

Management of Postharvest Decay of Avocado Fruit

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Research objectives of this project concern four subject areas: 1) the identity and prevalence of fungi isolated from decayed avocado fruit; 2) use of postharvest thermal conditioning to minimize subsequent decay losses; 3) evaluation of “snap” and “clip” harvest on postharvest decay; 4) the impact of postharvest transport and packingline handling on the incidence of postharvest decay.

New in 2002:

- 1. A summary by season and by year (2000 to 2002) of fungi isolated and identified from 2,233 decayed avocado fruit was prepared.**
- 2. Reductions in postharvest rot by postharvest thermal conditioning treatments were effective in a large test conducted in 2002 and confirm results from prior years.**
- 3. Results from other workers about ‘snap’ and ‘clip’ harvest and its impact on stem end rot repeated in Spain and New Zealand corroborate and help us interpret findings in California.**
- 4. A small accelerometer, that recorded the number and force of impacts and sent this data to a receiver by wireless transmission, was placed inside a large fruit or encased in a silicone body, and it was used to quantify impacts during passage of fruit down an avocado packing line.**
- 5. Increasing postharvest rot incidence by water applications to trees.**

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- 1. A summary by season and by year (2000 to 2002) of fungi isolated and identified from 2,233 decayed avocado fruit.**

The identity and prevalence of fungi isolated from decayed avocado fruit has been studied previously. Horne (1934) stated the most destructive pathogens of avocados in California were rhizopus rot (caused by *Rhizopus stolonifer*), Dothiorella rot (caused by *Dothiorella* spp.), and anthranose (caused by *Colletotrichum gloeosporioides*), and infrequently he observed rot by *Alternaria*, *Fursarium*, *Pestalotia*, and *Phytophthora* spp.. Cappellini, Smoot, et al (1983) reported a similar spectrum of pathogens. Ceponis, and Lightner (1980) reported

that among 428 California avocado shipments inspected in the New York market from 1972 to 1985, anthranose, “unidentified decays”, and rhizopus rot occurred in 25.9, 10.3, and 1.9 percent of the shipments, respectively, with other diseases less than 0.5%. No comprehensive survey of diseases and pathogens has been made since that time.

Consistently in our survey work since 1998, among avocados from many sources within California, the most important fungi were again those seen in prior isolations, *Dothiorella*, *Colletotrichum*, and *Alternaria*. For example, in 2002 we isolated them from 38%, 13%, and 4% of decayed fruit, respectively. During rainy periods, however, *Colletotrichum* incidence became predominant, and management of this pathogen during rainy periods becomes particularly important. We found rhizopus rot, which is exclusively a wound-requiring pathogen like *Alternaria*, to be rare. We compiled the isolations by season and year (**Figure 1**). *Colletotrichum* and *Dothiorella* typically make large lesions on fruit, while those caused by *Alternaria* are typically much smaller. The class of “other fungi” we report includes isolations from very small lesions and many of these are incidental saprophytic fungi that are not true pathogens. *Colletotrichum* predominated 2001 isolations and was less common in 2000 and 2002, primarily because many of the isolations were made during rainy periods, where this pathogen's incidence increases greatly.

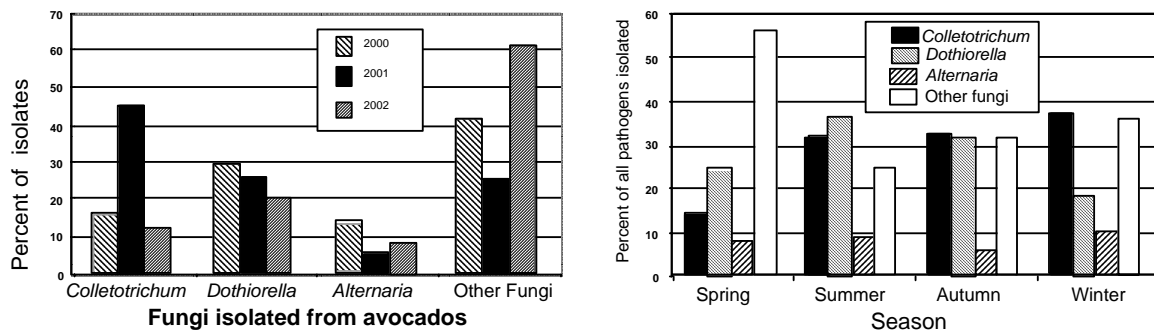


Figure 1. The occurrence of fungi isolated from decayed avocado fruit depicted by year of isolation (left) and season (right). *Colletotrichum* and *Dothiorella* typically make large lesions on fruit, while those caused by *Alternaria* are typically much smaller. The class of “other fungi” includes isolations from very small lesions and many of these are incidental saprophytic fungi that are not true pathogens.

