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Quality Attributes of White Flesh Peaches and Nectarines Grown Under California Conditions

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Abstract

A large variability in titratable acidity (TA), soluble solids concentration (SSC), SSC/TA, bruising and chilling injury (mealiness and flesh browning) susceptibility and market life was determined for several white flesh peach and nectarine cultivars grown under San Joaquin Valley, California conditions. During ripening "off" the tree, SSC did not increase nor did TA decrease; thus, the SSC/TA remained the same. Because of this characteristic, these white flesh stone fruit can be eaten when still firm if hard texture is not a concern. A ripening treatment at the retailer or shipping point is not advised due to fast softening and high bruising susceptibility. Because of their fast softening, careful postharvest temperature management is recommended. In general, a longer market life (at least 5 weeks), based on chilling injury, was measured on the white flesh nectarine cultivars than on the white flesh peach cultivars.

Introduction

In recent years, the number of cultivars and production of white flesh peaches and nectarines has rapidly increased in California. In spite of this, there is a lack of information on their quality attributes, bruising potential, and chilling injury (CI) susceptibility (8). The understanding of their quality attributes and postharvest behavior is fundamental to developing a safe postharvest handling protocol. The two more important white flesh nurseries classified these cultivars as non-acid, sub-acid and low-acid. The cultivars are also highly susceptible to bruising (1, 3, 11, 13). Consumer preference for white flesh peaches and nectarines may vary according to individual consumer preference and/or ethnic background. In general, these new cultivars appear to be very popular among consumers of Asian ethnic backgrounds, but these cultivars are not well known by other American consumer ethnic groups (4).

We believe that in order to avoid consumer confusion and search for new markets, a classification of these new white flesh cultivars based on measured titratable acidity and consumer preferences should be attempted. Also, knowing their bruising potential and chilling injury susceptibility will help to determine how late mation, we evaluated these quality attributes on several white flesh cultivars for two seasons.

Materials and Methods

During two seasons, an evaluation of the mature and ripe chemical composition, bruising and chilling injury susceptibility of several white flesh peach and nectarine cultivars was carried out at the F. Gordon Mitchell Postharvest Laboratory (University of California, Kearney Agricultural Center).

Initial Quality Evaluation

Fruit quality attributes of California-well mature (CA-well mature) fruit at harvest and after ripening were evaluated for several white flesh peach and nectarine cultivars. Quality attributes such as soluble solids concentration (SSC), titratable acidity (TA), and firmness were measured according to our quality evaluation protocol (7, 8, 10).

Bruising Susceptibility

Bruising susceptibility was determined by subjecting fruit with different firmnesses to three bruising energy levels (G). Impact bruising potential was created by dropping fruit from different heights onto a surface of known firmness. The impact bruising energy was measured with an els were selected based on our previous packinghouse bruising potential survey. An automatic ranch pack situation with a gentle basket and/or tote dampers had one or more impacts of ~66 G's. A standard automatic gentle packing operation had at least one or more impacts of ~185 G's; and a standard automatic rough packing operation had one or more impacts of ~245 G's. Bruising susceptibility was expressed as bruise size in relation to fruit firmness at a given bruising potential level.

