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# **The effect of heat treatment on post-harvest quality of fresh-cut nectarine**

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**The work investigate the effect of short-term heat treatment on quality of fresh-cut nectarines, cv Orion. This treatment may have effects on the fruit beyond their stated purpose because a high temperature stress can trigger changes in plant tissue that affect many physiological processes. These processes include inhibition of ethylene production and other ripening and senescence related processes, induction of defense compounds against pathogens, attack and induction of resistance to other stresses, including low temperature stress. The result of the treatment is to maintain fruit quality following the heat treatment. In this work, a pre-cutting heat treatment at 40°C for 50 min and modified atmosphere packaging (5 kPa O<sub>2</sub> and 5 KPa CO<sub>2</sub>) storage was evaluated. The quality-affecting parameters were evaluated by physical and chemical methods (firmness, colour, pH, soluble solids content and titratable acidity) and by the evaluation of physiological aspects (PPO activity) as well as the changes in headspace gas composition during storage for 11 days at 4°C. Significantly lower concentrations of O<sub>2</sub> in the package atmosphere were recorded for heat-treated slices. In contrast, hot water treatment did not reduced firmness loss. Moreover an insignificant effect of heat treatment and modified atmosphere on chemical composition (total soluble solids and titratable acidity) and colour parameters was observed. Also for the polyphenoloxidase activity no significant changes was recorded.**

Keywords: Orion, modified atmosphere packaging, minimally processed fruits, storage, hot water treatment.

## **Introduction**

Fresh-cut fruits are an important developing category of food production because of attributes such as convenience and fresh-like quality. Minimally processed fruits have shorter shelf-life than the whole counterparts because they are more sensitive to enzymatic browning and tissue softening. These damages are stimulated by wounding of the tissue. Browning of the cut surfaces is one of the most limiting factors for the shelf-life of fresh-cut fruit and vegetables (Salcini and Massantini, 2005). Cut surface browning as well as excessive flesh softening and pit cavity breakdown are the major causes of quality deterioration in peach and nectarine slices (Gorny et al., 1998). For these reasons, the fruit processing industry requires the development of techniques capable of keeping safe shelf-life and preserving the original visual and organoleptic fresh-like characteristics of fresh-cut produces. Current treatments to maintain quality and extend the shelf-life of

fresh-cut peach and nectarine include edible coatings (Chiabrando and Giacalone, 2013; Pizato et al., 2013), heat treatment (Candir et al., 2009; Fruk et al., 2012) and modified atmosphere packaging (Gourny et al., 1999; Malakou and Nanos, 2005). Exposure of the fruits to high temperature after harvest has been widely used, as this heat treatment increases the tolerance to subsequent chilling, delays ripening and softening, and reduces pathogen levels and disease development in several fruits (Lurie, 1998). Moreover heat treatment is free from chemical residues and more feasible for commercial application to post-harvest treatment of stone fruit. Previous studies have shown that high temperature treatments maintained fruits firmness (Bustamante et al., 2012), slowed the ripening process as well as the decay development during storage (Lurie and Crisosto, 2005; Budde et al., 2006), controlled post-harvest diseases (Karabulut et al., 2010) and maintained fruit quality (Zhou et al., 2002).

The objective was to evaluate the efficacy of heated water treatments at relatively high temperatures (40°C) to improve quality and shelf-life of fresh-cut nectarines stored in modified atmosphere packaging.

## **Material and method**

### **Fruits**

Nectarines (cv Orion) were harvested at commercial maturity, and stored (4°C and 95% relative humidity) before processing. Intact nectarines before cutting were dipped in a thermostatically controlled water bath at 40°C for 50 min. Control fruits were not dipped in hot water. Then each fruit was cut with a sharp stainless steel knife and slices (mean slice 3 cm thickness). Twenty-five slices were randomly selected and packaged in a 30 µm polypropylene plastic bags of 25 cm×15 cm in size (Corapack, Brenna, Italy). The packages were completely sealed (UNIMEC packaging systems, Italy) and then were stored at 4°C and 95% RH in darkness for 11 days.

### **Analysis**

#### **Gases composition**

The concentrations of oxygen and carbon dioxide inside the packages were monitored daily by sampling (0.5 ml) the headspace using a CANAL 121 (Vizag, Gas Analysis, France). A syringe was inserted into the package through a rubber seal placed on the film. Gases were analyzed with an electrochemical sensor for O<sub>2</sub> level and an infrared sensor for CO<sub>2</sub> level. The instrument was calibrated towards air. Results were expressed as kPa of O<sub>2</sub> and CO<sub>2</sub> inside the bags. Gas analysis were performed at 1, 3, 4, 6, 7, 10 and 11 days of cold storage at 4°C.

#### **Quality measurements**

Colour analysis were performed at 1, 3, 4, 7 and 11 days of cold storage at 4°C. L\*, a\*, and b\* values were determined at two points along each side of the cut surface using a Minolta chromameter (CR400; Minolta, Ramsey, NJ, USA).

Measurements of firmness were performed on 25 slices per treatment with hand-held Shore Durometer (T.R. Turoni, Italy) (Kappel et al., 1996; Poovaiah and Nukaya, 1979).

