SENSORY QUALITY PERFORMANCE OF TWO NECTARINE FLESH TYPOLOGIES EXPOSED TO DISTANT MARKET CONDITIONS

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ABSTRACT

The objective of this research was to evaluate the shelf life of two nectarine flesh typologies in order to determine the exporting potential of fresh nectarines to distant markets. "Maria Dolce" (subacid fruit type) and "Venus" (normal fruit type) nectarines were harvested at two maturity stages, based on fruit ground color. Fruits were stored at 0C and 90% R.H. for 14 or 42 days, simulating storage duration aimed respectively to shipping to close or distant marketplaces. Nectarines were evaluated after a period of ripening at 20C, when flesh firmness reached 9.8–19.6 N. Visual appearance, color, aroma, flesh texture, sweetness, sourness, juiciness, flavor and acceptability were evaluated. Both varieties presented a better eating quality when harvest was delayed. "Maria Dolce" presented high storage ability, reaching even at 42 days the same acceptability of fruit not subjected to cold storage. "Venus" showed a significant decrease in acceptability, indicating a not sufficient tolerance to long storage.

PRACTICAL APPLICATIONS

The poor eating quality of fresh nectarines destined to distant markets is one of the main problems that are facing some countries as Chile, which is a conspicuous exporter of off-season stone fruits to the Northern Hemisphere and Latin America. This research is focused on the comparison of quality of a

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normal fruit type nectarine, which is one of the most cultivated in Chile, and of a subacid nectarine; experimental design simulated two exportation regimes for close or distant marketplaces. Subacid types have been recently available in the world variety assortment system and the sensorial quality performance has yet not been tested after long postharvest storage.

INTRODUCTION

The Chilean fresh nectarine industry is focused mainly on foreign markets. In fact, nearly 65% of the total crop is currently exported worldwide, and it is the most important supplier of the total off-season peach and nectarine marketed in the U.S.A. (ODEPA 2005). Near markets, such as Brazil and Colombia, demand to keep fruits for 6–10 days, stored in cold chambers, until they reach the final destination, i.e., super or wholesale markets. Instead, North American and European markets for the Chilean nectarines would require fruits that should be kept in cold chambers for up to 35 days. In general, peaches could not stand cold storage for such a long time with their eating quality unchanged; however, nectarines are more suitable to face this particular requirement. The presence of new fruit typologies obligates to test the performance in terms of postharvest and eating quality on a singular genotype base. The subacid flesh is one of these nontraditional typologies, having an outstanding fruit quality and high consumer acceptance when fruit is above a specific soluble solid content (SSC) regardless of acidity (Crisosto *et al.* 2006). These nectarines have not yet been tested for tolerance to the long postharvest conditions required by the Chilean fruit industry. New tolerant genotypes would be of great use, since nectarines exposed to long term postharvest storage usually suffer chilling injury (Retamales *et al.* 1992; Lurie and Crisosto 2005; Crisosto 2006) that seriously affects eating quality. However, nectarine cultivars are generally less susceptible to chilling injury than the peach cultivars. Among peaches, melting flesh cultivars are more susceptible to chilling injury than the firmer nonmelting flesh cultivars (Brovelli *et al.* 1999; Crisosto *et al.* 1999).

The nectarine maturity at harvest is a key factor in determining the potential sensory quality of fruits and their sensitivity to mechanical damages (Mitchell *et al.* 1994). Fruit maturity controls quality attributes, such as SSC, titratable acidity (TA), firmness and market life potential (Crisosto *et al.* 1995). In general, ripe SSC and ripe TA determine consumer acceptance. For "Elegant Lady," a traditional-type peach, the ripe SSC used for consumer evaluation was 12.4% and a ripe TA of 0.74% (Crisosto *et al.* 2003). An anticipated harvest would not permit the normal fruit development affecting its aroma and flavor, even if the flesh would soften. On the other hand, a late

harvest produces fast fruit quality deterioration (Manolopoulou and Mallidis 1999). When fruits are destined to distant markets, they should be harvested firm to withstand manipulation during packing and transport. Firm fruits do not express totally their flavor for consumption (Vendrell and Carrasquer 1994). Fruit quality can be improved by delaying harvest at least until physiological maturation is completed on the tree (Bonghi *et al.* 1999). Harvest should be executed before fruits reach the climacteric period, when ethylene production is triggered, thus the metabolic changes of ripening will occur during postharvest (Pretel *et al.* 1993). Fruit quality is determined by a complex combination of attributes. It is known that the high incidence of SSC affects consumer acceptance (Parker *et al.* 1991; Ravaglia *et al.* 1996), but this relationship is cultivar specific, so there is not a single reliable SSC threshold that assures consumer satisfaction for all varieties (Crisosto and Crisosto 2005). As SSC is one of the most important maturity indexes that determines the harvest opportunity, the subacid cultivars could be harvested in advance, reaching the benefits of such physiological condition (i.e., resistance to manipulation) without affecting the eating quality, because they always are beyond the satisfaction consumers threshold, according with Crisosto and coworkers (Crisosto *et al.* 2003).

