Postharvest Biology and Technology 93 (2014) 49–60

Contents lists available at ScienceDirect

Postharvest Biology and Technology

journal homepage: www.elsevier.com/locate/postharvbio

Suitability of nectarine cultivars for minimal processing: The role of genotype, harvest season and maturity at harvest on quality and sensory attributes

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ARTICLE INFO

Article history:
Received 23 October 2013
Accepted 6 February 2014

Keywords:
Cling-stone
Consumer acceptance
Fresh-cut
Melting
Postharvest
Prunus persica L. Batsch
Ready-to-eat

ABSTRACT

Six cling-stone melting nectarine cultivars (‘Big Top’, ‘Luciana’, ‘Honey Royale’, ‘Nectareine’, ‘Big Nectared’ and ‘Nectalady’) were cut and dipped into an aqueous solution of 2% ascorbic acid, 1% citric acid and 1% calcium chloride before being stored in amorphous polyethylene terephthalate trays. Their suitability to be processed as fresh-cut product was then investigated on the basis of their initial quality, browning potential and sensory attributes as well as the changes in these parameters after processing. At harvest, two maturity stages were selected for each cultivar based on their index of absorbance difference. Nonetheless, no significant effect of maturity stage at harvest was observed for most of the physico-chemical and/or sensory parameters during storage. On the contrary, differences among cultivars were emphasized when comparing ethanol and acetaldehyde production, polyphenol oxidase (PPO) activity, volatiles production, sensory profile, and consumer acceptance. ‘Honey Royale’ and ‘Nectalady’ wedges showed higher volatiles production, whereas ‘Big Nectared’ and ‘Luciana’ had a slightly lower browning index (BI). In the sensory evaluation, ‘Nectareine’ had the highest acceptability scores, whereas ‘Big Nectared’ had the lowest. The significant correlations between volatiles, sensory attributes and degree of liking observed in this study underline the importance of aroma in fresh-cut products.

1. Introduction

Peach and nectarine (*Prunus persica* L. Batsch) are the second most important fruit crop in the European Union (EU) with an annual production of ca. 4.3 million tons (FAOSTAT, 2012). Spain is the third largest producer worldwide, only surpassed by China and Italy.

Currently, international current market trends depict a rise in consumption of fresh-cut products mainly motivated by consumer changes in the life-style together with the increased awareness on health promoting properties associated with fresh fruit consumption (Abadías et al., 2008). The commercial success of fresh-cut peach and nectarine has been limited due to their short shelf-life, mainly because of cut surface browning, flesh softening and pit cavity breakdown problems, among others (Gorny et al., 1999). Moreover, not all peach and nectarine cultivars are suitable to be used as ready-to-eat products and the selection of good quality raw material with more robust processing characteristics is vital to the success of these products. Specifically, cultivars with the ability to retain physico-chemical characteristics, such as low browning tendency, optimum texture and viscosity, and retention of the characteristic sensory profile, are highly desirable. Although it is well known that phenotypic differences among cultivars could significantly affect the shelf-life of peach and nectarine wedges (Mitchell and Kader, 1989; Gorny et al., 1998, 1999), which cultivars are best suited for fresh-cut nectarine products is still unknown.

The processing of fresh-cut fruit involves a series of mechanical operations such as peeling, removing stone or pips, and cutting, which in turn limits the shelf-life of products. Such operations lead to cell rupture, releasing and bringing together enzymes and substrates as well as eliminating the natural barrier that is the skin, which controls the diffusion of gases and provides an obstacle to microbial contamination (Artés et al., 2007). The physiological behavior of the minimally processed fruit tissue is somewhat similar to that observed in vegetable tissue that has been damaged or exposed to stress situations. This includes an increase in respiration activity and the production of ethylene, the initiation

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http://dx.doi.org/10.1016/j.postharvbio.2014.02.007
0925-5214/

of softening and an enhanced susceptibility to enzymatic browning and microbiological deterioration together with weight loss. Cutting operations may often lead to enzymatic browning, mainly catalyzed by the enzyme polyphenol oxidase (EC 1.14.18.1; PPO) (Zawistowski et al., 1991). Some recent advances for the maintenance of fresh-cut fruit quality with respect to the use of chemical compounds, include plant natural antimicrobials and antioxidants, as well as calcium salts for maintaining texture (reviewed in Oms-Oliu et al., 2010).

The aim of the present study was to investigate the suitability of six different cling-stone melting nectarine cultivars to be processed as fresh-cut produce based on their initial quality as well as their biochemical, physiological and sensory properties during shelf-life.

