Market Life Update for Peach, Nectarine, and Plum Cultivars Grown in California

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Abstract

The susceptibility to chilling injury (CI) was evaluated for peach, nectarine, and plum cultivars from different breeding sources. Cultivars were segregated into three categories (A, B, and C) according to their susceptibility to CI symptoms when exposed to 0 ^{o}C or 5 ^{o}C storage temperatures up to 5 weeks. Cultivars in Category A did not develop any symptoms of CI after 5 weeks of storage at either temperature. Cultivars in Category B developed symptoms only when stored at 5 ^{o}C within 5 weeks of storage. Cultivars were classified as Category C when fruit developed CI symptoms at both storage temperatures within 5 weeks of storage. Approximately 60% of the peach, 50% of the nectarine, and 40% of the plum cultivars tested developed CI symptoms when stored at 5 ^{o}C (Category B&C). However, these percentages were reduced to 35% for peach, 30% for nectarine, and 14% for plum cultivars when stored to 0 ^{o}C during postharvest handling. Thus, the importance of proper temperature management, and the application of preconditioning or other reliable treatments to extend market life during postharvest handling is well demonstrated. This information provides guidance for shippers and handlers in selecting cultivars for long distance marketing.

1. Introduction

Peach, nectarine and plum fruit are highly perishable (decay, weight loss, excessive softening) and can deteriorate quickly at room temperature. Low temperature during storage and/or shipping extends fruit market life by decreasing the rate of deterioration. However, fruit from some cultivars develop lack of juiciness (mealiness or woolliness), flesh browning, black pit cavity, flesh translucency (gel breakdown), red pigment accumulation (bleeding), and fail to ripen and lose flavor after prolonged cold storage and/or after ripening at room temperature (Lurie and Crisosto, 2005). These symptoms are also reported under internal breakdown (IB) or chilling injury (CI) (Lurie and Crisosto, 2005), that include symptoms such as flesh browning, woolliness (Von Mollendorff, 1992), or in plums flesh translucency (Dodd, 1984) and gel breakdown (Crisosto et al., 1999). Since these symptoms mainly develop during fruit ripening after cold storage, this problem is usually not noticed until fruit reaches consumers (Bruhn et al., 1991; Crisosto, 2005). The onset of these symptoms determines the true postharvest storage/shipping potential because CI development reduces consumer acceptance (Crisosto et al., 1999; Mitchell, 1987). Susceptibility to CI symptoms varies according to genetic background (Dodd, 1984; Harding and Haller, 1934; Peace et al., 2005), maturity (Von Mollendorff, 1987), and orchard factors (Crisosto et al., 1997). Because of increased global marketing, especially exchanges between the Southern and Northern hemispheres taking advantage of the on and off seasons requiring at least 3 to 5 weeks of market life (shipment, handling at production and receiving), the knowledge of cultivar market life is essential to assure good arrival and consumer satisfaction. Also, it is important to understand cultivar temperature susceptibility and market life potential to predict if any special treatment such as preconditioning or controlled atmosphere storage will be beneficial. Thus, as a short-term solution, proper temperature management for packers, shippers, transportation, buyers and receivers (Crisosto, 2005), and

preconditioning/preripening treatments at the shipping point (Crisosto et al., 2004) are commercially used with success in California, Chile and other locations.

The objective of this work was to continue our previous evaluation of the influence of postharvest handling temperature (0 ^{o}C vs. 5 ^{o}C) on the susceptibility of new commercially available California stone fruit cultivars to CI. Information on cultivar storage/shipping potential at both temperatures is fundamental in developing prepackaging, storage, shipping and retail postharvest handling protocols to maintain stone fruit postharvest quality. Furthermore, the variability in CI susceptibility among cultivars is valuable to geneticists and breeders to develop stone fruit cultivars free of CI, to understand the genetic inheritance of CI, and to locate the genes related to these disorders (Peace et al., 2005).

