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Editor

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POSTHARVEST BROWN ROT CONTROL OF PEACH AND NECTARINE

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Management of postharvest brown rot decay of peaches and nectarines begins with preharvest disease control programs. Brown rot control programs are essential for production of these crops in California.

Currently, the most effective program relies on the use of fungicides applied as dilute or concentrate sprays during bloom and preharvest, as well as postharvest fungicide treatments.

Overview of Disease Cycle. Brown rot can be caused by either *Monilinia fructicola* or *M. laxa*, but in most peach and nectarine orchards in California *M. fructicola* is more common. The disease cycle begins in the spring with blossom infection. Inoculum of *M. fructicola* includes ascospores and conidia. Ascospores are produced for a short period (2-3 wk) in the spring from apothecia that develop on fallen mummies; whereas conidia are formed on mummies and infected peduncles or more rarely from twig cankers. In peach and nectarine, blossom blight results almost entirely from anther infection; whereas, infected petals usually fall off before the pathogen can enter the hypantheum. Symptoms of blossom blight begin with anther necrosis followed by rapid death of the floral tube, ovary, and peduncle. The fungus can grow into the spur or shoot and cause gumming but these tissues are not usually damaged extensively. Once the blossom is killed, the fungus produces abundant, dusty,

buff-colored tufts of conidia on the dead blossom tissues. **These conidia function as a fresh source of inoculum for fruit infections.** In California, any evidence of blossom blight could cause disease levels at harvest to reach epidemic proportions. Quiescence of incipient infections of green-immature fruit may occur, but mature, ripe fruit are more susceptible to infection. Fruit infections begin as dark brown circular lesions that enlarge until the fruit is completely decayed. As fruit become mummified on the tree branch, toxins produced can result in severe dieback of branches.

Environmental Conditions Favoring Disease. The incidence of brown rot is influenced by temperature and wetness periods including rainfall, fog, dew, and irrigation practices. Air-borne ascospores that are only produced for approximately a 2-3 week period in the spring or wind-borne conidia that contaminate plant tissues, can germinate during prolonged wetness periods (>4 hrs) and penetrate susceptible host tissues. Disease development is dependent on temperature. Favorable temperatures for blossom infection begin at temperatures greater than 55^{o}F; optimum temperatures for fungal growth are between 70-75^{o}F.

Fungicide Treatments for Blossom and Fruit Protection. Based on University of California guidelines, two blossom applications should be applied at pink bud (5% bloom) and full bloom (80% bloom). **We do not endorse or make recommendations of fungicides or adjuvants.** Fungicides available include: coppers, sulfurs, ziram, captan (Captan), clorothalonil (Bravo), the sterol biosynthesis inhibitors - triforine (Funginex) and myclobutanil (Rally); the dicarboximides - iprodione (Rovral) and vinclozolin (Ronilan); and the benzimidazoles - benomyl (Benlate) and thiophanate-methyl (Topsin-M). Additionally, localized systemic activity of benomyl or iprodione has been demonstrated with blossom (almond) and fruit (peach and cherry) tissue. For control of brown rot of fruit follow the manufacturer's labeled directions for each fungicide. Benzimidazole-resistant isolates of *Monilinia* and *Botrytis* spp. have been found in stone fruit and nut tree orchards. Currently, dicarboximide resistance has <u>not</u> been detected for *Monilinia* species in California.

Recently, the first two authors have demonstrated that iprodione (dicarboximide) mixed with 1% summer oils (e.g. Omni Supreme Oil) can improve the efficacy of the fungicide for control of brown rot blossom blight and fruit rot (CTFA Annual Report - 1992-93). Oil emulsions increase the solubility and coverage of iprodione on plant surfaces, however, oils alone are not effective for control of brown rot. Evaluations of iprodione-oil mixtures on almond, apricot, peach, nectarine, and prune have shown significant benefits for brown rot control under high disease pressure. Oils are available and labeled for insect control of stone fruit crops at rates of 1-4 gals/A as dormant, delayed dormant, or summer applications. As indicated by manufacturers, do not apply captan or chlorothalonil in combination with or immediately before or closely following oil sprays. Plant injury may occur. Similarly, oil sprays should not be used with, before, or after sulfur treatments. We have used 1% rates of oil (1 gal/100 gal/A) tank mixed with iprodione without any phytotoxicity to blossoms or fruit. We have also tested higher rates such as 4% mixtures (4 gal/100 gal/A) and we have observed some marginal leaf necrosis. Research is ongoing to determine the effects of intermediate rates of oil in combination with iprodione. Characteristics of summer oils preformulated with emulsifiers that minimized plant injury include: Low viscosity (we have tested 70-90 sec oils) and Unsulfonated Residues (UR rating) of greater than 92%.

Non-fungicide Treatments for Fruit Protection.

In 1992-93, we have demonstrated that preharvest calcium treatments (e.g., calcium formate, calcium chloride) applied as non-fungicidal, nutrient fruit sprays of peaches and nectarines (3, 2, and 1 week before harvest) reduce preharvest and postharvest brown rot. Natural incidence of disease is decreased by approximately 50%. In postharvest inoculation studies using *M. fructicola*, severity of disease was also decreased. Calcium treatments maintain the natural host resistance of fruit (CTFA 1991-93; Cling Peach Advisory Board 1991-93). Potentially, these treatments could be integrated with other disease control programs including fungicides. In 1993, calcium formate and iprodione-oil provided the most effective control and was similar to an experimental compound evaluated. In 1994, we will continue to evaluate iprodione-oil treatments, as well as new formulations of calcium that improve penetration of calcium into fruit tissue for brown rot control on peaches and nectarines.

EVALUATION OF SKIN COLOR AS A MATURITY INDEX FOR NEW CHERRY CULTIVARS GROWING IN THE SAN JOAQUIN VALLEY

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Due to high temperatures during the summer months, cherry production in the San Joaquin Valley has been limited by the large production of double or spur fruits. In the last 10 years, new cherry cultivars which do not develop high numbers of double fruits have been introduced in the Fresno area. These varieties are available and some orchards have come into production. As skin color development may be inhibited under warm conditions, we studied the reliability of skin color as an indicator of fruit maturity for these new cherry cultivars growing in the San Joaquin Valley (Fresno area).

PLAN AND PROCEDURES

A study of the reliability of skin color as a cherry maturity index for fruits from 'Brook', 'Garnet', 'Ruby', 'Tulare', 'King', and 'Bing' cultivars was carried out during the 1991 and 1993 seasons. To minimize fruit quality variability induced by location and orchard management, in the 1991 season, cultivars growing in the same orchard were used during the 1993 season.

Sample Collection: During the 1991 season, five healthy trees were randomly selected for each variety. Fruits at different maturity stages determined by skin color were collected during the commercial harvest time. Approximately ten pounds of fruit per maturity stage per tree were collected for each cultivar. Within four hours after picking, fruits were hydrocooled in ice and water for a period not longer than 30 minutes until the fruit flesh reached close to 0^{o}C (32^{o}F). After precooling, fruits were placed in storage at 0^{o}C (32^{o}F) for 20 days for postharvest evaluation. Soluble solids content (SSC), pH and titratable acidity were measured from juice extracted with a food press and filtered through cheesecloth. SSC was measured with a temperature compensated refractometer previously calibrated with distilled water and a 20% sucrose solution. Six grams of juice were weighed into a 100 ml beaker and 50 ml of distilled water added and the pH measured. The sample was titrated with O.1N NAOH to an end point of pH 8.2, the titratable acidity is expressed as percent of malic acid.

During the 1993 season, a comparison of fruit postharvest performance among fruit from different cultivars collected directly from the same orchard was carried out. Fruits were picked and placed into a tray and immediately transported to the F. G. Mitchell Postharvest

Lab at the Kearney Agricultural Center. Fruits were hydrocooled (within four hours) until the fruit flesh reached close to 0°C (32°F) and packed in 20 pound wooden boxes before being placed in storage at 0°C (32°F) for later postharvest evaluation.

