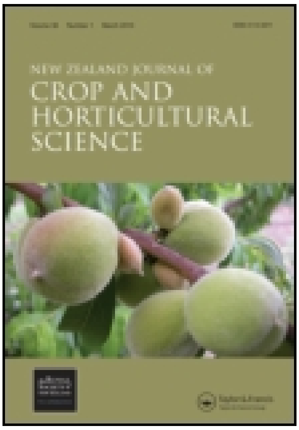

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Does the maturity at harvest affect quality and sensory attributes of peaches and nectarines?

R Infante [a] , D Aros [a] , L Contador [a] & P Rubio [a]

[a] Department of Plant Sciences, University of Chile, Casilla, 1,004, Santiago, Chile

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Does the maturity at harvest affect quality and sensory attributes of peaches and nectarines?

R Infante*, D Aros, L Contador and P Rubio

Department of Plant Sciences, University of Chile, Casilla 1,004, Santiago, Chile

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Fruit quality has been described as a property that depends on many factors. Harvest time is one such factor, described as negatively affecting the fruit quality of peaches and nectarines when carried out at early stages of maturity. In order to assess this, fruit from peach cultivars '2B40', 'Elegant Lady' and 'Sweet September', and nectarine cultivars 'Antares' and '5A29' were harvested at three maturity levels, based on ground skin colour (M1 = green-yellow, M2 = pale yellow and M3 = yellow), and evaluated at harvest and after a ripening period. Evaluations included instrumental characterization, sensorial analysis and e-nose. Flesh firmness was the parameter that best segregated the three maturity levels. Sensorial attributes and acceptability did not show differences between stages of maturity, while e-nose data clustered M1, M2 and M3 into different groups. These results suggest that the maturity level at harvest, within the range evaluated in this research, does not affect the sensory quality of the product, in spite of the aroma assessed with an e-nose revealing differences among them.

Keywords: peach; nectarine; harvest time; sensory quality; electronic nose; acceptability

Introduction

Fruit quality has been described as a property that depends mainly on the variety, but also on environmental conditions, packaging, transportation, supplier and, ultimately, the consumer (Layne 2007). Fruit quality is evaluated through technical parameters such as soluble solids concentration (SSC), titratable acidity (TA), flesh firmness, and flesh and skin colour (Infante et al. 2008a). Abbott (1999) suggested that sensory aspects such as texture, flavour and aroma are also of prime importance for fruit quality. Thus, the overall quality evaluated through sensory analysis and determined by trained panels could be more important than conventional methods (Infante et al. 2008a). Maturity stage at harvest has been described as a key factor affecting fruit quality (Shewfelt et al. 1987; Kader 1999; Layne 2007), but this is difficult to determine since flesh firmness (Remorini et al. 2008) and ground skin colour, among other parameters described to determine fruit ripeness, do not evolve coordinately during stone fruit maturation (Infante et al. 2008a).

The harvest of peaches at early maturity stages has been associated with a low-quality product (Bonghi et al. 1999) expressed, for example, by brown or mealy flesh (Fernandez-Trujillo et al. 1998). In addition, the antioxidant capacity of the fruit may be affected, along with a sharp decrease in organic acids, excessive softening, colour changes and a decrease in nutritional compounds (Remorini et al. 2008). These negative effects determine the poor quality of the fruit and lead to the dissatisfaction of consumers (Crisosto et al. 2006). Peaches and nectarines are climacteric fruits, which are characterized by showing a

*Corresponding author. Email: rinfante@uchile.cl

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rise in respiratory rate and ethylene production during ripening (Giovannoni 2001; Ferrer et al. 2005). Ethylene plays an important role in regulating metabolism in the post-harvest fruit, and is involved in changes in skin colour, texture, sugar accumulation and aroma (Bonghi et al. 1999; Crisosto & Crisosto 2005).