The objective of this research was to evaluate the sensory quality of a regular fruit type and a subacid flesh type nectarine, genotypes that differed on the TA level at harvest, being the subacid type half acid than a normal type (Bellini 1996). Both varieties were harvested at two maturity stages and submitted to storage conditions simulating necessities for transport to close and distant markets.

MATERIALS AND METHODS

Fruit and Postharvest Conditions

Nectarine (*Prunus persica* (L.) Batsch var. nucipersica C. K. Schmeid.) cultivars "Venus" (normal fruit type) and "Maria Dolce" (subacid type) were harvested and separated in two ripening stages by ground color: green (M1) and yellow (M2). Further to the skin ground color, each group was characterized by the common maturity indexes used by the industry (Table 1).

Immediately after picking, part of the fruit was kept for 7 days in a ripening chamber (20C) until the sensory evaluation. Fruits for storage were sorted and transferred to plastic trays, wrapped with fenestrated polyethylene bags and kept on 8.2 kg boxes, with two trays each. Fruits were maintained in a cold chamber (0C and 90% H.R.), and then were removed after 14 or 42 days and transferred to a ripening chamber (20C) for another 4 days until the flesh reached an adequate firmness for consumption (9.8–19.6 N).

TABLE 1.
HARVEST CHARACTERIZATION OF NECTARINES VARIETIES "VENUS" AND "MARIA DOLCE" AT TWO MATURITY STAGES

Harvest maturity	Venus		Maria Dolce	
	M1	M2	M1	M2
Flesh firmness (N)	90.0 ± 26.6	76.4 ± 19.2	52.5 ± 27.1	47.5 ± 18.9
SSC (%)	9.2 ± 0.6	10.3 ± 0.8	14.0 ± 1.7	16.4 ± 1.9
TA (%)	1.03 ± 0.01	1.01 ± 0.04	0.50 ± 0.06	0.41 ± 0.02
Covering color (% surface)	45.4 ± 9.6	72.5 ± 14.0	62.9 ± 7.5	72.5 ± 10.9

Data represent the mean of 12 fruits ± standard deviation.
SSC, soluble solids content; TA, titratable activity.

Quality Parameters

Firmness was measured on opposite cheeks of each fruit with a penetrometer (Effegi, Milan, Italy) using an 8 mm diameter probe. A wedge-shaped slice of flesh was taken longitudinally from each fruit, peeled and juiced. SSC was determined with a digital refractometer (Atago, Tokyo, Japan) and TA by titration of 10 mL of juice with 0.1 N NaOH to pH 8.2 and expressed as % malic acid.

Sensory Attributes

A quantitative–qualitative analysis was performed. Evaluations were scored based on a 15-point continuous scale marked with three milestones (0 = extremely poor, 7.5 = not like, not dislike and 15 = excellent). Panelists analyzed visual appearance, aroma, sweetness, sourness, texture, juiciness, flavor and acceptability.

Statistical Analysis

A completely factorial randomized design, 2 varieties × 2 maturity levels × 3 periods (fruit not submitted to cold storage and ripened after 7 days, fruit kept for 14 days at 0C and ripened for 4 days and fruit kept for 42 days at 0C and ripened for 4 days) was used for acceptability. Data were subject to analysis of variance. Afterwards, means were separated by Student-Newman-Keuls Multiple Range Test ($P < 0.05$) using InfoStat (2004). A principal component analysis was applied in order to characterize the sensory attributes.

Fruit firmness, SSC and covering color evaluations were executed on a singular fruit base with 12 replications for each; TA was performed on four replications of juice samples pooled from three fruits each. Sensory attributes evaluation were assessed by 12 trained testers and acceptability by 24 (12 trained and 12 untrained).

