

CENTRAL VALLEY POSTHARVEST NEWSLETTER

COOPERATIVE EXTENSION

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Carlos H. Crisosto
Editor

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CAN WE REDUCE POTENTIAL ABRASION DAMAGE DURING THE HARVESTING OPERATION?

C. H. Crisosto

Pomology Department, UC Davis/ Kearney
Ag. Center Parlier

Kevin Day

UC Coop. Ext. Tulare County

'Snow Giant' peaches were harvested on August 10, 1996 by using tote and plastic half-bin (~650 lbs) harvesting systems and a field packed system as a control. The field packed system consisted of picking fruit directly from the tree, packing it in boxes with tray packs (18 fruit), and placing the boxes inside half-bins for transportation from the orchard to the loading area. This system was used as a control because it has been demonstrated that transport in tray packs produces less damage. The tote system consisted of picking fruit from the tree and placing them in clean plastic containers (totes); then they were placed inside half-

bins and transported to the loading area. The plastic half-bin system is the traditional harvest system in which the fruit is picked from the tree into a harvesting bucket, carefully dumped inside the plastic half-bin and transported to the loading area. All of the fruit utilized in this evaluation were transported from the orchard to the loading area (0.8 miles) on a 4-bin trailer equipped with springs for cushioning. The average speed of the tractor did not exceed 6 mph. The road was well paved and in good condition.

Fruit samples were collected directly from the trees (field packed) and immediately after bin dumping. Fruit samples from the two harvesting systems were collected after arrival at the loading area. To evaluate potential abrasion damage at the different steps, four replications of 18 fruit were utilized for each step. The potential abrasion symptoms were considered as inking potential, simulating the case of

contamination with iron in the hydrocooler or wash water during brushing. To measure potential abrasion damage the fruit were submerged for one minute in a solution of 100 ppm of FeCl_3 , then stored for three days at 38°F to permit complete visual expression of the symptoms. The area with symptoms of damage by abrasion was measured with a 10 mm diameter loop (area equivalent to 78.5 mm²) and the areas were added.

Potential abrasion damage and the percent culls were higher in the fruit picked into half-bins and transported to the loading area than the fruit that were tote-picked and transported to the loading area (Table 1). Potential abrasion damage was very low on fruit picked directly from the tree or collected from the bins after dumping. Potential abrasion damage became visible only on fruit samples after their arrival at the loading area. There were no cull problems on fruit sampled before being hauled to the loading area.

Table 1. Potential abrasion damage of 'Snow Giant' peach during the picking operation and hauling within the orchard using the tote and plastic half-bin harvesting systems.

Arrivals	Potential ^y	
	Area (mm ²)	% Culls (area \geq 78.5 mm ²)
Tree	3.4 b	0.0 b
After dumping into half bin	8.9 b	0.4 b
Loading area		
Half bins	47.9 a	20.8 a
Totes	24.0 b	8.4 ab
P-value	0.0069**	0.0480**
LSD 0.05	23.9	16.0

^z Measured with a 10 mm diameter loop (78.5 mm²), equivalent to the maximum area allowed for discoloration.

^y Fruit dipped in 100 ppm FeCl_3 solution for 1 min and evaluated after 3 days at 38°F.

IS SKIN BROWNING IN WHITE FLESH PEACH AND NECTARINE CULTIVARS INDUCED DURING HARVESTING/TRANSPORTATION TO PACKINGHOUSE?