RESULTS

Evaluation of skin color as a indicator of fruit quality and storage potential: During our two seasons of this study, the fruit maturity stage determined by skin color influenced the SSC and TA in the different cultivars. An important increase in SSC and a slight increase in TA occurred in 'Brooks', 'King' and 'Tulare' and 'Bing', 'Brooks' and 'Garnet' when fruit changed color from light mahogany to dark mahogany color. In all of the cultivars studied during the two seasons, pH remained stable during the maturation period.

During the 1991 season, `Bing' cherry collected at the USDA minimum maturity color, (red mahogany) had a higher soluble solids content (SSC) than 'Brooks', 'King' or 'Tulare' and the same pH (Table 1). There were no significant differences in the SSC or pH among 'Brooks', 'King' and 'Tulare' cherry cultivars. However, 'Brooks' presented the lowest titratable acidity (TA), 'Bing' the highest and there was no difference in TA between 'Tulare' and 'King'.

Table 1. Fruit quality characteristics at the optimal maturity stage (red mahogany) of four cherry cultivars growing under high crop conditions, San Joaquin Valley, 1991.

Cultivar	SSC (%)	pH	Titratable Acidity (TA)	Ratio (SSC/TA)
Bing	17.3a[z]	3.7a	0.45a	38.8c
Brooks	15.0b	3.7a	0.27c	55.0a
King	14.3b	3.8a	0.32b	44.0b
Tulare	14.7b	3.8a	0.34b	43.4b

[z] Different letters within the column indicate significant differences among the means.

During the 1993 season, SSC and TA also varied among the different cultivars harvested at the red mahogany stage (USDA minimum maturity color) but pH values were stable. 'Bing' presented the highest SSC, followed by 'Brooks', 'Garnet', 'King', 'Tulare' and finally 'Ruby' which had the lowest SSC. 'Brooks' had the lowest TA and 'Bing' had the highest. 'Tulare', 'King' and 'Ruby' were not significantly different from each other but all had significantly lower TA's than 'Garnet' (Table 2).

Table 2. Fruit quality characteristics at the optimal maturity stage (red mahogany) of six cherry cultivars growing under low crop conditions, San Joaquin Valley, 1993.

Cultivar	SSC (%)	pH	Titratable Acidity (TA)	Ratio (SSC/TA)
Bing	18.2a[z]	3.6a	0.35a	52.8c
Brooks	17.6ab	3.6a	0.19d	93.1a
Garnet	17.3ab	3.6a	0.27b	62.9b
King	16.5bc	3.7a	0.24c	68.7b
Ruby	15.4bc	3.7a	0.22c	70.7b
Tulare	16.5c	3.7a	0.24c	68.9b

[z] Different letters within the column indicate significant differences among the means.

In both seasons, 'Brooks' had a significantly higher SSC/TA ratio than 'King' and 'Tulare', while 'Bing' was significantly lower.

During the 1991 season, fruit postharvest quality performance after 20 days at 0°C (32°F) was significantly influenced by the skin color at picking time. Quality comparison among cultivars should not be done due to different locations. For these new cultivars

studied during the 1991 season, the red mahogany stage resulted in a longer storage life than the earlier (solid pink) and the later maturity (dark) stages (Table 3). Increases in the number of soft fruits and pitting incidence occurred on fruits picked at the dark mahogany maturity stage. After a 20-day storage period at 0°C (32°F), about half of the fruit of 'King' and 'Tulare' cherry cultivars picked at the red mahogany stage had become soft and/or presented some type of fruit blemish in contrast to 90% of the fruit when picked at the dark mahogany stage. During our studies, due to fast precooling (within 4 hours) after harvest and gentle handling during harvesting, the percentage of fruits presenting brown stems was not one of the main factors limiting cherry fruit quality after 20 days of storage at 0°C (32°F).

Table 3. Influence of three maturity stages, determined by skin color, on fruit characteristics of different cherry cultivars after 20 days of storage at 32°F, San Joaquin Valley, 1991.

	Fruit Characteristics (%)			
Skin Color	Soft	Shrivelling	Pitting	Green pedicels
Brooks				
Solid Pink	33 a	90 a	13 a	33 a
Red	53 b	53 b	27 b	50 a
Dark	57 b	57 b	40 c	37 a
Tulare				
Solid Pink	53 a	43 a	10 a	27 a
Red/Black	53 a	33 b	23 b	23 a
Black	90 b	10 b	70 c	13 a
King				
Solid Pink	57 a	63 a	17 a	43 a
Red/Black	63 a	60 a	27 a	47 a
Black	80 b	60 a	23 a	37 a

Skin color changes measured after 20 days at 0°C (32°F) storage was dependent on the cultivar and maturity stage at picking time (Table 4). In 'Brooks', fruits picked at the red mahogany stage did not turn dark by the end of the 20 day storage period. This was in contrast to 'King' and 'Tulare' where a large percentage of fruit picked at the light and red mahogany stages changed to the dark color stage. Decay and bronzing was higher on fruit picked at the dark mahogany stage than at the red mahogany stage. Other fruit quality parameters were not affected when the fruit was picked at the red or dark mahogany stage.

Table 4. Percentage of fruits changing color for different cherry cultivars picked at three different maturities after 20 days of storage at 0°C (32°F), San Joaquin Valley, 1991.

Maturity Stage (Skin color)	Solid Pink	Red Mahogany	Dark
Brooks			
Solid Pink	77 a	23 a	0 a
Red Mahogany	0 b	100 b	0 a
Dark	0 b	0 b	100 b
Tulare			
Solid Pink	73 a	27 a	0 a
Red Mahogany	0 b	60 b	40 b
Dark	0 b	0 c	100 c
King			
Solid Pink	50 a	50	0
Red Mahogany	0 b	43	57
Dark	0 b	0	100

Conclusions

1) For the these new cultivars, skin color at harvest is a good indicator of cherry quality under San Joaquin Valley conditions.

2) Skin color during and after storage (retailer) is not a good indicator of high fruit quality for 'King' and 'Tulare'.

3) For these new cultivars, fruits picked at the red mahogany stage assures the longest potential postharvest life.

Shrivelling in fruit picked at the solid pink stage, and decay and bronzing on fruit picked at the dark mahogany stage were the main problems during cherry postharvest storage life. Pitting becomes a problem after a postharvest period of 7 days.

4) Because of fast cooling temperature management conditions, stem browning was not as important as it is under commercial conditions.
5) Postharvest dark color development depended on cultivar and maturity stage at picking time. For instance, 'Brooks' does not develop dark color when picked at the red mahogany stage as does 'King' and 'Tulare'.

OCCURRENCE OF MOLDY CORE AND CORE ROT OF 'FUJI' APPLE IN CALIFORNIA

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Moldy core of apple has been recorded in the United States, Australia, New Zealand, Canada, the United Kingdom, South Africa, and the Netherlands (Spotts, 1990). The most common fungi associated with moldy core and dry core rot are *Alternaria*, *Stemphylium, Cladosporium, Ulocladium, Epicoccum, Coniothyrium*, and *Pleospora herbarum*. Many cultivars of apple are affected, including 'Delicious', 'Golden Delicious', 'Gravenstein', and 'Idared' (Spotts, 1990). However, during late summer to early fall of 1993 moldy core was very common in 'Fuji' apple in the San Joaquin Valley.