In 2000 and 2002, weakly virulent or saprophytic fungi (“Other fungi”) were more common than in the relatively wet 2001, when true pathogens predominated. *Dothiorella* and *Alternaria* incidence was relatively constant among all three years’ isolations. When organized by season, *Colletotrichum* incidence was lower in the spring and similar in frequency at other times. *Dothiorella* was most frequent in the summer and autumn, while *Alternaria* was generally constant throughout the year. The weakly virulent or saprophytic “Other fungi” predominated in the spring, which means most of the decay lesions were very small at that time and the fruit were in general less affected by decay.

A summary limited to two months (January and July, 2001) isolations from the same groves near Fallbrook is shown (**Figure 2**). In this case, the predominance of stem end rot by *Colletotrichum* is evident in the January isolations, which were made after two days’ rain. In July, *Colletotrichum* remained important, but body rot by this pathogen and other fungi increased.

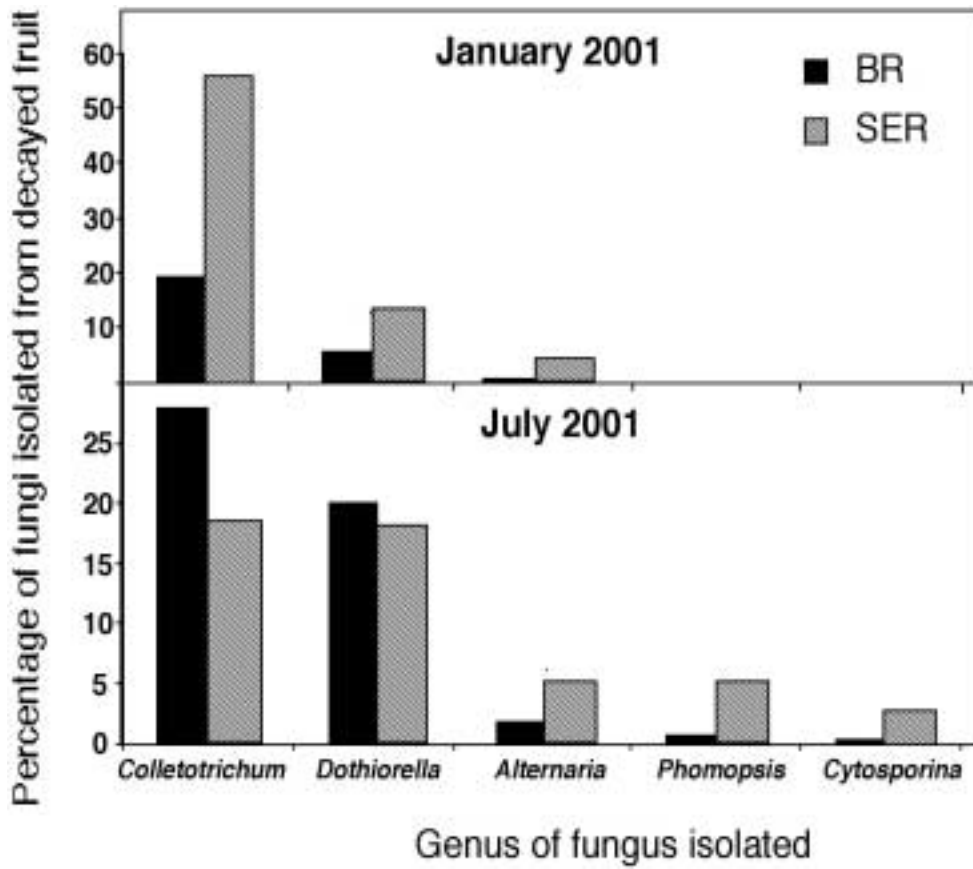


Figure 2. Genera of fungi isolated from body rot (BR) or stem-end rot (SER) lesions on decayed avocado fruit harvested from three locations near Fallbrook in January and July 2001. Sample sizes: January 2001, n = 460, July 2001, n = 386.