Carlos H. Crisosto, David Garner,
Rodrigo Cifuentes
Pomology Department, UC Davis/
Kearney Ag. Center, Parlier
Kevin Day,
UC Coop. Ext., Tulare County

To determine if skin browning (skin discoloration disorder) was related to abrasion damage produced during the harvesting operation, fruit samples were taken at different steps of the harvesting operation and at different steps during hauling to the packinghouse. Fruit were picked using plastic totes, placed in wooden bins and loaded in a truck (without air bag suspension) to be transported to the packinghouse. Twenty-four fruit of 'Summer Sweet' were sampled for each of the three replicates used per step. Fruit were collected directly from the trees, from the totes after placing the totes in the full size wooden bins, and at arrival to the packinghouse on three different dates. The distance between the orchard and the packinghouse was approximately 10 miles on a paved road. Visual and potential abrasion damage incidence was measured as an aggregate area by using a 10 mm diameter loop. To measure the potential abrasion damage, fruit were dipped in a 100 ppm FeCl_3 solution for 1 min, held for 4 days at 41°F, then evaluated.

There were no culls because of skin browning from fruit collected directly from the trees (Table 1). Low levels of skin browning incidence (% culls) and intensity (area) were measured on fruit picked into totes, but collected after bin loading, before being hauled to the loading point (Table 1). High levels of skin browning incidence and intensity were observed on fruit sampled at arrival at the packinghouse on all three

sampling dates. Under these conditions, the abrasion damage occurring during transportation to the packinghouse was the cause of the skin browning. Since fruit samples were not collected at the loading point within the orchard, it is not possible to conclude if abrasion damage occurring during hauling within the orchard contributed to the cause of skin browning. Loose fruit in the totes during handling and/or dirt in the

totes may also contribute to skin browning. The potential abrasion damage was high on fruit collected at any step during harvesting and hauling, except on fruit sampled directly from the trees. This high potential abrasion damage points out the high susceptibility of this cultivar to skin discoloration development if the fruit comes in contact with heavy metals during postharvest handling.

Table 1. Visual and potential abrasion damage of 'Summer Sweet' peach measured on different arrival dates after the tote-picking operation and truck hauling to the packinghouse.

Arrivals	Visual		Potential ^y	
	Area ^z (mm ²)	% Culls (area ≥ 78.5 mm ²)	Area ^z (mm ²)	% Culls (area ≥ 78.5 mm ²)
Tree	9.0 c	0	1.6 c	4.2
"Totes"	13.1 c	8.3	37.6 c	29.2
Arrival 7/11/96	54.0 ab	45.8	158.7 a	79.2
Arrival 7/12/96	37.6 b	25.0	101.4 b	66.7
Arrival 7/15/96	61.5 a	47.6	94.2	52.4
P-value		0.0001**		0.0001**
LSD 0.05		20.6		40.2

^z Measured with a 10-mm diameter loop (78.5 mm²), equivalent to the maximum area allowed for discoloration.

^y Fruit dipped in 100 ppm FeCl₃ solution for 1 min., and evaluated after 4 days at 41°F.

CAN WE REDUCE ABRASION DAMAGE DURING TRANSPORTATION TO THE PACKINGHOUSE?

Carlos H. Crisosto,
Rodrigo Cifuentes, David Garner
Pomology Department, UC Davis/
Kearney Ag. Center, Parlier

'Snow Giant' peaches were collected on July 29, 1996 using three different harvesting systems: field packed (corrugated box), picked into plastic totes, and picked into plastic half-bins (bulk). The field packed

boxes and totes were transported to the packinghouse inside plastic half-bins. Two plastic half-bins were loaded with totes and field packed fruit in the same bin. In bulk fruit bins, a layer of dense foam (4 inches) was placed on the top of the bins to immobilize the fruit in the top layers. These two half-bins were loaded above the rear axle of the truck (worst position), one in the bottom position (1) and the other in the top position (3). On the other side of the truck, the two half-full bins or totes and field packed fruit were loaded in the same

positions (1 and 3). Each bin was properly marked for ease of recognition upon arrival to the packinghouse. After harvesting, fruit were transported to the packinghouse by using a 48-foot truck equipped with an air bag suspension system. The truck utilized for this transportation test had a total bin capacity of 72 half-bins (12 half-bins long, 2 half-bins wide, and 3 half-bins high). The cargo capacity was approximately 42,000 lbs. The distance from the orchard to the packinghouse was approximately 70 miles; a trip of approximately one hour and fifteen minutes.

