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# Effect of antioxidant agents on sensory profile of some aromatic fresh-cut peaches

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ABSTRACT

Fresh-cut peach is very perishable, being discoloration or browning the main factors affecting loss quality and consumer acceptability. The aim of the study was to investigate the effect of chemical treatments on sensory peaches profile 'Pesca di Bivona' and 'Pesca di Leonforte' landraces, treated with 2 % ascorbic acid and 1 % calcium lactate (AA), or 1 % ascorbic acid and 1 % calcium lactate and 0.5 % citric acid (SOL) during 12 days of storage. 150 g of peach fruit slices were placed in rigid bi-oriented polystyrene bags and stored for 3, 5, 7 and 12 days at 5 ± 1 °C in passive atmosphere condition. For each sampling day color, sensorial analysis, respiration rate, firmness, total soluble solids, titratable acidity, ascorbic acid and total phenols were measured. Our results showed that the use of ascorbic acid in combination with calcium lactate gave the best results in terms of overall liking in both 'Pesca di Bivona' and 'Pesca di Leonforte' genotypic groups after 7 days of storage. However, 'Pesca di Bivona' and 'Pesca di Leonforte' landraces had a different behavior to antioxidant treatments with AA in terms of browning, acidity, vitamin C and total phenolic content maintaining a high smell, flavor and juice attributes.

## 1. Introduction

The demand for fresh-cut fruits and vegetables has increased in recent years due to changes in the lifestyle of consumers [1]. However, the processing required to make these products increase their metabolism, resulting in faster spoilage, biochemical changes, and increased susceptibility to microbial contamination [2]. Fresh-cut peach is very perishable, being firmness losses and discoloration or browning the main factors that reduce its quality and consumer acceptability. Indeed, fruit color and appearance attract the consumer and provide an indication of freshness and flavor [3].

To inhibit enzymatic activity effect, various authors have focused their scientific research on physiological changes caused by the application of antioxidants on minimally processed fruits. Browning could happen due to polyphenol oxidase (PPO), peroxidase (POD) and ascorbic acid oxidase (L-ascorbate oxidase). Ascorbic acid, both in single and associated form, seems to be widely employed to limit browning effects [4–6]. Ascorbic acid is a hydro-soluble vitamin, not synthesizable by human which can be incorporated only through fruit consumption. In peaches and nectarines, vitamin C could be present as L-ascorbic (AA) reversibly oxidized to form L-acid dehydroascorbic (DHA), one more oxidation produces diketogluconic acid with no biological function [7]. Vitamin C quantity depends on both cultivar and maturity index [8]. The application of citric acid diminishes decay in postharvest fresh-cut peaches reducing texture losses, taste, aroma, and nutritional quality and maintain high levels of sucrose and fructose. Moreover, losses of malic acid and citric acid are delayed, and a remarkable increase in C6 compounds and δ-decalactone, γ-decalactone, and γ-dodecalactone could be observed, thus promoting the normal conversion of herbaceous odors to fruity odors, and even maintaining the rich chlorogenic acid and L-epicatechin contents. The use of ascorbic and/or citric acid in combination with calcium has an important effect on the stabilization of membranes and cell walls, preserving their integrity and functionality and protecting them from being hydrolyzed by enzymes responsible of fruit softening [9,10].

In other works, the application of heat treatment on peach fruit at 40

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°C for 70 min before cutting resulted in no significant effect on color attributes [11] while temperature of 50 °C for 10 min, effectively controlled browning and retained firmness during storage of fresh-cut peach [12]. Therefore, the susceptibility to deterioration of minimally processed peaches and nectarines depends largely on the variety [13,14]. 'Pesca di Bivona' and 'Pesca di Leonforte', white- and yellow-flesh non-melting clingstone peaches, ripen from late June to the end of September the former [15,16], and from early September to the first week of November the latter. These cultivars are autochthonous of the Sicilian region and obtained the certification of Protected Geographical Indication (IPG) under the EC Regulation n. 622 of 15 July 2010 [17]. 'Pesca di Bivona' landraces are very appreciated by consumers due to their persistent aroma and excellent flavor [18]. Among those, 'Settembrina di Bivona' and 'Settembrina di Leonforte' landraces were the most suitable to be processed as fresh-cut products because of the high-quality attributes such as the persistence of high values of overall liking, peach odor, visual appearance and crunchiness scores during storage [19]. The use of ascorbic and/or citric acid along with calcium lactate, could preserve the browning flesh and enhance the texture attributes of 'Pesca di Bivona' and 'Pesca di Leonforte' as it was obtained in other peaches and nectarines [4,6,20]. However, it is unknown whether these treatments have any effects on the sensory attributes of 'Pesca di Bivona' and 'Pesca di Leonforte' groups during minimal processing. Therefore, the objective of this study was to evaluate the effect of chemical treatments on the persistence of flavor and smell in white and yellow flesh landraces during shelf-life.

## 2. Materials and methods

### 2.1. Plant material, ripening conditions and fruit cutting

The research was conducted during the summer season in 2021, on white and yellow flesh peaches (*Prunus persica* (L.) Batsch). Fruits were harvested from 15 trees of each of four non-melting white-flesh peach landraces of the 'Pesca di Bivona' group: 'Murtiddara', 'Bianca', 'Agostina' and 'Settembrina', and three non-melting yellow-flesh landraces of the 'Pesca di Leonforte' group: 'Settembrina'′, 'Giallone' and 'Ottobrina'. These cultivars were grafted on GF 677 (*Prunus persica* x *Prunus amygdalus*) rootstock and grown in commercial orchards located in Sicily in Bivona (AG) (37°37′05″N 13°26′26″E, 503 m a. s. l.) and Leonforte (EN) (37°39′0″N 14° 24′0′ E 656 m a. s. l.). Two hundred fruits of each cultivar were hand-picked at commercial harvest time that occurred on June 25, July 18, August 15, September 10, for 'Murtiddara', 'Bianca', 'Agostina', 'Settembrina di Bivona', respectively; and on September 12, September 22, October 15 for 'Settembrina di Leonforte', 'Giallone', 'Ottobrina', respectively. Ripening stage at harvest was determined on 30 fruit per landrace, in terms of fruit flesh firmness, measured with a penetrometer with an 8 mm probe applied at the fruit check after skin removal.

Mean fruit weight (grams) was 122.1 ± 2.2, 131.0 ± 2.0, 159.4 ± 4.2, 173.2 ± 4.9 for 'Murtiddara', 'Bianca', 'Agostina', 'Settembrina di Bivona', respectively; and 108.2 ± 2.2, 101.1 ± 1.2, 158.0 ± 4.2 for 'Settembrina di Leonforte', 'Giallone', 'Ottobrina', respectively. Immediately after harvest, fruit were transferred to the laboratory and dipped in chlorinated water (100 mg $kg^{-1}$ of free chlorine) for 60 s. Then fruit were cooled in a forced air-cooling unit at 1 ± 0.5 °C at 90 % of relative humidity (RH), for 5–6 h and held overnight until cut. Peaches were peeled and cut into slices with a ceramic knife. Slices were 1.5 ± 0.2 cm thick and 6.4 ± 0.6 cm wide.11-13 peach fruit slices (≈150 g) for each landrace were packed.

### 2.2. Chemical treatments and packaging

Immediately after being cut, peach sliced were dipped for 30 s in solutions containing: 2 % ascorbic acid and 1 % calcium lactate (w/v) (AA); 1 % ascorbic acid, 1 % calcium lactate and 0.5 % citric acid (w/v) (SOL) and distilled water as control (CTR). The solutions were kept at 25 °C for 20 min and then homogenised at 3.000 rpm for 10 min using an ULTRA-TURRAX® (IKA T 25, Staufen, Germany).

After treatments, slices were put into bi-oriented 250 cc polystyrene (PS) boxes sealed with film of selective permeability ($O_2$ and $CO_2$ permeability $5.31 \times 10^{-4}$ and $1.68 \times 10^{-3}$ μl $m^{-2}s^{-1}$ Pa-1105, respectively) (Carton Pack s.r.l., Rutigliano, Italy). For both treatments and control and for any storage time, 945 boxes (3 treatments x 9 replicates x 5 time of storage x 7 landraces) were used. Fresh-cut peach fruit were stored at 5 °C and 90 % RH for 3, 5, 7, 12 days, to simulate refrigerated storage conditions. For each sampling date, $O_2$ and $CO_2$ concentration, color, firmness, weight loss, sensory analysis, total soluble solids, titratable acidity, ascorbic acid and total phenols were analyzed.

### 2.3. Package $O_2$ and $CO_2$ analysis

The $O_2$ and $CO_2$ levels inside each package were measured at each sampling day (3, 5, 7 and 12) using a PBI Dansensor Checkpoint $O_2$ and $CO_2$ analyzer (Topac, Hingham, MS, USA) with zirconium and infrared detectors, respectively. The unit is designed to measure package atmospheres and automatically withdraw samples through a tube fitted with a needle inserted in the package. Results were expressed as kPa and as means of 9 replicates ± standard error (SE).

### 2.4. Color

The color of each slice (9 replicates for each landrace and sampling date) was measured with a portable colorimeter (Minolta CM2500R, 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. Color changes were quantified in L*, a* and b* color space and ΔE was calculated as $\Delta E = \sqrt{(L_0^*-L^*)^2+(a_0^*-a^*)^2+(b_0^*-b^*)^2}$ considering the difference between the color measured just after the cut (T0) and the color measured at 3, 5, 7 and 12 d after storage. The color parameters were used to calculate the Browning Index $BI = \frac{100\ (x^*0.31)}{0.17}$, where $x = \frac{a_t+1.75L_t}{5.645L_t+a_0-3.012b_t}$ [21].

### 2.5. Sensorial analysis

Sensory analysis was performed on a sample of one slice for seven landraces and three treatments after 0, 3, 5, 7, 12 days of cold storage at 5 ± 1 °C. The sensory analysis was conducted at postharvest laboratory of the University of Palermo in September and October 2021. The sensory evaluation test was performed by an expert panel of 11 judges (six men and five women, 25–60 years old) with a broad expertise in sensory evaluation of fruits. During preliminary orientation sessions (20 h), 13 descriptors were selected for the definition of the sensory profile, generated on the basis of the citation frequency (>60 %) and listed below: crunchiness, browning, peach smell, herbaceous smell, floral odor, sweet, acid, bitter, juicy, peach flavour, herbaceous flavour, floral flavour, overall liking.

During the evaluation, all the 11 panellists completed independently a short questionnaire covering the quality indicators. The evaluation was carried out from 10:00 to 12:00 a.m. in a normalized testing room with individual booths under white lights. Samples were presented in a white plastic plate and tasted 1 h after they were taken out of the cold room [22]. The sample order for each panellist was randomized and water was provided for rinsing between samples. The judges evaluated the intensity of each descriptor by assigning categorical scores of 1 (absence of sensation), 2 (just recognizable), 3 (very weak), 4 (weak), 5 (slight), 6 (moderate), 7 (intense), 8 (very intense) and 9 (extremely intense) [23].

### 2.6. Firmness and weight loss

Fruit hardness was tested with a flat tip of fruit texture analyzer (Instron 5564, Norwood, MA, USA). Each slice (six replicates for each treatment and sample date) was compressed to a depth of 4 mm using a 2.5-cm flat tip at a speed of 5 mm $s^{-1}$, and the maximal force was expressed in kg $cm^{-2}$. Weight loss (WL) was determined by weighing each box at day 0 (Wi) and after storage (Wd) using a precision balance (Gibertini, Novate Milanese, Italy) with accuracy to two decimal places and it was expressed in percentage (%):

$$\text{Weight loss } (\%) = [(\text{Wi} - \text{Wd})/\text{Wi}] \times 100$$

### 2.7. Total soluble solids and titratable acidity

Total soluble solids (TSS) and titratable acidity (TA) were measured on 6 slices randomly chosen from the remaining 6 packages/landrace. TSS content was measured using a digital refractometer (Atago Palette PR-32 digital refractometer, Atago Co., Ltd-Tokyo, Japan). Titratable acidity (TA) was measured on 5 g of filtered juice added to 50 mL of distilled water. The sample was titrated to pH 8.2 with 0.1 N NaOH and the results were expressed as mass of malic acid per volume of juice (g $L^{-1}$).