Quality analyses were performed at 1, 4, 7 and 11 days of cold storage at 4°C. Total soluble solids (TSS) content was determined in the juice from 25 slices with a digital refractometer Atago PR-101 (Atago, Japan) at 20°C and results expressed as °Brix.

Titrate acidity (TA) was determined by titration with 0.1 N NaOH up to pH 8.1, using 10 ml of diluted juice in distilled H<sub>2</sub>O and results were expressed as meq/L.

#### Determination of PPO activity

Determination of the PPO activity was performed at 4, 7 and 11 days of cold storage at 4°C.

*Enzyme extraction.* A portion of 50 g of nectarine slices was mixed with a buffer solution (1:1) at pH=6.5 containing 1M NaCl (Sigma-Aldrich Chemie, Steinheim, Germany) and 5% polyvinylpyrrolidone (Sigma-Aldrich Chemie, Steinheim, Germany). The mixture was blended and homogenized using an Ultra Turrax T25 (IKAs WERKE, Germany). The homogenate was centrifuged at 12000 rpm for 30 min at 4°C (Centrifuge AVANTITM J-25, Beckman Instruments Inc., U.S.A.). The supernatant was collected and filtered through Whatman 1 paper (Whatman Intl., U.K.), and the resulting solution constituted the enzymatic extract, which was used for enzyme activity determination.

*PPO activity measurement.* Polyphenoloxidase activity was determined according to the method of Soliva-Fortuny et al. (2001). Enzyme activity was assayed spectrophotometrically by adding 3 mL of 0.05 M catechol (Sigma-Aldrich Chemie, Steinheim, Germany) and 75 µL of extract to a 4.5 mL quartz cuvette of 1 cm path length. The changes in absorbance at 400 nm were recorded every 5 s up to 3 min from the time the enzyme extract was added using a Beckman Du<sup>®</sup>530 spectrophotometer. One unit of PPO activity was defined as a change in absorbance of 0.001 per min and mL of enzymatic extract immediately after extract addition. The initial reaction rate was estimated from the linear portion of the plotted curve. All determinations were performed in triplicate.

#### Statistical analysis

The experimental design was completely randomized with three replications, each replication consisting of 25 slices. Data were analyzed by analysis of variance using statistical procedures of the STATISTICA ver. 6.0 (Statsoft Inc., Tulsa,OK,USA). The source of variance being hot water treatment. Tukey's test HSP (honestly significant differences) was used to determine significant differences among treatment means. Means values were considered significantly different at  $P \leq 0.05$ .

## Results

### Gas analysis

Significant differences were observed between heat-treated and untreated nectarine slices regarding the composition of O<sub>2</sub> and CO<sub>2</sub> in the head space of packages along the evaluated period (Figg. 1 and 2). Higher O<sub>2</sub> levels were found in control nectarines whereas significantly lower levels were found in treated slices. This result suggest that hot water treatment induced a reduction in the respiration rate and in the metabolic processes.

Fig. 1. Evolution of O<sub>2</sub> (KPa) during cold storage of nectarines. \* The astericks (\*) indicates the value is statistically different from that corresponding to control ( $P \leq 0.05$ ).

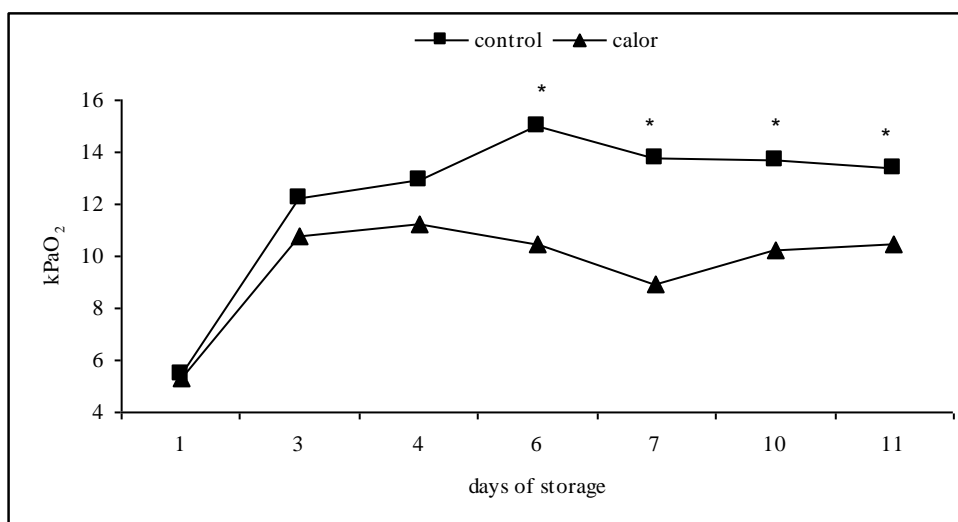
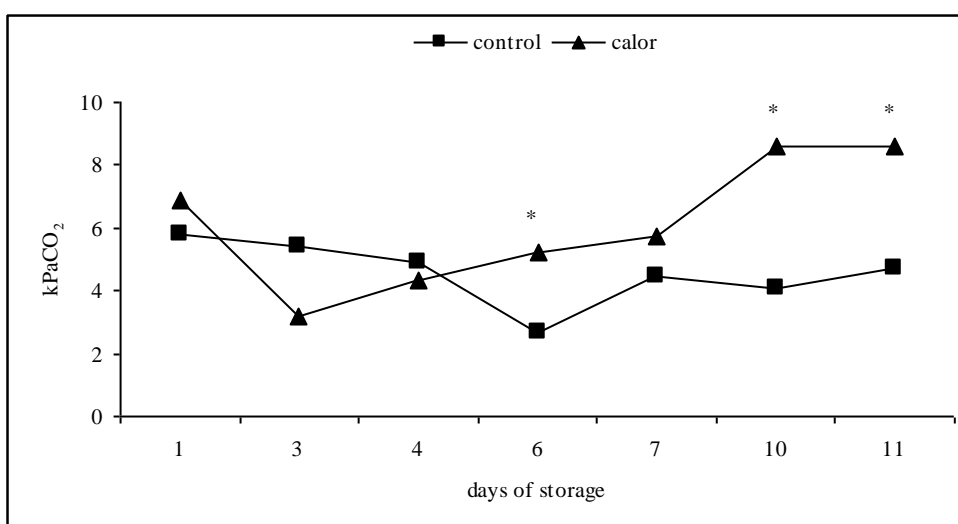


