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Shelf-Life and Quality of Fresh-Cut Peach Cv 'Ruby Rich' at Different Maturity Stage

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'Ruby Rich' is a yellow-flesh peach cultivar that ripens during the last week of May and the first of June. This fruit is characterized by distinct colour and size, which make it highly appreciated by consumers, particularly, in the local markets. However, is known about 'Ruby Rich' minimal processing physiology. The aim of this study was to investigate the effect of passive atmosphere, during 12 d, on shelf-life and quality of fresh cut peach fruit, at different ripening stages. 'Ruby Rich' peach fruits were picked at mature-green stage (MG) (55.0 ± 0.5 N), and ripe stage (RP) (35.7 ± 0.7 N) determined by flesh firmness. Fruits were washed, peeled, sliced and stored for 0, 3, 5, 7 and 12 days after cut, six replications were used for each storage time. Scores of appearance and firmness, weight, colour, respiration rate, soluble solids total, ascorbic acid and phenols were observed. Significant differences occurred on MG treatment in terms of visual quality, flesh firmness, polyphenols and ascorbic acid. Results shows that peach slices (RP) maintain the shelf life condition for 5 d. at 5 °C with the best results in terms of solid soluble content and flavour.

1. Introduction

Sensory quality, in the broadest sense, e.g. flavour, taste, texture etc., is one of the primary reasons consumers purchase peach fruit, and the development of knowledge to evaluate eating quality has become an important focus for postharvest biologists and technologists. The achievement of overall quality in peach fruit exhibits several peculiarities, and there is a close link between 'on-tree physiological maturity' and postharvest performance. In the last decade, minimally processed products became largely popular among consumers, demanding ready-to-eat fruits and healthy food with functional compounds. Therefore, new products and technologies, such as UV-C irradiation, edible coatings, active packaging, etc. (Sortino et al., 2015), can make the industrial optimisation of fresh-cut processing easier (Gonzales-Aguilar et al., 2007). Visual quality is one of the most important quality parameters, according to the consumers, and this is, often, altered by fruit browning, dehydration and decay. When fruit comes to browning, the enzyme polyphenol oxidase (PPO) (Li-Qin et al., 2009) and the phenol content are important aspects to take into accounts (Oms-Oliu et al., 2010). Peach and nectarines are suitable fruits for fresh-cut processing (Buesa et al., 2011; Allegra et al., 2015a). The shelf life of fresh-cut peaches may last from 3 to 9 days (Fuentes-Perez et al., 2014) because of their differences in terms of flesh softening, aroma and appearance. The processing protocols include always: selection of fruit with firmness ranging between 35 and 50 N (Gorny et al., 1999); pre-storage at low temperature for 12-24 hours; cleaning; drying; cutting into slices; chemical or physical treatments; packaging; storage at 4-5 °C. Peach cv 'Ruby Rich®' (*Prunus persica* L. Batsch), is melting peach with 100% intense redskin and a yellow melting flesh with sub-acid flavor. The objective of this work is to investigate the effect of cutting on peach cv 'Ruby Rich' during 12 days at different ripening stages: mature-green stage (MG) (55.0 ± 0.5 N), and ripe stage (RP) (35.7 ± 0.7 N).

2. Materials and methods

This study was conducted during the summer season in 2015, on 'Ruby Rich®' harvested from 12 trees, grafted on GF 677 (*Prunus persica x Prunus amygdalus*) rootstock, grown in a commercial orchard located in

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Basilicata (Italy). 'Ruby Rich' peach fruits were picked at mature-green stage (MG) (55.0±0.5 N), and ripe stage (RP) (35.7 ± 0.7 N) determined by flesh firmness. 'Ruby Rich ®' fruits (n > 350) were selected for uniformity of size and absence of defects. Firmness was measured after removing a small disc of skin from each cheek of the fruit by a penetrometer with an 8-mm-diameter probe (Turoni Forlì, Italy); total soluble solid (TSS) was measured in the juice pressed from each fruit using a digital refractometer (model PR-101, Atago, Co., Tokyo, Japan).