### 2.8. Ascorbic acid and total phenolic content

Ascorbic acid concentration was determined according to Rapisarda and Intelisano [24], by liquid chromatography HPLC (PerkinElmer, Australia), using an injector (Rheodyne with 20 mL loop), a photodiode detector, a Knauer Eurospher II 100-5C18 column 250 mm 4.6 mm I.D. (Berlin, Germany) and a similarly packed precolumn. The elution was performed with a buffer solution consisting of $KH_2PO_4/H_3PO_4$ at pH 2.3, at a flow rate of 16.7 mL $s^{-1}$, the wavelength was at 260 nm. An aliquot of freshly prepared pulp (5 g) was homogenised with 25 mL of 3 % metaphosphoric acid, centrifuged, filtered through a 0.45 mm Whatman Puradisc and HPLC injected. The concentration of ascorbic acid was calculated from the experimental peak area by analytical interpolation in a standard calibration curve and was expressed as mg $kg^{-1}$ of fresh weight (FW). Total phenolic content was determined according to the Singleton and Rossi method [25], using the Folin–Ciocalteau reagent (FC) and the gallic acid as a standard. The FC reagent relies on the transfer of electrons in alkaline medium from phenolic compounds to phosphomolybdic/phosphotungstic acid complexes, which are determined spectrophotometrically at 700 nm. Thirty grams of peach fresh tissue for each replicate was homogenised with methanol (1:10, w/v) for the phenolic extraction. 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 $kg^{-1}$ of fresh weight (FW).

### 2.9. Statistical analysis

Data were analyzed according to a randomized block design with 7 landraces, 4 periods of storage and 3 treatments as variability factors. One-way ANOVA was carried on $O_2$ and $CO_2$, color, firmness, weight loss, TSS, TA, ascorbic acid and total phenols. For each storage time, the analysis of variance was focused on all landraces. The sensory evaluation score analyses were carried out by two-way ANOVA, with the landrace as the first factor and the time of storage as the second factor. Significant differences ($p \leq 0.05$) were evaluated with Tukey's test (Systat 13, for Windows was used as statistical software).

## 3. Results and discussion

### 3.1. Color and browning

The loss in visual appearance of non-melting white- and yellow-flesh peach landraces processed as fresh–cut product is related to a reduction in lightness and increased in browning during shelf life. Our results showed that these changes are well described in all the color parameters measured and by the evaluations carried out by the trained panel.

At the end of the experiment, within the 'Pesca di Bivona' genotype not all the landraces responded significantly to the treatments with ascorbic or citric acid and calcium lactate (Table 1). Among the ecotypes studied, it is worth highlighting the results obtained in 'Settembrina di Bivona' landrace. In particular, the color results for this ecotype showed that the treatments with AA and/or SOL maintained the initial values (T = 0) of lightness until 7 days of storage. It is important to note that for 'Murtiddara' landrace treated with AA the lowest B-index value on the 3rd day of storage was obtained. In another work Dawson et al. [26], observed that despite pre-freezing treatment with 2 % of ascorbic acid on peach slices, browning occurred in all samples. In addition, for 'Agostina' control slices, similar values of lightness (L*) and color variation (ΔE) were observed until 7 days of storage. Significant differences were found between SOL, AA and CTR treatments in terms of L*. Indeed, the lower mean values occurred in the SOL treatment slices rather than in other samples treated (AA) and untreated (CTR). The ΔE values of 'Agostina' showed significant differences on the 3rd day of storage when SOL slices had higher values than AA and CTR treatments (Table 1). Conversely, 'Bianca' landrace was the one with the worst results for color after treatments with AA and SOL. In fact, after 7 days of storage, results showed the lowest lightness value (L* = 66.5) and the highest B-index value (61.1) if compared to the other treated landraces (Table 1).

'Settembrina di Bivona' treated and untreated increased significantly its L* mean value from the 7th to the 12th day of storage. This behavior can be associated to the water translucency on flesh surface [27]. Lightness (L*) values decreased significantly in 'Murtiddara', 'Bianca' and 'Agostina' landraces slices from cut until the 12th day of storage. This decreases in L* frequently occurred during fresh-cut storage due to water and color flesh losses. Other authors showed that an increase in L* parameter is closely related to the development of whiteness of the samples [28] treating them with radio frequency (RF) heating water [29], while its reduction is due to the onset of browning in the samples.

Regarding to 'Pesca di Leonforte' genotype, significant statistical differences were obtained among all the treatments and landraces (Table 2). For instance, 'Settembrina di Leonforte' slices peach fruit had the highest values of lightness after 7 days of storage, regardless of the type of treatment, compared to the other landraces; although 'Settembrina' control slices had a lower B-index value after 7 days of storage, AA treatment was the one that showed the best results in terms of color variation and lightness. Contrary, 'Giallone' landrace treated with AA and SOL showed lower values in terms of B-index and L* than the control one, albeit statistically significant differences were found between treatments (Table 2).

'Ottobrina' slices peach fruit showed a decrease in terms of L* mean value from the 3rd to the 5th day of storage in all treatments. An opposite trend was observed for the same landrace and storage time, where the ΔE values increased rapidly both in the control and in SOL treatment (35.6 % and 92 %, respectively); while in AA treatment, the increase was more gradual from the 3rd to the 5th day of storage (23.9 %). In this case, the effect of ascorbic acid + calcium lactate delayed browning of flesh peach samples in fact a significant difference to other treatments was found. The use of $CaCl_2$ in combination with Soy Protein Isolate (SPI) enhanced the ΔE value on fresh-cut peach compared to SPI without $CaCl_2$ [30]. Allegra et al. [31] demonstrated that the use of calcium ascorbate treatment applied to fruit slices of 'Coscia' and 'Abate Fétel' Pears (*Pyrus communis* L.) significantly extended their shelf-life

**Table 1**
Colorimetric traits of landraces of the 'Pesca di Bivona' fruit (cvs *Murtiddara, Bianca, Agostina* and *Settembrina di Bivona*) at 0, 3, 5, 7 and 12 days of storage at 5 ± 1 °C and 90 ± 5 % RH (relative humidity) after all treatments. Means with different letters are significantly different at $p \leq 0.05$ using Tukey's HSD test. Different lowercase letter denotes significant differences ($p \leq 0.05$) among different treatments and cultivar for the same sampling time. Letter "a" or "A" denotes the highest value. Different capital letters denote significant differences ($p \leq 0.05$) among different sampling times for the same treatment and cultivar.

| Treatment | Storage (day) | | | | | |
|---|---|---|---|---|---|---|
| ***Murtiddara*** | | **L*(C)** | **a*(C)** | **b* (C)** | **ΔE** | **B-index** |
| CTR | **0** | 72.9Ab | −3.90Aa | 23.4Cns | - | - |
| | **3** | 71.1Ba | −1.95Cd | 27.5Ba | 7.08Aa | 48.1Aa |
| | **5** | 69.2Ca | −2.66Ba | 29.0Aa | 7.52Ba | 50.8Ba |
| | **7** | 69.8CBb | −1.92Cd | 27.6Ba | 6.63BCa | 48.2Aa |
| | **12** | 73.1Aa | −1.39Dd | 26.4Ba | 5.11Ca | 44.4Aa |
| AA | **0** | 72.9Ab | −3.93Aa | 23.4C | - | - |
| | **3** | 69.6Bb | −2.92Bc | 32.5Ab | 5.06Cb | 39.4Cb |
| | **5** | 66.7Cc | −1.62Cb | 30.7Ba | 8.68Ab | 54.4Ab |
| | **7** | 65.7Cd | −0.79Df | 30.5Ba | 8.64Ab | 53.8Ab |
| | **12** | 65.1Cb | −1.11De | 31.4Ab | 7.27Bb | 42.2Ba |
| SOL | **0** | 72.9Ab | −3.99Aa | 23.4C | - | - |
| | **3** | 69.5Bb | 0.192Ab | 25.0Bc | 7.39Ca | 49.9Ca |
| | **5** | 70.3Ba | −0.63Cc | 29.5Aa | 8.05Bb | 54.1Bb |
| | **7** | 70.7Ba | 1.15Be | 28.7Aa | 10.23Ac | 57.7Ac |
| | **12** | 72.4Aa | 1.45Bd | 26.0Ba | 9.93Ac | 56.9Ab |
| ***Bianca*** | | **L*(C)** | **a*(C)** | **b* (C)** | **ΔE** | **B-index** |
| CTR | **0** | 72.9Ab | −2.83Ab | 24.8C | - | - |
| | **3** | 69.2Bb | −1.79Cd | 31.4Ba | 8.3Ba | 57.4Ba |
| | **5** | 69.8Ba | −2.015Bd | 30.6BCab | 7.7Ba | 54.4Ca |
| | **7** | 68.1Bc | −0.92De | 32.6Aa | 9.7Aa | 64.0Aa |
| | **12** | 67.8Ca | −0.36E | 32.2Aa | 9.4Aa | 63.8Aa |
| AA | **0** | 72.9Ab | −2.91Ab | 24.8D | - | - |
| | **3** | 69.6Ab | −1.618Cd | 30.4Ca | 7.7Ba | 55.3Ab |
| | **5** | 69.0a | −2.672Bd | 31.0Ba | 8.4Ba | 54.7Aa |
| | **7** | 67.2Bc | −1.402Dd | 31.6Bab | 9.7ACa | 65.1Ba |
| | **12** | 68.1BCa | −1.85Dc | 32.7Aa | 10.5ACab | 64.0Ba |
| SOL | **0** | 72.9Ab | −2.83Ab | 24.8C | - | - |
| | **3** | 69.8Bb | −2.66Ac | 30.2Ba | 7.8Ca | 57.9Ca |
| | **5** | 68.5Bb | −1.73Be | 29.8Bb | 8.1Ca | 55.5Da |
| | **7** | 66.50Cb | −0.88Ce | 30.9Bb | 9.8Ba | 61.1Bb |
| | **12** | 65.4Cd | −0.25Df | 32.4Aa | 11.7Ab | 68.6Ab |
| ***Agostina*** | | **L*(C)** | **a*(C)** | **b* (C)** | **ΔE** | **B-index** |
| CTR | **0** | 72.5Ab | −2.64Ab | 24.41A | - | - |
| | **3** | 69.0Ba | −1.18C | 27.31Ba | 7.35Aa | 50.42Aa |
| | **5** | 71.7Aa | −0.56D | 26.84Ba | 6.82Aa | 46.31Ba |
| | **7** | 71.4Aa | −1.79Bd | 26.98Ba | 6.06Aa | 45.80Ba |
| | **12** | 67.1Ba | −0.02Ef | 26.97Ba | 8.76Aa | 60.87Ba |
| AA | **0** | 72.9Ab | −2.64Ab | 24.41A | - | - |
| | **3** | 70.6Ba | −0.74Be | 24.98Ab | 7.13Aa | 44.08Ab |
| | **5** | 71.2Ba | −2.36Ad | 25.70ABa | 5.97ABa | 41.74Bb |
| | **7** | 70.1Ba | −2.06Ab | 26.23Ba | 5.47Ba | 45.38Aa |
| | **12** | 68.2Ca | −0.75Be | 26.69Ba | 8.91Ca | 57.36Cb |
| SOL | 0 | 72.5Ab | −2.64Ab | 24.41C | - | - |
| | **3** | 66.4Bb | −1.89Cd | 29.09Dc | 12.03Ab | 63.48Ac |
| | **5** | 66.8Bb | −2.17Bd | 32.46Bb | 6.54Ca | 45.15Ba |
| | **7** | 67.6Ab | −1.35Dd | 31.37Cb | 7.84Bb | 45.09Ba |
| | **12** | 65.3Bb | −0.93De | 33.26Ab | 8.06Ba | 53.11Cc |
| ***Settembrina*** | | **L*(C)** | a*(C) | **b* (C)** | **ΔE** | **B-index** |
| CTR | **0** | 75.82Aa | −4.2Ba | 23.53B | - | - |
| | **3** | 75.61Ba | −3.9Bb | 23.89Ba | 5.89Ba | 35.24Aa |
| | **5** | 75.7Ba | −4.6Ab | 23.82Ba | 5.2BCa | 36.20Aa |
| | **7** | 77.34A | −4.6Aa | 23.85Ba | 4.93Ca | 30.25Ba |
| | **12** | 82.86Aa | −4.1Bb | 27.13Aa | 9.75Aa | 35.73Aa |
| AA | **0** | 75.82Aa | −4.2Ca | 23.53D | - | - |
| | **3** | 75.19Ba | −5.5Aa | 25.68Ba | 6.0Ba | 33.96Ba |
| | **5** | 75.58Ba | −5.1Aa | 24.64Ca | 6.53Bb | 32.17Bb |
| | **7** | 76.54Ba | −4.7Ba | 23.82CDa | 4.57Ca | 30.66Ca |
| | **12** | 80.42Ab | −4.3Cb | 27.55Aa | 8.82Aa | 35.88Aa |
| SOL | **0** | 75.82Aa | −4.2Ba | 23.53C | - | - |
| | **3** | 75.45Ba | −4.1Bb | 21.75Db | 7.72Cb | 29.15Ab |
| | **5** | 73.79Bb | −3.5Cc | 26.81Bb | 11.35Ac | 39.29Bc |
| | **7** | 75.53Ba | −4.2Ba | 25.73Bb | 7.10Cb | 34.91Cb |
| | **12** | 81.77Ab | −5.0Aa | 28.72Aa | 9.02Ba | 37.28Cb |