Moldy core of 'Fuji' apple was brought to our attention on 1 September 1993 when a grower brought the first samples of suspected infected fruit for diagnosis. Several other samples of 'Fuji' apples from various locations in the San Joaquin Valley were brought into our laboratory later in September and October 1993. After apples were cut in half, isolations were made in petri plates containing acidified potato-dextrose agar (APDA) to culture and identify the pathogen involved. All the infected apples were observed under a dissecting microscope and recorded for the presence or absence of a mite which was detected in most of the apples with moldy core brought to the laboratory on 1 September 1993. We isolated consistently (77 to 100%) from the decayed tissues of 'Fuji' apples several strains of a *Coniothyrium* species. Other fungi isolated were *Alternaria* species (2.4 to 7.9%) and a *Fusarium* species (1.6 to 2.4%). Five samples, representing `Fuji' apples from five different locations, for which systematic counts were made showed a 50, 57, 64, 81, and 86% incidence of the mite. We also examined healthy apples for the presence of this mite in the core area.

The morphology, the mycelial growth, and the spore dimensions (4.5 - 5 6) x 2.3 - 2.5 Φm) of the fungus isolated fit with those described for *Coniothyrium sporulosum* (=*Coniothyrium fuckelii*). Mites were not found in the core area of healthy apples examined, but 83% of these apples had the mite among the floral parts in the calyx area.

Moldy core is distinguished from other apple rots by its growth in the center of the fruit. In other words, the rot starts from the center of the fruit (close to the carpels and seeds) and it progresses towards the outside of the fruit, becoming a relatively dry rot. The moldy core caused by *Coniothyrium* species is characterized by the white or light grey mycelium present in the locules; the white mycelium of the fungus, becoming very distinct particularly as a fine layer on the dark brown seeds. The rot invades the fruit flesh, resulting in a firm rot. Tissues from naturally-

infected 'Fuji' fruit become light to dark brown. Lesions have a distinct edge of lighter brown color while the center of the rot is dark brown. Tissues are firm and spongy, slightly moist, sometimes light brown zones alternating with dark brown zones are obvious. Apples have a distinctive slightly sweet odor when cut open. Occasionally the rot reaches the external surface of the fruit usually, close to the stylar or the stem-end depressions, where the brown discoloration becomes obvious. Juice leaking from the calyx sinus was found in some of the apples which had very advanced core rot. Occasionally, pycnidia of the pathogen can be found on the surface of the carpels and along the calyx sinus. Samples brought to the laboratory in mid October showed a 15% incidence of fruit with pycnidia, primarily on the carpels and along the sinus of the calyx.

Diagnosis in the field. According to observations of apple growers and ours, external symptoms in the field are rare, with the exception that infected 'Fuji' apples have a discolored light yellow color and fall prematurely. Similar premature coloring and dropping of fruit were described in 'Red Delicious' apples in Georgia caused mainly by *Botryosphaeria obtusa*, although such fungi as *Conoithyrium, Alternaria*, and *Fusarium* species were also present (Taylor, 1955). Taylor in 1955 reported another way to distinguish fruit with moldy core is by knocking the outside of a fruit with the index finger. Apples which have moldy core sound like a hallow ball, while healthy fruit sound different (filled mass). In a preliminary experiment, about 40 'Fuji' apples from a commercial packing house were marked as "core-rotted" apples using this method. In addition, 40 more apples were marked as "good" (healthy) apples. When the suspected "core-rotted" apples were cut in half, 90-95% had core rot. When the "good" apples were cut in half only 10-16% had core rot (percent range because we used two replications of 20 fruit for each category). To diagnose moldy core in the field look for external symptoms which can show first in the calyx or the stem depressions. This is because the decay lesions grow as a sphere (since they initiate from the center of the apple). Therefore, because calyx and stem depressions will be reached sooner by the edge of the decay, the rot will show first on either of these areas of the infected apples. Premature yellowing of fruit while the majority of fruit are still green is a diagnostic symptom that can be used to distinguish fruit with moldy core or core rot.

Although we received several samples of 10 to 30 apples from about six different locations in San Joaquin Valley, we consistently (77 to 100%) isolated mainly strains of *Coniothyrium* species and we are under the process of confirming the identification of the species. Fungi that were associated with core rot of 'Starking' apples in South Africa included *Alternaria alternata* (59%), *Pleospora herbarum* (9%), a *Coniothyrium* species (6.5%), and *Penicillium funiculosum* (6%) (Combrink et al, 1985). In California 'Fuji' apples, however, the most commonly isolated fungus from moldy core or core rot was a *Coniothyrium* species.

'Fuji' apple has an open sinus which connects the core out to the calyx floral remnants. The mite that was isolated from 'Fuji' apples was identified to be an acarid, *Tarsonemus confusus*, a member of the family Tarsonemidae. Members of this family are fungivorous, suggesting that perhaps these mites feed on the *Coniothyrium* somehow somewhere and when the mites enter the apple sinus can plant the minute spores of the pathogen in the core area. However, because of the lack of experimental evidence some of the above statements are hypothetical.

Disease Cycle. Essentially we know nothing about the life cycle of this pathogen and the disease cycle is unknown and until we investigate the life cycle of the pathogen we

have to rely on findings in other regions. Wet weather during spring can create conditions favorable for growth and sporulation of the fungi that cause core rot. Although we do not know details about the moldy core distribution in the field, growers reported that the incidence of moldy core was more common in shady areas within the canopy. In one occasion, in 1990 we found a `Granny Smith' apple with lesions on the surface which at that time were tentatively identified as *Coniothyrium* species. In general, *C. sporulosum* is a cosmopolitan species, causing stem blight and cankers in Roseceae plants, especially *Rubus* and *Malus* species (Farr et al, 1989).

Experimental. In a preliminary experiment, 'Fuji' apples obtained from a commercial packinghouse were inoculated with either a spore suspension of *Coniothyrium* or with a suspension prepared from a culture of *Coniothyrium* species contaminated with adults and eggs of *Tarsonemus confusus* mite. Spore suspension contained at least 10^6 spores of *Coniothyrium* per ml solution. Ten to 23 apples were inoculated by injecting the suspension using a 1" (23 G) syringe through the sinus of each apple. Ten non-inoculated, wounded or nonwounded fruit served as controls. None of the wounded or nonwounded, non-inoculated fruit were infected by *Coniothyrium*, however, 65% of the fruit that were inoculated with *Coniothyrium* and mites developed typical moldy core symptoms 25 days after inoculation. Only 28% of the apples decayed after inoculation with a spore suspension of *Coniothyrium* that did not contain mites. Reisolations were made on APDA plates to confirm that decay was caused by the fungus we used to inoculate the apples. Typical colonies of *Coniothyrium* were recovered from 35.7% of the apples showing suspected decay by *Coniothyrium* of those inoculated with *Coniothyrium* spore suspension and mites, and from 20.8% of the apples inoculated with a spore suspension of *Coniothyrium* alone. Reisolation of the fungus inoculated on the apples completes the Koch's postulates for the causal agent of moldy core disease of 'Fuji' apples. Isolations from the core area of non-inoculated fruit revealed no fungal pathogens, with the exception of a yeast, *Aureobasidium pullulans*, which was isolated occasionally.

This preliminary experiment indicates that the mite, *Tarsonemus confusus*, which was found associated with moldy core, may play a role in carrying the spores of the fungus and perhaps in creating small wounds that can facilitate infections by *Coniothyrium*. Research needs to be continued to determine the life cycle of *Coniothyrium* species in `Fuji' apple orchards and discover the way the core area is infected by spores of this pathogen. It is interesting that moldy core or core rot were not recorded in 'Granny Smith' apples in the San Joaquin Valley in 1993. 'Fuji' apples observed in this study and 'Red Delicious' reported by Taylor (1955) apparently are susceptible to core rot because both these cultivars have a characteristic sinus connecting the central core chamber with the calyx cup.

