Effect of Preharvest Factors and Bruising in Stone Fruit Decay

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Introduction

The fruit skin (cuticle and epidermis) provides barrier protection against infection by pathogens. Most fungi are unable to penetrate healthy fruit skin and must enter through wounds. Fruit resistance to infection resulting from the biochemical action of tissues is not the result of a single compound or a single mechanism. Multiple systems with complex interactions may be involved in decay resistance.

Immature fruit appear to be resistant to pathogens due in part to fungitoxic compound(s) already present at the infection point. Even if immature fruit are penetrated by fungi, in many cases the fungus is unable to colonize the tissue. Commonly, a high degree of resistance is maintained until the fruit approaches maturity. This loss of resistance occurs at the same time that fruit firmness is decreasing. This means that softer, over-mature fruit not only are more susceptible to mechanical injury and infection but also lack the biochemical resistance of immature fruit. Cultural practices may condition fruit to different susceptibilities to disease, however there is little information on the relationship between preharvest factors and bruising on decay incidence. Also, postharvest handling will affect decay development. This article briefly describes the possible relationships between bruising, irrigation, nitrogen and calcium fertilization, and fruit decay incidence.

Bruising

Physical damage causes fruit surface wounding which facilitates entrance and development of rot organisms. Furthermore, cuts, punctures and bruises to the fruit will usually increase ethylene production, accelerating softening of surrounding fruit causing them to become more susceptible to mechanical injuries, thus, decay. Physical wounding may occur at any time from harvest until the fruit is consumed. Wounds may include punctures, cuts and various types of bruises. Punctures and cuts are easily recognized, and should be prevented as much as is possible. Bruises result from rough or improper handling, poorly designed equipment, improper packaging or inadequate supervision during handling of the fruit. They are often more difficult to recognize and remove than cuts and punctures.

Harvesting

In 1992, Kevin Day (UC Farm Advisor, Tulare County) and I evaluated the effects of picking containers and bin trailer types on bruise and decay incidence using a number of different peach and nectarine cultivars. Fruit used in these experiments were collected from the UC Kearney Agricultural Center as well as other orchards at commercial harvest time. The type of picking container used significantly affected the incidence of bruising. In our trials with ‘Flavorcrest, ‘Red Top, and ‘Rich Lady’ peaches, there was less impact bruising on fruit harvested into picking buckets than on fruit harvested into picking bags. And, in ‘O’Henry’ peaches, fruit picked into pick-pack containers (plastic) had nearly half the impact bruising as peaches picked into picking buckets. Another important factor in fruit bruising was the care taken by the individual pickers. For ‘September Red’ nectarine, the percentage of fruit with impact bruises varied from 17- 31% and the number of bruises per fruit from 0.4- 0.7 depending upon the individual picker.

The cleanliness of the picking container was another important factor. Fruit picked into dirty nylon or canvas bags developed more decay during storage then fruit picked into clean containers in our ‘September Red’ nectarine trial. Since the incidence of abrasion damage did not vary among the different picking containers used, we suspect the differences in decay were due to the presence of inoculum in the dirty containers. When we compared decay incidence of fruit picked early in the morning to that of fruit picked in the afternoon, we found the decay incidence was higher for the fruit harvested late, except when dirty containers were used in which case decay was high at both picking times. This again suggests the accumulation of inoculum in the picking bag during the course of the day. One interesting occurrence we were unable to account for was that fruit picked early in the day had more impact bruising than fruit picked later, though abrasion damage was not affected by the picking time.

Hauling

Comparisons between standard solid axle trailers and rubber axle trailers were made with fruit picked into painted wooden bins. Fruit hauled within the orchard in bins on the rubber axle trailers had less bruising than fruit hauled on standard trailers. Abrasion damage was not affected by trailer type. Similar results were obtained during a long haul test (5 mile ride). It is important to point out that physical damage levels after the picking, dumping and hauling operations were not much higher than physical damage levels just after the picking and dumping operations. Our data indicated that hauling less than 5 miles did not contribute greatly to fruit physical damage. Most of the damage occurred during picking, dumping and hauling within the orchard.

