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# Effect of prolonged cold storage on the sensory quality of peach and nectarine

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ABSTRACT

To maintain peach and nectarine quality after harvest, low temperature storage is used. Low temperatures induce physiological disorders in peach, but the effect of cold storage on the sensory quality of the fruit before it is damaged by chilling injury syndrome remains unclear. To evaluate the cold storage effect on the sensory quality two peach cultivars ('Royal Glory' and 'Elegant Lady') and two nectarines ('Ruby Diamond' and 'Venus') were harvested at a standardized firmness level and subjected to quality evaluations and sensory analysis at harvest and after storage at 0 °C for 35 d. For both time points, a supplementary ripening followed such that homogeneous flesh firmness and suitability for consumption was achieved.

The fruit segregation through the Durofel firmness (DF), evaluated using a non-destructively method (Durofel device), allowed the formation of a uniform group of fruit in terms of flesh firmness (FF), showing scores between 45.1 and 55.9 N. The average FF in fruit ripened immediately after harvest was 22.9 N and 25.6 N in fruit ripened after cold storage for 35 d.

The "acceptability" of fruit is highly correlated with "aroma", "sweetness", "juiciness", "texture" and "flavor". Only the "acid taste" parameter had no significant correlation with "acceptability" or with the other parameters evaluated.

It is possible to conclude that the sensory quality and acceptability of peach and nectarine are characteristic of each cultivar and change, depending on the time elapsed after harvest. In general, it was confirmed that nectarine cultivars have a more consistent quality than peach cultivars.



## 1. Introduction

Peach ripening is a complex process that cannot be measured by a single factor. Many parameters change during the final phase of fruit development; therefore, the challenge is to define an appropriate approach that can identify parameters of the peach ripening process that may predict fruit quality after harvest.

Peach firmness is a significant characteristic in terms of quality; it is important for determining the optimum harvest date (Infante, 2012), and during postharvest, it is useful to follow maturity evolution during storage (Zhang et al., 2010). The classical method to evaluate firmness objectively destroys the fruit because it consists of penetrating a cylindrical probe through the pulp and registering the maximum load necessary to overcome the fruit resistance (Magness and Taylor, 1925).

From the sensory point of view, the ripeness stage of peach at harvest is the basis of a high-quality product and is meant to ensure the best balance between consumer satisfaction and fluid logistic management; however, such balance is not easy to achieve. An early harvest produces a product that can be easily handled along the commercial chain but does not allow for optimal eating quality (Bonghi et al., 1999; Crisosto et al., 2006). A tree-ripe fruit guarantees consumer acceptance but is highly susceptible to bruising and rapid deterioration during harvest and packaging. Infante et al. (2012) demonstrated that three peach cultivars and two nectarine cultivars harvested between 30 and 70 N flesh firmness and evaluated at an equal firmness (18–22 N) were indistinguishable to a trained sensory panel. These results indicate that certain genotypes can be harvested with firmer flesh without affecting sensory quality. However, this response is true only over a certain flesh firmness range. This response is also cultivar-dependent; therefore, it cannot be extrapolated to all genotypes.

In general, fruit quality traits, such as soluble solids concentration (SSC) and titratable acidity (TA) are related to maturation and to the sensory quality of the fruit (Kader, 1999). Crisosto and Crisosto (2005) investigated the minimum "ripe SSC" required

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for peach and nectarine cultivars to reach high consumer acceptance with similar firmness, as well as low (0.30–0.50%) and high (0.70–0.90%) TA (i.e., malic acid). The concepts of "ripe SSC" and "ripe TA" are related to the state of fruit maturity at consumption. At "ripe SSC" and "ripe TA" the flesh firmness is approximately 4.5–17.8 N, and the consumer's acceptance potentially reaches its maximum (Crisosto and Crisosto, 2005). It was observed that the degree of acceptance was significantly associated with "ripe SSC" but not with "ripe TA". Furthermore, there was no significant interaction between these two parameters.

To maintain the quality of fruit during postharvest, low temperatures are used to reduce the speed of the metabolic processes associated with ripening. Unfortunately, low temperatures adversely affect the sensory quality and induce some postharvest physiological disorders, such as chilling injury (Lurie and Crisosto, 2005).

One means of assessing the quality of a product is through sensory analysis, a discipline used to measure, analyze and interpret reactions of food characteristics perceived by sight, sound, taste, smell and touch (Szczesniak, 2002). Sensory evaluation cannot be performed instrumentally; instead, the instruments are well-trained people.

The aim of this research was to evaluate the cold storage effect on the sensory quality of 'Elegant Lady' and 'Royal Glory' peach and 'Venus' and 'Diamond Ruby' nectarine harvested at a standardized firmness level and measured non-destructively through a uniaxial probe using a Durofel device.