Control. Because we do not know anything about the life cycle of the pathogen, its epidemiology, or its vectors, we cannot propose any effective measures. At least, if mites are responsible in carrying the spores of the pathogen in the core area of 'Fuji' apples, one can assume that controlling the mites may control the disease. One of the growers who brought apples with moldy core for diagnosis, when asked whether he had done something different in 1993 from 1992, mentioned that he had not controlled the mites in 1993.

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WHAT'S NEW WITH APPLES?

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Harvest Maturity Study

The 1993 season marked the beginning of our studies with 'Gala', 'Fuji' and 'Summerfeld' apples to explore the effect of harvest maturity on postharvest storage life and quality. These studies are being conducted with the close cooperation of Wes Asai, Farm Advisor, Stanislaus County. The information this study will generate is needed to enable growers to make informed decisions on harvest dates and storage conditions for these newer apple varieties. It is critical to develop California-based information. Some of the questions we hope to answer include: "Are we sacrificing quality or storage life of 'Fuji' or 'Gala' apples by delaying harvest to improve red color?", "What are the benefits of CA storage for 'Fuji' and 'Gala'?", "What are the postharvest characteristics of 'Summerfeld' apples and how well do they store?".

Each variety was harvested on 4 or 5 dates separated by 10 days from orchards near Modesto. On each harvest date, fruit were picked from trees which had not yet been harvested that season. Harvest periods began before typical commercial harvest and extended beyond commercial harvest periods. At harvest, apples were evaluated for firmness, starch staining, ground color, percent blush, soluble solids and titratable acidity. Presence of watercore or moldy core was noted. Subsamples of fruit were placed into storage at 32^{o}F under air or CA (1.5% oxygen, 1.5% carbon dioxide). 'Gala' apples were removed from storage after 2, 3, 4 and 5 months in air and 4 and 5 months in CA. 'Summerfeld' apples will be evaluated after 2, 3, 5, and 7 months in air and 5 and 7 months in CA. `Fuji' will be evaluated after 3, 5, 7 and 9 months in air and 7 and 9 months in CA.

Each time fruit is removed from storage, firmness is determined. Apples are then ripened 5 days after which they are evaluated for firmness, soluble solids, titratable acidity, ground color, internal quality, decay and physiological disorders (bitter pit and scald). Informal taste tests are also conducted.

Although the tests are not complete, preliminary results provide important information. As we have known, as fruit hang on the tree, red blush and soluble solids increase while firmness, starch and titratable acidity decrease (Table 1). The starch index

(0 to 6), which has been shown to be a useful indicator of harvest maturity for several apple varieties, including 'Granny Smith', does not appear to be useful for 'Fuji' because the starch degrades very early. Most of the starch had disappeared by the third harvest date tested. The starch index could be useful for 'Gala' but it is too soon to know.

Controlled atmosphere storage of 'Gala' apples had several positive effects (Table 2). After 5 months of storage, CA fruit were firmer, maintained higher soluble solids and titratable acidity, and had greener ground color. Comparison between air and CA storage is not yet available for 'Fuji'.

The results for 'Summerfeld' apple are preliminary at this time as there was no previous information for postharvest performance of this apple. While some disorders have been noted such as bitter pit, many of these could be related to the "less than ideal" cultural conditions for the orchard from which this apple is currently available. In taste tests, most tasters preferred this apple to 'Fuji' and 'Gala'. 'Summerfeld' appeared to have higher acidity levels (0.5%) than either 'Fuji' (0.35%) or 'Gala' (0.35%) as well as moderately high soluble solids (14 to 15%).

We hope that this study will continue at least one to two more years to develop a solid foundation of postharvest information for these varieties.

Table 1. Characteristics at harvest of 'Gala' and 'Fuji' apples.

Blush	Firmness (lbf)	% Soluble solids	% Acidity	Starch*	Ground color**	%
'Gala'						
July 8; 100 DFB	23.4	10.2	0.39	0.0	-12.6	16
July 19; 110 DFB	19.1	10.8	0.36	1.2	-8.5	29
July 29; 120 DFB	16.5	13.0	0.31	4.3	-1.2	80
Aug. 6; 130 DFB	13.5	13.7	0.27	5.7	5.6	89
'Fuji'						
Sept. 3; 160 DFB	19.4	14.7	0.42	3.7	-17.1	20
Sept. 13; 170 DFB	17.1	15.3	0.37	4.0	-15.8	36
Sept. 23; 180 DFB	16.2	15.8	0.34	5.4	-13.0	60
Oct. 4; 190 DFB	16.3	16.8	0.28	5.9	-12.3	60
Oct. 14; 200 DFB	16.6	16.7	0.31	5.9	-9.6	77

*Starch: 0 = high starch; 6 = no starch
**Ground Color = Ground color; more negative number = more green.

Table 2. Comparison of 'Gala' apples after 5 months storage in air and CA.

	Firmness (lbf)	% Soluble Solids	% Acidity	Ground Color**

	Air	CA*	Air	CA	Air	CA	Air	CA
July 8	19.8	20.6	13.8	13.6	0.24	0.36	1.7	1.0
July 19	15.6	18.2	12.6	13.3	0.23	0.35	3.3	1.2
July 29	14.6	15.7	13.7	14.3	0.21	0.31	3.6	2.9
Aug. 6	10.9	12.4	13.7	14.2	0.16	0.27	4.0	3.8

* CA = Controlled atmosphere (1.5% oxygen, 1.5% carbon dioxide)
** Ground color: 1 = green; 2 = light green; 3 = light yellow; 4 = yellow.

Controlled Atmosphere and Internal Browning in 'Fuji'

In an effort to determine the cause of internal browning which has been observed in CA stored 'Fuji', Joe Grant, San Joaquin County Farm Advisor, harvested 'Fuji' apples on 4 dates separated by 2 weeks and placed them into CA storage with 2% oxygen and carbon dioxide levels of 0.04%, 1.5% and 3.0%. In 1992, the results suggested that only late harvested fruit would develop internal browning. For this late harvested fruit, internal browning was more severe with higher carbon dioxide levels in the storage atmosphere. Air stored fruit never developed internal browning. To confirm these results, the study was repeated in 1993; however, it is too early to know the results.

Moldy core in 'Fuji'

If you grow 'Fuji', I am sure you know that moldy core was a major problem for California grown 'Fuji' apples in 1993. Isolations were made from apples throughout the state. In nearly every case, the same organism was identified. Pathologist Themis Michailides at the Kearney Agricultural Center identified the organism as *Coniothyrium* spp. This fungus has been described in the past as a core rot organism in apples but is usually not very common. Because it generally has not caused much rot, little is known about *Coniothyrium*. In general, core rot organisms infect at blossom time; however, fungicidal sprays are not always effective. A detailed study of this disease is needed to determine how to reduce decay.

'Granny Smith' storage scald

Efforts are continuing to develop an alternative to DPA for control of storage scald. In 1992, results from short prestorage hot water dips were encouraging. Scald was dramatically reduced in comparison to untreated fruit. However, scald control was not complete, particularly after 6 months of storage in air. The study was expanded in 1993 to include more temperatures and immersion times. The best treatments after 3-1/2 months of storage were 117°F for 10 minutes and 122°F for 5 minutes, both giving almost 100% control. Additional fruit will be evaluated after 6 months of air storage.

PRECONDITIONED KIWIFRUIT RETAIL HANDLING

Carlos H. Crisosto,
Pomology Dept., UC Davis/KAC

Most consumers prefer to purchase kiwifruit which are near full ripeness. On the other hand, when consumers buy unripe kiwifruit and they don't know how to properly ripen them, it is creating a bad reputation for the kiwifruit industry and it is not helping to improve kiwifruit consumption.

In an effort to ensure a high quality ready-to-eat product, many California kiwifruit shippers are preconditioning kiwifruit prior to shipment. This preconditioning program is designed only for fruit shipped in the early season.