2. Use of postharvest thermal conditioning to minimize subsequent decay losses.

The impact of postharvest storage temperatures on the incidence of postharvest decay is well known, but few have developed thermal regimes into a strategy that minimizes these losses. Bezuidenhout (1983) reported temperature was a major factor in determining the extent of anthracnose development. Fitzell and Muirhead (1983) reported that reducing ripening temperature from 24°C to 17°C reduced subsequent anthracnose incidence, which was similarly shown for stem end rot in a similar study by White and coworkers (1998). Reeder (1975) reported anthracnose on 'Fuchs' and 'Waldin' avocados was reduced by storage at 4.4°C for 3-4 weeks before ripening compared 7.2 or 10°C, although chilling injury occurred on these varieties at these temperatures. Johnson et al (1990) recommended storage of avocados at 7°C before ripening at 16-20°C to reduce stem end rot caused primarily by *Dothiorella*, based on research originally done with mangos to control this pathogen. In 1957, Newsom reported that cold-hardy avocados could be ripened at about 15°C and anthracnose would be "practically eliminated" although ripening was very slow compared to ripening at higher temperatures. In preliminary tests, Arpaia and Sievert (unpublished) observed that storing 'Hass' avocados at 5°C for relatively long periods (weeks) followed by ethylene treatment (100 ppm for 24 h) and ripening at 20°C very substantially reduced subsequent stem end rot and body rot incidence among the ripe fruit compared to those ripened immediately after harvest. This regime did not cause chilling injury or other harm to the fruit. This was repeated in later tests and similar suppression of stem end rot was attained by storage for one to two weeks at 5 or 10°C before ripening at 20°C, with or without ethylene treatment before ripening. Our results, reported in past progress reports, corroborate the work in New Zealand of Hopkirk et al (1994), who reported stem end rot and body rot of Hass avocados were significantly reduced by storage for 2 or 3

weeks at 4, 6, or 10°C before ripening at 20°C. They also reported decay reductions did not happen if the fruit were stored at 0 or 2°C, and not if the cold storage period was 4 weeks or longer.

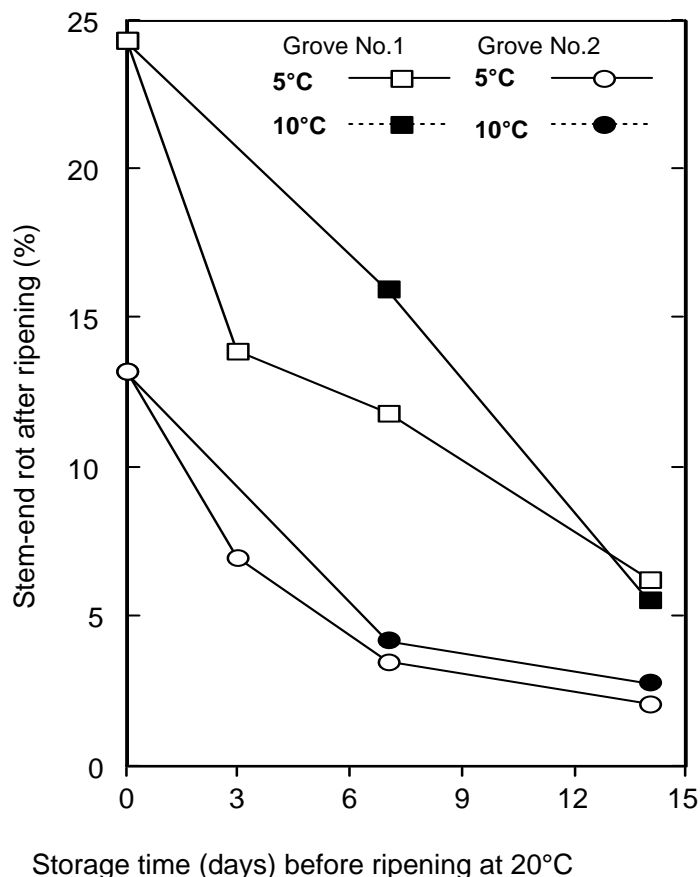


Figure 3. Influence of postharvest storage of avocado fruit at 5 or 10°C before ripening at 20°C on the incidence of stem-end rot at soft-ripe. The test was repeated with fruit from grove no. 1 and no. 2. Each point is the mean stem-end rot percentage of three boxes of 48 fruit each.