RESULTS AND DISCUSSION

Harvest Maturity

"Venus" SSC at harvest did not exceed 10.3% SSC (Table 1), quite a low value considering that 12 is reported as a threshold that assures a high acceptability of nectarines and peaches (Crisosto *et al.* 2003). Even though nectarines are climacteric fruits, no important variation of SSC should be observed during postharvest (Altube *et al.* 2001); therefore, the observed level at harvest would be almost the same after a long postharvest period. This low SSC also affected the flavor perception, because the initial TA observed in "Venus" was reduced from 1.00 to 0.69 after 42 days (data not shown). Since SSC is low and TA decreased, the ratio SSC : TA is responsible for the insipid flavor, confirming the tight association between acceptability and these parameters. However, the establishment of a minimum quality index based on SSC or SSC : TA needs to be evaluated for each stone fruit cultivar (Crisosto *et al.* 2004). The color showed differences between both maturity stages, being higher in M2. This was also observed on blushed surface at harvest between both varieties, with the level in "Maria Dolce" higher than in "Venus." Also in this case, the blushed surface at harvest was the same after cold storage (data not shown).

"Maria Dolce," on the other hand, showed quite a high score for SSC even on M1. This result should be underlined because it is showing that this genotype could allow the harvest of firm fruit combined with good quality level, assuring high resistance to handling and long storage ability. Further, "Maria Dolce" showed a better covering color than "Venus," meeting the consumers' preferences for red-colored fruits. In fact, a high correlation was observed between visual appearance and color (0.76), evidencing the importance of the blush covering surface on these kind of fruits (Fig. 1).

Acceptability

"Maria Dolce" showed statistically a better acceptability than "Venus," being the last on the refusal zone (below 7.5). This variety is described by the breeder who released it as a "gusto miele" variety type that means "honey taste" (Bellini 1996); this particular attribute could be responsible of the unusual lasting of its high acceptability score. These promising results suggest the worth to evaluate other subacid varieties available in the market under the conditions requested for countries, like Chile, that export their produce overseas. Consumers' perception for these kind of fruits, in particular markets, should be tested; Eastern countries' consumers would prefer subacid genotypes (Bacon 2004), but Mediterranean consumers would prefer the traditional fleshed nectarines (not published data). Californian breeders have responded to favorable consumer acceptance with rapid development of improved

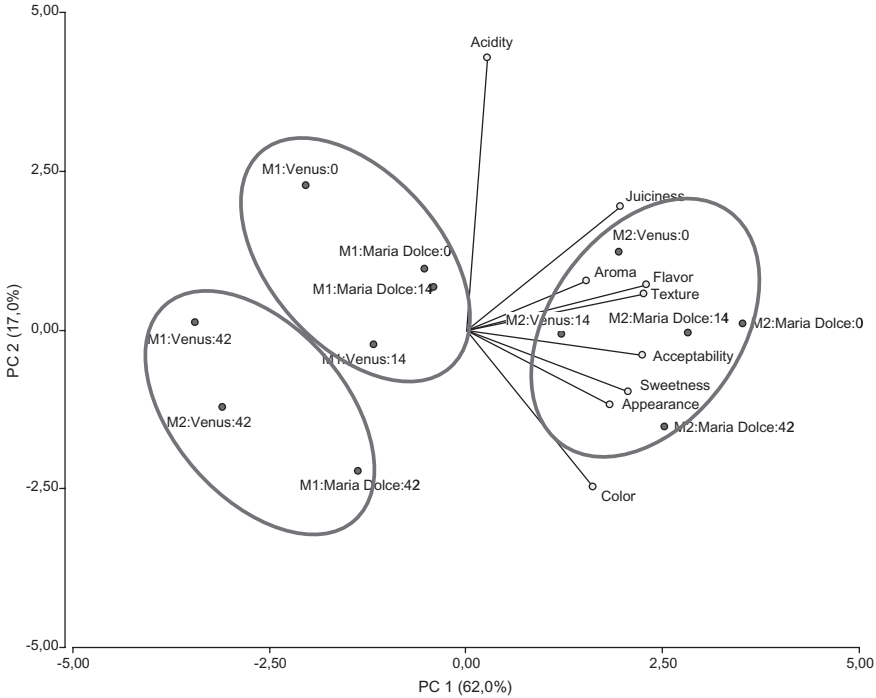

FIG. 1. PRINCIPAL COMPONENT ANALYSIS OF NECTARINES "VENUS" AND "MARIA DOLCE" SENSORIAL QUALITY ATTRIBUTES EVALUATED AFTER A 0C POSTHARVEST PERIOD PLUS A VARIABLE RIPENING PERIOD AT 20C

Fruits were harvested at two maturity stages: M1 = green ground color and M2 = yellow ground color on fruit not submitted to cold chamber (0), and after 14 and 42 days in cold chamber.

low-acidity cultivars in both white and yellow-fleshed types and growers have aggressively planted the new cultivars in recent years. During the 4-year period of 1999–2002, 32% of all peach trees and 52% of all nectarine trees sold were low-acidity types (Bacon 2004).

