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Sensory Evaluation of Tangerine Hybrids at Multiple Harvests

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The University of Florida and USDA/ARS have active citrus scion breeding programs. Hybrids that pass many selection steps and approach release are evaluated for horticultural traits and postharvest characteristics. Seven advanced selections and three commercial cultivars were harvested multiple times from research sites in Lake Alfred and Leesburg, FL. A panel of 10 members was trained to evaluate citrus fruit and reached an agreement for 10 descriptors of fresh tangerines. Fruit were washed, sanitized, peeled, and halved longitudinally so that one-half of each fruit was evaluated by the taste panel, and the other half was analyzed for quality parameters (total soluble solids and titratable acidity). Segments of each half fruit were then separated, cut in half, and placed in a fruit bowl to assure that each panelist would evaluate a sample composed of multiple fruits. Half segments (about 10) were served in 4-oz plastic cups, together with reference standards for sensory evaluation. In general, panelists could perceive increased ripeness as distinct from increased sweetness, and decreased sourness paralleled with decreased bitterness. For most selections, juiciness decreased with maturity, except for 'Murcott' and its low seed mutant. There were no specific trends for tangerine, fruit and floral flavors due to harvest maturity; however, sulfury and pumpkin/spicy flavors increased with maturity for some selections, and may be an indicator for over-ripe fruit. 'Temple' remained stable over harvest times, with more orange than tangerine flavor.

Tangerine (or mandarin) (*Citrus reticulata* Blanco) is largely dedicated to the fresh market, in contrast to orange that can be either eaten as a fresh fruit or processed into juice. China is the main producer of fresh tangerines, followed by EU-27. The United States is only fifth in fresh domestic consumption (USDA, FAS, 2011). In the U.S., fresh tangerines are mainly produced in California and Florida, with productions of 8,300–8,500 × 10^3 boxes in California, and 3,000 × 10^3 boxes in Florida in 2009–2011 (USDA, NASS, 2011). Tangerine consumption has increased in the last decade, reportedly due to the ease of peeling and desirable flavor, in comparison with other citrus such as oranges and grapefruit (House et al., 2011; Tietel et al., 2011). With the active breeding programs in Florida as well as in California, there is a need to provide growers and packers with practical information on new variety releases. The literature is in general lacking data on citrus fruit quality during development and maturation (Bai et al., 2009). The objective of this study was to evaluate quality of advanced selections or newly released tangerine cultivars, throughout their seasons of maturity.

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Materials and Methods

Plant material and storage conditions

Seven advanced selections and three commercial cultivars were harvested multiple times from research groves in Lake Alfred (University of Florida, Citrus Research and Education Center – UF-CREC) and Leesburg (USDA, ARS), FL (Table 1). The two numbered USDA selections were harvested in Leesburg, and the remaining samples all came from Lake Alfred. USDA 6-13-44 is an early season easy-to-peel mandarin, hybrid of 'Lee' and 'Nova', known in California as 88-2 (University of California, Riverside; http://www.citrusvariety.ucr.edu/). USDA 5-51-2 is a mid-season hybrid that originated from a hybrid of 'Clementine' by 'Orlando'. 'Sunburst', a hybrid of 'Robinson' and 'Osceola',

Table 1. Tangerine selections/hybrids and harvest dates in 2010–2011 at two locations in Florida.

Location	Selection	Harvest date: 2010–2011
Leesburg	USDA 6-13-44	Dec. 8; Jan. 3
	USDA 5-51-2	Dec. 8; Jan. 3
Lake Alfred	Sunburst	Dec. 8; Jan. 3
	13-51	Dec. 8; Jan. 3
	Sugar Belle®	Dec. 8; Jan. 3; Jan. 20
	411	Dec. 8; Jan. 3; Jan. 20; Feb. 2
	B3-LS	Jan. 20; Feb. 2; Mar. 9
	Murcott	Jan. 20; Feb. 2; Mar. 9
	LS Murcott	Jan. 20; Feb. 2; Mar. 9
	Temple	Jan. 20; Feb. 2; Mar. 9