**Table 2**

Color characteristics of Leonforte peach fruit (cvs *Settembrina, Giallone* and *Ottobrina di Leonforte*) at 0, 3, 5, 7 and 12 days of storage at 5 ± 1 °C and 90 ± 5 % RH (relative humidity) after all treatments. Means with different letters are significantly different at $p \leq 0.05$ using Tukey's HSD test. Different lowercase letter denotes significant differences ($p \leq 0.05$) among different treatments and cultivar for the same sampling time. Letter "a" or "A" denotes the highest value. Different capital letters denote significant differences ($p \leq 0.05$) among different sampling times for the same treatment and cultivar.

| Treatment | Storage (day) | | | | | |
|---|---|---|---|---|---|---|
| ***Settembrina*** | | **L*(C)** | **a*(C)** | **b* (C)** | **ΔE** | **B-index** |
| CTR | **0** | 69.21Aa | 7.83Ab | 57.89Ac | - | - |
| | **3** | 67.79Bb | 4.84Be | 56.95Ab | 5.32Cd | 137.4Be |
| | **5** | 71.07Aa | 5.4Ba | 54.25Bb | 7.06Ac | 136.6Bd |
| | **7** | 68.63Bb | 7.5Ab | 55.85Bb | 7.31Ac | 147.6Ad |
| | **12** | 70.51Aa | 4.83Ba | 54.63Bb | 6.52Bd | 131.2Ce |
| AA | **0** | 69.21ABa | 7.83Ab | 57.89Ac | - | - |
| | **3** | 68.48Bc | 6.19Bc | 59.03Ab | 5.79da | 147.6Bb |
| | **5** | 70.45Aa | 5.16Cb | 57.66Ba | 5.77Bd | 144.9Cc |
| | **7** | 70.21Aa | 6.11Bc | 57.15Ba | 6.3Ad | 146.7ACd |
| | **12** | 67.78Bb | 6.23Bb | 55.78Ca | 5.62Bd | 150.1Aa |
| SOL | **0** | 69.21Aa | 7.83Bb | 57.89Ac | - | - |
| | **3** | 67.84Bc | 6.29Cb | 56.36ABa | 6.91Ac | 145.9Bc |
| | **5** | 70.22Aa | 4.96Db | 55.89Bb | 5.71Bd | 148.1Bb |
| | **7** | 67.04Bb | 8.53Aa | 55.74Bb | 6.16ABd | 155.6Aa |
| | **12** | 69.7Aa | 5.55Db | 53.63Cc | 6.81Ad | 136.6Cd |
| ***Giallone*** | | L*(C) | a*(C) | b* (C) | ΔE | B-index |
| CTR | **0** | 66.5Bb | 4.9Cc | 59.75Ab | - | - |
| | **3** | 64.73Cd | 5.60ABd | 52.944Cc | 10.49ABa | 143.5Bd |
| | **5** | 67.53ABb | 4.45Cb | 52.062Cc | 9.86Bb | 151.0Ab |
| | **7** | 65.19Bc | 6.42Bc | 52.475Cc | 10.64Ab | 149.8Ac |
| | **12** | 70.27Aa | 7.21Ans | 55.894Ba | 10.18Bb | 134.7Cd |
| AA | **0** | 66.55Bb | 4.9Cc | 59.75Ab | - | - |
| | **3** | 62.78Ce | 6.42Bc | 56.4Ba | 8.5Bb | 148.3Bb |
| | **5** | 65.03Bc | 5.78Ba | 54.8Bb | 7.9Cc | 145.4Cc |
| | **7** | 63.55Cd | 8.42Aa | 53.8Cc | 10.31Aba | 153.5Ab |
| | **12** | 69.19Aa | 7.89Ans | 56.5Ba | 8.87Bc | 144.8Cb |
| SOL | **0** | 66.53Bb | 4.9Cc | 59.75Ab | - | - |
| | **3** | 59.75De | 7.67Bb | 55.059Bb | 8.4Cb | 168.2Ab |
| | **5** | 62.11Cc | 7.9Bb | 54.4Bb | 8.95Ca | 161.6Bc |
| | **7** | 59.84Dc | 8.7Ab | 53.8BCd | 11.35Aa | 159.6Bb |
| | **12** | 69.5Aab | 7.58Bns | 54.7Bb | 9.76Bc | 144.8Cc |
| ***Ottobrina*** | | L*(C) | a*(C) | b* (C) | ΔE | B-index |
| CTR | **0** | 70.73Ba | 8.56Aa | 66.99Aa | - | - |
| | **3** | 74.08Aa | 7.89Bb | 59.21Bb | 10.35Da | 143.5Bd |
| | **5** | 67.39CDb | 6.32Ca | 55.91Cb | 14.04Ba | 148.3Ab |
| | **7** | 66.42Dc | 6.25Cc | 55.55Cb | 13.88Ca | 149.5Aa |
| | **12** | 68.65Cb | 5.82Da | 53.4Dc | 15.27Aa | 134.5Cd |
| AA | **0** | 70.73Aa | 8.56Aa | 66.99Aa | - | - |
| | **3** | 71.9Ab | 7.04Bb | 59.2Aa | 10.41Ca | 132Db |
| | **5** | 65.37Cb | 7.59Bb | 56.7Ba | 12.9Bb | 148.3Ca |
| | **7** | 66.51BCa | 6.4Ca | 55.83Ca | 13.71ABns | 165.4Ab |
| | **12** | 67.58Bc | 6.79Cb | 54.82Cc | 14.08Ab | 151.6Ba |
| SOL | 0 | 70.73Aa | 8.56Aa | 66.99Aa | - | - |
| | **3** | 71.06Ab | 8.22Aa | 62.5Ba | 7.65Cc | 168.2Aa |
| | **5** | 65.28Bc | 6.82Ba | 55.8Cb | 14.69Aa | 161.7Ba |
| | **7** | 66.42Bc | 6.25Bc | 55.5Cb | 13.88Ba | 153.7Cb |
| | **12** | 66.71Bab | 6.33Bb | 53.7Dd | 15.59Aa | 144.4Dc |

because it inhibited considerably browning and color changes expressed as ΔE in fresh-cut pear slices. The use of calcium ascorbate and calcium lactate in fresh-cut pineapple showed that treatments maintained a good sensory acceptability of fresh-cut pineapple even prolonging storage-life up to 5 days under cold storage [30].

### 3.2. Total soluble solids and titratable acidity

Total soluble solids content showed significant differences within the landraces belonging to the 'Pesca di Bivona' genotype (Table 3). The TSS content at harvest might be attributed to the different harvesting periods and genotypic characteristics among the landraces evaluated. Among the cultivars, 'Bianca' was the one that stood out for the highest content of TSS being control slices those that provided the highest content after 7 days of storage (°Brix = 14.4) although no significant differences were observed among AA and SOL treatments (°Brix = 13.9). However, on 'Settembrina' landrace, SOL treatment was the one that provided the lowest TSS values (°Brix = 8.5) compared to CTR and AA treatments. With respect to 'Murtiddara' slices peach,TSS content no significant differences were observed after 7 days of storage among treatments (Table 3). 'Agostina' and 'Settembrina' had a slightly lower TSS content values compared to 'Murtiddara' and 'Bianca'.

Even among the different landraces belonging to 'Pesca di Leonforte' group, TSS and TA content varied significantly as the storage time increased (Table 4). TSS content on 'Settembrina', 'Giallone' and 'Ottobrina' had a downward trend during storage from cutting to the 7th days of storage.

In fact, 'Giallone' slices treated with SOL had the lowest TSS content compared to AA and CTR on the 7th day of storage. At the same storage period 'Settembrina di Leonforte' peach slices treated with AA showed a

**Table 3**
Total soluble solids (°Brix), and Titratable acidity (g malic acid $L^{-1}$) in minimally processed 'Bivona' peach fruit (cvs *Murtiddara, Agostina, Bianca di Bivona* and *Settembrina*) immediately after harvest (T0) and after 3, 5, 7 and 12 days of storage.