The characterization of the quality of stone fruit has become an essential tool in the management of their post-harvest performance. These measurements are generally performed using destructive methods, which often have limitations because they do not accurately reflect what happens in the fruit. For this reason, in recent years the use of non-destructive methods to assess maturity has become more popular. The electronic nose (e-nose), which is composed of chemical sensors that mimic the human nose, is one device that is able to segregate samples by non-destructive sampling, using the global emission of volatile compounds (Ampuero & Bosset 2003). It has been demonstrated that the e-nose has the ability to distinguish peaches at different stages of maturity and to predict, with reasonable accuracy, flesh firmness (Benedetti et al. 2008).

Work performed by Crisosto & Crisosto (2005) aimed to establish whether SSC and TA were associated with higher liking degrees by peach and plum consumers. However, the parameter that mainly determines the post-harvest performance of peach is neither SSC nor TA, but rather the flesh firmness of the fruit. Therefore, the objective of this study was to evaluate, through both destructive and non-destructive methods, whether the maturity level at harvest, as determined by the ground colour of the skin, affects the quality and sensorial attributes of peaches and nectarines.

Materials and methods

The study was conducted at an experimental station of the University of Chile (33°48′14.85′S; 70°40′6.54′W) in the Metropolitan Area of Chile during January and March 2009. The peach cultivars evaluated were the genotype ‘2B40’ (‘Elegant Lady’ open pollinated, which corresponds to an advanced selection belonging to Australis Breeding®, a breeding programme developed between the University of Chile and Andes New Varieties Administration Inc), ‘Elegant Lady’ and ‘Sweet September’, and the nectarine cultivars ‘Antares’ and ‘5A29’ (‘Red Diamond’ × ‘August Red’ belonging to Australis Breeding®). The post-harvest and sensorial evaluations were conducted at the Fruit Quality Laboratory of the University of Chile.

Fruit characterization

Fruits were harvested at three maturity levels, established by the background colour of the skin (M1 = green-yellow, M2 = pale yellow and M3 = yellow), which corresponds to the most common harvest index used by growers for determining the commercial harvest of a peach orchard (Brovelli et al. 1999). Maturity levels M1 and M2 of the genotype ‘2B40’ were harvested on 21 January, and M3 was harvested 1 day after; M1 of ‘Elegant Lady’ was harvested on 14 January, M2 8 days after, and M3 16 days after; M1 of ‘Sweet September’ was harvested on 13 March, M2 2 days after, and M3 4 days after; M1 of genotype ‘5A29’ was harvested on 29 February, M2 8 days after, and M3 11 days after; M1 of ‘Antares’ was harvested on 16 January, M2 7 days after, and M3 8 days after. At the lab, a characterization of the maturity level of the fruit at harvest was performed using the quality parameters.

Afterwards, fruits were stored in a ripening chamber that was adjusted to 20 ± 2 °C and 75–80% RH, until maturity for consumption was reached, which corresponds to a flesh firmness range of around 8.8–13.2 N (Infante et al. 2008a). The number of days elapsed between harvest and the evaluation of the quality parameters and the sensory analysis at proper flesh firmness for consumption is shown in Table 1. All the following evaluations were performed at harvest and at maturity for

Table 1 Quality parameters evaluated at maturity of harvest and maturity for consumption on the peaches '2B40', 'Elegant Lady' and 'Sweet September', and the nectarines '5A29' and 'Antares', harvested at three maturity levels (M1, M2 and M3).