is the most widely grown early-season mandarin in Florida, harvested between October and December; it was used as a commercial standard in this study. UF experimental hybrid "13-51" matures mid-season. Sugarbelle® is a new mandarin released by the UF IFAS citrus breeding program. It is similar to Minneola tangelo, but with earlier maturity, greater disease resistance and superior flavor. Selection 411 from UF is large, easy to peel and it is generally considered to have excellent flavor. Selection B3-LS is an experimental mid- to late season UF hybrid with few to no seeds. 'Murcott' is the most widely grown mandarin in Florida and was used as the late-season commercial standard. It ripens from mid-January to early April and contains 10–20 seeds per fruit. LS Murcott is an irradiated mutation of 'Murcott', still under evaluation. 'Temple' is a putative hybrid of a mandarin and sweet orange of unknown parentage, with rich flavor with some characteristics of orange fruit (Miyazaki et al., 2012).

Immediately following harvest, fruit were brought to the USDA Citrus and Subtropical Products Laboratory in Winter Haven, FL. They were washed, sanitized, stored at 5 °C overnight, and evaluated the next day by a trained taste panel.

A panel of 10 members was trained for eight 1½-h sessions. Training included development of a vocabulary to describe the quality of the tangerines, and development of reference standards that panelists could use to compare with quality and intensity of descriptors in samples (Table 2). A 16-point scale was used to evaluate each attribute (0 = none, 1 = low, 15 = high).

Table 2. Descriptors and reference standards used in the descriptive sensory evaluation of tangerine hybrids. Reference standards were provided to trained panelists at each evaluation.

Descriptor	Reference standard
Sweet	6% sucrose in water
Sour	0.2% citric acid in water
Bitter	0.1% caffeine in water
Tangerine flavor	Tangerine oil (5.6 mL/100 mL) in a sugar/acid solution[z]
Fruity-non-citrus flavor	A mixture of passion fruit, mango and pineapple juice, and guava and peach nectar
Floral flavor	Linalool (10 ppb) in a sugar/acid solution[z]
Pumpkin/vegetable/spicy flavor	Tropical calabaza pumpkin homogenate
Sulfury flavor	Thawed juice of tangerine hybrid 1-105-106
Green/underripe	Underripe green 'Valencia' fruit
Overripe	Ripe fruit stored at room temperature

[z]Sugar/acid solution: 6% sucrose + 0.2% citric acid in water.

On the day of the panel, fruit were peeled, and halved longitudinally so that one-half of each fruit was evaluated by the taste panel, and the other half was analyzed for quality parameters (total soluble solids and titratable acidity). Segments of each half fruit were then separated, cut in half, and placed in a fruit bowl to assure that each panelist would evaluate a sample from multiple fruits. Half segments (about 10) were taken from the mix and served in 4-oz plastic cups (Solo Cups Co., Urbana, IL) , together with reference standards for sensory evaluation. Filtered water and unsalted crackers were provided to panelists to cleanse their palate between samples. Sample evaluation was performed in individual booths under red lighting to mask sample color.

The half segments set aside for instrumental analysis were juiced using a commercial table-top juicer (Model 932, Hamilton-Beach, Washington, NC) and frozen at –20 °C until further analyzed. Soluble solids content (SSC), determined as refractive index, was measured with a digital ATAGO PR-101 refractometer (Atago Co., Tokyo, Japan), and titratable acidity (TA) was calculated from titration of 10 mL of juice with 0.1 mol·L^{-1} NaOH to a pH 8.1 endpoint using a 808 Titrando (Metrohm, Riverview, FL). The SSC/TA ratio was calculated as an indicator of maturity, as well as quality.

Statistical analysis was performed on sensory data using Senpaq 4.1 (Qi Statistics, Reading, UK), a software specialized in analysis of sensory data.

Results

The 2010 season was unusual in that early freezes occurred in December, as early as 1 Dec. 2010, and reoccurred until 31 Dec., and continued through Jan. and Feb. 2011. The Leesburg location was more affected by freezes than Lake Alfred, being further north, with night temperatures dipping as low as –7 °C (19 °F) for several nights (Fig. 1). Therefore, evaluation of Leesburg fruit had to be stopped after Jan. 2011. In addition, bloom time in spring 2010 was nearly one month later than normally occurs in Florida. The cooler than normal winter temperatures are generally associated a slower rate of decline in acidity, and together with the shortened fruit growth period, 2010–2011 was generally acknowledged as a "high-acid" year in the citrus industry.