| Treatment | | *Murtiddara* | | *Agostina* | | *Bianca di Bivona* | | *Settembrina* | |
|---|---|---|---|---|---|---|---|---|---|
| | day | °Brix | TA (malic acid) | °Brix | TA (malic acid) | °Brix | TA (malic acid) | °Brix | TA (malic acid) |
| **CTR** | 0 | 12.5 ± 0.1 | 8.45 ± 0.32 | 11.0 ± 0.16 | 6.18 ± 0.12 | 14.5 ± 0.1 | 9.43 ± 0.1 | 9.5 ± 0.2 | 6.11 ± 0.12 |
| | **3** | 12.6 ± 0.16a | 8.65 ± 0.25b | 10.8 ± 0.15ns | 5.74 ± 0.26ns | 14.6 ± 0.09ns | 9.49 ± 0.25ns | 9.7 ± 0.29ns | 6.15 ± 0.11a |
| | **5** | 12.7 ± 0.11a | 9.03 ± 0.32b | 10.6 ± 0.13 | 5.74 ± 0.28 | 14.4 ± 0.08 | 9.38 ± 0.17 | 9.6 ± 0.24 | 5.62 ± 0.11b |
| | **7** | 12.4 ± 0.12a | 11.6 ± 0.34a | 10.9 ± 0.15 | 5.72 ± 0.17 | 14.4 ± 0.18 | 8.42 ± 0.30 | 9.6 ± 0.13 | 4.89 ± 0.16d |
| | **12** | 13.0 ± 0.05b | 9.02 ± 0.40b | 10.6 ± 0.20 | 5.05 ± 0.23 | 14.3 ± 0.14 | 9.18 ± 0.21 | 9.5 ± 0.15 | 5.06 ± 0.15c |
| **AA** | **3** | 12.4 ± 0.07b | 12.6 ± 0.91a | 10.8 ± 0.07ns | 6.03 ± 0.24a | 14.2 ± 0.20a | 8.42 ± 0.33ns | 9.2 ± 0.17ns | 5.58 ± 0.16a |
| | **5** | 12.3 ± 0.20b | 9.02 ± 0.17b | 10.4 ± 0.10 | 5.01 ± 0.24b | 13.7 ± 0.15b | 8.52 ± 0.27 | 9.3 ± 0.11 | 4.97 ± 0.22b |
| | **7** | 12.7 ± 0.14a | 13.6 ± 0.21a | 10.4 ± 0.17 | 4.90 ± 0.18c | 13.9 ± 0.15 ab | 7.85 ± 0.19 | 9.9 ± 0.20 | 5.14 ± 0.19b |
| | **12** | 11.8 ± 0.16c | 9.02 ± 0.36b | 10.3 ± 0.13 | 5.33 ± 0.19b | 13.0 ± 0.17c | 8.00 ± 0.30 | 10.1 ± 0.17 | 4.71 ± 0.12c |
| **SOL** | **3** | 12.9 ± 0.13a | 14.6 ± 0.30a | 11.0 ± 0.16ns | 5.94 ± 0.21a | 13.5 ± 0.23b | 8.61 ± 0.31a | 9.6 ± 0.25a | 5.47 ± 0.10a |
| | **5** | 12.3 ± 0.11c | 9.02 ± 0.20c | 10.9 ± 0.15 | 5.85 ± 0.29a | 13.6 ± 0.17b | 8.58 ± 0.22a | 9.3 ± 0.21a | 5.48 ± 0.25a |
| | **7** | 12.6 ± 0.12b | 15.6 ± 0.19b | 10.9 ± 0.07 | 5.38 ± 0.42a | 13.9 ± 0.07a | 8.49 ± 0.26a | 8.5 ± 0.38b | 4.70 ± 0.18c |
| | **12** | 12.6 ± 0.17b | 9.02 ± 0.16c | 10.2 ± 0.22 | 4.43 ± 0.21b | 13.4 ± 0.15b | 7.81 ± 0.25b | 8.6 ± 0.12b | 5.03 ± 0.30b |

(n = 6 replicates per cultivar and sampling date). For each cultivar and parameters, different letters indicate significant differences between sampling dates and treatment (Tukey's test at $p \leq 0.05$).

**Table 4**
Total soluble solids (°Brix), and Titratable acidity (g malic acid $L^{-1}$) in minimally processed Leonforte peach fruit (cvs *Settembrina, Giallone* and *Ottobrina*) immediately after harvest (T0) and after 3, 5, 7 and 12 days of storage.

| Treatment | day | *Settembrina* | | *Giallone* | | *Ottobrina* | |
|---|---|---|---|---|---|---|---|
| | | °Brix | TA (malic acid)) | °Brix | TA (malic acid) | °Brix | TA (malic acid) |
| **CTR** | **0** | 13.1 ± 0.5 | 6.58 ± 1.1 | 12.10 ± 0.12 | 6.90 ± 0.49 | 13.2 ± 0.55 | 6.02 ± 0.76 |
| | **3** | 13.2 ± 0.13a | 6.38 ± 0.17a | 12.1 ± 0.27a | 7.30 ± 0.45a | 13.9 ± 0.22a | 6.38 ± 0.57a |
| | **5** | 12.8 ± 0.12a | 5.56 ± 0.18b | 12.6 ± 0.15b | 6.42 ± 0.35b | 13.3 ± 0.15b | 5.86 ± 0.32a |
| | **7** | 11.6 ± 0.30b | 5.53 ± 0.20b | 12.9 ± 0.22b | 5.26 ± 0.31c | 13.3 ± 0.10b | 5.31 ± 0.26 |
| | **12** | 12.1 ± 0.16a | 5.62 ± 0.12b | 11.5 ± 0.14c | 5.04 ± 0.26c | 12.8 ± 0.13c | 5.33 ± 0.29 |
| **AA** | **3** | 11.3 ± 0.19b | 5.81 ± 0.22a | 11.8 ± 0.13b | 6.81 ± 0.27a | 12.9 ± 0.10a | 5.90 ± 0.19ns |
| | **5** | 10.5 ± 0.23c | 4.97 ± 0.25c | 11.7 ± 0.23b | 6.29 ± 0.24b | 12.6 ± 0.18b | 5.55 ± 0.19 |
| | **7** | 12.3 ± 0.23a | 5.69 ± 0.29b | 12.2 ± 0.14a | 5.64 ± 0.26c | 12.3 ± 0.10c | 5.24 ± 0.14 |
| | **12** | 12.4 ± 0.23a | 5.66 ± 0.10b | 11.4 ± 0.17b | 5.46 ± 0.37c | 13.0 ± 0.11a | 5.60 ± 0.30 |
| **SOL** | **3** | 12.5 ± 0.18a | 6.10 ± 0.23a | 12.1 ± 0.15a | 6.13 ± 0.30a | 12.6 ± 0.16a | 5.62 ± 0.27a |
| | **5** | 12.0 ± 1.2a | 4.82 ± 0.21b | 11.7 ± 0.25a | 5.72 ± 0.26a | 12.8 ± 0.15a | 5.48 ± 0.15a |
| | **7** | 11.8 ± 0.19a | 5.16 ± 0.19b | 11.0 ± 0.26b | 4.94 ± 0.35b | 12.5 ± 0.12a | 5.19 ± 0.15b |
| | **12** | 11.4 ± 0.22b | 5.16 ± 0.18b | 11.2 ± 0.17b | 4.80 ± 0.23b | 11.7 ± 0.15b | 4.96 ± 0.22b |

(n = 6 replicates per cultivar and sampling date). For each cultivar and parameters, different letters indicate significant differences between sampling dates and treatment (Tukey's test at $p \leq 0.05$).

higher TSS content than SOL and CTR peach slices. A similar trend was also observed on 'Ottobrina' control slices showing the highest TSS content.

Similar results were observed by Bordonaba et al. [32] in relation to genotype and harvesting period on 6 fresh-cut melting nectarines during storage. Nogales-Delgado et al. [33] observed a decreased in TSS during their shelf life on 4 fresh-cut nectarine cultivars. This reduction in TSS was also observed by Falagàn et al. [34] who stated that it was due to the consumption of organic acids and sugars with respiratory activity during the maturation process with changes affecting the glucose/fructose ratio [35]. Meng et al. [36] studied the effect of cold storage alone or combined with Methyl Jasmonate (MeJa) treatment and observed that MeJa enhanced TSS/TA ratio and restraining the decrease of TSS in peach fruits probably due to enzyme changes and increased calcium content in the flesh cell wall.

Regarding to titratable acidity content, after 7 days of storage, 'Murtiddara' and 'Settembrina' slices peach treated with SOL (1 % ascorbic acid, 1 % calcium lactate and 0.5 % citric acid) showed the highest and lowest value in terms of TA 15.6 and 4.70 g $L^{-1}$, respectively (Table 3). AA treatment, after 7 days of storage, determined a significant increase in the TA of 'Murtiddara' landrace compared to control slices. A similar trend was also observed by Yang et al. [37], in which the highest TA values were found on peaches treated with citric acid after 6 days of storage compared to the control ones (untreated). However, slices of 'Agostina' and 'Bianca' landraces treated with AA showed a reduction in TA of 20.7 % and 16.7 %, respectively, compared to the control after 7 days of storage (Table 3). 'Pesca di Leonforte' groups showed a decrease in terms of TA in all treatments during storage (Table 4). 'Settembrina di Leonforte' and 'Ottobrina' treated with SOL showed a significant reduction on the 12th day of storage if compared to CTR and AA treatment.

### 3.3. Firmness and weight loss (%)

Firmness and weight loss are strictly related and their values have a downward trend with storage time increase. AA and SOL treatments have been able to modify the qualitative and quantitative decay, sometimes improving it in according to the response of the ecotype. In fact, 'Murtiddara' control slices, suffered an abrupt reduction in firmness after cutting (T0) until the 3rd day of storage. Moreover, this decrease in firmness was more marked from the 7th to 12th day of storage on control slices (from 3.1 to 1.2 kg $cm^{-2}$). After 12 days of storage 'Murtiddara' slices peach treated with AA presented the best results in terms of firmness (Table 5). On the 7th day of storage, no significant differences were observed between the treatments on 'Bianca' landrace regarding to the firmness, while 'Agostina' treated with AA showed significant

**Table 5**
Firmness (kg cm$^{-2}$), and Weight loss (%) in minimally processed Bivona peach fruit (cvs *Murtiddara, Agostina, Bianca di Bivona* and *Settembrina di Bivona*) immediately after harvest (T0) and after 3, 5, 7 and 12 days of storage.

| Treatment | day | *Murtiddara* | | *Agostina* | | *Bianca di Bivona* | | *Settembrina* | |
|---|---|---|---|---|---|---|---|---|---|
| | | Firmness (kgcm$^{-2}$) | Weight loss (%) | Firmness (kgcm$^{-2}$) | Weight loss (%) | Firmness (kgcm$^{-2}$) | Weight loss (%) | Firmness (kgcm$^{-2}$) | Weight loss (%) |
| **CTR** | 0 | 4.5 ± 2.1 | - | 4.5 ± 2.2 | - | 4.5 ± 1.9 | - | 4.5 ± 0.2 | - |
| | **3** | 3.2 ± 0.1a | 1.1 ± 0.2b | 3.8 ± 0.1a | 1.66 ± 0.6c | 4.0 ± 0.1a | 1.4 ± 0.2b | 4.5 ± 0.9 | 0.1 ± 0.1 |
| | **5** | 3.1 ± 0.1a | 1.43 ± 0.3b | 3.6 ± 0.1b | 1.73 ± 0.8c | 3.2 ± 0.1b | 1.2 ± 0.6b | 4.1 ±0.4 | 0.4 ± 0.1 |
| | **7** | 3.2 ± 0.3a | 2.6 ± 0.6a | 2.9 ± 0.3c | 2.72 ± 0.1b | 3.4 ± 0.4b | 2.2 ± 0.8b | 4.6 ± 0.8 | 1.8 ± 0.1 |
| | **12** | 1.2 ± 0.3b | 3.02 ± 0.4a | 1.6 ± 0.2d | 2.95 ± 0.3a | 2.1 ± 0.2c | 2.8 ± 0.2a | 3.5 ± 0.5 | 2.06 ± 0.1 |
| **AA** | **3** | 4.4 ± 0.1a | 1.6 ± 0.1ns | 4.5 ± 0.7a | 0.03 ± 0.2c | 4.2 ± 0.1a | 1.2 ± 0.7ns | 4.2 ± 0.1a | 0.2 ± 0.1b |
| | **5** | 4.3 ± 0.2a | 1.2 ± 0.7 | 4.4 ± 0.1a | 0.21 ± 0.4b | 3.7 ± 0.1b | 1.5 ± 0.2 | 4.3 ± 0.1a | 0.3 ± 0.6 ab |
| | **7** | 3.7 ± 0.1b | 1.6 ± 0.2 | 4.0 ± 0.7a | 1.90 ± 0.1a | 3.3 ± 0.3bc | 1.5 ± 0.6 | 4.1 ± 0.2a | 1.1 ± 0.4 ab |
| | **12** | 3.1 ± 0.4c | 1.82 ± 0.3 | 2.3 ± 0.3b | 0.33 ± 0.05b | 3.0 ± 0.1c | 2.0 ± 0.3 | 2.1 ± 0.1b | 1.2 ± 0.2a |
| **SOL** | **3** | 4.1 ± 0.13a | 1.6 ± 0.5b | 4.0 ± 0.1a | 1.4 ± 0.2b | 4.2 ± 0.23a | 1.61 ± 0.3b | 4.1 ± 0.5a | 0.7 ± 0.1b |
| | **5** | 3.0 ± 0.11b | 2.02 ± 0.2 ab | 2.9 ± 0.5b | 1.5 ± 0.2b | 3.3 ± 0.17b | 1.8 ± 0.2b | 4.3 ± 0.2a | 0.4 ± 0.2c |
| | **7** | 2.6 ± 0.12b | 2.6 ± 0.5a | 2.3 ± 0.6b | 1.8 ± 0.4 ab | 3.2 ± 0.7b | 1.9 ± 0.5b | 3.9 ± 0.3b | 1.8 ± 0.1a |
| | **12** | 2.6 ± 0.17b | 3.02 ± 0.4a | 2.2 ± 0.2b | 2.3 ± 0.2a | 3.1 ± 0.15b | 2.8 ± 1.0a | 3.6 ± 0.2b | 2.03 ± 0.3a |

