

Pulp browning and bioactive compounds in fruits from peach trees grafted on different rootstocks

ABSTRACT

Aims: This study aimed at evaluating the quality of Chimarrita peaches from plants grafted on seven rootstocks on the day they were harvested and after 21 days of cold storage, followed by 3 days at room temperature.

Study design: The experiment was conducted as a randomized experimental design in factorial scheme 7 rootstocks and 2 storage periods, with four repetitions of twenty fruits.

Place and Duration of Study: The experiment was carried out at the Universidade Federal de Pelotas, Brazil. The experiment was conducted during the 2014/2015 season.

Methodology: The peach orchard used Chimarrita cultivar grafted in seven rootstocks. Evaluations were carried out at the beginning of the experiment (harvest) and after 21 days of cold storage, followed by a 3-day commercialization simulation period at room temperature. Peaches were analyzed regarding pulp browning, content of total phenols, antioxidant activity, firmness and soluble solids.

Results: Pulp browning was more intense in fruits picked from trees grafted on Tsukuba, Nemaguard, Flordaguard and Aldrighi rootstocks. Peaches with the highest content of phenolic compounds were picked from trees grafted on Okinawa on the day they were harvested and from trees grafted on Tsukuba and Flordaguard after storage. The highest antioxidant activity was found in peaches from trees grafted on Capdeboscq when they were harvested and on Nemaguard and Okinawa after storage.

Conclusion: Peach rootstocks influence phenolic compounds, antioxidant activity and soluble solids at the time of harvesting and after storage. Pulp browning was less intense in peaches picked from plants grafted on the Okinawa rootstock after cold storage followed by commercialization simulation. Phenolic compounds, antioxidant activity and firmness of peaches decreased after storage, regardless of the rootstock.

Keywords: *Prunus persica*; fruit quality; storage; preservation.

1. INTRODUCTION

Since the high perishability of peaches makes them need immediate commercialization and consumption after harvest, some storage method must be used for extending their preservation period [1,2]. In general, from the 15th to the 20th day of cold storage, when peaches are removed from cold rooms and kept at room temperature, there is loss of quality, such as rot, wooliness, pulp browning and pulp softening [3,4].

Pulp browning is the characteristic that cannot be seen externally, *i. e.*, it can only be seen when the fruit is cut to be consumed. The more susceptible to internal browning, the lower the life of the peach after harvest [5]. Pulp browning is one of the disorders that usually show in peach pulp after storage and some bioactive compounds, such as phenolic compounds, may be related to it [6,7].

The literature reports that both low temperature and the cultivar may lead to high occurrence of pulp browning [8]. However, there is little data on the relation between the rootstock and the quality of fruits after cold storage and how it influences pulp browning and bioactive compounds.

Rootstocks may affect the quality of peaches when they are harvested [9,10, 11], since they may interfere in the absorption of water and nutrients, influence the vigor of the crown cultivar and affect fruit ripening and preservation [12]. Studies of orange [13] and apple [14] storage have already shown that rootstocks can modify physicochemical characteristics of the fruits. In peaches, bioactive compounds may depend on the cultivar [15,16] storage period [16] and rootstock [11].

Therefore, this study aims at evaluating whether the rootstock affects bioactive compounds, pulp browning and physico-chemical characteristics of Chimarrita peaches after harvest.

2. MATERIAL AND METHODS

2.1 Location and climatic conditions

The experiment was conducted in a teaching orchard at the Palma Agricultural Center (Centro Agropecuário da Palma; CAP) belonging to the Federal University of Pelotas (Universidade Federal de Pelotas) in the municipality of Capão do Leão, in the state of Rio Grande do Sul (RS), latitude 31°52'00" S and longitude 52°21'24" W, Brazil.

According to the classification of Köppen, the climate of the region is type Cfa, namely humid and temperate with hot summers [17]. The region has an average annual rainfall and temperature of 1500 mm and 17.9 °C, respectively. The experiment was conducted during the 2014/2015 harvest seasons.

2.2 Treatments and experimental design

The peach orchard used consisted of the *P. persica* (L.) Batsch Chimarrita cultivar grafted in Aldrichi, Capdeboscq, Flordaguard, Nemaguard, Okinawa, Tsukuba, and Seleção Viamão rootstocks. The orchard was planted in 2006 with a "V" type plant-organization system with 5 m of space between rows and 1.5 m between plants, amounting to a density of 1.333 plants ha⁻¹. The 'Chimarrita' cultivar needs from 200 to 600 hours of intense cold. Its fruits are large, with white pulp and ideal to be consumed *in natura* [18].

Peaches were randomly picked from the trees and taken to the laboratory LabAgro in the Federal University of Pelotas to be standardized in terms of their ripening stage. In order to follow the quality of the peaches, four repetitions of twenty fruits were used per treatment. Evaluations were carried out at the beginning of the experiment (harvest) and after 21 days of cold storage at 0±1°C, followed by a 3-day commercialization simulation period at room temperature, i. e., 22±1°C (21+3 days).