2.1 Fresh-cut processing

One hundred fifty 'Ruby Rich' for treatment (MG or RP) were stored at 1± 0.5 °C and 90% RH for 1d and used for cutting. Peach fruits were dipped in chlorinated water (100 ppm of free chlorine) for 360s and defective fruits were eliminated. Fruits were cut into slices with a ceramic knife. Slices were 1.5 ± 0.2 cm thick and 6.4 ± 0.6 cm wide. About 110g of peach slices were packed in polyethylene terephthalate (PET) packages and sealed with a composite film (PP-PET), 64 mm, O_2 permeability = 5.30 X 10^{-8} µL m^{-2} s-1 Pa^{-1}. Packages were stored at 5 ± 1 °C and 90% relative humidity (RH) for 12 d., to simulate refrigerated storage conditions. Quality parameters of fresh-cut slices were analysed at the beginning of the experiment (after cut = day 0) and 3, 5, 7 and 12 days after storage, on six slices per replicate for treatment (2 treatments combinations x 5 time of storage x 9 replicates = 90 bags).

2.2 Qualitative attributes

Weight loss was expressed as percentage reduction with respect to initial time, using the following equation: *% weight loss = [(Initial fruit bags weight – Final fruit bags weight) x 100] / initial fruit bags weight*. Flesh color was measured with a portable colorimeter (Minolta CR 400 HEAD, Minolta, Osaka, Japan) equipped with an 8-mm measuring head and a C illuminant (6774 K). The instrument was calibrated using the manufacturer's standard white plate. Colour measurements were quantified in L*, a* and b* color space. Color changes were calculated as ΔE, considering the difference between the color measured just after the cut (day 0), and the colour measured 3, 5, 7 and 12 days after storage (Allegra et., 2015a)

2.3 Visual quality, crunchiness and flavor score

For the sensory analysis six panelists were recruited at the University Campus of Viale delle Scienze (University of Palermo) and its surronding area, in June 2015. The panelists were selected basing on the following criteria: 50% males, 50% females; age mean 40 years old; availability to attend all training; no allergies to peach; consumers of fresh peach. Each descriptor test was carried out using 1 slices as single replicate, at each sample date (0, 3, 5, 7 and 12 days after packaging) Allegra et al., 2016. All the descriptors were quantified using a subjective 5-pt rating scale (where 5 = max and 1 = min).
(1) Visual quality score resulted from the observation of color, visible structural integrity and visual appearance. The 5-pt rating scale for visual quality (color, structural integrity and appearance) was: 5 = very good, 4 = good, 3 = sufficient (limit of marketability), 2 = poor (limit of usability) and 1= very poor (inedible).
(2) Crunchiness score was determined using the resistance to chewing described by Allegra et al. (2015b).
(3) Flavor of the peach was evaluated using the following indicators of intensity: 5 = very high, 4 = high, 3 = sufficient (limit of marketability), 2 = low and 1 = none.

2.4 In-package O2 and CO2

At each sample date, six bags per treatments were used to measure CO_2 and O_2 content in the bag headspace using a PBI Dansensor Checkpoint O_2 and CO_2 analyzer (Topac, Hingham, MS, USA) equipped with zirconium and infrared detectors, respectively.

2.5 Total phenol content

Total phenol content was determined according to Singleton and Rossi (1965), using the Folin-Ciocalteau reagent (FC) and gallic acid as a standard. Thirty grams of peach fresh tissue for each replication were homogenised with methanol (1:10, w/v). After filtration through a Whatman grade N. 1 filter paper, methanolic extracts were concentrated under reduced pressure and the residue was suspended in 50% (v/v) aqueous methanol and used for phenolic content assay. Results were expressed as mass of gallic acid equivalents (mg L^{-1} fresh weight). Average values were calculated from the results of 6 measurements in different slices for each sample.