Cultivar	Evaluation time	Maturity level	Firmness (N)	SSC (%)	TA (%)	SSC/TA	Hue
'2B40'	Harvest	M1	68.55c[1]	13.13a	1.03b	11.18a	40.19b
		M2	44.62b	12.75a	0.58a	22.36b	31.66a
		M3	21.67a	12.89a	0.37a	35.37b	31.84a
	Consumption	M1 + 4[2]	5.98	12.88a	0.62b	20.80a	33.37a
		M2 + 3	6.86	13.05a	0.44a	32.10b	31.36a
		M3 + 1	15.30	13.79b	0.37a	37.93b	35.77a
'Elegant Lady'	Harvest	M1	67.27c	10.82a	0.92b	11.79a	85.41b
		M2	40.21b	12.07b	0.68a	17.63b	49.98a
		M3	12.55a	11.92b	0.69a	17.40b	49.57a
	Consumption	M1 + 7	14.12	11.21a	0.39a	29.16b	51.63b
		M2 + 3	8.83	12.63b	0.66b	19.36a	39.78a
		M3 + 1	9.90	12.69b	0.65b	19.51a	39.48a
'Sweet September'	Harvest	M1	61.39c	9.12a	0.15c	62.95a	102.35b
		M2	44.13b	11.45b	0.08a	143.90c	81.30a
		M3	27.16a	11.63b	0.10b	115.13b	76.37a
	Consumption	M1 + 6	13.14	11.68ab	0.12b	99.44a	67.48a
		M2 + 4	17.85	11.03a	0.09a	129.59b	79.65a
		M3 + 2	19.81	12.10b	0.10a	127.72b	69.12a
'5A29'	Harvest	M1	66.49c	10.94a	0.71a	15.51a	95.37c
		M2	43.15b	12.63b	0.69a	18.46b	87.04b
		M3	13.83a	14.38c	0.69a	20.91c	67.16a
	Consumption	M1 + 5	12.75	12.76a	0.69b	18.56a	87.04b
		M2 + 3	8.14	15.64b	0.53a	28.03b	73.46a
		M3 + 1	7.45	15.50b	0.57a	27.94b	68.73a
'Antares'	Harvest	M1	72.28c	11.42a	1.12c	10.24a	48.55a
		M2	45.90b	12.20b	0.73b	16.51b	48.41a
		M3	19.91a	13.33c	0.94a	14.7b	39.63a
	Consumption	M1 + 5	5.98	11.48a	0.74a	15.61b	62.62b
		M2 + 2	7.16	12.02a	0.93b	13.02a	47.93a
		M3 + 1	7.45	14.71b	0.82a	18.08c	39.74a

[1]Different letters in the same column indicate significant differences using Tukey ($P \leq 0.05$).
[2]Indicate the number of days the fruit was kept at the ripening chamber, 20 ± 2 °C and 75–80% RH.

consumption. Flesh firmness was determined using a manual penetrometer with a 7.9 mm diameter plunger (Effegi FT-327, Milan, Italy) on two opposite points of the equator of each fruit. SSC was measured using a temperature-compensated refractometer (Atago ATC PAL-1, Tokyo, Japan). The juice from five fruits was pooled to form a composite sample and its TA was measured by titration of 2 ml juice with 0.1 M NaOH and expressed as % (w/v) of malic acid equivalent, using an automatic Easyline titrator (Schott, Mainz, Germany). Ground skin colour was measured using a portable CR-400 tri-stimulus colorimeter (Minolta, Osaka, Japan) with illuminant D65, at 2° observation angle, and the CIELab system, and the hue angle was calculated using the formulae $h = \tan - 1(b^*/a^*)$ (McGuire 1992).

Sensorial analysis

Sensorial analysis was performed on individual booths by a trained panel composed of 12 adults. A 12-hour training period of the panel for fresh fruit evaluation was carried out, where criteria were discussed and standardized in order to reach a common definition of the quality parameters. Slices of fruit at maturity for consumption were evaluated on a white plate, and prepared less than 5 min before the analysis to ensure softness and avoid flesh browning. Each sample was identified with a random three-digit numerical code. The sensorial attributes evaluated were: 'appearance', 'aroma', 'sweetness', 'acidity', 'juiciness', 'texture' and 'peach/nectarine flavour'. Also, the visual appearance of a whole fruit was evaluated. The evaluation guidelines included a continuous scale for each attribute, ranging from 0 (lowest level) to 15 (highest level).

Acceptance was also evaluated by a non-trained panel composed of 40 individuals, using the following hedonic scale: 'like extremely' (=9); 'like very much' (=8); 'like moderately' (=7); 'like slightly' (=6); 'neither like nor dislike' (=5); 'dislike slightly' (=4); 'dislike moderately' (=3); 'dislike very much' (=2); and 'dislike extremely' (=1) (Ortiz et al. 2008). Percentages of satisfied (>5), indifferent (=5) and unsatisfied (<5) consumers were calculated.