2.3 Traits evaluated

Peaches were evaluated in relation to the occurrence of internal browning, the appearance of the fruit pulp and the numbers of fruits, with and without this symptom, were visually evaluated by repetition and results were expressed as percentage; total phenolic compounds (mg Gallic acid per 100 g of sample) were determined according to the adapted method [19] using the reaction with the Folin-Ciocalteu reagent; antioxidant activity (mg trolox per 100 g fresh weight) was determined using the radical DPPH method adapted from Brand-Williams [20]; firmness of the pulp (Newtons), was measured at two opposite points in the equatorial region of peeled fruit using a manual penetrometer (model 53205, TR TURONI-Italy) with an 8 mm tip; and soluble solids (°Brix) were measured using an Atago digital refractometer®.

2.4 Statistical analysis

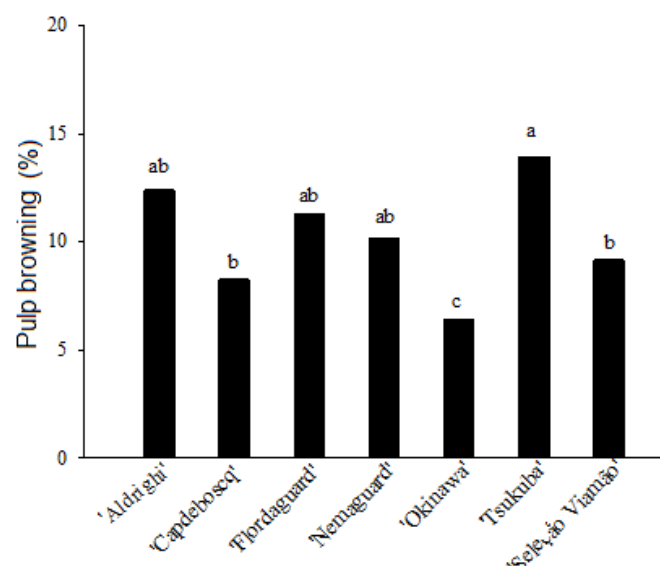
The experiment was conducted as an entirely randomized experimental design in factorial scheme 7 x 2 (7 rootstocks and 2 storage periods), with four repetitions of twenty fruits. Data were submitted to the analysis of variance by the F-test. Means were compared by the Tukey's test, where p≤0.05 using the Assitat software [21].

3. RESULTS AND DISCUSSION

Peach pulp browning was observed after 21 days of cold storage and a 3-day commercialization period (21+3 days). Pulp browning was more intense in fruits from trees grafted on Tsukuba, Nemaguard, Flordaguard and Aldrichi rootstocks after storage (Figure 1) whereas the lowest percentages were found in the Okinawa rootstock at 21+3 days of storage. Pulp browning may be the result of the enzymatic oxidative process, which involves both phenolic compounds (substrate) and oxidative enzymes [22, 6, 7].

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Figure 1 - Pulp browning of Chimarrita peaches from trees grafted on different rootstocks after 21 days of cold storage, followed by a 3-day commercialization simulation period

Lack of suppression and/or reduction in the availability of any of these components in the enzyme reaction may inhibit pulp browning. Pulp browning has been associated with damage caused by low temperature, *i. e.*, in the cell, since low temperature alters membrane permeability, it limits the transport of substrate and, consequently, affects the metabolism of fruits [23].

Peaches with the highest content of phenolic compounds on the day they were harvested were the ones from trees grafted on the Okinawa rootstock whereas the lowest contents were found in Flordaguard, Nemaguard, Seleção Viamão and Umezeiro rootstocks (Table 1). After 21+3 days of storage, the highest contents of phenolic compounds were found in peaches from trees grafted on Tsukuba and Flordaguard rootstocks.

Table 1: Total phenols and antioxidant activity of Chimarrita peaches from trees grafted on different rootstocks on harvest day and after 21 days of cold storage, followed by a 3-day commercialization simulation period

Rootstocks	Total phenols		Antioxidant activity	
	Harvest day	21+3 days	Harvest day	21+3 days
Aldrighi	52.66 abA	27.60 bcB	188.86 bA	128.32 bB
Capdeboscq	58.73 abA	33.98 bB	235.61 aA	112.43 cB
Flordaguard	50.87 bA	35.53 abB	157.79 cA	125.67 bB
Nemaguard	50.56 bA	33.54 bB	146.98 cA	139.81 aB
Okinawa	63.74 aA	21.92 cB	202.68 bA	148.64 aB
Tsukuba	60.70 abA	43.39 aB	147.25 cA	114.88 cB
Seleção Viamão	48.58 bA	23.77 cB	138.39 cA	124.16 bB

Means followed by equal letters, lowercase in the columns and uppercase in the lines, do not differ by Tukey's test, at 5% probability ($p \leq 0.05$).