2.6 Estimation of vitamin C

At each sample date, 6 slices fruits for each ripening stage were analyzed. L-Ascorbic acid content (mg /100g of fresh weight.) of the pulp was determined with the Megazyme kit (Bray Business Park, Bray, Co., Wicklow, Ireland).

2.7 Statistical analysis

The experimental fresh-cut design consisted of 2 treatments (MG and RP), with observations made at 0 d, 3 d, 5 d, 7 d and 12 d. after cutting. Analysis of variance was applied to data collected. Significant differences (P≤0.05) were evaluated with Tukey test. The statistical software Systat 13.0 for Windows was used.

3. Result and discussion

3.1 Qualitative attributes

TSS did not change significatively in both treatments, 'MG' and 'RP', during storage (P≤0.05) at 5 °C, but significant differences occurred between treatments 'MG' and 'RP' (Table 1). In other studies, TSS contents in fresh-cut peach, decreased for cvs 'Ruby Rich', 'Spring Lady', and 'Ryan Sun', and increased in others, such as cvs 'Summer' 'Rich' and 'O'Henry' during storage (Fuentes Pérez et al., 2014). The slices peach 'RP' showed no significant weight loss during the first 3 days of storage, contrarily, a significant increase (P≤0.05) was observed during the next 5 days (Figure 1).

Appearance of fresh-cut fruit is the most important driver of liking for consumers, and it strongly influeces consumers choice and decision to buy (Crisosto and Tonutti, 2015). In this study we observed that visual quality and flavor, in 'RP' slices, maintained the limit of marketability during 7 days of storage. Contrarily, with regards to the sample 'MG', the flavor evaluations appeared not marketable after 5 days of storage (Table 1). The extent of color loss during storage (ΔE) did not change significantly with time of fruit ripening until 5 d., though 'RP' slices show values higher than 'MG' (P≤0.05) at 7th and 12th days (Table 1). However, in the yellow-flesh peaches discoloration towards darker or lighter shades is less obvious than in white-flesh peaches (Allegra et al., 2015b). The value of crunchiness score decreased significantly (P≤0.05) for each treatment during storage, but differences among treatments appeared 5d after storage, when 'RP' slices reported the lowest firmness score.

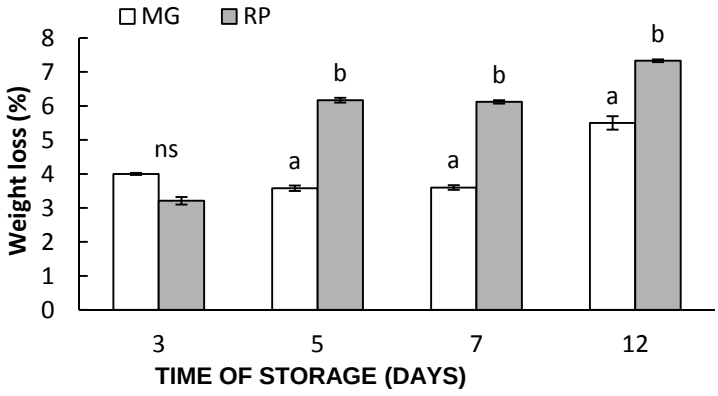

Figure 1 Weight loss (%) of fruit slices of 'Ruby Rich®' peach harvested and processed at the following stages: commercially ripe (MG) and ripe on tree (RP) both stored for 3, 5, 7 and 12 d at 5 °C. Different letters indicate significant differences between treatments at each sampling date. Tukey significant test was applied at P ≤ 0.05. Data are means ± S.E. (n = 6).

3.2 Head spaces gas composition

'Ruby Rich®' peach, after cutting and packaging under passive atmosphere, have changed the value of O_2 and CO_2. In this study, the O_2 (%) content inside the packages decreased during storage and did not show significant values for the bags containing 'MG' and 'RP'. The increase of CO_2 accumulation was observed after 3 d. of storage in all sample slices, picked at mature-green stage and ripe stage. Significant differences occurred between the bags containing 'RP' slices and those with 'MG', in fact, results show an accumulation of 16.5% CO_2 after 7d of storage for 'RP' and a value of 10.2% CO_2 for 'MG' (Table 1).