Market Life

Market life of ten white flesh peach and seven white flesh nectarine cultivars commercially grown in California was tested based on chilling injury (CI) symptoms developed when fruit were stored under 0°C or 5°C temperatures. Fruit samples (100 fruits) of each cultivar were harvested at the California-well mature stage from each of three trees (replications) growing at the Kearney Agricultural Center (KAC) or from other commercial orchards with similar orchard management conditions near the KAC. Sun exposed and medium size fruit were sampled from the same canopy height. Fruit were forced-air cooled to 0-2°C within 6 hours of harvest and then stored at either 0 or 5°C (with 90% relative humidity) for up to 5 weeks. Fruit commercially packed were stored in 18 cubic meter chambers with 12 hours air exchange. Postharvest fungicide dipping (1,200 mg/liter of iprodione) was used, so that in most cases fruit decay did not develop during the storage period. Weekly, three groups of 10 fruit samples from both storage temperatures (0 and 5°C) were ripened (at 20°C) until firmness reached between 10-18 N (measured with the UC-Davis penetrometer, 7.9-mm tip) prior to CI symptom evaluation. The ripening period prior to CI evaluation varied from 3-7 days depending on cultivar softening rate. We assured that fruit were soft, but not mushy at the CI evaluation. Fruit were evaluated for different manifestations of CI such as lack of juiciness (flesh mealiness or wooliness), flesh browning, flesh bleeding, and flesh translucency (gel breakdown). Observations were made on the mesocarp and the area around the pit immediately after the fruit were cut transversally to the plane of the suture. Fruit that had a dry appearance and little or no juice after hand squeezing were considered mealy or wooly. Fruit were also informally tasted for a feeling of graininess (like sand in mouth) and/or "off flavors" to corroborate visual mealiness (wooliness) assessment. Fruit with uniform non-marked margin browning areas spreading from the pit cavity into >25% of the flesh area were considered commercially affected with flesh browning (7, 9, 10). Market life was subjectively defined as the number of weeks each cultivar lasted under continuous storage at 0°C and/or 5°C, without exceeding 20% flesh mealiness or 15% flesh browning symptoms (>25% of the flesh area).

Results and Discussion

Harvest Quality Evaluation

During the 1995 season, white flesh peach firmness measured on the cheeks varied from 49.8 to 65.8 N. The weakest position on the fruit also varied according to cultivar. Fruit firmness differences up to approximately 26.7 N were determined between the cheek and the weakest point for 'Snow Bright,' 'Sugar Lady,' and 'Snow Giant' cultivars. A large variability in SSC, TA and SSC/TA was measured. Coefficients of variability of 13, 24, 2.8 and 410 were calculated for cheek firmness, SSC, TA and SSC/TA, respectively. 'Arctic Rose' nectarine had a higher SSC and TA compared to the five peach cultivars tested (Table 1).

During the 1996 season, white flesh peach firmness measured on the cheeks varied from 41.8 to 75.1 N. The weakest position on the fruit also varied according to cultivar. Fruit firmness differences up to approximately 8.9-22.2 N between the cheek and the weakest point were determined for the different peach cultivars (Table 1). Coefficients of variability of 40, 66, 0.8 and 126 were calculated for cheek firmness, SSC, TA and SSC/TA, respectively. Levels of SSC (9.8-12.8%), TA (0.24-0.41%) and SSC/TA (25-47) varied

Table 1. Stone fruit quality attributes measured at harvest, 1995 and 1996.

Cultivar	Titratable acidity[z]	Date	Firmness (N) Cheek	Firmness (N) Weakest point	(%) SSC	(%) Titratable Acidity	SSC/ Titratable Acidity
1995							
PEACH (white flesh)							
Snow Flame	NA	1 Jun	45.9	29 (shoulder)	11.2	0.80	11
Snow Bright	NA	13 Jun	49.8	30 (tip/suture)	10.3	0.43	24
White Lady	NA	26 Jun	61.8	53 (suture/tip)	10.7	0.53	21
Sugar Lady	NA	5 Jul	52.5	34 (suture)	11.5	0.34	34
Summer Sweet	NA	10 Jul	65.8	54 (shoulder)	13.0	0.55	24
Snow Giant	NA	4 Aug	51.6	30 (shoulder)	14.3	0.30	48
LSD 0.05			11.4	17.8	2.2	0.04	18.8
NECTARINE (white flesh)							
Arctic Rose	NA	6 Jul	56.5	8.7 (suture)	18.7	0.62	30
1996							
PEACH (white flesh)							
Snow Bright	NA	5 Jun	53.4	40.9 (tip/suture)	10.8	0.30	36
Sweet Scarlet	NA	7 Jun	44.0	36.9 (shoulder)	11.0	0.27	41
White Lady	NA	19 Jun	60.0	37.4 (suture/tip)	11.0	0.34	32
Sugar Lady	NA	25 Jun	55.6	46.7 (suture)	12.6	0.27	47
Snow Ball	NA	3 Jul	57.8	44.0 (shoulder)	10.6	0.32	33
Sugar Giant	NA	8 Jul	47.6	36.9 (shoulder)	9.8	0.28	35
Summer Sweet	NA	16 Jul	46.3	37.4 (shoulder)	11.8	0.34	35
Snow Giant	NA	26 Jul	44.5	23.6 (shoulder)	11.6	0.37	31
Champagne	SA	22 Jul	71.6	45.4 (shoulder)	12.0	0.41	29
Snow King	NA	31 Jul	59.6	46.7 (shoulder)	11.6	0.27	43
September Snow	NA	14 Aug	75.2	50.3 (shoulder)	10.8	0.31	35
LSD 0.05			15.5	10.9	1.1	0.08	8.1
NECTARINE (white flesh)							
Arctic Star	LA	5 Jun	44.9	38.3 (shoulder)	11.3	0.42	26
Arctic King	ST	13 Jun	42.3	34.7 (tip)	10.8	0.97	11
Arctic Glo	ST	14 Jun	60.9	39.6 (tip)	14.4	1.45	10
June Pearl	SA	19 Jun	59.6	52.5 (suture)	10.0	0.39	26
Arctic Rose	NA	3 Jul	75.6	62.3 (suture)	15.2	0.61	25
Arctic Queen	NA	16 Jul	68.9	51.2 (shoulder)	17.4	0.59	30
Bright Pearl	SA	22 Jul	56.5	41.8 (shoulder)	14.8	0.33	45
Fire Pearl	SA	24 Jul	58.3	49.4 (shoulder)	15.8	0.37	41
LSD 0.05			16.6	13.7	4.0	0.3	18.5