Instrumental evaluation of the aroma

Aromatic profiles of eight fruits per sample were evaluated at maturity for consumption through an e-nose model EOS 853 (SACMI, Imola, Italy). Individual fruits were placed in an air-tight glass container (1500 mL) for 10 min at 22 °C and the headspace was analysed by the e-nose equipped with six electrochemical sensors and configured with the following programme: 'pre-acquisition' phase for 30 s; 'acquisition' phase for 1800 s; and 'waiting' phase for 1800 s. Instrumental synthetic air was used as a gas carrier, and for all the evaluations the same flow (150 mL s^{-1}), chamber temperature (22 °C) and relative humidity (80%) were used. During the acquisition phase, the e-nose recorded a set of data (values of electric resistance in ohms) for each electrochemical sensor. The data were analysed using a 'single point' algorithm (SACMI) based on the average of the highest electrical resistance scores registered. Each measurement recorded was identified by a six-component vector and plotted on a two-dimensional graph.

Experimental design and statistical analysis

Evaluations of ground skin colour, flesh firmness, SSC and TA were statistically analysed using a block design, where each cultivar was treated as a block; each block had five replicates consisting of three fruits each. Firmness was used as a covariant for evaluations performed on maturity for consumption. Analysis of variance (ANOVA) at a significance level of $P \leq 0.05$ was conducted and, when significant differences were found between treatments, Tukey's test for multiple comparisons was performed. For all the statistical analyses, the software 'Infostat' (Córdoba, Argentina, 2004) was used.

For the sensorial analysis, the data were statistically analysed using ANOVA and means were separated with SNK multiple rank test ($\leq 5\%$). There were 12 replicates and one fruit was considered an experimental unit.

Eight replicates, using one fruit as an experimental unit, were evaluated through the e-nose, and the data were analysed by a principal components analysis (PCA), using the Nose Patters Editor program (SACMI, Imola, Italy).

Results and discussion

Fruit characterization

Flesh firmness at harvest showed significant differences among the three maturity levels, with average values of 65.7 N (M1), 43.15 N (M2) and 22.56 N (M3). This result reveals that the ground colour of the skin is an adequate harvest index that is correlated with flesh firmness. The stone fruit industry has often used various quality parameters, but particularly flesh firmness because softening of the fruit is the limiting factor of the potential lifespan of the product across the commercial chain. In this experiment, the number of days elapsed between the harvests of two consecutive maturity levels was different among the cultivars tested. The homogeneity of maturation within a tree is a genotype-specific trait; while for some genotypes there are significant differences in the ripeness of fruits at a given time, for other genotypes there is little variability in ripeness. The best-known consequence of such behaviour is that some peach cultivars could be harvested in one or two pickings, while for others it is necessary to do several harvests.

At consumption, the average firmness dropped to 10.39 N (M1), 9.77 N (M2) and 11.98 N (M3), which were reached after 4–7 days at 20 °C for M1, after 2–4 days for M2, and after 1–2 days for M3 (Table 1). Crisosto et al. (2006) noted the importance of the stage of maturity regarding fruit commercialization and consumption, and identified firmness as the most appropriate maturity index, suggesting that flesh firmness of around 26.5–35.3 N is ready for commercialization and between 8.8–13.2 N is ready for consumption. To reduce the effect of the high variability of the flesh firmness of the fruit at the moment of consumption, which in ‘2B40’ was 5.98 N for M1 and 15.30 N for M3, the covariance of the flesh firmness was used for the proper analysis of the other parameters.