In terms of maturity stages, M2 was above the indifferent threshold, while M1 was not accepted. The ripest fruit level (M2) for both varieties presented statistically higher acceptability. A well-known axiom states that fruits should be picked unripe to stand a long postharvest, while, in our results, both varieties that were more mature when picked showed a better performance. It is interesting to highlight that Maria Dolce's acceptability scores were always beyond the indifference point, reaching quite high media for all conditions (9.33) (Table 2). The proper nectarine harvest maturity for fruit destined to long cold storage should be determined in a singular genotype basis. As

TABLE 2.
ACCEPTABILITY MEASURED ON A CONTINUOUS SCALE (0 = DISLIKE EXTREMELY. 7.5 = NEITHER LIKE NOR DISLIKE AND 15 = LIKE EXTREMELY) OF NECTARINES HARVESTED AT TWO MATURITY STAGES AND TESTED AFTER COLD STORAGE AND RIPENING

	Acceptability score
Var	
Venus	6.63 a
Maria Dolce	9.33 b
M	
M1 (green skin)	6.86 a
M2 (yellow skin)	9.10 b
SP	
42 days at 0C + 4 days at 20C	6.85 a
14 days at 0C + 4 days at 20C	8.20 b
0 days at 0C + 7 days at 20C	8.89 b
Significance	
Var	*
M	*
SP	*
Var × M × SP	NS

Different letters on the same column showed statistical differences (5%) independently for each parameter.
Var, variety; M, maturity stage; SP, storage periods; NS, not significant.
*, differences are significant for Var, M and SP, but not for Var × M × SP.

observed before, acceptability is tightly associated with sweetness and flavor (Fig. 1); both attributes also dependent of SSC and SSC : TA. It is reasonable that a subacid nectarine with low TA, even in hard flesh picked fruits (Bellini 1996) with high SSC, the acceptability would be high.

In terms of storage periods, the far distant market condition showed a dramatic drop, reaching the refusal zone. Either fruit destined to a near market or fruit not submitted to cold storage were evaluated on the acceptance zone, and they did not show statistical differences on acceptability (Table 2).

Quality Attributes

The first two principal components (PC1 and PC2) explained 79.0% of the total variance in the score plot (Fig. 1). Quality attributes showed significant correlations among them; particularly, acceptability is highly correlated with sweetness ($r = 0.94$), flavor ($r = 0.91$), texture ($r = 0.91$) and juiciness ($r = 0.79$). The high correlation between flavor and texture and sweetness

should be underlined. Sourness is the exception, being independent from acceptability ($r = -0.04$) and from any other quality attribute considered. Other studies on peaches presented positive correlations between flavor, sweetness and aroma (Giacalone *et al.* 2006) and especially between aroma and flavor. Minguzzi and coworkers (Minguzzi *et al.* 2000) indicated that acceptability is mainly associated with sweetness and aromatic intensity, in agreement with the high correlations obtained in this study.

Three clusters were formed, the first one, constituted by fruit of the ripest stage (M2) not submitted to cold storage, and "Maria Dolce" M2 either destined to close or distant marketplaces. These treatments presented the highest values for all sensory attributes, especially acceptability, sweetness, flavor, juiciness and texture. Particularly unusual is the presence, in the same cluster, of fruit recently harvested and fruit picked 6 weeks before, sharing the best scores for quality parameters. The second cluster, which did not show particular association with any parameter and presented lower values for all of them, was constituted by "Venus" M1 not submitted to cold storage and destined to close market, plus the less ripe "Maria Dolce" not submitted to cold storage and destined to close and distant markets. The third cluster, constituted by "Venus" after 42 days of cold storage, and "Maria Dolce" M1 after 42 days, which obtained the lowest values for all the sensory parameters evaluated (Fig. 1), coinciding with Lleó *et al.* (1999), who state that peach long-term cold storage affects sensory quality negatively, because of the appearance of mealy, soft and juiceless fruit. The variability of these treatments could be a result of the interaction of other not considered variables – like the appearance of off-flavors or chilling injury – common disorders expressed on nectarines submitted to long-term postharvest periods (Crisosto *et al.* 1999; Lurie and Crisosto 2005).

CONCLUSIONS

The ripest "Venus" either not submitted to cold storage or after 14 days of cold storage evidenced the highest acceptability for this genotype (Fig. 1), reinforcing the idea that this normal type flesh nectarine could be appropriated only to close distant markets. "Maria Dolce" presented higher acceptability rates than "Venus" either on a simulation of a near or of far marketplace condition, suggesting the convenience of evaluating, on a larger scale, these novel genotypes for the exporting Chilean fruit industry.

Adequate information should be provided to consumers about the difference of traditional and subacid flesh on nectarines, and the different flesh types should be sorted properly and presented to consumers as different products.

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