(n = 6 replicates per cultivar and sampling date). For each cultivar and parameters, different letters indicate significant differences between sampling dates and treatment (Tukey's test at $p \leq 0.05$).

differences compared to SOL and CTR. A different behavior occurred on CTR, AA and SOL 'Settembrina di Bivona' sample slices in which the effect of antioxidant treatment reduced the firmness 4.4 %, 8.8 % and 13.3 %, respectively.

Cut slices with yellow-flesh of the landraces belonging to 'Pesca di Leonforte' genotype responded differently to the treatments as the storage time varied. For 'Giallone', no significant statistical differences were observed in terms of firmness for all treatments on the 7th day of storage. 'Settembrina di Leonforte' slices peach treated with AA was the one that showed the best firmness (3.7 kg cm$^{-2}$) value on the 7th day of storage (Table 6). It could be due to this ecotype, the genotypic component is predominant over the other factors. Slices of 'Ottobrina' showed greater firmness when treated with AA (3.3 kg cm$^{-2}$) compared to the control (2.4 kg cm$^{-2}$) and to the treatment with SOL (2.9 kg cm$^{-2}$). In fresh-cut peach and nectarine the use of chemical or natural treatments maintained firmness during shelf-life [38]. The use of *Aloe vera* Gel at 30 % blended with Chitosan at 1.5 % on peach fruit gave the highest firmness (10.61 lbinch$^{-2}$) compared to the other treatments during the 36 days of storage [39].

With respect to weight loss parameter, 'Murtiddara', 'Bianca' and 'Settembrina di Bivona' control sample slices decrease significantly during storage but after 7 days AA treatment showed the best results (Table 5). Similar results were obtained for 'Agostina', observing the highest percentage of weight loss for control slices compared to SOL and AA treated-slices on the 7th day of storage. Regarding 'Pesca di Leonforte' groups, different behavior was observed between landraces. Indeed, antioxidant treatments in 'Giallone' slices showed the worst results in terms of weight loss compared to control samples. For 'Settembrina di Leonforte' no significant differences of weight loss were obtained between the treatments on the 7th day of storage. Different trend was observed on 'Ottobrina' slices in which AA treatment presented the best results compared to SOL and CTR treatment. Our results showed that effectiveness of treatment can be linked to the landrace's behavior although weight loss in fruits is mainly due to water loss from the tissue surface as a result of respiration and transpiration processes during storage [40] or due to mild heat pre-treatment [11] or UV radiation [41]. In other species, the use *Opuntia ficus-indica* (OFI) mucilage in combination with *Aloe arborescens* reduced the weight loss in kiwi fruit [42]. The same results occurred in breba fig or papaya treated with OFI mucilage or *Aloe vera* gel showing that natural edible coating can induce a reduction in respiration and transpiration in order to avoid high weight loss [43,44].

### 3.4. $O_2$ and $CO_2$ inside packaging

Significant Statistical differences were observed between treated and

**Table 6**
Firmness (kg cm$^{-2}$), and Weight loss (%) in minimally processed Leonforte peach fruit (cvs *Settembrina, Giallone* and *Ottobrina*) immediately after harvest (T0) and after 3, 5, 7 and 12 days of storage.

| Treatment | day | *Settembrina* | | *Giallone* | | *Ottobrina* | |
|---|---|---|---|---|---|---|---|
| | | Firmness (kg cm$^{-2}$) | Weight loss (%) | Firmness (kg cm$^{-2}$) | Weight loss (%) | Firmness (kg cm$^{-2}$) | Weight loss (%) |
| **CTR** | **0** | 4.7 ± 2.2 | - | 4.6 ± 1.1 | - | 4.4 ± 0.9 | - |
| | **3** | 3.9 ± 0.6a | 0.6 ± 0.6ns | 4.2 ± 0.1a | 1.1 ± 0.2c | 3.5 ± 0.3a | 1.4 ± 0.8b |
| | **5** | 3.8 ± 0.9a | 0.8 ± 0.3 | 2.9 ± 1.1b | 1.3 ± 0.8 cb | 3.4 ± 0.4a | 1.2 ± 0.3b |
| | **7** | 3.3 ± 0.9b | 1.7 ± 0.9 | 2.0 ± 1.3bc | 1.6 ± 0.3b | 2.4 ± 0.1b | 2.2 ± 1.3 ab |
| | **12** | 2.1 ± 1.2c | 0.9 ± 0.3 | 2.1 ± 0.3c | 3.02 ± 0.5a | 1.8 ± 0.9b | 2.8 ± 1.2a |
| **AA** | **3** | 4.2 ± 0.1a | 0.3 ± 0.02b | 3.4 ± 0.1a | 2.6 ± 1.4ns | 4.2 ± 0.3a | 0.2 ± 0.1b |
| | **5** | 4.1 ± 1.3a | 0.7 ± 0.4 ab | 3.3 ± 0.2a | 2.2 ± 1.2 | 3.7 ± 0.1b | 0.5 ± 0.2b |
| | **7** | 3.7 ± 1.0a | 1.2 ± 0.09a | 1.7 ± 0.1b | 3.6 ± 1.9 | 3.3 ± 0.5b | 1.5 ± 0.3a |
| | **12** | 1.3 ± 0.2b | 1.3 ± 0.06a | 1.1 ± 0.6b | 3.82 ± 1.3 | 1.9 ± 0.8c | 2.0 ± 0.9a |
| **SOL** | **3** | 4.0 ± 1.1a | 0.4 ± 0.02b | 2.1 ± 0.13a | 3.6 ± 0.2a | 4.2 ± 0.1a | 0.61 ± 0.3b |
| | **5** | 3.9 ± 0.9a | 0.5 ± 0.2b | 2.2 ± 0.11a | 3.0 ± 0.7b | 3.3 ± 0.8 ab | 0.8 ± 0.2b |
| | **7** | 2.9 ± 0.1b | 1.8 ± 0.04a | 1.6 ± 0.12b | 3.6 ± 0.1a | 2.9 ± 0.4b | 1.9 ± 0.2a |
| | **12** | 1.2 ± 1.2c | 2.3 ± 0.2a | 1.2 ± 0.17c | 3.82 ± 1.1a | 1.5 ± 0.1c | 2.1 ± 0.2a |

(n = 6 replicates per cultivar and sampling date). For each cultivar and parameters, different letters indicate significant differences between sampling dates and treatment (Tukey's test at $p \leq 0.05$).

untreated yellow flesh slices regarding $O_2$ and $CO_2$ content inside the package during storage time. It is well known that oxygen level decreases as the storage time increases, when cut fruit slices are stored in passive atmosphere [44] or when are treated with different antioxidant substances [45].

As could be expected, significant differences were observed between treatments for the landraces belonging to 'Pesca di Bivona' group as the storage time varied. In detail, 'Murtiddara' slices treated with AA, in terms of oxygen content, recorded the highest value on the 7th day of storage (7.4 kPa) if compared to CTR (6.1 kPa) and SOL treatment which presented the lowest value (3.5 kPa) (Fig. 1).

However, no significant differences occurred at the 12t$^h$ day of storage for all treatments. In terms of $CO_2$ concentration, 'Murtiddara' CTR slices showed significant differences during the storage time with respect to the other treatments. 'Murtiddara' control slices showed the lowest values of $CO_2$ after 7 days of storage (9.6 kPa) compared to AA (10.9 kPa) and SOL treatment (12.5 kPa). Significant differences between treatments were also observed for 'Bianca' peach slices in terms of $CO_2$ (Fig. 2). 'Bianca' SOL slices presented the highest $CO_2$ content inside the package throughout storage compared to control slices and the other treatments applied.

A sharp reduction in $O_2$ occurred after cutting in 'Agostina' landrace, being this reduction greater in slices treated with AA, SOL and control (Fig. 3). Specifically, on the 7th day of storage, the oxygen content in AA slices was the lowest (4.2 kPa) compared to the SOL treatment (5.2 kPa) and the control (6.0 kPa) samples.

However, no significant differences were found, on the 12th day, between CTR and SOL treatment with values of 2.2 and 2.1 kPa, respectively. The production of $CO_2$ inside packaging was greater in slices treated with AA (16.6 kPa) than in CTR (14.6 kPa) and SOL treatment (14.9 kPa) after 7 days of storage. As regards 'Settembrina di Bivona', from the 3rd to the 7th day of storage, a gradual increase in $CO_2$ concentration and gradual reduction in $O_2$ was observed for all treatments, and no significant differences were found between treated and control slices (Fig. 4).

Our results showed that antioxidant treatments had no effect on $O_2$ and $CO_2$ inside packaging. A similar trend was observed by Ramirez et al. [46] on fresh-cut nectarine treated with chitosan, pectin and sodium caseinate showing an increase up to the 3rd day of storage for all the treatments and control (uncoated). However, Manganaris et al. [47] reported no significant differences in terms of respiration rate between peach samples dipped in different calcium-based solutions (calcium chloride, calcium lactate and calcium propionate) and control ones (untreated).

Oxygen content of 'Giallone' slices shown a similar trend for CTR and AA treatment (Fig. 5). Indeed, it was slightly more gradual if compared to SOL treatment. At 12 days of storage, 'Giallone' peach slices showed the highest $CO_2$ in SOL treatment (20.2 kPa) whilst no significant variation was observed between AA and CTR treatment.

Although all white and yellow peaches studied were harvested at the same ripeness stage, our results showed a difference in $CO_2$ and $O_2$ production on both treated and untreated slices. For instance, 'Settembrina di Leonforte' sample slices presented a drastic $O_2$ reduction from cutting to the 3rd day of storage in all treatments, although this trend was even more marked in SOL treatment (from cutting 20.2 kPa–5.5 kPa on the 3rd day of storage). However, after 7 days of storage, the highest oxygen values were detected for AA and control slices (6.1 kPa), while SOL treatment showed the lowest mean values (3.5 kPa). 'Settembrina di Leonforte' slices peach, treated with AA showed the lowest $CO_2$ values (15.2 kPa) after 7 days of storage than SOL treatment and control, 21.5 and 20.1 kPa, respectively (Fig. 6).