Packaging system

Six boxes each of California well-mature 'O'Henry' peaches and 'Prima Diamond' nectarines were commercially volume fill or tray-packed. Fruit were gently transported to the KAC and stored to simulate postharvest handling. Upon arrival to the F. Gordon Mitchell Postharvest Laboratory, fruit were subjected to a simulated rough postharvest handling of approximately 200 G as measured with the IS-100 impact sensor. Then, fruit were stored at 0°C (32°F) and 95% relative humidity for a seven-day period (simulating a storage period in California). After that, fruit were placed at 4°C (39.5°F) for 4 days (simulating highway truck transportation to a distribution center), followed by 3 days at 5°C (41°F) (simulating a retail store display). Weight loss, visual appearance, and stone fruit defects such as bruising and decay incidence were measured at the end of the simulated marketing period. Decay incidence was also measured after 15 days at 20°C (68°F) and 95% relative humidity (decay incubation period).

For both cultivars, volume fill fruit had more water loss, bruising and decay incidence than tray-packed fruit (Table 1). In 'O'Henry' peaches, volume fill fruit lost more than twice as much water and had twice the incidence of bruising as tray-packed fruit. A similar situation occurred with the nectarine cultivar. Decay incidence, measured at the end of the simulated marketing period, reached 6 and 9% for the peach and nectarine volume filled fruit, respectively. No decay was observed on the tray-packed nectarines while the peaches had 3% decay.

When decay incidence was measured after 15 days at 20°C (68°F) and 95% relative humidity, volume fill fruit had a higher decay incidence than tray-packed stone fruit. Volume fill peaches had 77% decay while tray-packed had only 43% decay. Volume fill nectarines had 85% decay while tray-packed had only 26% decay (data not shown).

A different experiment was designed to study the influence of impact bruising on fruit deterioration. For this, fruit were collected after commercial packing with fungicide (Iprodione) and wax, and gently transported to KAC. Upon arrival at the F. Gordon Mitchell Postharvest Laboratory, 'Prima Diamond' nectarines were subjected to 0 cm (0 G), 1 cm (108 G), 5 cm (250 G), and 10 cm (396 G) drops onto a naked steel surface. Then the fruit were spray inoculated with *Monilinia fructicola* spores (cause of brown rot) on the area of impact. Three boxes for each of the four treatments were used for this experiment. Impact bruising levels were selected from our box filling survey of the stone fruit industry over the last three years using the IS-100. During this survey, we measured impacts ranging from 70-206 G in the volume fill box filling operations, while only 33-78 G was measured in the tray-packed box filling operations. To simulate a market handling period, fruit were stored at 0ºC (32°F)and 95% relative humidity for one week (simulating a storage period in California). After that, fruit were placed at 5°C (41°F) for 4 days (simulating storage at a distribution center) followed by 3 days at 20°C (68°F) (simulating a retail store display). Weight loss, bruising (incidence and intensity) and decay were measured at the end of this market handling period.

Table 1. *Influence of packaging system on water loss, and bruising and decay incidence of 'O'Henry' peach and 'Prima Diamond' Nectarine.*

'O'Henry' Peach

Treatments	Water loss (%)	Brusing (%)	Decay (%)
Volume fill	4.2 a[z]	25 a	6 a
Tray-packed	1.7 b	12 b	3 b

'Prima Diamond' Nectarine

Treatments	Water loss (%)	Brusing (%)	Decay (%)
Volume fill	4.0 a	52 a	9 a
Tray-packed	2.7 b	24 b	0 b

[z] Different letters within the column indicate significant differences between the treatments by the $LSD_{0.05}$ means separation test.

Water loss, bruising and decay incidence increased as the drop heights increased. Dropping fruit from a 5 and 10 cm height onto steel increased the impact G force and fruit deterioration. Bruising intensity (bruise area) and incidence (%), water loss, and decay incidence increased significantly when fruit were dropped from heights greater than 1 cm. The one-cm drop height did not induce deterioration on this nectarine cultivar.