Table 1. Evolution of chemical and physical parameters for fruit slices of 'Ruby Rich®' peach harvested and processed at commercial ripeness (MG) and ripe on tree (RP), stored 3, 5, 7 and 12 d. at 5 °C.

	Different parameters *of cv Ruby Rich* during shelf life									
Ripeness stage	**MG**	**RP**	**MG**	**RP**	**MG**	**RP**	**MG**	**RP**	**MG**	**RP**
Day	0		3		5		7		12	
Visual quality score (5-1) n= 6	5.0ns	5.0	5.0a	3.6b	4.0a	3.3b	3.3ns	3.1	2.3ns	2.6
Crunchiness score (5-1) n= 6	5.0ns	5.0	5 ns	4.3	4.0a	3 b	3.6a	2.0b	2.0a	1.0b
Flavor score (5-1) n= 6	5.0ns	5.0	3.3a	5.0b	3.0a	4.3 b	2.0a	3.3b	1.0ns	1.0
Solid Soluble total (SST) n= 6	10.0a	12.0b	10.3a	12.1b	10.2a	12.4b	9.9a	13.2b	10.2a	13b
CO_2 inside packaging (%) n= 6	0.2ns	0.2	3.4 ns	4.2	6.3 ns	6.0	8.8ns	7.9	10.2a	16.5b
O_2 inside packaging (%) n= 6	20.0ns	20.0	16.2ns	15.5	13.3ns	12.1	6.4ns	5.8	4.1ns	3.2
Delta E (color) n= 9	-	-	2.2ns	2.5	3.1ns	2.5	4.2a	10.1b	8.8 a	13.6b

Different letters indicate significant differences between treatments at each sampling date. Tukey significant test was applied at P ≤ 0.05.

3.3 Ascorbic acid and polyphenols total content

A wide variation in ascorbic acid and polyphenols total content (PT), at different ripeness stages was observed (Figure 2 and 3). Ascorbic acid content in 'RP' peach slices reported higher values than in 'MG', in all samples, but no significant differences occurred at 7 th and 12 th days. Ascorbic acid was mainly present in the peel (Gil et al., 2002) and in slices of peach treated with 2% ascorbic acid and 1% calcium lactate, or 1% ascorbic acid, 1% calcium lactate and 0.5% citric acid; these treatments showed higher values of ascorbic acid content than untreated peach (control slices) after 12 day of storage (Todaro et al., 2015). The Figure 3 shows the different trend of polyphenols content in slices of peach. In fresh cut peach the trend of polyphenol contents, during shelf-life conditions, depends on various factors, such as: temperature, genotype, chemical and physical treatments (Allegra et al., 2015a; Buesa et al., 2011). In this study, the PT increased in 'MG' slices, but decreased in 'RP' slices, highlighting significant differences between the two samples.