Kiwifruit which has been held in cold storage for more than five weeks will not respond to ethylene treatment applied either at the time of shipping or in your own warehouse. After this period, the rate of fruit softening is only temperature dependent.

The success of this preconditioning protocol depends on temperature management and can be controlled by measuring kiwifruit firmness (see kiwifruit firmness testing). A mature kiwifruit is usually harvested and shipped with a flesh pressure (firmness) of 18-14 lbs.

As warehouse managers and retailers are important players in this ripening program, they should be instructed on how to measure fruit firmness, and handling preconditioned or ripened kiwifruit.

1. Preconditioned kiwifruit firmness must be checked upon arrival to the warehouses. Firmness measurement at the shipping time is also advised. Fifteen kiwifruit should be taken from the upper corner box in the pallet. Do not worry if the kiwifruit feel hard when you check firmness by hand pressing. At these levels of firmness kiwifruit still feel hard when hand pressed. Preconditioned kiwifruit should arrive at warehouses (Denver, Indianapolis, Virginia, etc.) with a firmness near 10 pounds but never lower than 5 pounds.

2. Kiwifruit should always be kept at a low temperature and enclosed with liners (lower than 45^{o}F), except if they are going to be consumed within the next 3 days. Based on kiwifruit rotation in your warehouse, kiwifruit softening rate can be controlled by temperature management. Temperatures evaluated in warehouses were in the 40-55^{o}F temperature range.

3. Cooled kiwifruit enclosed with liners should be moved to the retail market before they reach 5 pounds to avoid vibration and impact bruising damage during transport-ation and handling in the warehouse and retail store. Try to keep your kiwifruit enclosed in liners as long as you can.

4. After delivery to the retail store, if the room temperature is near 68-77^{o}F and flesh firmness near 8 pounds, kiwifruit will lose near one pound per day until reaching about 2 lbs. pressure ("optimum eating stage"). As kiwifruit will continue to deteriorate in the display, kiwifruit should be placed in a cool room overnight to prolong their postharvest life. Frequent rotation and placing the softest kiwifruit at the front of the display is advised.

5. Consumers should be informed that preconditioned kiwifruit or kiwifruit ready-to-eat should be refrigerated if they are not to be eaten immediately.

Kiwifruit Firmness Testing at the Retail: A penetrometer is a quick, easy instrument to use to determine kiwifruit firmness. Either a hand-held or drill press-mounted instrument can be used.

1. Take five kiwifruit from the upper corner box in the pallet. Let kiwifruit warm up to near 68^{o}F before taking flesh firmness measurements.

2. Remove a nickel-sized slice of skin on each side-cheek of the kiwifruit with a potato peeler or knife.

3. Hold the kiwifruit against a hard, stationary surface such as a table-top or wall.

4. Slowly force the pressure tester tip *(use the smaller 5/16" tip for kiwifruits)* to the depth of the inscribed line on the end of the plunger. Results are more consistent when the same person always performs the firmness tests.

5. Reset the tester gauge and record each

reading to the nearest half pound.

6. Total the firmness readings and divide by the number of measurements to find the average firmness for the lot.

'FUYU' PERSIMMON STORAGE RECOMMENDATIONS

Carlos H. Crisosto
Pomology Dept., UC Davis/KAC

During this season, I have been asked several times about the proper storage conditions for 'Fuyu' persimmons.

'Fuyu' persimmons completely lose their astringency before harvest and can be consumed, contrary to 'Hachiya', while they are still firm. In general, harvest time is determined according to the fruit color and size. A color chart for 'Fuyu', consisting of 6 color shades, is being used in Japan and New Zealand. The best method of harvesting is to clip the fruit with small clippers (orange clippers) from the tree, leaving the calyx attached to the fruit. It is also possible to snap the fruit from the tree but this practice is not recommended as it may injure the fruit and adjoining shoot. During harvesting and packaging fruit must be handled carefully to avoid bruising, which is likely to result in marking which becomes visible as the fruit ripens. Penicillium, Botrytis and Cladosporium fungi may infect 'Fuyu' persimmons during storage, especially, if the skin has been damaged during postharvest handling.

The optimum cold storage temperature for 'Fuyu' persimmons is 32°F (0°C). According to New Zealand information, 'Fuyu' can be stored for about 2 months, however, this storage period can be shortened if ethylene is present.

Fuyu' persimmons are very sensitive to chilling injury which is expressed by fast fruit softening, flesh browning, translucency (jelly-like consistency) during and after storage. These symptoms appear more severe after 2-4 days at 68°F (20°C) following storage. Chilling injury is more rapid and severe at 41°F (5°C), especially, combined with ethylene exposure. Studies led by Dr. Kader in our department demonstrated that exposure to 1 and 10 ppm ethylene at 68°F (20°C) resulted in accelerated softening to less than 4 pounds (limit for marketability) after 6 and 2 days, respectively. Exposure to 1 and 10 ppm ethylene at 41°F (5°C) will induce fruit firmness below 4 pounds (soft) after 15 and 8 days, respectively. Therefore, ethylene removal and/or exclusion during packaging and storage at 32°F (0°C) operations is strongly recommended for maintaining quality and extending 'Fuyu' persimmons storage life potential.

Studies in Japan indicated that 'Fuyu' persimmons under controlled atmosphere storage conditions can be kept for up to 5 to 6 months. Researchers from Israel claim that commercial persimmon storage was extended from 1.5 to 4.5 months at 32°F (0°C) by modified atmosphere packaging (MAP) in a 0.08-mm low-density polyethylene film. Also, MAP retarded fruit softening and maintained internal and external quality during the subsequent week at 68°F (20°C).

Further studies on the role of ethylene and 'Fuyu' persimmon chilling injury are being carried out by Dr. Kader and Associates at the Pomology Department (Davis). This information will be presented during the First Central Valley Research Update Meeting.

SKIN NITROGEN LEVEL AFFECTS FRUIT RED COLOR AND RATE OF WATER LOSS IN 'FANTASIA' NECTARINE (*PRUNUS PERSICA* L., BATCH, VAR NECTARINE)

Carlos H. Crisosto, Scott Johnson,

Pomology Dept., UC Davis/KAC
Kent Daane,
BioControl, UC Berkeley
Themis Michailides,
Plant Pathology Dept., UC Davis
Gayle Crisosto, David Garner
UC Kearney Ag. Center

During the 1992 and 1993 seasons, fruit red color development decreased as nitrogen increased from 2.09 to 3.48% leaf or from 1.12-1.71% skin. Nitrogen levels did not affect initial and postharvest fruit quality of fruit from 20-year old 'Fantasia' trees picked at the same ground color. However, rate of weight loss for fruit from the highest nitrogen treatment was greater than for fruit from the lower nitrogen treatments. Anatomical studies of mature nectarines indicated differences in cuticle thickness and density between fruit from the lowest, middle, and highest nitrogen treatments. Fruit from the lowest nitrogen treatment had significantly denser cuticles (13.5 $\Phi g/mm^2$) than middle (10.7 $\Phi g/mm^2$) or highest (9.5 $\Phi g/mm^2$).