2. Materials and Methods

Seventeen peach, 16 nectarine and seven plum cultivars, commercially grown in California, were tested for susceptibility to CI in 2004. All cultivars were picked at the California Well-Mature stage according to the California Tree Fruit Agreement (CTFA) ground-color chips. For each cultivar, a 100 fruit sample was collected from each of three trees (replications) growing at the UC Kearney Agricultural Center (KAC) or from other commercial orchards with similar management conditions near the KAC. Outer canopy, medium size fruit were sampled from the same canopy position height. Fruit were forced-air cooled to 0-2 ^{o}C within 8h of harvest and then stored at either 0 or 5 ^{o}C (with 90% relative humidity) for up to five weeks. A postharvest fungicide dip (1.2 $g \cdot L^{-1}$ of iprodione) was used after the washing operation and before packaging.

Three groups of 10-fruit samples were collected weekly from both storage temperatures (0 ^{o}C and 5 ^{o}C), were ripened (at 20 ^{o}C) until firmness reached between 10-18

N (measured with a UC-Davis penetrometer with a 7.9-mm tip) prior to CI symptom evaluation. The ripening period prior to CI evaluation varied from 3 to 7 days according to cultivar softening rate. Fruit were soft, but not mushy, for the CI evaluation. Fruit were evaluated for different manifestations of CI such as lack of juiciness (mealiness or woolliness), flesh browning, flesh bleeding, and flesh translucency (gel breakdown) as has been previously described (Crisosto et al., 1999; Nanos and Mitchell, 1991). Maximum market life was subjectively defined as the number of weeks that a cultivar lasted without exceeding 20% mealiness or 15% flesh browning symptoms ($\geq$25% of the flesh area) when stored at 0 ^{o}C and minimum market life was subjectively defined as the number of weeks that a cultivar lasted without exceeding 20% mealiness or 15% flesh browning when stored at 5 ^{o}C (Crisosto et al., 1999).

The cultivars were classified into the following three categories, according to their storage/shipping potentials at each storage temperature: A. CI nonsusceptible and temperature insensitive (fruit with at least 5 weeks of storage/shipping potential at both temperatures); B. CI nonsusceptible (at least 5 weeks of storage/shipping potential) at 0 ^{o}C but CI susceptible at 5 ^{o}C (less than 5 weeks of storage/shipping potential) (temperature sensitive); C. CI susceptible (less than 5 weeks of storage/shipping potential) at both storage temperatures.

3. Results and Discussion

Mealiness and flesh browning (data not shown) were the major CI symptoms among most of the peach (Table 1), nectarine (Table 2), and plum (Table 3) cultivars tested. The type of symptoms and the storage/shipping potential based on CI, depended on the cultivar and storage temperature. Some cultivars did not develop any mealiness or flesh browning

symptoms. For plums, development of flesh browning was always accompanied by flesh translucency (gel breakdown). In all of the peach, nectarine, and plum cultivars, storage/shipping potential was longer at 0 ^{o}C than at 5 ^{o}C. Storage/shipping potential at 5 ^{o}C varied from less than 1 week to more than 5 weeks. Storage/shipping potential at 0 ^{o}C varied from 1 to more than 5 weeks.

Of the 17 peach cultivars, five yellow flesh ('Brittney Lane', 'Country Sweet', 'Crimson Lady', 'May Sweet', and 'Super Rich') and two white flesh ('Spring Snow' and 'Sunlit Snow') did not develop any mealiness and/or flesh browning symptoms after 5 weeks at either storage temperature (Category A). Four of the white flesh peach cultivars ('Ivory Princess', 'Saturn', 'Snow Fire', and 'Snow Kist') did not show symptoms when stored at 0 ^{o}C for at least 5 weeks, but they developed CI at 5 ^{o}C (Category B). When fruit were exposed to 5 ^{o}C, storage/shipping potential for 'Ivory Princess' and 'Saturn' was reduced to 3 weeks, while for 'Snow Fire' and 'Snow Kist' it was reduced to 2 weeks. The other five yellow flesh ('Autumn Flame', 'Kaweah', 'Rich May', 'September Flame' and 'Sweet Dream') and one white flesh ('Sugar Lady') peach cultivars (Category C) developed CI symptoms very early ($\leq$3 weeks) at both storage temperatures (Table 1), except for 'Rich May' which had a maximum market life (0 ^{o}C) of 4 weeks and a minimum market life (5 ^{o}C) of 3 weeks.