We conducted a thermal conditioning test where harvested ‘Hass’ avocado fruit at were stored at 5 or 10°C before ripening at 20°C and determined the incidence of stem-end rot at soft-ripe. Unlike prior tests, we employed briefer storage periods of 3, 7, and 14 days in cold storage before ripening. The test was repeated with fruit from two groves, where of three boxes of 48 fruit each were used for each combination of temperature and storage periods (**Figure 3**). We found reductions of similar magnitude as was found in prior tests. A cold storage treatment of 2 weeks duration was needed to eliminate most of the decay; treatments of 3 or 7 days were less effective. Storage temperatures of 5 or 10°C during this period were equally effective.

3. Evaluation of “snap” and “clip” harvest on postharvest decay.

In 1998, Arpaia and Hofshi reported that among Hass avocados from San Diego County, California, the incidence of stem-end rot (SER) after storage and ripening among ‘snap’ harvested avocados was 15.0% while the incidence among ‘clip’ harvested avocados was 38.3%. They reported the primary advantage of “snap” harvest was a decrease in labor of about 30% to pick fruit and that snap harvested fruit had the same quality as ‘clip’ harvested fruit. Other workers reported SER incidence was reduced when avocados were ‘snap’ harvested (Darvas et al, 1990; Farré, 2000; Johnson and Kotze, 1994), while in New Zealand, which is generally has a wet climate, ‘snap’ harvest increased, rather than decreased, SER incidence and was not an acceptable practice (White, et al. 1998). Arpaia and Hofshi (1998) found ripening rate did not differ among ‘clip’ and ‘snap’ harvested Hass avocados, which corroborated work

by White et al (1998), Eaks (1973), and Farré (2000), but contrasted with others where removal of the stem increased the ripening rate of Hass avocados (Tingwa and Young 1975) or slowed ripening of Fuerte avocados (Darvas et al, 1990). Slower ripening was associated with elevated anthracnose (*Colletotrichum*) incidence (Johnson and Kotze 1994). Harvest during rainy periods is not recommended (Johnson and Kotze 1994), and may impact results when testing 'snap' or 'clip' harvest. Wet fruit are more easily infected by stem end rot and body rot pathogens (Darvas et al. 1990). In our work, we found stem end rot incidence was very low after either 'snap' or 'clip' harvest among summer harvested fruit, while it was much higher among 'snap' than 'clip' harvested fruit picked after a rainy period. Therefore, reasonable conclusions about these methods are: 1) snap harvest has significant advantages during dry harvest periods; and 2) snap harvest should be avoided if harvest is conducted during rainy periods (when harvest should not occur anyway).

4. The impact of postharvest transport and packingline handling on the incidence of postharvest decay.

As reported in a prior report, tests we did in 2001 showed transport to and handling within an avocado packinghouse only slightly increased stem end rot and body rot was not different compared to careful hand packing. However,



recent advances in the technology to quantify physical impacts, in particular miniature, wireless accelerometers that can be placed within fruit, has greatly facilitated characterizing the number and severity of handling impacts experienced by avocados during handling. Missing from our earlier report was quantification of impacts the fruit experienced during handling. The number and force of impacts was quantified with an accelerometer during normal operation of the facility. The accelerometer (see picture; Produce Wizard, PEI Innovations Inc., Charlottetown, Canada) was placed within: 1) a silicone casing that approximated an avocado in size

and weight; or 2) within the enlarged seed cavity of a firm avocado. This fruit was larger than most fruit processed, but a large fruit was needed to contain the accelerometer. To compare the impacts recorded in the silicone body or in avocado fruit, each was dropped eight times from 2 ft and the impacts recorded. Impacts (gravity, \pm SD) recorded by eight drops of 2 ft of the silicone body or in an avocado were 87.4 g (\pm 9.1) or 62.0 g (\pm 14.0), respectively. Processes included tipping the bins to dump fruit onto a flat belt which carried them to dry rotating cleaning brushes, followed by grading table, followed by a weight sizer, then they were distributed to packing stations, and the fruit were packed by hand into the fiber board boxes. Passage of the accelerometer through the packingline was done 5 times. Measurable impacts (> 2 g) occurred at nine locations and were highest at the field bin dump (Table 1). None of these impacts was of sufficient force to cause significant injuries, other than minor surface skin spots or lenticel darkening. Few studies have quantified the influence of handling care and sanitation on the incidence of postharvest avocado decay. Among fruit where the important pathogens require wounds for infection to occur, such as pome or citrus fruit, careful handling and sanitation measures are of great value. Furthermore, pathogens of these fruit produce abundant spores on fruit within the packinghouses, where they are stored for months, and the air-borne spores contaminate the entire facility increasing decay rates. In contrast with pathogens of citrus and apple in packinghouses and storages, the major pathogens of avocado can both enter the fruit through directly through the skin or through wounds (Darvas et al. 1987a, 1987b), they typically infect in the groves, and they don't produce and liberate abundant spores within the packinghouses, so many of the reasons to implement measures to improve sanitation or reduce injuries are probably of less importance in avocado packinghouses. Field management to reduce these diseases currently relies on good orchard hygiene and regular copper fungicide sprays.