According to Gil [24], phenolic compounds are the main sources of antioxidants and attributed the amount of the compounds to both the crown cultivar and the rootstock. According to Santos [16],

phenolic compounds in peaches differ among cultivars and storage periods at room temperature. The authors evaluated four peach cultivars (Diamante, Biuti, Douradão and Aurora) and observed that the Biuti one had the highest content of phenolic compounds in fruits with and without storage.

Peaches from all rootstocks had their contents of phenolic compounds decreased after storage by comparison with the harvest day (Table 1). Vieites [25] observed that phenolic compounds decreased in avocados when they were submitted to cold storage. Decrease in contents of phenolic compounds after fruit storage may result from the oxidation of these compounds at cold temperature [26] and from the accelerated process of fruit ripening [25]. These changes are due to the hydrolysis of glycosides by glycosidases while oxidation of phenols is carried out by phenoloxidases and polymerization of free phenols [27].

Antioxidant activity in peach pulp was higher in fruits from tress grafted on the Capdeboscq rootstock than in fruits from the other rootstocks on the day peaches were picked (Table 1). However, after storage, the highest content of antioxidant activity was found in fruits from Chimarrita peach trees grafted on Nemaguard and Okinawa rootstocks.

According to Scalzo [28], the highest content of antioxidant activity in peaches came from rootstocks that rendered plants with more rigor and root and crown development. The literature reports that the genotype influences the determination of antioxidant activity in peaches directly [15, 16], besides the rootstock [24, 10, 11].

Contents of antioxidant activity in peach pulp decreased after 21+3 days of storage by comparison with the harvest day, regardless of the rootstock. However, Santos [16] observed that the antioxidant activity in peaches from Biuti, Douradão and Aurora increased after 5 days of storage at room temperature. In the experiment reported by this paper, peaches were stored at low temperatures, around $0\pm1^{\circ}\text{C}$, and then kept at room temperature for three days. This fact may have been the reason why there was decrease in the antioxidant activity in this study.

Regardless of the rootstocks, fruits did not show any difference related to pulp firmness when they were picked and after 21+3 days of storage (Table 2). However, there was high loss of firmness in peaches in the periods under evaluation; fruits had visual symptoms of over ripening, wilting and loss of pulp consistency. Loss of firmness may be due to the solubilization of cell wall components [2, 29].

Table 2: Pulp firmness and soluble solids of Chimarrita peaches from trees grafted on different rootstocks on harvest day and after 21 days of cold storage, followed by a 3-day commercialization simulation period

Rootstocks	Pulp firmness		Soluble solids	
	Harvest day	21+3 days	Harvest day	21+3 day
Aldrichi	25.13 aA	3.60 aB	11.73 bcB	13.55 bA
Capdeboscq	22.69 aA	3.35 aB	12.23 bcB	14.25 abA
Flordaguard	23.66 aA	3.50 aB	11.06 cB	14.02 abA
Nemaguard	21.19 aA	3.02 aB	11.20 cB	13.85 bA
Okinawa	18.43 aA	3.82 aB	14.20 aB	15.10 aA
Tsukuba	18.03 aA	3.05 aB	11.06 cB	13.85 bA
Seleção Viamão	24.03 aA	2.96 aB	13.23 bcB	13.72 bA

Means followed by equal letters, lowercase in the columns and uppercase in the lines, do not differ by Tukey's test, at 5% probability ($p \leq 0.05$).

Peaches from trees grafted on the Okinawa rootstock had higher content of soluble solids than fruits from other rootstocks on the day they were harvested (Table 2). After 21+3 days of storage, the highest contents of soluble solids were found in peaches from tress grafted on Okinawa, Capdeboscq and Flordaguard rootstocks. In this case, the 'Okinawa' rootstock provided higher content of soluble

solids to Chimarrita peaches on the day they were harvested and after 21+3 days of storage. This rootstock also led to high amounts of total soluble solids to both Talismã and 'Tropical' cultivars [30]. Soluble solids in peaches increased after storage, in all rootstocks. It may have been the result of the evolution of fruit ripening which causes increase in the content of sugar in fruits [31].

4. CONCLUSION

Pulp browning was less intense in peaches picked from plants grafted on the Okinawa rootstock after cold storage followed by commercialization simulation. Peaches with the highest contents of phenolic compounds were picked from trees grafted on the Okinawa rootstock on harvest day. Antioxidant activity in peaches was higher in fruits from trees grafted on the Capdeboscq rootstock, on harvest day, while, after storage, it was higher in peaches from trees grafted on both Nemaguard and Okinawa. Phenolic compounds, antioxidant activity and firmness in peaches decreased after cold storage followed by commercialization simulation, in all rootstocks. Peaches from trees grafted on the Okinawa rootstock had the highest contents of soluble solids.

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