Similar results were obtained by Wang et al. [48] who demonstrated that hydrogen sulfide ($H_2S$) suppressed the increase in respiration rate and weight loss and delayed the firmness losses on fresh-cut peach slices. Other authors showed that the effect of antioxidant treatments delayed $O_2$ and $CO_2$ production improving the quality of fresh-cut nectarine [49–51]. With respect to 'Ottobrina' landrace (Fig. 7), no significant differences were observed in terms of $CO_2$ and $O_2$ on the 7th day of storage reaching values of 19.5 % and close to 3 %, respectively.

### 3.5. Sensory analysis

The use of natural or chemical additives in combination with modified atmosphere packaging (MAP), active or passive atmosphere conditions, can prolong shelf-life of fresh-cut fruit. However, its effects can positively or negatively influence its most important sensory attributes. The expert panel was able to discriminate different fresh-cut fruit in terms of fruit smell, crunchiness, aroma and sweetness and to relate those parameters to fruit acceptability [52].

Within the genotypic group 'Pesca di Bivona' some differences were observed in terms of sensorial profile among the landraces after 7 days of storage compared to the judgment given after cutting (T0). 'Murtiddara' fresh-cut maintained a high level of peach smell both treated with AA and/or SOL compared to control slices after 7 days of storage (Fig. 8). Sweetness attribute decreased with the storage time in all the treatments probably due to a simultaneous increase of acid attribute which was lower in control slices (5.0 pt) compared to those treated with AA or SOL (7.0 pt and 7.8 pt, respectively) on the 7th day of storage.

These results show a high correlation with mean values of TA (Table 3) highlighting an increment of 30.8 %, 54.5 % and 84.6 % for CTR, AA and SOL respectively, conversely no correlation with TSS content was observed (Table 3). 'Murtiddara' fresh-cut slices

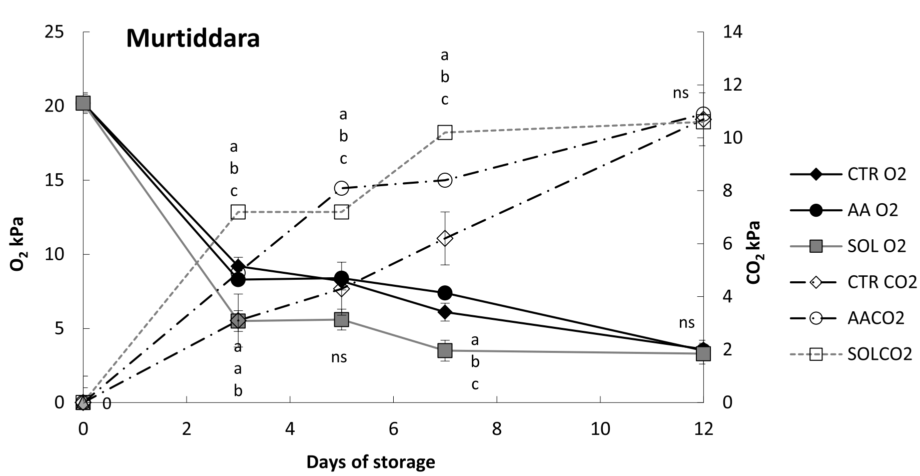


**Fig. 1.** Oxygen and Carbon dioxide content (kPa) inside packages with fruit slices of 'Murtiddara' landrace (Pesca di Bivona) treated with 2 % ascorbic acid and 1 % calcium lactate (AA), or 1 % ascorbic acid, 1 % calcium lactate and 0.5 % citric acid (SOL) or not treated (CTR) during storage for 3, 5, 7, 12 days at 5 ± 1 °C.

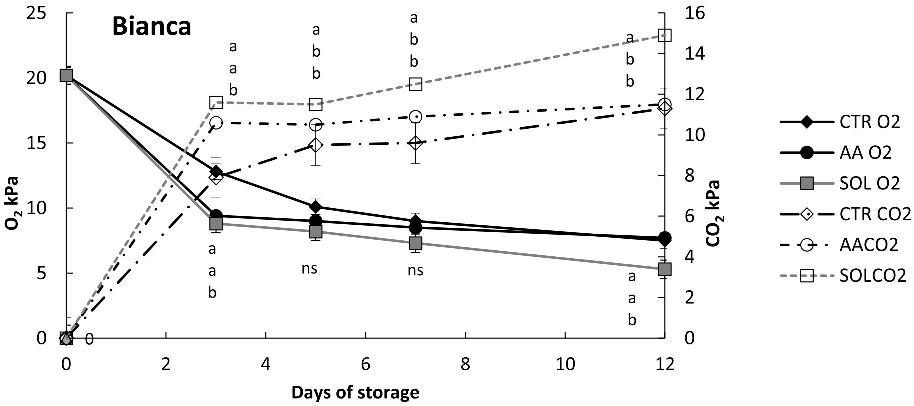


**Fig. 2.** Oxygen and Carbon dioxide content (kPa) inside packages with fruit slices of 'Bianca' landrace (Pesca di Bivona) treated with 2 % ascorbic acid and 1 % calcium lactate (AA), or 1 % ascorbic acid, 1 % calcium lactate and 0.5 % citric acid (SOL) or not treated (CTR) during storage for 3, 5, 7, 12 days at 5 ± 1 °C.

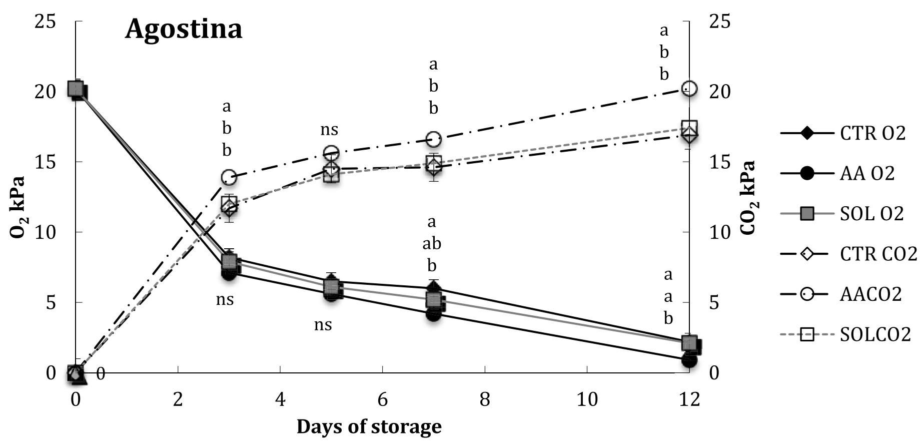


**Fig. 3.** Oxygen and Carbon dioxide content (kPa) inside packages with fruit slices of 'Agostina' landrace (Pesca di Bivona) treated with 2 % ascorbic acid and 1 % calcium lactate (AA), or 1 % ascorbic acid, 1 % calcium lactate and 0.5 % citric acid (SOL) or not treated (CTR) during storage for 3, 5, 7, 12 days at 5 ± 1 °C.

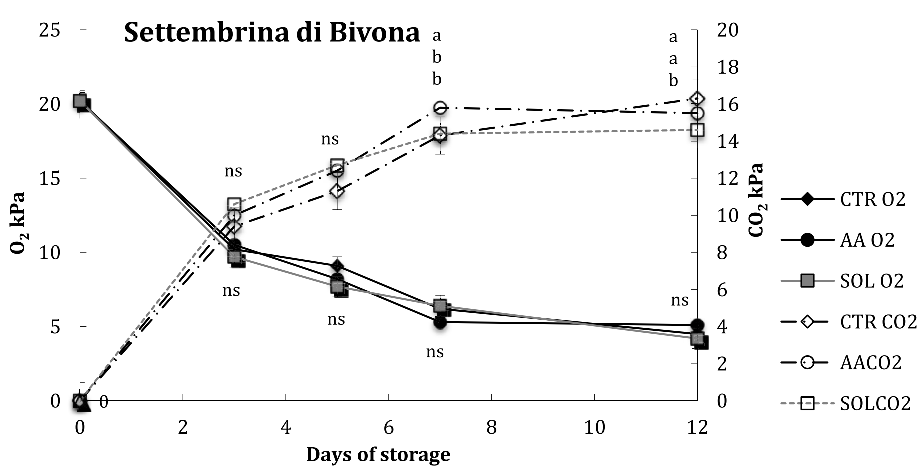


**Fig. 4.** Oxygen and Carbon dioxide content (kPa) inside packages with fruit slices of 'Settembrina di Bivona' landrace (Pesca di Bivona) treated with 2 % ascorbic acid and 1 % calcium lactate (AA), or 1 % ascorbic acid, 1 % calcium lactate and 0.5 % citric acid (SOL) or not treated (CTR) during storage for 3, 5, 7, 12 days at 5 ± 1 °C.

maintained a high level of peach flavor when treated with AA or SOL (7.0 pt for both treatments) conversely it drastically decreased in control samples (3.0 pt). After 7 days of storage, 'Agostina' slices treated with AA and SOL showed a higher peach smell compared to CTR slices. Similarly, sweetness and peach flavor attributes increased with AA and SOL treatments for the same storage period. These values are related to a decrease of TA from the day 0 until the 7th day of storage. Therefore, the judges detected an increment of sweetness attribute. A similar trend was

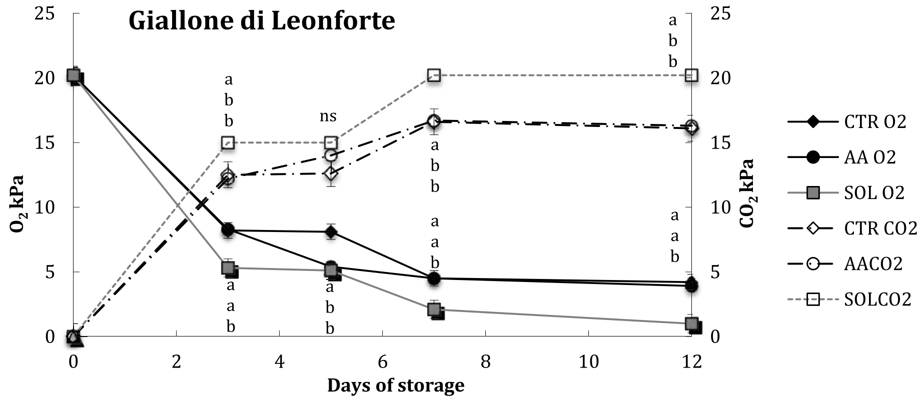


**Fig. 5.** Oxygen and Carbon dioxide content (kPa) inside packages with fruit slices of 'Giallone' landrace (Pesca di Leonforte) treated with 2 % ascorbic acid and 1 % calcium lactate (AA), or 1 % ascorbic acid, 1 % calcium lactate and 0.5 % citric acid (SOL) or not treated (CTR) during storage for 3, 5, 7, 12 days at 5 ± 1 °C.

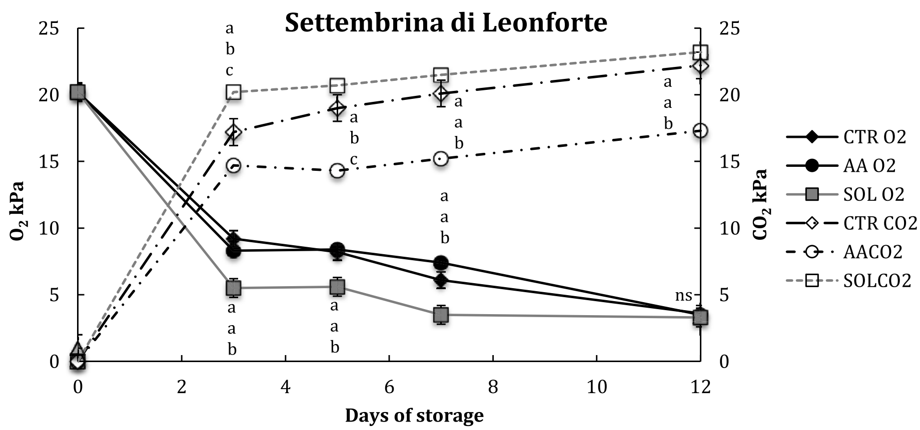


**Fig. 6.** Oxygen and Carbon dioxide content (kPa) inside packages with fruit slices of 'Settembrina di Leonforte' landrace (Pesca di Leonforte) treated with 2 % ascorbic acid and 1 % calcium lactate (AA), or 1 % ascorbic acid, 1 % calcium lactate and 0.5 % citric acid (SOL) or not treated (CTR) during storage for 3, 5, 7, 12 days at 5 ± 1 °C.