All the peach and nectarine cultivars evaluated showed increasing values of SSC at consumption throughout M1 to M3 (Table 1). It was observed that the genotype ‘2B40’ did not show differences in SSC among maturity levels, possibly attributable to the fact that in this case M1 and M2 were harvested on the same day, and M3 the day after. This could suggest that SCC is more determined by the photosynthetically active radiation (PAR) absorbed when fruits are still on the tree, rather than other parameters such as flesh firmness or ground skin colour. ‘Elegant Lady’, ‘2B40’ and ‘5A29’ showed significant differences in SSC at consumption, with M2 and M3 having higher values than M1. Lower values of TA at consumption were found in all the cultivars when compared with harvest maturity; however, despite some significant differences, a non-clear pattern was found for this parameter among the maturity levels (Table 1). These results agree with Murray & Valentini (1998), who found significant differences only in firmness but no clear variations in SSC and TA observed among different maturity levels of the peach cultivars ‘Flordaking’ and ‘Dixiland’. Moreover, Ziosi et al. (2008) also found different firmness among stages of maturity for ‘Stark Red Gold’ while SSC remained constant. In this study, ‘Sweet September’ showed the lowest TA at harvest and consumption, with values of around 0.08–0.15%, as would be expected as it corresponds to a sub-acid cultivar (Infante et al. 2008b). Due to the decreasing TA observed during the storage period, all the cultivars showed higher SCC/AT scores at consumption, as observed previously (Eccher Zerbini et al. 2006). Nevertheless, a clear pattern was not observed for this parameter relating to maturity level, excepting genotypes ‘2B40’ and ‘5A29’ where significant differences were observed between M1, M2 and M3 (Table 1).

As expected, at harvest, ground skin colour showed decreasing hue values throughout stages of maturity in all the cultivars, with significant differences between M1 compared with M2 and M3, except for ‘Antares’. Ferrer et al. (2005) suggested that hue changes are well correlated with colour variation from yellowish to orange-yellow during peach maturation. Hence, lower hue values were observed in all the cultivars at maturity for consumption when compared with harvest maturity.

Sensory analysis

The sensorial evaluation performed by the trained panel did not show significant differences among maturity levels for 'acidity', except for '2B40', where M3 was significantly lower than M1 and M2 (Table 2). Furthermore, the sub-acid 'Sweet September' was the lowest rated for this attribute, which supports the TA data previously shown in this study.

Excluding 'Sweet September', 'aroma' and 'juiciness' were rated higher in fruit harvest at level M2 for all the cultivars, although no significant differences were obtained. 'Aroma' showed differences among maturity levels only for the cultivar 'Antares', while 'sweetness' and 'peach/nectarine flavour' were different in three of five cultivars, both generally being rated higher in M2 and M3 than in M1 (Table 2). Previous studies have shown a positive correlation between 'aroma', 'sweetness' and 'flavour' (Crisosto et al. 2006; Giacalone et al. 2006) and similar results were obtained in this sensorial evaluation where, for example, 'Sweet September' and '2B40' showed the lowest and highest values for these three parameters, respectively. 'Appearance' was in general rated higher in fruit harvested at more mature levels, except for '2B40' and 'Antares', where no significant differences were observed. M2 and M3 showed higher values for 'texture', with significant differences in '5A29', 'Antares' and 'Elegant Lady' (Table 2).

With the exception of genotype '5A29', no significant differences were detected by the non-trained panel in 'acceptability' of fruit harvested at different maturity levels (Table 3). Thus, although some sensory attributes evaluated by the trained panel were related to stage of

Table 2 Sensorial analysis performed by a trained panel at maturity for consumption on the peaches '2B40', 'Elegant Lady' and 'Sweet September', and the nectarines '5A29' and 'Antares', harvested at three maturity levels (M1, M2 and M3). Continuous scale ranging from 0 (lowest level) to 15 (highest level) for each attribute.