[z]Titratable acidity denomination according to nurseries: ST = standard; NA = no acid (Wilson's nursery); SA = sub acid (Bright's Nursery); and LA = low acids.

Table 2. White flesh peach and nectarine fruit titratable acidity (TA) and SSC/TA changes during ripening "off" the tree, season 1995 and 1996.

Cultivar	Titratable Acidity[z]	Harvest (%) TA	Harvest SSC/TA	Ripe (%) TA	Ripe SSC/TA
1995 Season					
PEACH					
Snow Flame	ST	0.70	16	0.73	15
Snow Bright	NA	0.39	27	0.30	26
White Lady	NA	0.53	20	0.38	30
Sugar Lady	NA	0.34	34	0.36	32
Summer Sweet	NA	0.55	24	0.58	22
Snow Giant	NA	0.24	57	0.20	69
LSD 0.05		0.25	20.9	0.20	28
NECTARINE					
Arctic Rose	NA	0.62	30	N.A.	N.A.
1996 Season					
PEACH					
Snow Bright	NA	0.29	41	0.31	38
Sweet Scarlet	SA	0.25	44	0.24	47
White Lady	NA	0.34	32	0.24	56
Sugar Lady	NA	0.27	47	0.36	35
Snow Ball	SA	0.32	33	0.39	27
Sugar Giant	NA	0.28	35	0.31	32
Summer Sweet	NA	0.34	35	0.40	30
Champagne	NA	0.41	29	0.43	28
Snow Giant	NA	0.37	31	0.31	37
Snow King	NA	0.27	43	0.37	32
September Snow	NA	0.31	35	0.33	33
LSD 0.05		0.07	8.9	0.09	13.0
NECTARINE (white flesh)					
Arctic Star	LA	0.42	25	0.46	24
Arctic King	ST	0.97	11	0.82	13
Arctic Glo	ST	1.45	10	1.20	12
June Pearl	SA	0.39	26	0.30	33
Arctic Rose	NA	0.61	25	0.63	24
Arctic Queen	NA	0.59	30	0.63	28
Bright Pearl	SA	0.33	45	0.32	46
Fire Pearl	SA	0.37	41	0.42	36
LSD 0.05		0.58	18.5	0.45	17.2

[z]Titratable acidity denomination according to nurseries: ST = standard; NA = no acid (Wilson's nursery); SA = sub acid (Bright's Nursery); and LA = low acids.

Table 3. Minimum flesh firmness (kilos-force) necessary to avoid commercial bruising at three levels of bruising potential (Bruising Susceptibility).