The yellow flesh ('Diamond Bright', 'Diamond Ray', 'Honey Blaze', 'Kay Sweet', and 'Ruby Sweet') and white flesh ('Arctic Jay', 'Arctic Star', and 'Ruby Pearl') nectarine cultivars did not develop CI symptoms at either temperature when stored for 5 weeks (Category A). The white flesh ('Arctic Snow', 'Arctic Sweet', and 'Fire Pearl'), and yellow flesh ('Summer Blush') nectarine cultivars had a storage/shipping potential at 0 ^{o}C of at least 5 weeks, but when they were stored at 5 ^{o}C, storage/shipping potential was reduced to 3 weeks or less. Storage/shipping potential was reduced from 5 weeks to 1 week when

'Summer Blush' was stored at 5 ^{o}C (Table 2). The yellow flesh ('August Glo', 'September Free', and 'Zee Glo') and white flesh ('Grand Pearl') nectarine cultivars developed CI symptoms at both storage temperatures (Category C). For these cultivars, storage/shipping potential was 3 weeks or less when stored at either temperature, except for 'Zee Glo', in which market life potential was still 3 weeks when exposed to 5 ^{o}C.

'Betty Anne', 'Flavorich', 'Joanna Red', and 'October Sun' plum cultivars were classified as Category A since they did not develop CI symptoms when stored at 0 ^{o}C or 5 ^{o}C for 5 weeks (Table 3). 'Hiromi Red' and 'Purple Majesty' developed CI symptoms within 5 weeks even when stored at 0 ^{o}C but their market life potential was reduced to 3 weeks or less when stored at 5 ^{o}C (Category B). For all of the plum cultivars, longer storage/shipping potential was achieved when stored at 0 ^{o}C than at 5 ^{o}C (Table 3). In all of the CI susceptible cultivars, the development of mealiness and flesh browning symptoms was delayed, and also the intensity of flesh browning was lower, when the fruit were stored at 0 ^{o}C rather than 5 ^{o}C. Other researchers have reported that CI develops more rapidly in fruit held at 3 ^{o}C to 5 ^{o}C than in fruit stored at 0 ^{o}C (Crisosto et al., 1999).

Conclusions

This work points out the detrimental effect of even 7 day exposure to a storage temperature of 5 ^{o}C on postharvest storage/shipping potential of stone fruit. Thus, proper postharvest temperature management (near 0 ^{o}C) during storage, shipping and retail marketing can extend peach, nectarine, and plum postharvest storage/shipping potential (Mitchell, 1987) and is strongly recommended for all cultivars.

Although this is data collected during one growing season and we reported that orchard factors and environmental conditions can affect market life (Crisosto et al., 1997), we

believe that this cultivar evaluation is contributing information to make decisions on planting and/or how to manage these new cultivars.

For those cultivars that develop mealiness and/or flesh browning symptoms within 1-2 weeks under both storage temperatures, rapid marketing is recommended. This information provides guidance for shippers and handlers in selecting cultivars for long distance marketing and/or using preconditioning treatment (Crisosto et al., 2004) on cultivars that are CI susceptible.

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Table 1. Effects of storage temperature on storage/shipping potential of peach cultivars[z].

Category[y]	Cultivar	Plant breeding program	Fruit type			Storage/ shipping potential (weeks)	
			Flesh-stone adhesion	Flesh texture	Flesh color	0 °C	5 °C
A	Brittney Lane	Zaiger	Clingstone	Melting	Yellow	5	5
	Country Sweet	Zaiger	Clingstone	Melting	Yellow	5	5
	Crimson Lady	Bradford	Clingstone	Nonmelting	Yellow	5	5
	May Sweet	Zaiger	Clingstone	Melting	Yellow	5	5
	Spring Snow	Zaiger	Clingstone	Melting	White	5	5
	Sunlit Snow	Zaiger	Clingstone	Melting	White	5	5
	Super Rich	Zaiger	Clingstone	Melting	Yellow	5	5
B	Ivory Princess	Bradford	Clingstone	Melting	White	5	3
	Saturn	Bailey	Freestone	Melting	White	5	3
	Snow Fire	Zaiger	Freestone	Melting	White	5	2
	Snow Kist	Zaiger	Clingstone	Melting	White	5	2
C	Autumn Flame	Doyle	Freestone	Melting	Yellow	1	0
	Kaweah	Zaiger	Freestone	Melting	Yellow	2	1
	Rich May	Zaiger	Clingstone	Melting	Yellow	4	3
	September Flame	Burchell	Clingstone	Melting	Yellow	2	1
	Sugar Lady	Zaiger	Freestone	Melting	White	3	2
	Sweet Dream	Zaiger	Clingstone	Melting	Yellow	1	0