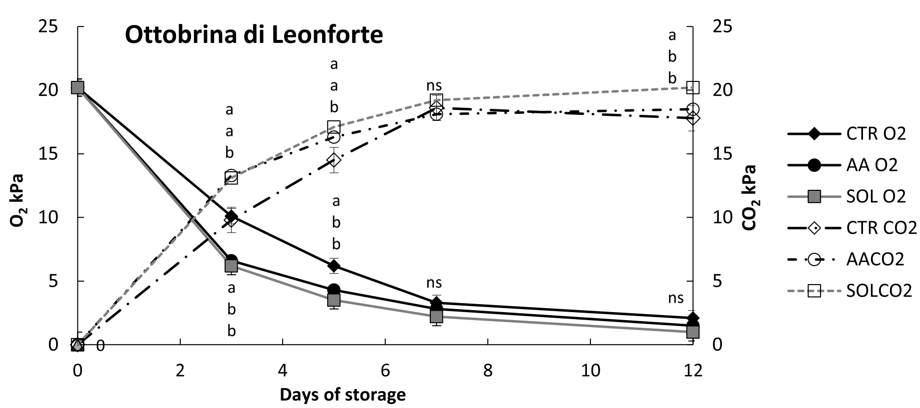


**Fig. 7.** Oxygen and Carbon dioxide content (kPa) inside packages with fruit slices of 'Ottobrina' landrace (Pesca di Leonforte) treated with 2 % ascorbic acid and 1 % calcium lactate (AA), or 1 % ascorbic acid, 1 % calcium lactate and 0.5 % citric acid (SOL) or not treated (CTR) during storage for 3, 5, 7, 12 days at 5 ± 1 °C.

observed in 'Bianca' slices treated with AA and/or SOL. In fact, AA and SOL treatments induced a higher peach flavor and higher smell attributes as well as juiciness. However, acidity attribute increased with AA and/or SOL treatment compared to CTR slices. In this case, no correlation was observed between TA and sensorial analysis with regard to the acidity attribute.

Although for 'Settembrina di Bivona' landrace initial peach smell judgment was the lowest among the other ecotypes, this one was almost unvaried when fresh-cut slices were treated with AA after 7 days of storage. Acidity attribute of slices sample slightly increased with AA and SOL treatment, while it decreased for control treatment on the 7th day of storage. Therefore, it's possible that adding ascorbic or citric acid

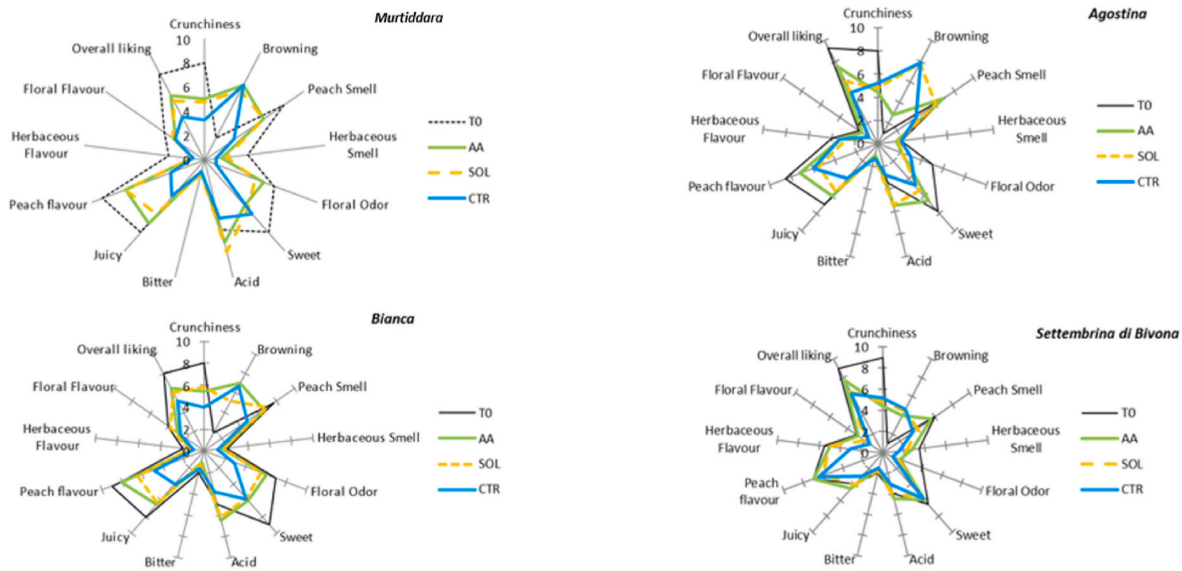


**Fig. 8.** Sensory analysis of 'Pesca di Bivona' slices treated with 2 % ascorbic acid and 1 % calcium lactate (AA), or 1 % ascorbic acid, 1 % calcium lactate and 0.5 % citric acid (SOL) or not treated (CTR) during storage for 7 days at 5 ± 1 °C.

increased the perception of acidity on mean values judgment.

Peach flavor attribute remained at a very good level during storage time, although AA treatment was the one that obtained the best results (7 pt) compared to SOL treatment (6 pt) after 7 days of storage. Different results showed by Manganaris et al. [53], on canned peaches, treated with different sources of calcium, reported that both calcium chloride and calcium propionate imparted undesirable flavor. However, in this work, aroma and smell attributes were not affected by the use of calcium lactate in combination with ascorbic acid.

Even in yellow-flesh peaches, changes in sensory profile of fresh-cut slices were observed during storage. However, treatments played a key role ensuring that sensory and organoleptic qualities remain as unchanged as possible over time.

For example, 'Settembrina di Leonforte' showed the highest value of peach smell when fresh-cut slices were treated with AA obtaining values of 7.9 pt at the time of cutting (T0) and 7.2 pt after 7 days of storage (Fig. 9).

For this sensory parameter, control samples obtained more than halved its value on the 7th day of storage. In this landrace up to the 7th day of storage mean values of TSS decreased and those of TA increased, respectively (Table 4), while sweetness and acidity attributes decreased during storage time being their reduction less remarkable in treated slices (with AA and/or SOL) compared to control ones.'Settembrina di Leonforte' peach flavor attribute was the highest when slices were treated with AA (7.1 pt) compared to those treated with SOL and control ones (6.5 pt and 4.2 pt, respectively) on the 7th day of storage. Felts et al. [54] observed that flavor attribute increased during cold storage time in relation to the ripeness stage. Also, for 'Giallone' landrace, peach smell attribute decreased as the storage time increased. However, the best result was obtained with AA treatment (5.3 pt) compared to SOL treatment (4.8 pt) and control one (4.3 pt) after 7 days of storage. A similar decreasing trend was also observed for peach flavor sensory parameter for the same storage period. Sweetness and acidity attributes decreased

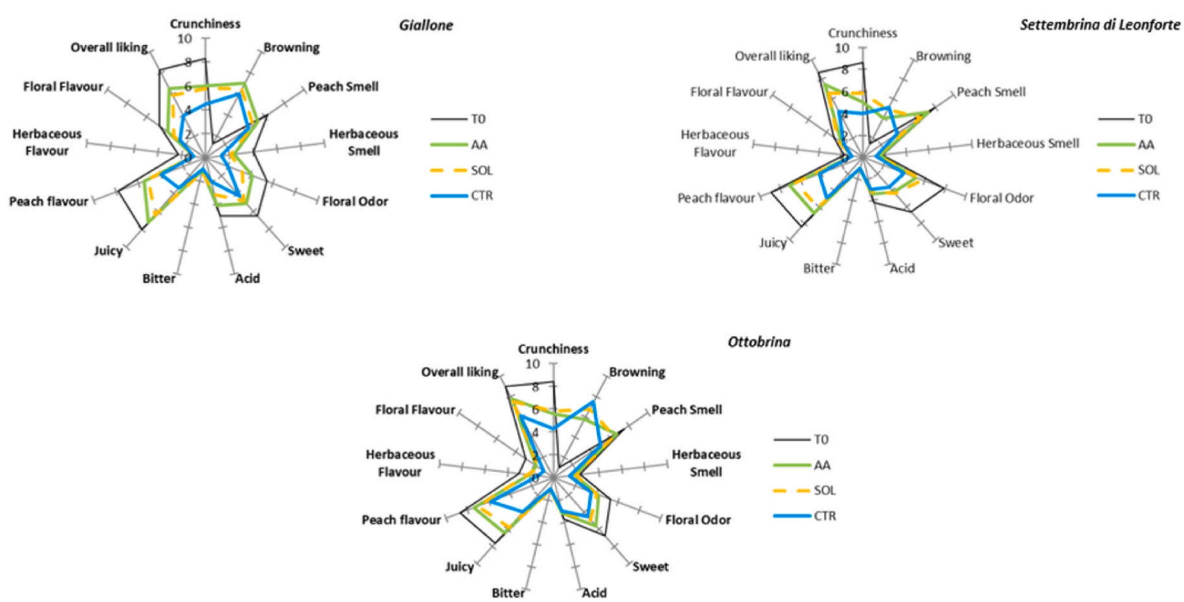


**Fig. 9.** Sensory analysis of 'Pesca di Leonforte' slices treated with 2 % ascorbic acid and 1 % calcium lactate (AA), or 1 % ascorbic acid, 1 % calcium lactate and 0.5 % citric acid (SOL) or not treated (CTR) during storage for 7 days at 5 ± 1 °C.

in treated (AA and/or SOL) and control fresh-cut slices; however, this reduction was more remarkable in control samples. In particular SOL treatment, followed by AA treatment showed a significant correlation ($p \leq 0.05$) with mean values of TSS and TA than control (Table 4). In overall, 'Giallone' landrace showed the greatest reduction in most of the sensory attributes evaluated in cut slices during storage.

'Ottobrina' landrace had a particular behavior, probably due to the late ripening of the fruits. Control slices showed a greater susceptibility to browning after 7 days of storage when compared to those treated with AA and/or SOL probably due to a greater PPO activity. Sweetness attributes for this landrace were the highest and acidity ones were the lowest, respectively compared to the other landraces, regardless of whether the samples were treated or not after 7 days of storage. Peach smell attribute was higher with AA and SOL treatments (6.7 pt and 6.4 pt, respectively) than the control one, although the latter obtained an acceptable judgment (5.0 pt) on the 7th day of storage. The same trend was also observed for peach flavor sensory parameter. Herbaceous flavor for this landrace was the highest compared to the other ecotypes [18].

