Orchard Factors Affecting Postharvest Stone Fruit Quality

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Although stone fruit quality cannot be improved, only maintained, after harvest, little research has been conducted on the influence of preharvest factors on stone fruit postharvest quality and potential postharvest life. We believe that the maximum fruit quality for each cultivar can be achieved only by understanding the roles of preharvest factors in fruit quality. This article reviews the influences of orchard factors, such as mineral nutrition, irrigation, crop load, and fruit canopy position on fruit quality, market life potential, and internal breakdown (IB). The literature indicates that quality, market life, and IB are related to preharvest factors. Thus, there is a need to continue studying these factors to deliver high quality fruit to the consumer.

In recent years the production of stone fruits has increased rapidly, but consumption has remained low at ≤2.7 kg.year⁻¹ per capita for nectarines and peaches and ≤0.6 kg.year⁻¹ per capita for plums and fresh prunes (U.S. Dept. of Agr., 1994). Surveys conducted to explain the low rate of consumption of stone fruits found that consumers were bothered mainly by lack of flavor and IB problems (Bruhn et al., 1991). Since production is still increasing, more attention must be given to the production and delivery of high-quality stone fruits to increase consumer demand.

Studies have associated high consumer acceptance with high soluble solids concentration (SSC) in many commodities (Kader, 1994; Parker et al., 1991), but there are more factors involved, such as acidity (Kader, 1994; Peterson and Evans, 1988), SSC/acidity ratio (Kader, 1994; Nelson, 1985; Rodan, 1988), phenolics (Robertson and Meredith, 1989), and volatiles (Romani, 1971). In peach (Prunus persica (L.) Batsch), plum (Prunus salicina Lindl.), and nectarine (Prunus persica var. nectarine (L.) Batsch), there is limited information on the relationship between consumer acceptance and ripe fruit chemical composition (Claypool, 1977; Kader, 1994; Mitchell et al., 1990). Since we do not have enough information on this subject, we are not able to propose any quality standards without detailed studies to support them (Crisosto, 1994a).

One important complex cause of quality deterioration and consumer complaints is fruit weight loss. It is the presence of flesh browning, flesh mealiness, darkened pit cavity, flesh translucence, red pigment accumulation (bleeding), and susceptibility to brown rot. Fruit gas exchange (permeability to CO₂ and C H₄ and cuticle thickness) and cuticle thickness also varied with N rates. Resistance to CO₂ and C H₄ was low in fruit from the higher N rates (Table 2).

The relationship between fruit N concentration and fruit susceptibility to brown rot [Monilinia fructicola (Wint.) Honey] has been extensively studied on stored nectarine fruit (Michailides et al., 1993). Wounded and brown-rot inoculated fruit from 'Fantasia' and 'Flavor Top' trees having more than 2.6% leaf N were more susceptible to brown rot than fruit from trees with 2.6% or less leaf N. Fruit anatomical observations and cuticle density measurements indicated that leaf N content and thickness in the skin was a function of the N treatments (Table 1). The leaf N concentration was proportional to the fruit N concentration and susceptibility to brown rot.

Table 1. Relationship between leaf nitrogen and percent of fruit surface that is...
differences in cuticle thickness among 'Fantasia' fruit from the low, middle, and high N treatments, but this can only partially explain the differences in fruit susceptibility to this disease (Michailides et al., 1995).

Foliar nutrient sprays. Little research has been done on the effect of foliar nutrient sprays, which supply small amounts of mineral nutrients, on fruit quality. Our observations and reports in the literature suggest that these sprays have little effect on fruit quality.

Our work with three commercial calcium foliar sprays on peach and nectarine (applied every 14 days, starting 2 weeks after full bloom and continuing until 1 week before harvest) showed no effect on fruit quality of mid- or late-season cultivars (Crisosto et al., 1993b, 1995a). These foliar sprays did not affect fruit SSC, firmness, decay incidence, or fruit flesh calcium concentration. Fruit flesh calcium concentration, measured at harvest varied among cultivars from 200–300 μg·g⁻¹, dry weight basis (Crisosto et al., 1993b). A lack of decay control was reported on 'Jerseyland' peaches grown in Pennsylvania, treated with k9ha-l (Conway et al., 1987). Even fruit treated at 70% more flesh calcium (490 vs. 287 pg·g⁻¹, dry weight basis) than untreated fruit showed no reduction in decay severity.

Postharvest vacuum infiltration of 1%, 2%, and 4% CaCl₂ solutions into mature peaches has been tested (Conway et al., 1987; Wills and Mahendra, 1989). This infiltration treatment increased flesh calcium concentration (Ca at 287 vs. 1088 μg·g⁻¹, dry weight basis) and fruit maintained higher flesh firmness during cold storage but did not show a reduction in decay incidence. Other potential benefits were negated by skin injury (Wills and Mahendra, 1989).

Recent research (Cheng and Crisosto, 1994; Crisosto et al., 1993a) suggests that these sprays on peaches and nectarines should be treated with caution because their heavy metal content (Fe, Al, Cu, etc.) may contribute to fruit skin discoloration.

Irrigation. Despite the important role of water in fruit growth and development, few specific studies have been done on the influence of the amount and the timing of water applications on peach quality at harvest and postharvest performance (Claypool, 1977; Crisosto et al., 1994b; Johnson et al., 1992; Johnson et al., 1994; Kader, 1988; Uriu et al., 1964; Veihmeyer and Hendrickson, 1949). An early report (Veihmeyer and Hendrickson, 1949) indicated a reduction in yield and fruit size, an increase in SSC, and a high incidence of IB of peaches when trees were allowed to grow without irrigation during the growing season on a shallow soil under California conditions. Water stress induced by allowing the soil water potential of a peach orchard to dry down to 0.5 MPa between irrigations resulted in increased fruit SSC compared to the normally irrigated optimum treatment (Uriu et al., 1964).