Cultivar	Harvest maturity	Sensorial attributes						
		Appearance	Aroma	Sweetness	Acidity	Juiciness	Texture	Peach/nectarine flavour
2B40	SM1	8.70a[1]	10.65a	12.25a	3.93b	11.21a	6.81a	11.75a
	SM2	10.34a	11.70a	12.11a	5.21b	11.44a	10.16b	11.38a
	SM3	7.94a	10.43a	10.43a	0.79a	9.94a	9.20ab	11.25a
5A29	SM1	7.50a	9.53a	7.61a	4.87a	8.25a	8.39ab	7.85a
	SM2	10.41b	10.51a	11.36c	4.41a	11.81b	7.03a	10.66b
	SM3	10.85b	9.91a	9.39b	6.49a	9.16a	9.78b	10.01b
Antares	SM1	10.06a	8.73a	9.00a	7.16a	10.43a	8.44a	8.90a
	SM2	11.10a	12.25b	9.54a	8.04a	10.63a	9.26a	10.56ab
	SM3	10.09a	10.79ab	10.10a	6.59a	9.41a	9.31a	11.04b
Elegant Lady	SM1	9.40a	12.01a	7.21a	7.29a	10.07ab	7.31a	9.62a
	SM2	11.39ab	12.64a	11.36b	8.86a	11.60b	10.86b	11.78b
	SM3	12.28b	10.81a	10.78b	6.71a	9.50a	9.61b	10.76ab
Sweet September	SM1	6.99a	8.73a	5.64a	1.84a	9.34a	7.38a	6.33a
	SM2	9.33a	8.56a	8.22ab	1.60a	9.17a	9.12ab	6.97a
	SM3	9.24a	7.23a	9.10b	1.80a	8.60a	9.91b	7.37a

[1]Different letters in the same column indicate significant differences, using a SNK multiple rank test ($P \leq 0.05$).

Table 3 Acceptability evaluated by a non-trained panel at maturity for consumption on the peaches '2B40', 'Elegant Lady' and 'Sweet September', and the nectarines '5A29' and 'Antares', harvested at three maturity levels (M1, M2 and M3).

Cultivar	Harvest maturity	Acceptability (1–9)	Accepted (%)	Indifference (%)	Rejected (%)
	SM1	6.62b[1]	73.3	13.3	13.3
5A29	SM2	8.26a	100.0	0.0	0.0
	SM3	7.91ab	96.6	3.4	0.0
	SM1	7.53a	95.0	2.5	2.5
2B40	SM2	7.50a	90.0	7.5	2.5
	SM3	7.56a	90.2	2.4	7.3
	SM1	7.20a	87.5	7.5	5.0
Antares	SM2	7.18a	87.5	7.5	5.0
	SM3	7.60a	100.0	0.0	0.0
	SM1	6.43b	77.5	12.5	10.0
Elegant Lady	SM2	7.28a	95.0	5.0	0.0
	SM3	7.15a	92.5	2.5	5.0
	SM1	6.31a	64.9	16.2	18.9
Sweet September	SM2	6.28a	71.9	12.5	15.6
	SM3	5.73a	58.3	16.7	25.0

[1]Different letters in the same column indicate significant differences, using SNK multiple rank test ($P \leq 0.05$).

maturity at harvest, 'acceptability' does not seem to be correlated with this factor. Crisosto et al. (2003) stated that there is no interaction between TA and SSC at harvest on the degree of liking for 'Elegant Lady' when SSC varied from 9% to 15%, and TA from 0.54% to 0.9%. High percentages of 'acceptability' were observed in all the cultivars (Table 3) apart from 'Sweet September', probably due to its lower level of 'acidity'—although Giacalone et al. (2006) correlated higher 'acceptability' with low acidity and high sweetness. Therefore, the lowest 'sweetness' observed in 'Sweet September' (5.64–9.10/15) perhaps explains its lower 'acceptability', as Harker et al. (2005) showed that consumers preferred fruit with high SSC (14–15%) rather than low SSC (9–10%). For sub-acid genotypes such as 'Sweet September', sugar accumulation on-tree occurs even when the flesh is firmer than occurs on normal cultivars, so they could be harvested with firmer flesh without affecting their final quality. In this experiment, although 'Sweet September' showed similar levels of 'acceptability' among maturity levels, this cultivar was the only one that had a higher number of unsatisfied consumers (rejecting the sample) for the ripest treatment (M3) than for M1 (Table 3). On the other hand, 'Elegant Lady' was the only cultivar that had 'acceptability' of the less ripe treatment (M1) lower than the 'acceptability' of the other two maturity levels. '5A29' showed a similar response when comparing M1 and M2, and M3 was the average of the two (Table 3). Both these cultivars correspond to genotypes of normal acidity, or balanced taste. When the trained panel evaluated these samples, the same trend was detected in the attribute 'sweetness', confirming the tight relationship between 'acceptability' and 'sweetness' perception.