INFLUENCE OF HARVESTING EQUIPMENT ON FRUIT PHYSICAL DAMAGE

Carlos H. Crisosto,
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Kevin Day,
Farm Advisor, Tulare County
David Garner, Gayle Crisosto,
UC Kearney Ag. Center

Effects of picking containers and bin trailer types on inking and bruise development were evaluated. Dirty nylon bags (DNB) and dirty canvas bags (DCB) induced higher bruising and inking development than clean canvas bags (CCB) and olive picking buckets (OPB) on 'September Red' nectarine. 'O'Henry' peaches picked with clean pick-pack containers (plastic) had nearly half the bruising and inking damage as peaches picked with OPB. Individual pickers affected fruit bruising incidence. On 'September Red' nectarine, the percentage of fruit with bruises varied from 17-31% and the number of bruises per fruit from 0.4-0.7 depending upon the individual picker. Fruit picked early in the day (7:00 A.M.) had more bruising and less inking damage than fruit picked later (9:00 A.M.). Inking incidence was higher on fruit picked into dirty containers during the late picking time. Decay incidence was higher on fruit harvested during the late pick, except when a dirty container (DNB) was used in which case decay was high at both picking times. Fruit hauled within the orchard on rubber axle trailers in painted wooden bins had less bruising than fruit hauled on the standard solid axle trailers. Inking and abrasion damage were not affected by trailer type. Hauling 5 miles or less did not contribute too much to fruit physical damage. Most of the damage occurred during picking, dumping and hauling within the orchard.

CALIFORNIA FUJI TOUR

Beth Mitcham,
Pomology Dept., UC Davis
Carlos Crisosto,
Pomology Dept., UC Davis/KAC

On January 5th through 7th, Gene Kupfermann, Washington State University and Jim Mattheis, USDA, ARS, Wenatchee joined Beth Mitcham, Postharvest Pomologist, UC Davis, Carlos Crisosto, Postharvest Pomologist, UC Davis, Kearney Agricultural Center and Harry Andris, Farm Advisor, Fresno County for an exploration tour of several 'Fuji' apple producing areas. We were joined by Tad Kazuki on several stops. Over the three day period we visited packing-houses in Stockton, Reedley, Sanger and Tulare. At each location we visited with the personnel and discussed California and Washington 'Fuji's. Our visitors from Washington were anxious to know if California 'Fuji' growers had experienced a skin-browning problem that has troubled

Washington State growers. The browning, which is not like sunscald apparently develops on the tree and is therefore different from storage scald. No one in California has reported such a problem; however, the recurring theme for California 'Fuji' growers seemed to be core rot and skin cracking or "checking". Further information on 'Fuji' core rot can be found in this newsletter. Skin cracking has been seen in previous years but appeared to be more severe this past season. The cracking seems to be worse in later harvested fruit and tends to darken during storage. There are several possible causes for these symptoms from injury to the waxy cuticle layer from sprays during fruit development, to over thinning of the cuticle in overmature fruit, or rapid fruit expansion during dry/wet cycles. At this point, we can only speculate.

REDUCING CHERRY PITTING INCIDENCE

Carlos Crisosto
Pomology Dept., UC Davis/KAC

Pitting and bruising incidence were assessed in 'Brooks' cherry growing under San Joaquin Valley conditions. In this year's survey, up to 38% of pitting incidence was already detected on fruit arriving at the packinghouse in our area. This pitting level increased up to nearly 70% during the packinghouse operations.

During harvesting operations, pitting was reduced but not eliminated by gentle fruit handling. In the packinghouse, the incidence of pitting and impact bruising on 'Brooks' sweet cherries was greatest when the flesh temperature was near 1°C (34°F), intermediate near 10°C (50°F), and the lowest near 20°C (50 and 68°F) during packing to minimize surface damage. Due to increased respiration rates at higher temperatures, however, cherries should be cooled to 0°C (32°F) within 4 to 6 hours of harvest.

The following recommendations for reduction of pitting during packinghouse operations were given by Jim Thompson as a result of his work done on 'Bing' cherries:

1) Cluster cutter damage can be reduced by slowing the belt speed or adjusting the tines so they touch the rough top belt. An even better option would be to develop a belt that allowed the tip of the tines to be below the surface that supports cherries. Saw type cluster cutters should be operated at high capacities as often as possible.

2) Shower type hydrocoolers should be designed to minimize the distance between shower pan and the fruit. An 8" distance between the conveyor and the shower pan eliminated pitting damage in one hydrocooler.

3) Use water transfer between a horizontal conveyor and a flighted inclined conveyor. Use smooth conveyor belts whenever it is possible.

4) Do not hand sort boxes after they have been filled, except perhaps to remove poor quality fruit on the surface of the pack.

More detailed information on this subject will be presented by Jim Thompson during the First Central Valley Cherry Workshop Meeting at the Kearney Agricultural Center on April 6.

STONE FRUIT POSTHARVEST RESEARCH UPDATE

Project Title:
Pre- and Postharvest Diseases of Fresh Market Peaches and Nectarines with Emphasis on Postharvest Fungicides

Effecting Decay Control

Dr. James E. Adaskaveg

Postharvest studies. Postharvest treatments for decay control of *Rhizopus stolonifer* were evaluated in laboratory and small scale postharvest treater studies, as well as in a commercial packinghouse. Optimal concentrations of iprodione and wax/oil emulsions were determined for effective decay control. Wax/oil concentrations in combination with iprodione were dependent on the product used but were generally ≥20% (e.g. Decco 251, Brogdex 522M). Iprodione used at a rate as low as 0.50 lb a.i./100 gal in combination with a wax/oil emulsion provided effective decay control similar to a treatment of dicloran at the label rate of 1.3 lb dicloran/100 gal. All emulsions evaluated without iprodione, as well as iprodione mixed with surfactants were not as effective for Rhizopus decay control as iprodione-wax/oil treatments. In commercial packinghouse studies, iprodione-wax/oil mixtures (Rovral 50WP 1 lb a.i./100 gal - Brogdex 522M) that were applied using two reciprocating air-nozzle sprayers provided effective Rhizopus decay control on 'Fantasia' nectarines. Quantitative chemical analyses indicated that the solubility of iprodione was increased in specific wax/oil formulations. Residue analyses were also done for all treatments and indicated that residues on fruit were similar to iprodione alone and did not exceed the established tolerance.

Highlights of 1993 Postharvest Control of Rhizopus Rot

1. In extensive laboratory and postharvest treater tests, as well as in a commercial evaluation using inoculated fruit, the efficacy of iprodione (Rovral 50WP) was dramatically and significantly improved with the addition of wax/oil emulsions (i.e. Decco 251, 255, Brogdex 522, 522M-1993 formulation) to effectively control Rhizopus rot, as well as brown rot Penicillium, Alternaria, and Botrytis decay of stone fruits. Control of Rhizopus rot was similar or equivalent to control obtained using Botran 75WP.

2. For iprodione-wax/oil emulsion: optimal concentrations of wax/oil emulsions (Decco, Brogdex Stone Fruit Waxes) were ≥ 20%; whereas effective concentrations of iprodione ranged from 0.5-1.0 lb ai/100 gal for effective control of Rhizopus rot.

3. Quantitative analytical chemistry indicated that the solubility of iprodione was increased in specific wax/oil formulations (including Decco 251, 255, and Brogdex); while residues on fruit were similar to iprodione alone and did not exceed the established tolerance.

Project Title:
Role of Cutinase in Pathogenicity of the Brown Rot Fungus, *Monilinia fructicola*

Richard M. Bostock, James E. Adaskaveg, Sally Madden

The principal objectives of this project are to 1) characterize and determine the role of cutinase in pathogenicity of *Monilinia fructicola*, and 2) identify factors in the fruit surface of disease resistant peach genotypes that may interfere with fungal penetration and colonization of the fruit. With respect to objective 2, the identification of these factors will help corroborate the proposed relationships between cuticle morphology, chemistry and resistance, and possibly provide biochemical markers useful in peach breeding for disease resistance. This year we have further characterized the *Monilinia* cutinase and anticipate having a purified enzyme preparation within the next few months. Most of the research effort during the past 6 months, however, has centered on development of analytical methods for and characterization of peach fruit phenols. In

this regard, we identified the principal phenols in peach peels as chlorogenic acid, catechin, caffeic acid, epicatechin, and several unknowns. Chlorogenic acid has been shown to be toxic to many fungi and is present at high levels in peach fruit peel and pulp tissue. Chlorogenic acid levels decline during the transition to susceptibility that occurs with fruit ripening. Chlorogenic acid content of the resistant Bolinha fruit is as much as twice that in susceptible genotypes. Chlorogenic acid content may provide an appropriate biochemical marker for disease resistance, but further research will be needed to firmly establish this relationship.