2. Materials and methods

2.1. Plant material and storage protocol

Fruit from six cling-stone melting nectarine cultivars ($n > 750$ per cultivar) were harvested at commercial maturity from local orchards situated in the region of Lleida (Catalonia, North-East Spain) and selected for uniformity of size and absence of defects (Table 1). These cultivars were selected due to their economic importance and their good postharvest potential based on preliminary studies (Echeverria et al., unpublished data). After each harvest date, commercial equipment (DA-Meter (TR Turoni, Forli, Italy) was used to pre-sort nectarines non-destructively by Vis spectroscopy of fruit according to the I_{AD} index at harvest (index of absorbance difference = A670–A720) (Ziosi et al., 2008). Fruit were then classified into two different maturity categories (M1 and M2) by decreasing values of I_{AD} index (Table 1). On the day of harvest, the fruit were transported to CITA (Centro de Innovación y Tecnología Alimentaria, Logroño, Spain), where they were processed before returning to Lleida under refrigerated conditions (5 °C) at the end of the same day. Nectarines were sanitized in a 100 ppm NaClO solution (pH = 6.5 with 10% (w/v) of citric acid) for 5 min at 4 °C and dried prior to cutting operations. After drying, fruit were cut longitudinally into 8 wedges including skin, using a manual slicer/corer (Kronen GmbH, Kehl am Rhein, Germany). The nectarine wedges were introduced in a plastic tray and dipped into an aqueous solution of 2% (w/v) ascorbic acid, 1% (w/v) citric acid and 1% (w/v) calcium chloride for 15 min. The wedges (200 g, approx. 10 wedges) were placed into amorphous polyethylene terephthalate (APET) trays (620 mL; ILPRA Systems, Barcelona, Spain) and covered with microperforated PET (polyethylene terephthalate; ACSA Films, Valencia, Spain) and stored at 5 °C up to 12 d.

2.2. Fruit quality determinations at harvest

Some physico-chemical parameters were monitored before [firmness, total soluble solids (TSS) and titratable acidity (TA)] and after processing (TSS and TA) during storage to assess the effect of the packaging on nectarine wedges. At harvest, the initial quality of the fruit from each cultivar and degree of maturity was determined on 20 fruit using standard protocols. Flesh firmness was measured on opposite sides of each fruit with a digital penetrometer (Model. 53205; Turoni, Forlí, Italy) equipped with an 8 mm diameter plunger tip. Two measurements were made on opposite sides of each fruit after the removal of a 1 mm thick slice of skin. TSS (%) were measured on nectarine juice using a digital hand-held refractometer (Atago, Tokyo, Japan) whereas acid content was measured on the same juice samples by titration using NaOH 0.1 N and results expressed as g malic acid L^{-1} sample.

2.3. Fruit quality determinations in minimally processed fruit

Five fruit wedges per package for each replicate ($n = 3$) at each degree of maturity were used for quality determination including firmness, TSS, TA and objective fruit color. Briefly, flesh firmness (N) was measured on each of the five wedges per replicate using a TA-XT2 Texture Analyzer (Stable Micro Systems Ltd., England, UK). The maximum penetration force required for a 4 mm diameter probe to penetrate into a nectarine cube of 20 mm × 20 mm × 20 mm to a depth of 10 mm was recorded. Test conditions were: pre-test speed, 2.0 mm/s; test speed, 5.0 mm/s; post-test speed, 5.0 mm/s. TSS and TA were measured at 20 °C as described above in juice extracted by crushing nectarine wedges in a domestic blender. Objective color values (L^*, a^* and b^*) were measured using a portable spectrophotometer CM-2600d (Konica Minolta Sensing, Japan) covering the range of wavelengths between 360 and 740 nm. All color measurements were taken on two equatorial sides of each fruit wedge. Flesh browning was measured by means of the browning index (BI) as shown in the equation below (Buera et al., 1986):

$$BI = 100 \times \frac{(x - 0.31)}{0.172}$$

where $x = (a^* + 1.75L^*)/(5.645L^* + a^* - 3.012b^*)$.

Table 1
Harvest dates, DA-values (I_{AD}) and quality parameters at harvest for two maturity stages at harvest (M1 and M2) of the six nectarine cultivars studied (average and standard deviation, SD).

Cultivar	Harvest date	Maturity stages	I_{AD}	Fruit weight (g)		Firmness (N)		TSS (%)		TA ($g\,L^{-1}$)	
				Average	SD	Average	SD	Average	SD	Average	SD
Big Top	29/06/2011	M1	0.78–1.01	159.1	22.7	49.0	11.1	13.5	0.3	0.72	0.04
		M2	0.49–0.70	172.4	19.2	48.3	9.7	12.2	0.3	0.65	0.02
Luciana	13/07/2011	M1	0.47–0.78	168.5	19.1	48.5	9.3	13.7	1.0	0.51	0.04
		M2	0.25–0.39	178.4	21.0	46.0	7.7	14.3	0.4	0.55	0.03
Honey Royale	27/07/2011	M1	0.77–1.05	224.2	17.2	59.4	5.4	13.6	0.2	0.37	0.05
		M2	0.45–0.69	227.3	25.7	57.1	6.2	12.7	0.4	0.36	0.02
Nectareine	27/07/2011	M1	0.34–0.53	199.1	19.1	46.6	6.3	14.5	0.6	0.43	0.02
		M2	0.18–0.29	400.01	20.6	46.4	6.0	00.01	1.2	0.40	0.01
Big Nectared	10/08/2011	M1	0.82–1.10	225.6	22.8	47.7	6.3	9.6	0.5	0.48	0.07
		M2	0.46–0.74	217.7	18.3	46.7	5.8	9.9	1.1	0.45	0.03
Nectalady	23/08/2011	M1	1.10–1.41	214.2	52.7	70.5	8.0	16.0	0.2	0.34	0.04
		M2	0.55–0.97	240.4	27.9	63.3	7.9	15.6	0.6	0.33	0.03

Abbreviations: N, Newtons; TSS, total soluble solids; TA, titratable acidity.