In this experiment, the treatment with the firmer flesh (M1 = 65.7 N) in practically all the cultivars showed SSC above 10%—this threshold of sugar content guarantees a high acceptability among consumers (Crisosto & Crisosto 2005). The initial flesh firmness of M1 and M2 was in the range in which peaches exhibit the lowest bruising injury potential during the packaging and transportation processes

(Crisosto et al. 2001), so it corresponds to what the industry considers the most suitable flesh firmness for a fresh peach. Further, flesh firmness ranging between 40 and 60 N at harvest allows peaches to be stored in cold storage for longer periods with less reduction in quality.

Instrumental evaluation of the aroma

For each cultivar evaluated, two principal components were informative enough to explain more than 85% of the variance. The different maturity levels at harvest were well discriminated in different clusters for the cultivars '2B40', 'Elegant Lady' and 'Antares' (Fig. 1A, B, E, respectively). In cultivars 'Sweet September' and '5A29', M1 was discriminated from the cluster grouping M2 and M3 (Fig. 1C, D). The differences observed among different levels of maturity could be due to variations in the volatile compounds during fruit ripening (Visai & Vanoli 1997; Zhang et al. 2011), which have been identified as lactones, benzaldehydes and alcohols in peaches (Horvat & Chapman 1990; Robertson et al. 1990). Biosynthesis of volatile compounds during fruit ripening has been described as a dynamic process that changes both qualitatively and quantitatively and, because of the climacteric nature of peaches and nectarines, this process continues after harvest (Horvat et al. 1990).

Similar results to those obtained in this study were found by Benedetti et al. (2008), who segregated three maturity stages in peaches and nectarines using the e-nose, and Defilippi et al. (2009), who distinguished between two different stages of maturity in apricot using the same instrument. Furthermore, Infante et al. (2008a) were able to discriminate between different cold storage periods of peach using the e-nose. Although positive correlations between e-nose and sensorial analysis have been previously reported (Di Natale et al. 2001), in the present study only the e-nose was able to distinguish between different maturity levels, while the sensory analysis was unable to establish differences for 'aroma' among them. This result likely reflects the differences in sensitivity between the e-nose and the trained panel, expressed by a homogeneity of the score observed for the descriptor 'aroma' in almost all the tested cultivars, except between M1 and M2 of 'Antares'. Other than differences in sensitivity, this result could be explained by an overestimation of the non-aromatic volatiles, which, in terms of human perception, are sensorially irrelevant, as has been previously reported in 'Castlebrite' apricots (Defilippi et al. 2009).

Fruit quality and ripeness

In summary, the fruit quality parameters flesh firmness and ground skin colour, and the e-nose are the most appropriate evaluations for discriminating between different stages of maturity. On the other hand, and perhaps more importantly from the consumer point of view, neither trained nor non-trained panels were able to discriminate between stages of maturity. These results suggest that the maturity level at harvest, within the range evaluated in this research, does not affect the sensory quality of the product, in spite of the aroma assessed with an e-nose revealing differences among them.

These results also question the generic rule that associates the best eating quality with a more mature peach at harvest (Robertson et al. 1992; Bonghi et al. 1999; Kader 1999), or 'tree ripe' fruit, as known in some markets. If the fruit is consumed at the proper flesh firmness—13–18 N according to Valero et al. (2007)—there are no remarkable differences between fruit that was picked 'tree-ripe' or with 60–70 N flesh firmness. This axiom could even be incorrect for sub-acid cultivars, as the extremely low acidity of these genotypes when harvested ripe is often negatively rated by consumers.