Upon arrival to the packinghouse, samples of fruit were collected for evaluation according to the harvesting system (treatment) and the position of the bins during transportation (subtreatment). To evaluate visual and potential abrasion damage, four replications of 36 fruit were utilized for each subtreatment, except for the field-packed treatment in which 30 fruit per replication were used. Half of the fruit from each replication were used for potential and the other half for visual abrasion damage evaluations. Potential abrasion damage was measured on fruit treated with a solution of 100 ppm FeCl_3 for one minute prior to storage. Fruit were placed in storage for four days at 41°F to allow full development of skin discoloration symptoms before evaluation.

There were differences in visual and potential abrasion damage between the different harvesting systems (Table 1). The field packed and tote-picked systems had the lowest visual abrasion damage (none). Under these systems, visual abrasion of 'Snow Giant' peaches was not affected by the position of the bin on the truck. Fruit picked bulk into plastic bins and transported

in bulk bins had more visual abrasion damage and culls (approximately 6%) than the other two treatments. However, there were significant differences between treatments for potential skin discoloration disorder (Table 2). Field packed fruit transported in the top or bottom positions had the lowest skin discoloration incidence; totes picked, transported in the bottom position had intermediate skin discoloration damage. However, totes picked and transported in the top position, and bin-picked regardless of transport position had the highest skin discoloration damage.

According to the results, it was observed that the percent of visual culls were low (0-6%) in spite of a transportation distance of 70 miles. This can be explained by the low susceptibility of 'Snow Giant' to abrasion damage, and/or that the entire harvesting and transportation operation was done cautiously. Bruising damage susceptibility can increase rapidly on riper fruit. Totes and plastic half-bins adequately cleaned and in good condition were used during harvesting. The clean half-bins were carefully dumped. The hauling within the orchard was done with trailers equipped with an improved air bag suspension system. The transport distance to the loading point was short (0.8 miles), on a well-paved road and at a speed no greater than 6 mph. Finally, unloading of the trailer was performed with extreme care.

Based on our work, we can suggest that better visual abrasion reduction during transportation was attained with the field packed and tote-picked systems than with the bin-picked system. However, there was a higher abrasion potential on tote-picked fruit when transported in the top position versus the bottom position (3) on the truck.

Table 1. Visual and potential abrasion damage of 'Snow Giant' peach picked using three harvesting systems measured at arrival to the packinghouse.

Treatment	Visual		Potential ^y	
	Skin browning total ^z (mm ²)	% Culls (area ≥ 78.5 mm ²)	Inking total ^z (mm ²)	% Culls (area ≥ 78.5 mm ²)
Harvesting system				
'Field packed'	1.4 b	0.0 b	1.3 c	0.0 c
'Totes'	5.3 b	0.0 b	18.6 b	5.6 b
'Half-bins'	13.4 a	5.6 a	31.0 a	13.2 a
P-value	0.0001**	0.0032**	0.0001**	0.0001**
LSD 0.05	4.2	3.4	6.4	5.0
Bin Position				
Top (3)	6.1	0.9	19.7 a	7.9
Bottom (1)	7.3	2.8	14.2 b	4.6
P-value	0.4774	0.1756	0.0403**	0.1124
LSD 0.05	3.4	2.8	5.2	4.1
Interaction P-value	0.4975	0.1659	0.0043**	0.2006

^z Measured with a 10-mm diameter loop (78.5 mm²), equivalent to the maximum area allowed for discoloration.

^y Fruit dipped in 100 ppm FeCl₃ solution for 1 min and evaluated after 4 days at 41°F.

Table 2. Potential abrasion damage of 'Snow Giant' peach picked using three harvesting systems and measured at arrival to the packinghouse.