The descriptive analysis generated a profile for each cultivar. Figure 2 shows an example of such profile for the hybrid 411. Descriptors followed with an asterisk indicate statistical differences among harvest dates at $P < 0.05$, and those with an asterisk in parentheses at level $P < 0.10$. Descriptors "fruity-non-citrus," "ripeness," "sweetness" increased with harvest time, while "sourness" and "bitterness" decreased. The descriptor "pumpkin/

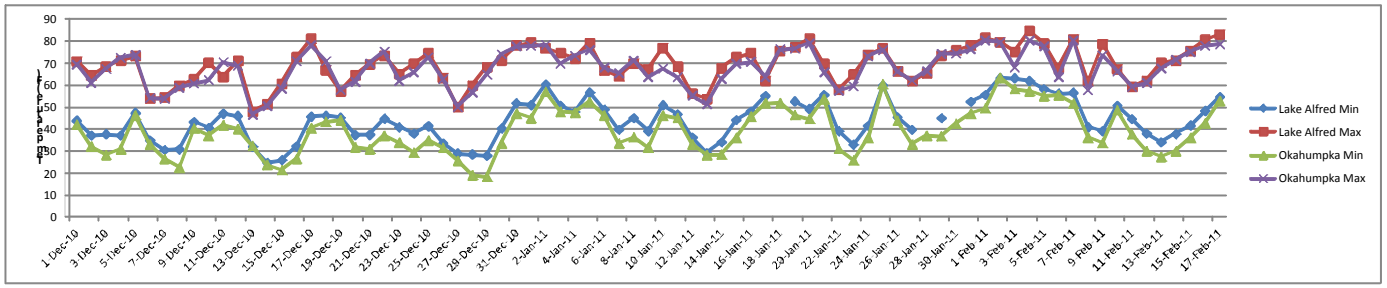
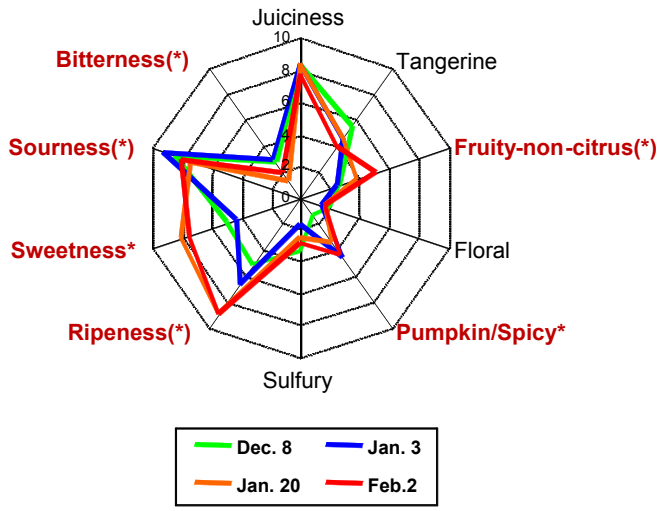


Fig. 1. Temperature recorded at Okahumpka (Leesburg) [purple (max) and green (min) lines] and Lake Alfred [red (max) and blue (min) lines] from 1 Dec. 2010 to 17 Feb. 2011.



*: significant between harvest dates at P<0.05

(*): significant between harvest dates at P<0.10

Fig. 2. Sensory profile of 411 tangerine hybrid with four harvest dates.

spicy" was rated low on the first harvest. Juiciness, tangerine, floral, and sulfury flavors did not change over time. In general, sulfury flavor was rated low and will not be used in subsequent descriptive panels of fresh tangerines.