Project Title:
Skin Discoloration on Peach and Nectarine Fruit

Carlos H. Crisosto, Scott Johnson, Guiwen Cheng, Kevin Day, David Garner and Gayle Crisosto

Inking on peach and nectarine fruit has become a frequent problem in the last decade in California, Washington and Colorado, as well as in other production areas in the world such as Italy, Australia, and Chile. Inking symptoms are seen as brown (skin browning), tan, or black spots (black staining) that are restricted only to the fruit skin.

As a result of three years of study, our understanding of inking has been improved. We have demonstrated that physical injury in combination with contamination are essential for inking development. Through our anatomical studies, we determined that the type of physical injury associated with inking was abrasion. The skin cells (epidermal cells), where the anthocyanin pigment is located, were collapsed while the underlying flesh cells (mesocarp cells) remained intact. Physical damage necessary for inking often occurs during harvest and transport operations within the orchard.

We found that iron was more effective than aluminum, copper, tin, zinc, or sodium in inducing inking on abraded fruit. In fact, 10 ppm iron was enough to induce inking at the physiological cell pH. Sound fruit, however, did not develop inking even when fruit were treated with 200 ppm iron or a pH 9 solution for 15 min.

Black staining susceptibility varied among cultivars according to cuticle thickness and it was not associated with the amount of anthocyanins in the skin. However, fruit browning was related to chlorogenic acid levels in the skin.

Our studies focused on the role of exogenous contamination occurring before or after skin injury on inking development yielded interesting results. In general, black spots required exogenous chemical contaminants and this contamination may occur during late fruit development, harvest or packing operations. Our 1993 season data showed that fungicide and foliar nutrient preharvest sprays may be acting as contaminants in inking development. This could explain differences in inking incidence for the same variety growing in different orchards.

Project Title:
Evaluation of New Techniques for Improving Stone Fruit Production, Fruit Quality, and Storage Performance

Kevin R. Day, R. Scott Johnson, Ted M. DeJong, Carlos H. Crisosto, Gayle Crisosto, Harry Andris

In the ongoing `May Glo'/`Sparkling May' high density comparison, the QUAD-V (9'x18') continues to perform as well as the KAC-V (6'x18'). Any differences in fruit size or yield have so far been a function of crop load.

We compared the effect of dormant shoot

heading on fruit size of `May Glo' nectarine. Fruit on unheaded shoots was slightly larger than fruit on headed shoots even with a 10% greater crop load. This may be evidence that heading of hangers should be performed only when necessary to reduce excessive thinning costs.

Preliminary research has shown that fruit position in the tree can be a factor in the amount and severity of internal breakdown on peaches and nectarines. Fruit developing in a high light environment tend to have less internal breakdown than fruit from shaded areas.

Summer pruning treatments tended to reduce soluble solids concentration (SSC), especially in the lower portion of the tree. Despite waiting as many as 11 days between harvests, fruit from the lower part of the tree never achieved SSC as great as those fruit at the top of the tree.

Summer pruning treatments reduced the amount of mealy fruit. Summer pruned trees consistently had less fruit displaying mealy, dry texture. After 20 days in storage, a large number of the fruit from unpruned trees was dry and mealy, especially fruit from the lower portion of the tree canopy. After 35 days in storage summer pruning was still of value in reducing this disorder. Summer pruning also reduced the amount of fruit displaying internal bleeding, but the differences were much less dramatic.

Project Title:

Effects of Nitrogen Fertilization on the Susceptibility of Fantasia Nectarines to Brown Rot and on the Biology of *Monilinia fructicola*

Themis J. Michailides, David P. Morgan, Brent A. Holtz, Hugo T. Ramirez, R. Scott Johnson, Carlos H. Crisosto, Kent A. Daane, Roland Kölliker, Liqun Hou

The objectives of this study were to determine the effects of nitrogen levels resulting from fertilizers on the susceptibility of nectarine blossoms to the brown rot fungus, *Monilinia fructicola.* In addition, we studied the effects of nitrogen fertilization on the biology of the pathogen and investigated whether or not nitrogen fertilization affects the susceptibility of nectarines to four other common postharvest pathogens (*Botrytis cinerea*, *Rhizopus stolonifer*, *Gilbertella persicaria*, and *Mucor piriformis*).

In early March 1993 more than 150 apothecia of *M. fructicola* per acre developed in the `Fantasia' nectarine orchard at the Kearney Agricultural Center. Although nitrogen fertilization did not affect levels of apothecia produced, more apothecia developed on north than south sides of tree berms, the areas where soil moisture was significantly greater. Nitrogen levels affected the levels of natural blossom blight in March and the incidence of infected fruit in July. Incidence of blossom blight and infected fruit increased with increasing nitrogen fertilizer levels (positive, linear correlations). In addition, increased nitrogen fertilization increased the levels of infected thinned fruit found on the ground (positive, linear correlation). Using an Andersen spore trap for 30 minutes (repeated three times) in each area, we found more spores of *M. fructicola* in the high (250-325 lbs nitrogen/acre/year) than in the low (0-100 lbs nitrogen/acre/year) fertilization area.

Nitrogen fertilization affected the efficacy of preharvest fungicide sprays (one or two Rovral or Rovral+Funginex) in controlling brown rot disease in the orchard. Fungicide sprays applied on trees fertilized with high nitrogen levels did not reduce fruit brown rot in the field; in contrast the same sprays applied on trees fertilized with the low nitrogen levels reduced significantly fruit brown rot in the field. Fungicide sprays, however, reduced postharvest brown rot of

noninoculated or inoculated fruit regardless of the fertilization level of trees.

In general, nitrogen did not affect the postharvest decay caused by *Botrytis cinerea, Rhizopus stolonifer, Mucor piriformis,* or *Gilbertella persicaria*, although the two latter postharvest pathogens resulted in smaller decay lesions on fruit from the unfertilized trees.

Project Title:

Evaluation of the Effect of Prestorage Heating and Controlled Atmosphere Storage on Development of Mealiness in Peaches and Nectarines

Elizabeth Mitcham, Carlos Crisosto, Themis Michailides

Mealiness or internal breakdown is the number one cause of consumer dissatisfaction with California peaches and nectarines. Prestorage heat treatments and storage under controlled atmosphere were evaluated for their effectiveness in reducing mealiness development. 'O'Henry' peaches and 'Fairlane' nectarines were selected for their susceptibility to mealiness. Fruit were obtained at harvest, transported to Davis and either heat treated and stored in air or stored under controlled atmosphere. 'Fairlane' nectarines were treated with fungicides while 'O'Henry' peaches were not. Fruit were heated in hot water at 100°F, 104°F or 108°F (`O'Henry' only) for 30, 45 and 60 minutes or in hot air at 104°F for 12, 24, 36 or 48 hours at 90+% relative humidity. After heating, fruit were stored at 41°F for 3 weeks and 5 weeks (`O'Henry') or 6 weeks (`Fairlane') before evaluation. For controlled atmosphere tests, fruit were stored at 41°F and 32°F in either air, 2% oxygen and 5% carbon dioxide or 2% oxygen and 17% carbon dioxide.

Fruit were evaluated for firmness, soluble solids, titratable acidity, heat injury, disease incidence and severity, mealiness, internal browning and bleeding. Decay with brown rot organisms was a tremendous problem for all experiments. Heat treatments significantly reduced decay development, especially for 'O'Henry' peaches which were not treated with fungicides. Hot air treatments were especially effective against decay with 100% control after 24 and 36 hours at 104°F. The decay attacked nearly all control fruit making comparisons after storage difficult.