Reducing the amount of applied water after harvest of early-season peaches and plums has shown no negative effects on yield in California (Johnson et al., 1992; Larson et al., 1988); however, timing of the water deficit interval is important. An increase in fruit defects, such as deep suture and double-fruit formation, has been reported for early-season 'Regina' peaches as a consequence of imposing a postharvest water stress (50% ET) in mid and late summer during the previous season (Johnson et al., 1992). These defects will reduce the final packout. A similar regulated water stress regime applied to early-season plums had a continuous and much thicker cuticle and a lower density of trichomes than fruits from the 150% ET. These differences in exodermis structure may explain the higher percentage of water loss from fruit from 150% ET compared to the others.

Girdling. Girdling 4–6 weeks before harvest is performed to increase peach and nectarine fruit size and advance and synchronize maturity (Day and De Jong, 1990; Johnson and LaRue, 1989). In some cases, girdling increases fruit SSC (Day et al., 1995; Marini et al., 1985), but also increases fruit acidity so that the taste resulting from the additional sugars may be masked.

Girdling can also cause the pits of peach and nectarine fruits to split, especially if it is done too early during pit hardening (Johnson and LaRue, 1989). Fruit with split-pits soften more quickly than intact fruits. Split-pits, as a consequence of girdling, have not been observed in Black Amber, Santa Rosa, Friar, and Royal Diamond plum cultivars; however, rapid fruit softening and severe tree weakening has been noted (Day et al., 1990).

Crop Load. Fruitlet thinning increases fruit size while also reducing total yield; thus, a balance between yield and fruit size must be achieved (Day et al., 1993). Generally, maximum profit does not occur at maximum marketable yield, since larger fruit bring a higher market price (Parker et al., 1991). Leaving too many fruit on a tree reduces fruit size and SSC (Crisosto et al., 1995a) in the early ripening 'May Glo' nectarine and late ripening 'O'Henry' peach (Fig. 1A&B).

Crop load on 'O'Henry' peach trees affected the incidence of IB measured after 1, 2, and 3 weeks at 5 °C (Crisosto et al., 1995a). Despite a large amount of mealy fruit for all lots, the overall incidence of mealiness and flesh browning in fruit from the high-crop load was low, intermediate in fruit from the commercial crop load, and the highest in fruit from the low-crop load. Bleeding was not affected by crop load.

Fruit Canopy Position. Initial fruit quality of several peach, nectarine, and plum cultivars according to fruit canopy position has been evaluated in differing production areas (Marini, 1991; Saenz, 1991).

<table>
<thead>
<tr>
<th>Irrigation amount (%)</th>
<th>Fruit weight (g)</th>
<th>SSC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>218 a</td>
<td>11.7 a</td>
</tr>
<tr>
<td>150</td>
<td>221 a</td>
<td>10.8 a</td>
</tr>
<tr>
<td>50</td>
<td>192 b</td>
<td>13.3 b</td>
</tr>
<tr>
<td>100</td>
<td>291 a</td>
<td>10.7 a</td>
</tr>
<tr>
<td>150</td>
<td>304 a</td>
<td>10.9 a</td>
</tr>
<tr>
<td>50</td>
<td>244 b</td>
<td>11.2 b</td>
</tr>
</tbody>
</table>

*ET = evapotranspiration.

Table 3. Effect of three irrigation regimes on fruit weight and soluble solids concentration (SSC) of 'O'Henry' peach at harvest.
Large differences in SSC, acidity, and fruit size were detected between fruit obtained from the outside and inside canopy positions of open-vase trained trees (Marini, 1991; Saenz, 1991). During the last five seasons, we have observed that fruit grown under a high-light environment (outside canopy) has a longer shelf life (storage and market) than fruit grown under a low-light environment (inside canopy). Summer pruning and leaf pulling around the fruit increases fruit light exposure and, when performed properly, can increase fruit color without affecting fruit size and SSC. Excessive leaf pulling or leaf pulling done too close to harvest, however, can reduce both fruit size and SSC in peaches and nectarines (Day et al., 1995).

During three seasons, we have found that fruit that developed in the more shaded inner canopy positions has a greater incidence of IB than fruit from the high-light, outer canopy positions (Crisosto et al., 1995a). Thus, fruit from the outer canopy have a longer potential market life, especially IB-susceptible cultivars (Table 4).

### CONCLUSIONS

Since stone fruit quality assessment has been limited to SSC, acidity, and fruit surface color measurements, we recommend adding sensory evaluation (taste panel and/or consumer acceptance) testing to future work on the relationship between orchard factors and fruit quality. Evaluation of the influence of preharvest factors on fruit quality needs to be conducted through to consumer acceptance and consumption. We recommend evaluating quality criteria at harvest and at different points during simulated shipping periods under various temperature regimes.

Additional fruit quality research is needed in relation to foliar calcium uptake, deficit irrigation near harvest, and the timing of nitrogen fertilization.

Current research indicates that flesh browning and mealy symptoms are associated with canopy position of the fruit. However, studies are needed to develop a better understanding of this relationship to maximize the market life of IB-susceptible stone fruit cultivars.

### Literature Cited


nectarines: California Tree Fruit Agreement, Sacramento, Calif.