Table 2. *Influence of drop height on impact bruising damage, water loss and decay incidence of 'Prima Diamond' nectarine.*

Drop Height (cm)	G	Bruising Intensity (mm^2)	Bruising Incidence (%)	Water Loss (%)	Decay (%)
0	0	0.0 a[z]	0 a	2.7 a	0 a
1	108	0.0 a	0 a	2.7 a	0 a
5	210	25.3 b	39 b	3.0 b	18 b
10	396	166.3 c	74 c	3.3 c	30 c

[z] *Different letters within a column indicate significant differences between the treatments by the $LSD_{0.05}$ means separation test.*

Nitrogen

Research over the last 10 years has established that peach and nectarine leaf nitrogen concentrations should be between 2.6 and 3.0% for best fruit quality in California. Michailides et al. demonstrated that 'Flavortop' nectarines from trees fertilized with 325 lbs/acre ammonium nitrate had a 12.5% natural infection rate by brown rot (*Monilinia fructicola*), as compared to 4.2% and 0% of the fruit from trees fertilized with 225, 175 and 100 lbs nitrogen per acre, respectively. Similarly, 76-90% of 'Fantasia' nectarines collected from trees that had been fertilized with 225-300 lbs ammonium nitrate per acre and spray-inoculated (without wounding) with a conidial suspension of *M. fructicola* were infected and developed 10 lesions per fruit, whereas 62-67% of fruit from trees fertilized with 100-175 lbs ammonium nitrate per acre were infected with only two to three lesions per fruit. Similar results were obtained with inoculated 'Flavortop' nectarines, although incidence and severity of disease were lower than on 'Fantasia'. In addition, blossoms of 'Fantasia' nectarines from trees fertilized with the higher levels of nitrogen, after spray-inoculating with a spore suspension of *M. fructicola*, had a greater incidence of infected stamens than similarly inoculated blossoms from trees fertilized with the low nitrogen levels. Blossoms of unfertilized trees were the most resistant to infection. Differences observed in the cuticle thickness of fruit from trees fertilized with different levels of nitrogen partially explains the differences in fruit susceptibility to this disease.

Calcium

Data gathered in 1991, 1992 and 1994 indicated that preharvest commercial foliar calcium sprays applied every 14 days, starting 2 weeks after full bloom and continuing until 1 week before harvest, did not reduce decay incidence of several peach and nectarine cultivars. Foliar calcium sprays had no affect on flesh calcium content. We feel that further research on foliar calcium applications to reduce fruit decay, including applications earlier than two weeks after full bloom, is necessary before commercial recommendations can be confidently made for stone fruit.

In our 1999 work, different formulations of calcium were selected for trial and included a carboxylic acid formulation, calcium nitrate, calcium acetate, calcium sulfate, and calcium chloride. The first application was made at petal fall and 4 other sprays were applied before harvest on 8 to 12 single tree reps. At each of 2 or 3 harvests, fruit samples were taken to measure the following: fruit firmness, color, soluble solids, acidity and bruising potential. Fruit was also evaluated for resistance to brown rot and susceptibility to inking. Calcium levels were measured in the fruit skin and flesh. None of the calcium formulations significantly increased flesh calcium concentrations and only one material, the amino acid complex, increased skin concentrations on all three sample dates. Physiological measurements of fruit performance at harvest and during storage also indicated that no calcium moved into the fruit by these treatments. Firmness at harvest and after 1 to 3 weeks of cold storage showed no improvement by any of the calcium formulations. The amino acid complex which slightly increased skin calcium seemed to induce some improvement in firmness after one week of storage, but the effect did not persist. Similarly, the calcium treatments showed no improvements in fruit size or decay, or reduction in internal breakdown symptoms such as juiciness, browning, or bleeding.

Irrigation

Anatomical studies revealed that peach fruit from deficit irrigation treatment (50% ET) had a thicker cuticle than fruit from the optimum (100% ET) and over (150% ET) irrigation treatments. The effect of irrigation management strategies on the quality and storage performance of 'O'Henry' peaches [*Prunus persica* (L.) Batsch] was studied for two seasons. The deficit irrigation treatment induced a higher fruit soluble solids concentration and lower fruit weight. The excess irrigation treatment, compared to the optimum treatment, increased the rate of fruit water loss without altering fruit quality and storage performance. Scanning electron microscope observations indicated a higher density of trichomes on fruit from the deficit and optimum irrigation treatments than from the excess irrigation treatment. Light microscopy studies indicated that fruit from deficit and optimum irrigation had a continuous and much thicker cuticle than fruit from the excess irrigation treatment. These differences in exodermis structure may explain the high percentage of water loss from fruit from the excess irrigation treatment compared to the deficit and optimum irrigation treatments.

Final Comments

There is little information on the role of preharvest factors and bruising on decay incidence that can be used commercially to reduce decay pressure. I believe that more applied and fundamental research on the role of preharvest factors and bruising on decay incidence should be pursued to develop tactics that can help to reduce decay incidence commercially.