### 3.6. Content in ascorbic acid and total phenolic content

Within the genotypic group 'Pesca di Bivona', ascorbic acid and total phenolic content presented significant differences for both landraces and storage time. Regarding to ascorbic acid content, a decrease was observed for all treatments and control slices in 'Pesca di Bivona' and 'Pesca di Leonforte' as reported by Veltman et al. [55], who define ascorbic acid as a quality nutrient parameter more sensitive than other nutrients to oxidative degradation during food processing and storage. All treated sample slices with AA and SOL of 'Pesca di Bivona' groups showed the lowest reduction in terms of ascorbic acid content compared to the control ones. It can be noted that control slices of each ecotype showed a reduction in ascorbic acid associated with the simultaneous decrease in phenol content. 'Murtiddara' control slices showed the lowest values for ascorbic acid content compared to AA (70.8 mg $kg^{-1}$) and SOL treatment (77. 8 mg $kg^{-1}$) (Table 7).

'Murtiddara' treated with AA was the one that provided the higher content of ascorbic acid (139.1 mg $kg^{-1}$) than SOL and CTR treatments. On the other hand, in 'Bianca' peach slices, a rapid and significant decline in the vitamin C content was observed from the 5th to the 7th day of storage, this loss in percentage was of 68 % and 77.1 % for AA and SOL treatment, respectively, conversely control slices showed a reduction about 12.1 %. On the 7th day of storage, ascorbic acid content was higher with AA treatment (44.3 mg $kg^{-1}$) than CTR and SOL treatment, 38.2 and 35.6 mg $kg^{-1}$, respectively. Different behavior was observed in 'Agostina' landraces regardless of treatments, in fact both iascorbic acid and phenol content values were the highest compared to those of the other landraces.

Regarding 'Pesca di Leonforte' groups, all the landraces had a significant reduction in vitamin C content from the cutting to the 12th day of storage (Table 8). Similarly, Sohail et al. [56] observed significant differences on peach slices when they were treated with ascorbic acid and/or citric acid. Marshall et al. [57] showed that ascorbic acid presented a behavior as a scavenger oxygen, because it oxidizes itself, therefore supplements of such antioxidant agent, have a positive effect on the final ascorbic acid content.

It should be pointed out that 'Settembrina di Leonforte' peach slices treated with AA showed significant higher ascorbic acid content after 7 days of storage (293.3 mg $kg^{-1}$) compared than CTR (15.3 mg $kg^{-1}$) and SOL treatment (58.5 mg $kg^{-1}$). 'Giallone' CTR sample slices showed a percentage of 1.1 % of ascorbic acid content reduction from cutting (day 0) to the 5th day of storage. Moreover, on the 7th day of storage, 'Giallone' slices peach treated with SOL and untreated showed the lowest ascorbic acid content, (30.2 mg $kg^{-1}$), while AA treatment was significantly higher (88.2 mg $kg^{-1}$). 'Giallone' treated with SOL, showed a sharp decrease between the 5th and 7th day (from 88.2 mg $kg^{-1}$ to 31.7 mg $kg^{-1}$ respectively). After 7 days of storage, 'Ottobrina' slices peach, treated with SOL provided the highest vitamin C (89.3 mg $kg^{-1}$) compared to CTR and AA treatment.

Regarding to total phenolic content in 'Pesca di Bivona' groups, it was observed that 'Murtiddara', 'Agostina' and 'Bianca' samples treated with AA, raised the content from the 3rd to the 5th day of storage, while only 'Settembrina' showed a reduction of its content for the same storage period. 'Agostina' treated with AA was the one that provided the highest phenolic content (1331.8 mg $kg^{-1}$). After 7 days of storage, ' Bianca' AA treatment was the one that presented the highest values in terms of phenolic content (505.7 mg $kg^{-1}$) compared to CTR and SOL treatment, 120.1 and 345.9 mg $kg^{-1}$, respectively. In all cases in 'Bianca' landrace the phenolic content decreased regardless of the treatment.

'Settembrina di Bivona' CTR samples (823 mg $kg^{-1}$) showed significant differences compared to SOL (345.3 mg $kg^{-1}$) and AA (345.2 mg $kg^{-1}$) treated sliced in terms of phenolic content after 7 days of storage. However, the results were highly variable depending on landrace and the storage time. Zhang et al. [58] observed a variable decrease in ascorbic acid content with increasing storage time by treating yellow peaches with different pre-cooling treatments.

Regarding to 'Pesca di Leonforte', significant differences ($p \leq 0.05$) were observed among the landraces belonging to this group in which the treatments played a key role in phenolic content. Indeed, AA treatment

**Table 7**
Ascorbic acid (mg $kg^{-1}$) and Total Phenolic content (mg $kg^{-1}$) in minimally processed Bivona peach fruit (cvs *Murtiddara, Agostina, Bianca di Bivona and Settembrina*) immediately after harvest (T0) and after 3, 5, 7 and 12 days of storage.

| Treatment | day | *Murtiddara* | | *Agostina* | | *Bianca di Bivona* | | *Settembrina* | |
|---|---|---|---|---|---|---|---|---|---|
| | | Ascorbic acid | Total Phenols | Ascorbic acid | Total Phenols | Ascorbic acid | Total Phenols | Ascorbic acid | Total Phenols |
| **CTR** | 0 | 80.9 | 1532.3 | 99.7 | 1009.3 | 88.4 | 770.3 | 101.5 | 1159.1 |
| | **3** | 78.2a | 1487.2b | 99.7a | 1066d | 79.2a | 729.7a | 98.21a | 998.4b |
| | **5** | 66.7a | 1389.1b | 90.7b | 1129.2c | 50.4b | 289.0b | 90.3a | 789.4d |
| | **7** | 48.3b | 789.4c | 68.2c | 1239.2b | 44.3c | 120.1c | 38.2b | 823.0c |
| | **12** | 39.2c | 1698.3a | 66.7c | 1387.4a | 13.2d | 289.8b | 25.8c | 1200.2a |
| **AA** | **3** | 120.7a | 1278.2b | 61.2c | 1479.1b | 98.2a | 849.1a | 119.2a | 983.7a |
| | **5** | 80.8b | 1365.5a | 132.8a | 1721.4a | 90.1b | 994.4a | 111.2a | 876.9b |
| | **7** | 70.8b | 959.2c | 139.1a | 1331.8c | 28.3b | 505.7b | 44.3b | 345.2c |
| | **12** | 37.9c | 836.1c | 88.1b | 1267.2c | 7.1c | 459.2b | 21.1c | 233.3d |
| **SOL** | **3** | 119.9a | 1392.1a | 76.2b | 1381.1a | 90.9a | 673.3a | 103.4a | 779.4b |
| | **5** | 110.2a | 1568.a | 100.9a | 1289.4b | 79.2b | 459.3b | 99.1a | 976.0a |
| | **7** | 77.8b | 1221.8c | 110.2a | 1231.3b | 18.1c | 345.9c | 35.6b | 345.3c |
| | **12** | 29.9c | 1121.1d | 88.9b | 1108.4c | 6.3d | 467.7b | 5.7c | 198.4d |

(n = 6 replicates per cultivar and sampling date). For each cultivar and parameters, different letters indicate significant differences between sampling dates and treatment (Tukey's test at $p \leq 0.05$).

**Table 8**
Ascorbic acid (mg $kg^{-1}$) and Total Phenolic content (mg $kg^{-1}$) in minimally processed Leonforte peach fruit (cvs *Settembrina, Giallone and Ottobrina*) immediately after harvest (T0) and after 3, 5, 7 and 12 days of storage.

| Treatment | day | *Settembrina* | | *Giallone* | | *Ottobrina* | |
|---|---|---|---|---|---|---|---|
| | | **Ascorbic acid** | Total Phenols | Ascorbic acid | Total Phenols | Ascorbic acid | Total Phenols |
| **CTR** | **0** | **364.3** | **645.8** | **89.3** | **1100.5** | **79.5** | **893.9** |
| | **3** | 349.7a | 547.4a | 86.1a | 987.3a | 80.4a | 749.5a |
| | **5** | 198.1b | 567.2a | 88.3a | 678.1c | 71.3a | 645.9b |
| | **7** | 15.3c | 389.5c | 30.2b | 863.8b | 64.8 ab | 389.3c |
| | **12** | 11.8c | 469.3b | 15.3c | 145.9d | 6.3c | 402.4c |
| **AA** | **3** | 448.1a | 809.7a | 91.3a | 1262.1a | 89.1a | 1001.8a |
| | **5** | 390.4b | 764.1b | 94.2a | 1102.5b | 81.4b | 982.9a |
| | **7** | 293.3c | 563.2d | 88.2a | 498.2c | 39.9c | 679.9b |
| | **12** | 14.1d | 667.9c | 7.3b | 321.7d | 13.3d | 601.5b |
| **SOL** | **3** | 324.4a | 756.2a | 92.4a | 1034.5a | 89.1a | 1012.3a |
| | **5** | 298.4a | 659.0b | 88.2a | 978.2b | 78.4b | 877.3a |
| | **7** | 58.5b | 677.4b | 31.7b | 346.9c | 89.3a | 798.2a |
| | **12** | 7.9b | 786.5a | 11.2c | 179.9d | 4.1d | 456.2b |

(n = 6 replicates per cultivar and sampling date). For each cultivar and parameters, different letters indicate significant differences between sampling dates and treatment (Tukey's test at $p \leq 0.05$).

followed by SOL treatment induced an increment of total phenolic content from cutting to the 3rd day of storage. Regarding to 'Giallone' landrace, a downward trend was observed in total phenolic content with an increasing storage time for AA and SOL treatments; however, the behavior of control slices was different because phenols percentage content increased up to 27.4 % from 5th to 7th day of storage. 'Ottobrina' landrace showed a decreasing content during the storage time as regards to total phenolic content for all treatments. In addition, on the 12th day of storage, AA treatment showed significant differences compared to CTR and SOL treatment, showing with the latter a percentage loss of 42.8 %. 'Settembrina di Leonforte' CTR slices showed a significant decrease from the 5th to the 12th day of storage while samples treated with AA showed a significant raise on the 3rd of storage and subsequently a decrease up to the 12th day, while a similar trend was found for SOL treated slices. Total phenolic content of 'Pesca di Leonforte' peach fruit was also studied by Scordino et al. [17], observing a decrease of mean values passing from commercial ripe to tree-ripe fruits stage. Huang et al. [59] observed a significant increase in phenolic content in fresh-cut peach treated with sodium alginate and nitric oxide during cold storage; while Jiang et al. [60] detected an initial increase and a subsequent decrease in their content after 8 days of storage when they were treated with a combination of 1-methylcyclopropene and phytic acid. The increase of the antioxidant capacity may be related to an increase in total phenolic content or stress conditions after cutting [61].

## 4. Conclusions

In the present study the use of a solution of ascorbic acid in combination with calcium lactate showed the best results in terms of overall liking in both 'Pesca di Bivona' and ' Pesca di Leonforte' genotypic groups after 7 days of storage. However, 'Pesca di Bivona' and 'Pesca di Leonforte' landraces had a different behavior to antioxidant treatments with AA in terms of browning, acidity attribute, vitamin C and total phenolic content, maintaining a high smell, and high flavor and juice attributes. Further studies to improve the shelf-life and maintain the sensory and organoleptic properties of fresh-cut slices are required for these native ecotypes in order to better enhance their marketability not only in the domestic market but within the European market as well.

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## Declarations ethics approval and consent to participate

Not applicable.

## Consent for publication

Not applicable.

## CRediT authorship contribution statement

**Alessio Allegra:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Fabrizio G. Casales:** Formal analysis, Visualization, Writing – original draft, Writing – review & editing. **María José Giménez:** Data curation, Visualization, Writing – original draft, Writing – review & editing. **Paolo Inglese:** Resources, Writing – original draft. **Alessandra Gallotta:** Data curation, Funding acquisition, Resources, Validation, Writing – original draft. **Roberta Passafiume:** Formal analysis, Investigation, Software. **Giuseppe Sortino:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.

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Not applicable.

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