Treatments		Skin discoloration disorder (SDD) (mm ²)	
Harvesting system	x	Bin position	
'Field packed'	x	Top bin position	0.6
'Field packed'	x	Bottom bin position	2.0
'Totes'	x	Top bin position	28.0
'Totes'	x	Bottom bin position	9.1
'Half-bins'	x	Top bin position	30.4
'Half-bins'	x	Bottom bin position	31.6
P-value			0.0043

IS CHLORINE DIPPING INDUCING SKIN BROWNING?

Carlos H. Crisosto, Rodrigo Cifuentes and David Garner,
Pomology Department, UC Davis/ Kearney Ag. Center, Parlier

The influence of different active chlorine concentrations on skin browning incidence (skin discoloration disorder) was studied on 'Snow Ball' peach. Ten fruit were used for each treatment. Treatments consisted of active chlorine solutions of 0, 100, 200 and 400 ppm at pH adjusted to 7.0; and 0 (pH= 5.6), 100 ppm (pH=8.6), 200 ppm (pH= 9.1), and 400 ppm (pH= 9.6). Treatment dipping time was 20 min. Fruit only exposed to air were used as a control. To reduce skin browning variability, brown spots were measured before the dipping treatments (approximately 8 hours after harvest) and 3 days after the dipping treatments. Fruit were stored at 33°F/85% RH before evaluation.

Skin browning was related to water dipping treatments (Table 1). Fruit exposed to air had lower skin browning incidence (27.5 mm²) than fruit dipped in water (106 mm²). This 27.5 mm² skin browning incidence may have been a carryover effect from the abrasion damage that occurred during harvest but its development took more than 8 hours to show up. The pH of the solution was an important factor in skin browning incidence. The 0 ppm solution at pH 5.6 had a higher skin browning incidence (70.7 mm²) than the 0 ppm solution at pH 7.0 (141.3 mm²). Skin browning incidence did not differ between the chlorine concentrations and air (Table 1). However, the chlorine dipping treatments with the pH not adjusted had higher skin browning incidence than the chlorine dipping treatments with the pH adjusted to 7.0. Since dipping increased skin browning, during fruit washing and rinsing, a chlorine dip between 100-200 ppm with the pH adjusted to 7.0 is advised.

Table 1. Influence of different chlorine concentrations on skin browning incidence of 'Snow Ball' white flesh peach.

Chlorine Concentration	♠ (mm ²) ^y
0 ppm ^z	106.0 a
100 ppm	31.4 b
200 ppm	23.6 bc
400 ppm	-2.0 c
P-value	0.0001**
LSD 0.05	29.8
pH adjusted to 7.0	26.5 b
pH not adjusted to 7.0	53.0 a
P-value	0.0145**
LSD 0.05	21.1
<u>pH x chlorine conc. (ppm)</u>	
7.0 x 0	70.7
7.0 x 100	31.4
7.0 x 200	15.7
7.0 x 400	11.8
5.6 x 0	141.3
8.6 x 100	31.4
9.1 x 200	31.4
9.0 x 400	7.9
Interaction	N.S.
P-value	0.108

^z Air control = 27.5 mm².

^y Differences between before and after dipping treatments.

IMPROVING THE RIPENING PROTOCOL FOR WAREHOUSES AND RETAIL STORES

Carlos H. Crisosto,
Pomology Department, UC Davis/
Kearney Ag. Center, Parlier

This is the first year for this project. The rate

of fruit softening (pounds of firmness lost per day) varied according to cultivar and fruit temperature. The rate of softening for peaches and nectarines was high at 25°C, moderate at 20°C and low at 10°C. Some cultivars had a higher rate of softening than others. The rate of softening was lower for plums than for peaches and nectarines. In contrast, white flesh nectarines and peaches had very high rates of softening at 20°C (approximately 4.0-6.0 lbs. lost per day). In addition to measurement with the UC firmness tester (destructive), ripening rates were also measured using a non-destructive firmness sensor (Durofel). It consistently and reliably described changes in fruit firmness during ripening.