Only in a few cases were heat treatments beneficial in reducing mealiness, internal breakdown and bleeding and in these cases symptoms were only slightly less than in control fruit. In most cases, heat treatment increased the development and severity of mealiness, internal breakdown and bleeding. Heated fruit remained as firm or firmer than control fruit but had increased amounts of surface browning and cracking in some cases.

Controlled atmosphere storage had mixed results for control of mealiness, internal browning and bleeding. Controlled atmosphere had a more positive effect during storage at 32°F instead of 41°F. In many cases, mealiness was enhanced by controlled atmosphere storage at 41°F. 'O'Henry' peaches had significantly less mealiness after 3 or 5 weeks storage at 32°F in controlled atmosphere. Seventeen percent carbon dioxide was particularly effective at reducing mealiness in these fruit. All controlled atmosphere-stored fruit were firmer than control fruit upon removal from cold storage; however, controlled atmosphere did not show any benefit for decay control in these experiments.

Although heat treatments showed benefits for decay control in the absence of fungicides, there was no benefit in reduction of mealiness and in many cases mealiness was enhanced. Controlled atmosphere storage may have benefits for shipping of export fruit and may reduce mealiness development at 32°F.

Further work on controlled atmosphere is needed to determine the optimum atmosphere for mealiness prevention.

Project Title:
Non-destructive Sensing of Quality Attributes in Peaches and Nectarines

David Slaughter, Carlos Crisosto, Paul Chen, Diane Barrett, Rie Oshii, Michael O'Mahony

The results indicate that near infrared light can be used to predict the soluble solids content in intact peaches and nectarines in 0.25 seconds. Attempts to reduce the measurement time by increasing the diameter of the fiber optic probe were unsuccessful. Since the start of this project, more accurate diode array systems have been developed at a cost of about three times the cost of the system reported here. The improvements of these new systems may allow faster measurements to be made.

Results also indicate that the near infrared measurement can be made without direct contact between the optical probe and the fruit. The non-contact measurements were less accurate, however, with a 5% decrease in correlation and 23% increase in standard error when compared to the contact measurement results. Additional research needs to be conducted to determine the effect of variability in probe to fruit spacing associated with variability in fruit size and shape.

The taste panel results indicate that certain individuals are more sensitive to sweetness in nectarines than other individuals, with trained taste panelists being able to consistently identify sweetness differences as low as 0.5% SSC. The difference in SSC between samples must be 2% or higher for the majority of tasters to be able to consistently identify the sweeter sample. The standard error of the near infrared technique for predicting soluble solids content is about 1% SSC. This level of error is comparable to the level of differences at which the majority of tasters could differentiate sweetness and indicates that the near infrared technique should be suitable for use in a commercial sorting operation.

Project Title:
Combination of Hot Water and Ethanol to Control Postharvest Decay of Stonefruit

Joseph L. Smilanick, Dennis A. Margosan, Delmer J. Henson, Gilbert F. Simmons

Postharvest decay continued to be as severe in 1993 as it was in 1992. In the summer of 1993, eight collections of 40-100 untreated fruit each were stored at 20°C. An average of 52.8% (range 15-100%) decayed during ripening. To control decay, we tested a range of brief treatments (75-150 seconds) of varied ethanol concentrations and water temperatures on peaches and nectarines. The treatments are brief so heating of fruit was minimal. Ethanol enhanced hot water treatment significantly, and reduced decay by as much as 90% compared to controls without any obvious injury to the fruit. It approached or equaled the control provided by iprodione (Rovral) or triforine (Funginex).

In the first year (1993) the most efficacious temperature-ethanol combinations were determined using primarily naturally-infected fruit. In four experiments to optimize ethanol concentration, treatment temperature, and immersion time, treatments of 10% ethanol at 50°C (122°F) for 150 seconds or 20% ethanol at 46°C (115°F) for 75 seconds reduced decay to 21.8% and 24.2%, respectively, from a mean of 80.5% decay among untreated controls. A 60 seconds dip in 1000 ppm iprodione reduced decay to a mean of 17.3%.

We evaluated the influence of these two ethanol treatments on the quality of nine cultivars. The fruit were evaluated after

fourteen days storage at 0°C and ripening for four days at 20°C. Preliminary summaries of the data indicate that surface color, internal appearance, and soluble solids were not influenced by any treatment. No off-flavors or odors were detected. Two late nectarines showed slight surface shrivel; we believe the extraction of natural waxes by the ethanol treatment may have accelerated drying. An unanticipated benefit of the ethanol treatment was a delay in softening during storage. In seven of the nine treated cultivars, fruit firmness was significantly greater after ethanol treatment than in the controls. The ethanol treated fruit were ca. 1 lb. force firmer than water-treated of untreated controls.

The ethanol content of seven cultivars was measured enzymatically within one day after treatment, and after storage at 0-1°C for 14 days followed by 4 days at 20°C. Fruit treated with 20% ethanol at 46°C for 75 seconds had ethanol residues of 535 ∀ 158 ppm and 92.5 ∀ 85 ppm for fruit analyzed within one day and after storage, respectively. Fruit treated with 10% ethanol at 50°C for 150 seconds had ethanol residues of 504 ∀121 ppm and 106 ∀ 125 ppm for fruit analyzed within one day and after storage, respectively.

The combination of ethanol and hot water can control postharvest decay effectively. Heating of fruit was minimal, residues were low and should pose a minimal regulatory issue, and the delayed softening of the fruit may be beneficial. Compared to prior studies utilizing hot water alone (Wells, 1971; Sommer, et al., 1968), equivalent efficacy could be obtained with temperatures as much as 6°C cooler (10.8°F) when ethanol was added. Unlike fungicides, however, the ethanol-heat treatments do not deposit persistent antifungal residues, so protection of fruit from re-contamination is important. Although fruit injury was rare or absent in all tests, evaluation of more varieties, especially early season varieties, is needed. We selected mid- and late-season varieties in 1993 because their natural decay potential was high. Evaluations of these treatments to control *Rhizopus, Mucor,* and *Gilbertella* are planned.

Project Title:

Quarantine Treatments and Strategies to Control Walnut Husk Fly in Stone Fruits for Export to New Zealand

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Quarantine treatments and strategies, including a methyl bromide fumigation, pest-free period, and poor host status of stone fruits were developed to rescind the New Zealand suspension on stone fruit imports from California due to potential walnut husk fly infestations. A 1993 trapping program in five counties of the San Joaquin Valley verified the pest-free period between stone fruit harvest and 1 July when stone fruits could be exported to New Zealand without the risk of walnut husk fly infestations. First emergence of adults occurred after the pest-free period in seven of eight trapping sites. A single adult was collected in a trap prior to 1 July in Fresno County. Peak populations of walnut husk fly occurred in walnut orchards and road side trees after early, midseason, and most late-season stone fruit cultivars had been harvested. The pest-free period, late development of peak populations, and poor host status of stone fruits show that the biological risk is negligible for accidental introductions of walnut husk fly into New Zealand through shipments of stone fruits from California.

Exposure to low temperature storage at 1-2°C for a minimum of 7 days was detrimental to walnut husk fly immatures in green walnuts. An increase in exposure time from seven days to 14 and 21 days was directly related to a decrease in survival of all life stages. The eggs and first and second instars were more susceptible than late third instars. An

increase in exposure time of third instars to low temperatures was related to a decrease in the survival of larvae, a decrease in the number of pupae reared from walnuts, and a decrease in the numbers of viable pupae. Potential walnut husk fly infestations in stone fruits will be adversely affected by low temperature storage which would help reduce the risk of infestations in exported fruit.