letters are significantly different within the same column at $P = 0.05$.