Table 1. Gravity ($g \pm$ standard deviation) force impacts measured by an accelerometer encased within a silicone body or an avocado passed through an avocado packinghouse. Each value is the mean of 5 replicates.

Packingline location	Accelerometer placement	
	Within avocado (g)	Within silicone body (g)
Field bin dump	21 \pm 18	27 \pm 13
Drop from flat dump belt to elevator	9 \pm 7	15 \pm 4
Drop from elevator to rotating brush bed	11 \pm 5	19 \pm 2
Drop from brush to grading table flat belt	7 \pm 2	9 \pm 4
Drop to pre-sizer bed at end of grading table	15 \pm 11	12 \pm 1
Drop and turn to elevator to singulator	9 \pm 4	21 \pm 3
Passage under fruit orientation wheel	4 \pm 3	11 \pm 3
Drop from sizer cups into pack stations	3 \pm 2	15 \pm 2

5. Increasing postharvest rot incidence by water applications to trees.

Several large experiments we have conducted have failed to generate much new information because the incidence of naturally occurring postharvest rot was too low to identify treatment effects. Postharvest rot incidence among avocados is greatly influenced by rainfall before harvest. Therefore, we conducted a test to see if water applications within the tree canopy just before harvest could increase the subsequent incidence of rot in storage. Hourly water mist applications were made on two 'Hass' trees for 24 and 48 hours. The water spray was applied in a mist for five minutes every hour and thoroughly wetted the fruit and foliage. Initially and after 24 and 48 hours, 30 fruit were clipped from each tree, for a total of 60 fruit observed from each interval. The fruit were placed at 20°C and each was cut and examined when they had softened to 1 to 2 pounds firmness.

The water applications did not increase body rot incidence (**Figure 4**). It may have increased stem-end rot incidence, although the increase in incidence was not large and there was no increase between 24 and 48 hours of water application, which would be expected if water was responsible for the increased incidence of stem end rot. We can only speculate about why the water applications did not increase the decay incidence very much. It is conceivable the duration of the wet period was too short or the humidity within the canopy was still too low, the water was excessive and washed away spores that were produced during the wet period, or ultraviolet light in bright sunlight killed many of the spores within the canopy.

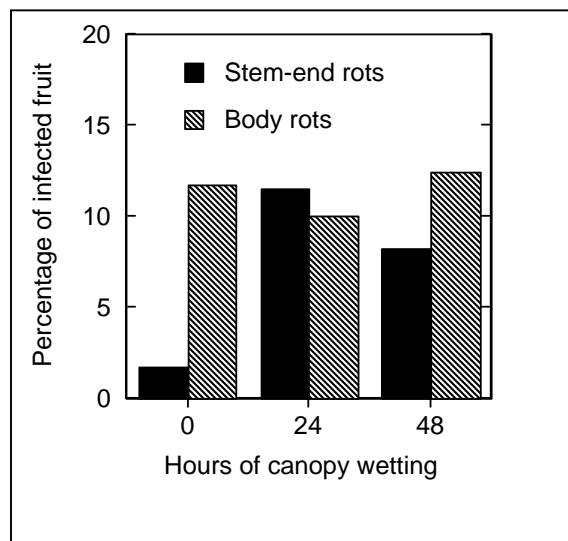


Figure 4. The occurrence of stem end rot and body rots on avocado fruit harvested from trees where water was sprayed into the canopy hourly for 24 and 48 hours. The fruit were harvested, ripened at 20°C, and examined when they had softened to 1 to 2 pounds firmness.

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