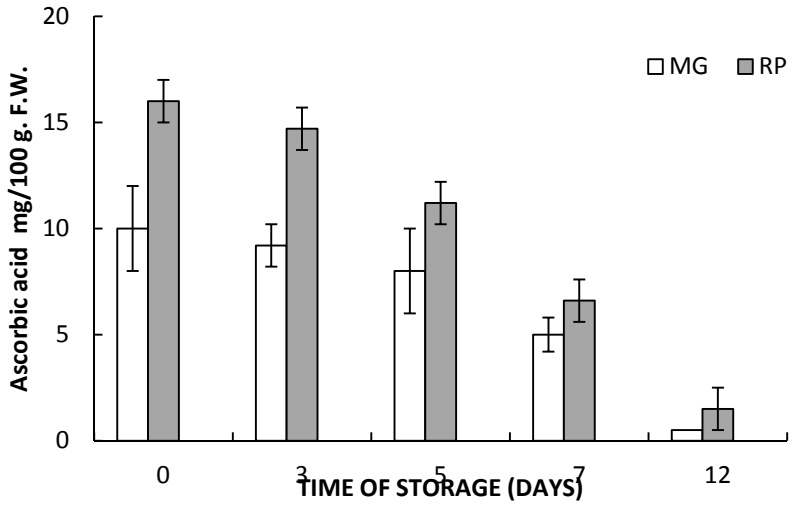

Figure 2 Ascorbic acid contens of fruit slices of 'Ruby Rich®' peach harvested and processed at the following stages: commercially ripe (MG) and ripe on tree (RP) both stored for 3, 5, 7 and 12 d. at 5 °C. Different letters indicate significant differences between treatments at each sampling date. Tukey significant test was applied at P ≤ 0.05. Data are means ± S.E. (n = 6).

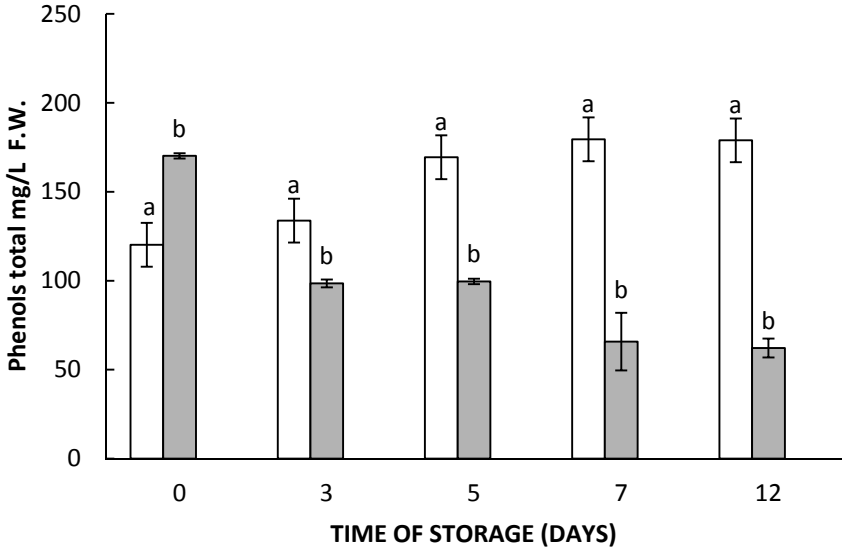

Figure 3 Phenols total contens of fruit slices of 'Ruby Rich®' peach harvested and processed at the following stages: commercially ripe (MG) and ripe on tree (RP) both stored for 3, 5, 7 and 12 d. at 5 °C. Different letters indicate significant differences between treatments at each sampling date. Tukey significant test was applied at P ≤ 0.05. Data are means ± S.E. (n = 6).

4. Conclusion

The study demonstrated that 'MG' slices of peach 'Ruby Rich®' stored at 5 °C for 7 days, maintained good values of many quality parameters, such as, for e.g. firmness, weight loss and total phenols. The 'RP' peach slices maintained the shelf life condition for 5 days at 5 °C with the best results in terms of solid soluble content and flavor. It was observed that, peach fruits, harvested at mature green (MG), maintain a good visual quality until one week of storage, contrarily, although the values of flavor and ascorbic acid decrease, results show that RP peaches maintain, always, higher values MG peaches. Apparently, the ripeness stage (MG) may be considered more suitable for the fresh-cut processing, considering that all parameter tested maintained values that demonstrate consumers' good acceptance one week after cutting.

This work is a further contribution to the research on fresh-cut processing of peach because it shows the influence of ripeness stage on nutraceutical content and flavour of fresh-cut peach.

Given the remarkable variability in peach germplasm, it appears interesting to extend this study to other cultivars which are commercialized in the Italian market, in order to know peach behavior respect to its varietal diversity and direct fresh-cut processing towards those cultivars that maintain higher organoleptic and nutritional profiles. Overall, the data presented may be of interest for the agro-industrial sector, in order to optimize the quality of minimally processed fruit.

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