[z] Information was obtained from personal communications with David Ramming, from Brooks and Olmo (1972), and Okie (1998), nursery catalogues and United States Patents.

[y] Category A = Nonsusceptible to internal breakdown at either storage temperature; B = Nonsusceptible to internal breakdown at 0 °C but susceptible at 5 °C; C = Susceptible to internal breakdown at both storage temperatures.

Table 2. Effects of storage temperature on storage/shipping potential of nectarine cultivars[z].

Category[y]	Cultivar	Plant breeding program	Fruit type			Storage/ shipping potential (weeks)	
			Flesh-stone adhesion	Flesh texture	Flesh color	0 °C	5 °C
A	Arctic Jay	Zaiger	Freestone	Melting	White	5	5
	Arctic Star	Zaiger	Clingstone	Melting	White	5	5
	Diamond Bright	Bradford	Clingstone	Melting	Yellow	5	5
	Diamond Ray	Bradford	Clingstone	Melting	Yellow	5	5
	Honey Blaze	Zaiger	Semi-freestone	Melting	Yellow	5	5
	Kay Sweet	Bradford	Clingstone	Nonmelting	Yellow	5	5
	Ruby Pearl	Bradford	Clingstone	Melting	White	5	5
	Ruby Sweet	Bradford	Clingstone	Melting	Yellow	5	5
B	Arctic Snow	Zaiger	Freestone	Melting	White	5	2
	Arctic Sweet	Zaiger	Clingstone	Melting	White	5	3
	Fire Pearl	Bradford	Clingstone	Melting	White	5	2
	Summer Blush	Bradford	Clingstone	Melting	Yellow	5	1
C	August Glo	Zaiger	Clingstone	Melting	Yellow	3	1
	Grand Pearl	Bradford	Clingstone	Melting	White	2	1
	September Free	USDA	Freestone	Melting	Yellow	3	1
	Zee Glo	Zaiger	Clingstone	Melting	Yellow	3	3

[z] Information was obtained from personal communications with David Ramming, from Brooks and Olmo (1972), Okie (1998), nursery catalogues and United States Patents.

[y] Category A = Nonsusceptible to internal breakdown at either storage temperature; B = Nonsusceptible to internal breakdown at 0 °C but susceptible at 5 °C; C = Susceptible to internal breakdown at both storage temperatures.

Table 3. Effects of storage temperature on storage/shipping potential of plum cultivars[z].

Category[y]	Cultivar	Plant breeding program	Fruit type	Storage/shipping potential (weeks)	
				0 °C	5 °C
A	Betty Anne	Zaiger	Clingstone	5	5
	Flavorich	Zaiger	Clingstone	5	5
	Joanna Red	Zaiger	Freestone	5	5
	October Sun	Chamberlin, Sr.	Semi-clingstone	5	5
B	Hiromi Red	Zaiger	Clingstone	5	3
	Purple Majesty	Bradford	Clingstone	5	3
C	Earliqueen	Zaiger	Clingstone	3	2

[z] Information was obtained from personal communications with David Ramming, from Brooks and Olmo (1972), Okie (1998), nursery catalogues and United States Patents.

[y] Category A = Nonsusceptible to internal breakdown at either storage temperature; B = Nonsusceptible to internal breakdown at 0 °C but susceptible at 5 °C; C = Susceptible to internal breakdown at both storage temperatures.