Cultivar	Bruising Potential (Drop Height[z]) -66 G (1 cm)	-185 G (5 cm)	-246 G (10 cm)
PEACHES (white flesh)			
Snow Bright	2.7[y]	3.2	3.6
Snow Flame	0.0	0.0	5.4
Snow Giant	0.9	0.9	5.4
Sugar Lady	0.0	2.3	2.3
White Lady	1.8	2.7	5.9
LSD 0.005	1.75	1.98	2.27
NECTARINES (white flesh)			
Arctic Rose	0.9	2.3	3.6
Fire Pearl	—	5.4	5.4
Bright Pearl	—	3.6	4.5
LSD 0.005	—	2.32	1.34

[z]Dropped on 1/8" PVC belt.
[y]Fruit firmness measured with a 7.9 mm tip. Damaged areas with a diameter equal to or greater than 2.5 mm were measured as bruises.

among cultivars (Table 1). For the white flesh peach cultivars tested, the average flesh firmness was approximately 53 N, SCC 11.0%, TA 0.31%, and SSC/TA 30.

White flesh nectarine firmness measured on the cheeks varied from 42.2 to 80.5 N. The weakest position on the fruit also varied according to cultivar. Fruit firmness differences up to approximately 4.5-17.8 N between the cheek and the weakest point were determined in the different nectarine cultivars (Table 1). Coefficients of variability of 55, 54, 18, and 405 were calculated for cheek firmness, SSC, TA and SSC/TA, respectively. The level of SSC (10.0-17.4%), TA (0.33-1.45) and SSC/TA (10-45) varied among cultivars. For the white flesh nectarine cultivars tested, average flesh firmness was 58 N, SSC 14.0%, TA 0.61%, and SSC/TA 26. Fruit TA showed the least variability among fruit quality characteristics when fruit were harvested at the CA-well mature stage. Seasonal conditions or orchard management (7, 8) may slightly affect TA levels in the white flesh stone fruit. We found that among the cultivars reported by the nurseries as non-acid or sub-acid and low acid, there was a large variability in TA and SSC/TA ratios. We believe this is the first step to create a new denomination based on TA and or SSC/TA that can help to avoid any potential consumer confusion. This new white flesh stone denomination should be based on consumer sensory perception of fruit based on TA.

Bruising Susceptibility

Bruising susceptibility was calculated at three bruising potential energy levels (66, 185, 245 G's) for several white flesh peach and nectarine cultivars (Table 3). Soft fruit were more susceptible to impact bruising than hard fruit. Among the white flesh peaches evaluated, 'Snow Flame' and 'Snow Giant' tolerated impact damage much better than 'Snow Bright,' 'Sugar Lady' and 'White Lady' when exposed to 185 G. Among the white flesh nectarines evaluated, 'Arctic Rose' and 'Bright Pearl' tolerated impact damage (185 G) much better than 'Fire Pearl.' The position of the weakest spot on the fruit varied depending on the cultivar. In general, early season cultivars softened faster at the tips and late season cultivars at the shoulders/sutures (Table 1). The tip/suture was the softest position for 'Snow Bright' and 'White Lady.' The shoulder was the softest position for 'Snow Flame,' 'Snow Giant,' 'Arctic Rose,' 'Fire Pearl,' and 'Bright Pearl.' The suture was the softest spot for 'Sugar Lady' and 'Arctic Rose.' On the commercial harvest date, there were up to 3 kilos-force difference in fruit firmness between the strongest and the weakest positions on the fruit.

Under specific conditions, the comparison of fruit bruising susceptibility (firmness) and postharvest handling and/or packing line bruising potentials (G's) will help to decide how late fruit

Table 4. White flesh peach cultivar market life under two storage temperatures based on chilling injury or internal breakdown symptom development.

Cultivar	Origin[z]	Fruit Type[y]		Market Life (weeks)	
		Fruit	Flesh Texture	0°C	5°C
(A) Non-susceptible to internal breakdown at 0°C and 5°C:					
Champagne		Freestone	Melting	5+	5+
Snow Flame	Doyle	Cling	Non-melting	5+	5+
Snow Bright	Zaiger	Freestone	Melting	5+	5+
(B) Non-susceptible to internal breakdown at 0°C, susceptible at 5°C:					
Snow Giant	Zaiger	Freestone	Melting	5+	3
Snow King	Zaiger	Freestone	Melting	5+	1.5
(C) Susceptible to internal breakdown at 0°C and 5°C:					
White Lady	Zaiger	Freestone	Melting	4	2
Sugar Lady	Zaiger	Freestone	Melting	4.5	3
Sugar Giant	Zaiger	Freestone	Melting	5	2.5
Summer Sweet	Zaiger	Freestone	Melting	4.5	2
September Snow	Zaiger	Freestone	Melting	4	2