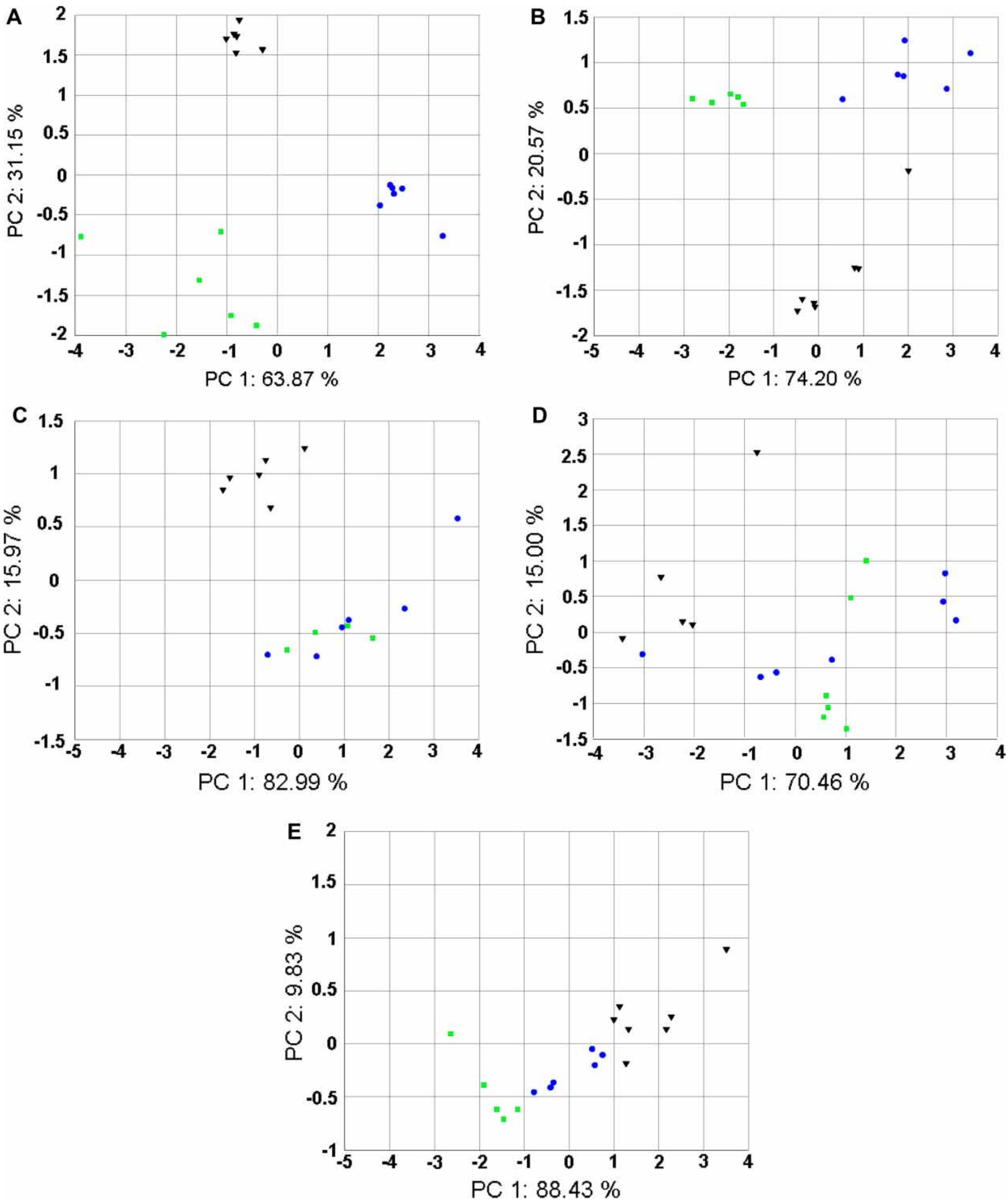

Figure 1 Principal component analysis determined with the electronic nose system EOS 835 at maturity for consumption for the peach genotypes '2B40' **(A)**, 'Elegant Lady' **(B)**, and 'Sweet September' **(C)**, and the nectarine genotypes '5A29' **(D)** and 'Antares' **(E)**, harvested at three maturity levels (M1 = ▾, M2 = ● and M3 = □).

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