In general, panelists perceived increased ripeness as increased sweetness and decreased sourness and bitterness. Increase in sweetness was often paralleled with an increase in fruity-non-citrus flavor. For most selections, juiciness decreased with maturity, except for 'Murcott' and its low seed mutant. There was no specific trend for tangerine and floral flavors due to harvest maturity; however, sulfury and pumpkin/spicy flavors increased with maturity for some selections, and may be an indicator for over-ripe fruit. 'Temple' remained stable over harvest times, with more orange than tangerine flavor. It had been found earlier that some tangerines develop a characteristic "pumpkin/spicy" flavor, in contrast to hybrids that have known orange (*Citrus sinensis*) in their parentage (Plotto et al., 2010). It was also found that esters and sesquiterpenes were produced in greater quantity in hybrids having *C. sinensis* in their parentage, such as 'Temple' (Miyazaki et al., 2011), and thus had more volatiles with a fruity and floral aroma (Miyazaki et al., 2012). In this study, 'Temple' was the only hybrid with a significant "floral" attribute increasing with harvest maturity.

The SSC/TA ratio generally increased with harvest maturity (Table 3). For the two USDA hybrids, USDA 5-51-2 and 6-13-2, the ratio jumped from 12.8 and 18.9 to 23.9 and 24.3, respectively. This change was perceived as a decrease in sourness and increase in ripeness and tangerine flavor in USDA 5-51-2, but no effect on flavor for USDA 6-13-44 (Table 4). The ratio also increased in 'Sunburst' and 13-51, with a parallel in increased sweetness, ripeness and decrease sourness. The increase in SSC/TA was greatest in the last harvest for Sugarbelle® and the last two harvests for selection 411, and corresponded to when changes in sweetness, sourness and ripeness were perceived by the taste panel. Changes in SSC/TA in 'Murcott' and LS Murcott were inconsistently perceived by the taste panel. There were no changes in 'Temple' descriptors except "floral" during the period of the study (Table 4).

Table 3. SSC/TA (standard deviation) of 10 tangerine hybrids harvested multiple times.

Hybrid	8 Dec.	3 Jan.	20 Jan.	2 Feb.	9 Mar.
USDA 5-51-2	12.8 (0.8)	23.9 (2.2)			
USDA 6-13-44	18.9 (1.0)	24.3 (0.3)			
Sunburst	8.7 (0.2)	11.2 (1.1)			
13-51	14.5 (0.2)	16.1 (0.9)			
Sugarbelle	10.1 (0.8)	9.0 (0.3)	16.1 (1.6)		
411	8.0 (0.2)	8.7 (0.6)	11.2 (1.1)	11.3 (0.2)	
B3-LS			14.7 (0.1)	16.3 (1.0)	19.2 (1.4)
Murcott			14.9 (1.2)	13.1 (0.8)	17.9 (0.5)
Murcott LS			13.6 (0.3)	13.7 (1.3)	17.2 (0.2)
Temple			8.4 (0.2)	10.3 (0.3)	10.2 (0.8)

Table 4. Changes in sensory profiles of 10 tangerine hybrids over multiple harvest dates.

Hybrid	Juiciness	Tangerine	Fruity	Floral	Pumpkin	Sulfury	Ripe	Sweet	Sour	Bitter
5-51-2	--	--	+	0	+	-	+	+	--	-
6-13-44	0	0	+	0	+	-	0	+	-	-
Sunburst	--	+	+	0	+	0	++	++	--	0
13-51	-	0	0	0	++	++	++	++	--	--
Sugarbelle	0	-	++	0	+	0	++	++	--	--
411	0	-	++	0	++	0	++	++	--	
B3-LS	-	--	-	-	++	0	0	0	--	0
Murcott	++	+	++	+	0	0	+	++	--	0
Murcott ls	++		++	0	+	0	++	+	-	0
Temple	0	0	-	++	0	0	0	0	0	0

"--": significant decrease ($P < 0.05$); "-": observed decrease but not significant; "0": no change; "+": observed increase but not significant; "++": significant increase ($P < 0.05$).

This study provides growers with information on the harvest window of new varieties that have been or soon will be released for commercialization. Varieties need to be observed for several years, as the 2010–2011 season saw unusually cold weather, which resulted in higher than normal levels of acidity, negatively affecting fruit quality in one location.

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