## 2. Materials and methods

### 2.1. Materials

Yellow-fleshed peach 'Royal Glory' and 'Elegant Lady' and yellow-fleshed nectarine 'Ruby Diamond' and 'Venus' were harvested from a commercial orchard near Santiago, Chile. The postharvest evaluations were performed at the Fruit Quality & Breeding Lab that belongs to the University of Chile, Santiago, Chile.

### 2.2. Methods

Two methods for assessing firmness were used: (1) "Durofel firmness" (DF), which corresponds to the uniaxial firmness measured non-destructively through a Durofel device (Agrotechnology, Tarascon, France) and expressed in Durofel firmness units (Vangdal et al., 2007), and (2) "Flesh firmness" (FF), which corresponds to the firmness measured through a typical Magness–Taylor test using a 7.9-mm diameter plunger (Effegi FT-327, Milan, Italy) that penetrates 10 mm into the flesh after the skin has been removed with a scalpel and is expressed in Newtons (N). The first method is related to the elastic modulus of the fruit during non-destructive compression (Harker et al., 2010).

Homogeneous sized fruit of the four cultivars were harvested when the ground color changed from green to light yellow. Fruit were transferred to the lab, and the DF of each fruit was assessed. Sixty fruit that showed a uniaxial firmness score between 52.3 and 58.1 Durofel firmness units were chosen for following the postharvest assay. From this total, 12 fruit were used to characterize the ripeness stage at harvest (i.e., quality parameters).

In addition, 24 fruit were kept in a chamber at 21 °C and 70–75% relative humidity (RH) until they reached a DF equal to 40–50 Durofel firmness units. Lastly, 24 fruit per cultivar were subjected to a prolonged cold storage period (0 °C and 80–90% RH) lasting 35 d and then followed by a period to induce flesh softening (21 °C and 80–90% RH) until the fruit reached 40–50 Durofel firmness units.

### 2.3. Quality parameters after ripening

The individual fruit mass (g) was determined using a precision electronic balance (Tech Masters, California, USA). The FF was measured on both "cheeks" of the fruit. Longitudinal slices from five fruit per sample were used to extract juice. The soluble solids concentration (SSC) was measured with a temperature-compensated ATC PAL-1 refractometer (Atago, Tokyo, Japan). The TA was assessed by means of an automatic Titroline Easy Titrator (Schott, Mainz, Germany). A 10 mL juice sample was titrated with NaOH 0.1 N until the organic acids were neutralized at pH 8.2–8.3. The results were expressed as percentage of malic acid.

The ground color was measured with a CR-400 portable tristimulus colorimeter (Minolta, Osaka, Japan), using illuminant D65, 2° observation angle and the CIELab system. In addition, the values of $a^*$ (green/red axis component) and $b^*$ (yellow/blue axis component) were transformed to hue values (Hue = $\tan^{-1}(b^*/a^*)$).

### 2.4. Sensory analysis

A descriptive analysis was carried out on ripe fruit not subjected to cold storage and ripe fruit after 35 d in cold storage. Evaluations were performed in individual booths by a trained panel of judges. For each sample, a 1/4 slice of fruit with skin was cut and placed onto a white porcelain dish. The samples were tested within 5 min from cutting to ensure glossiness and avoid flesh browning. Each dish containing the sample was randomly marked by a three-digit code that corresponded to the same code presented on the individual's evaluation guideline. The evaluation score sheet contained a continuous scale for each attribute, ranging from 0 to 15 and marked with the following three anchors: 0 = lowest level for that specific attribute; 7.5 = medium level for that specific attribute; and 15 = highest level for that specific attribute. This guideline was used previously for stone fruit quality evaluation (Infante et al., 2008a). The quality attributes evaluated were the following: "aroma", "sweetness", "acid taste", "juiciness", "texture" and "flavor". Twelve trained evaluators assessed the samples.

Acceptability was determined by a group of 24 adults. The evaluation guideline for acceptability used a hedonic scale marked with the following two anchors: 0 = extremely dislike, and 15 = extremely like.

### 2.5. Experimental design and statistical analysis

Data obtained at harvest was subjected to an ANOVA test with four treatments that correspond to the cultivars. Data obtained from the ripe fruit were compared using a Student's $t$-test analysis with two treatments (0 and 35 d of storage). A total of 12 repetitions were used for each storage time, excluding TA, where only three composite samples containing four fruit per sample were used.

For the sensory evaluation, a principal components analysis (PCA) was performed. The results were presented in a two-dimensional figure. Correlations between variables were also determined and displayed. Additionally, the sensory analysis results were compared through a $t$-test analysis between treatments per cultivar (at 0 and 35 d of cold storage). Significant differences were set at the 5% level ($p < 0.05$), and means were separated with the multiple-range Tukey test. The statistical program Infostat v2004 (Cordoba, Argentina) was used in all cases.

## 3. Results and discussion

### 3.1. Fruit characterization at harvest

The fruit segregation using a DF range of 50–70 Durofel firmness units allows the formation of a uniform group of fruit in terms of