[z]Plant breeding program.
[y]Information was obtained from personal communications with Gary Van Sickle, Kevin R. Day and David Ramming; from The Register of Fruit and Nut Varieties (Brooks & Olmo, 1972), Fruit, Berry and Nut Inventory (Whealy and Demuth, 1993), Handbook of Peach and Nectarine Varieties (Okie, 1998), and various nursery catalogs.

can be harvested and packed without causing bruising.

After Ripening Quality Evaluations

During these two seasons, ripening white flesh peaches and nectarines "off the tree" did not increase SSC or decrease acidity, thus the SSC/TA remained the same (Table 2). This lack of TA loss during ripening "off the tree" appears to be a characteristic of these low acid, white flesh, stone fruit cultivars. In general, yellow flesh peaches and nectarines lose from 10-30% of their TA measured at har-

Table 5. White flesh nectarine cultivar market life under two storage temperatures based on chilling injury internal breakdown symptom development.

Cultivar	Origin[z]	Fruit Type[y]		Market Life (weeks)	
		Fruit	Flesh Texture	0°C	5°C
(A) Non-susceptible to internal breakdown at 0°C and 5°C:					
Arctic Star	Zaiger	Clingstone	Melting	5+	5+
Arctic Glo	Zaiger	Clingstone	Melting	5+	5+
June Pearl	Bradford	Clingstone	Melting	5+	5+
Arctic Rose	Zaiger	Clingstone	Melting	5+	5+
(B) Non-susceptible to internal breakdown at 0°C, susceptible at 5°C:					
Arctic Queen	Zaiger	Freestone	Melting	5+	3
Bright Pearl	Bradford	Clingstone	Melting	5+	3
Fire Pearl	Bradford	Clingstone	Melting	5+	3

[z]Plant breeding program.
[y]Information was obtained from personal communications with Gary Van Sickle, Kevin R. Day and David Ramming; from The Register of Fruit and Nut Varieties (Brooks & Olmo, 1972), Fruit, Berry and Nut Inventory (Whealy and Demuth, 1993), Handbook of Peach and Nectarine Varieties (Okie, 1998), and various nursery catalogs.

vest after ripening, thus, their SSC/TA increases. Also, a more rapid rate of softening was observed in most of these white flesh cultivars than in yellow flesh types (8). This very rapid softening rate may induce fast deterioration and potential decay. Because of this rapid softening and lack of titratable acidity changes during ripening characteristics, we do not recommend that white flesh stone fruit be ripened at the shipping or retail points. In these white flesh cultivars, the consumers should carry out ripening just before consumption if softer fruit is desired. Also, fruit temperature should be kept near 0°C during postharvest handling.

Market Life

Maximum market life was shorter for most of the white flesh peach cultivars than the nectarine cultivars. Among the white flesh peach cultivars, 'Snow Flame,' 'Champagne' and 'Snow Bright' were not CI susceptible at either storage temperature within the 5 weeks evaluation period (Table 4). 'Snow Giant' and 'Snow King' cultivars did not develop CI symptoms at 0°C, but they did at 5°C. The other five peach cultivars were CI susceptible at both storage temperatures. Among the white flesh peach cultivars tested, the harvest season (early, middle, or late) did not affect CI susceptibility. In white flesh peaches, the market life at 0°C and 5°C varied respectively from more than 3 to more than 5 weeks, and 1.5 to more than 5 weeks. 'Arctic Star,' 'Arctic Glo,' 'June Pearl,' and 'Arctic Rose' white flesh nectarines did not develop CI symptoms at either storage temperature for at least 5 weeks (Table 5). 'Arctic Queen,' 'Fire Pearl,' and 'Bright Pearl' developed CI symptoms only when stored at 5°C. In these three cultivars, market life was reduced from more than 5 weeks to 3 weeks when fruit were stored at 5°C instead of 0°C.

In general, these white flesh cultivars have a lower TA than most of the commercial yellow flesh cultivars but the TA, bruising susceptibility, and market life varies among them.

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