Fig. 2. Evolution of CO<sub>2</sub> (KPa) during cold storage of nectarines during cold storage. \* The astericks (\*) indicates the value is statistically different from that corresponding to control (P≤0.05).



## Quality measurements

During storage, soluble solids content and titratable acidity decreased both in the control and in the heated slices (Table 1). The application of heat treatment did not modify the total sugar content, and no significant differences between control and treated fruits were found after storage. At the end of storage period, heated slices had lower acidity than the control slices in according with Lay-Yee and Rose (1994). The reduction of titratable acidity after application of heat treatment has been reported in several fruits, such as apples (Klein and Lurie, 1990), strawberry (Vicente et al., 2002) and grapefruit (Shellie and Mangan, 1994). This is probably due because the application of heat treatment provokes a temporary increase of the respiration rate and that a significant amount of organic acid is then used as substrate in this process.

Table 1. Quality parameters of nectarines during cold storage. \* The astericks (\*) indicates the value is statistically different from that corresponding to control ( $P \leq 0.05$ ).

parameter	treatment	days of storage			
		1	4	7	11
<b>shore</b>					
	control	35.65	37.99	34.28	35.56
	calor	27.36	42.07	29.77	33.53
		*	*	*	*
<b>TSS</b>					
	control	10.8	10.3	10.3	9.7
	calor	10.7	10.27	10.13	9.9
<b>Acidity</b>					
	control	98.13	96.42	93.13	86.96
	calor	95.41	92.11	51.87	66.75
		*	*	*	*
<b>PPO</b>					
	control		0.004	0.013	0.011
	calor		0.0047	0.016	0.011

Generally, minimal processing resulted in dramatic losses in firmness of fruits tissues. Nectarines slices showed a little increased and than a decreased in firmness during storage (Table 1). The increase in firmness may be explained by activation of pectin methyl esterase that has been demonstrated to be more active at high temperature (Steiner et al., 2006). At the end of storage heated slices had significantly lower firmness than the control.

No differences were obtained for PPO activity (Table 1). This could be due to the homogeneous nectarine tissue, considering that PPO activity differences at the wounded surface disappeared in the total mass of fruit, where there were no changes in PPO activity (Koukounaras et al., 2008).

Table 2. Colour parameters of nectarines during cold storage. \* The astericks (\*) indicates the value is statistically different from that corresponding to control ( $P \leq 0.05$ ).

parameter	treatment	days of storage				
		1	3	4	7	11
<b>L</b>						
	control	72.9	70.9	69.38	73.04	73.62
	calor	73.2	68.46	72.25	71.97	72.86
				*	*	
<b>h</b>						
	control	84.17	86.08	86.37	86.95	85.99
	calor	82.8	82.95	88.46	86.43	87.16
			*	*		

Changes in external color during nectarine slices fruit storage were evaluated through the hue angle and L\* parameter. No significant changes in lightness were observed both in treated and control slices, in accordance with Vicente et al (2002) in strawberry. After 1 day and at the end of storage no significant differences in hue angle were observed between treated and control fruits. Moreover, both treated and control fruits showed little changes in the hue angle through storage period (Table 2). Higher hue values were observed for the heat-treated slices throughout the storage period in accordance with (Koukounaras et al., 2008).

## Conclusion

The results obtained in this first work on applying a combination of heat treatment and cold storage to nectarine, cv Orion are not encouraging. Hot water treatment did not reduce firmness loss, moreover an insignificant effect of heat treatment and modified atmosphere on chemical composition (total soluble solids and titratable acidity) and colour parameters was observed. Also for the polyphenoloxidase activity no significant changes were recorded. More research is needed in this area to improve the treatment conditions and to understand the effect of heat treatments on metabolism of highly perishable products, such as fresh-cut fruits.

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