Final decay incidence was not affected by the post-packaging temperature regime (transportation/buyer handling). However, the onset of decay was related to the post-packaging temperature. Decay incidence was dependent on factors such as orchard management, postharvest handling, postharvest fungicide application and other practices.

FUNDAMENTAL STUDIES ON STONE FRUIT INTERNAL BREAKDOWN

Carlos H. Crisosto
Pomology Department, UC Davis/
Kearney Agricultural Center, Parlier

This is the second year of a potential 2 year project.

1. Developing a prediction test of IB

Ethylene, ethane and ion leakage determinations were used to detect membrane damage as a consequence of chilling injury in young leaves and shoots. Membrane leakage appears to be the most promising test to measure chilling injury. Changes in susceptibility to chilling injury (IB) during "ontogeny" and "growth" are being studied in peach, nectarine and plum tissues. If susceptibility to IB does not

change during "ontogeny", young leaves could be used to predict fruit susceptibility to IB in a plant breeding program.

2. Describing genetic inheritance of internal breakdown

The susceptibility of flesh browning and mealiness was evaluated in a large population of peach, nectarine, and plum cultivars from different genetic sources. Similar incidences of flesh mealiness and flesh browning were found in fruit with yellow or white flesh, melting or non-melting flesh, and freestone or clingstone types.

3. Developing optimum pre-ripening conditions to reduce IB

To test the influence of controlled delayed cooling treatments on stone fruit internal breakdown incidence, we used 'Summer Lady', 'Elegant Lady' and 'O'Henry' peaches. Delayed cooling periods of 24, 48 and 72 hours at 41, 50 and 68°F was used for this purpose. Delayed cooling treatments at 41 or 50°F for 24 hours were not effective in reducing IB symptoms. In fact, delayed cooling at 41°F increased the incidence of mealiness and flesh browning. However, delayed cooling at 50°F for 48 and 72 hours limited the development of flesh browning and mealiness. Delayed cooling at 68°F was the most effective in reducing flesh browning and mealiness after a subsequent storage period. This work shows the benefits of a controlled cooling delay to limit IB incidence, but it also points out the potential increase in IB incidence by uncontrolled delayed cooling.

4. Studying the potential role of Gibberellic Acid on IB development

Gibberellic acid (GA) applied at different times during the "pit hardening" period were tested for reduction of internal breakdown incidence. GA applied during pit hardening was more effective in delaying IB incidence than: the untreated, GA applied at the beginning of pit hardening, or GA applied at the beginning and during the pit hardening

period. After two weeks of storage a 5 °C (41 °F) fruit treated during the pit hardening period had half as much IB incidence as fruit from the other treatments. However, because of "El Niño" conditions, this trial should be repeated before any commercial recommendation can be made.

5. Developing new IB information

Comparisons between highly susceptible and non-susceptible IB cultivars, and IB susceptible fruit treated to prevent the development of the disorder suggest that polygalacturonase (PG) enzyme malfunction may not be the main cause of IB. Our studies suggest that another enzyme, β -galactosidase, that is active earlier during softening/ripening may have a more important role in regulating mealy texture development than PG.

THE CREATION OF POMOLOGY WEATHER SERVICES FOR CALIFORNIA ON THE WORLD WIDE WEB

Dr. Louise Ferguson
Fruit & Nut Res. and Info. Center
UC Davis/Kearney Ag. Center, Parlier

This is the first year of a 1 year project. Stone and pome fruit trees rely on sufficient chill hours for flowers and leaf buds to develop normally. If the buds do not receive sufficient chilling temperatures during winter to completely break dormancy, trees may develop physiological symptoms such as delayed foliation, reduced fruit set and reduced fruit quality. Growers and industry keep track of chilling hours beginning in November to get a sense of the orchard management practices needed and comparison of past year weather and crop load. In the past, the Fruit & Nut Research and Information Center (FNRIC) and farm advisors were the main source of information for winter chilling hours. The information was distributed through phone calls or data in newsletters which were distributed at different times depending on

the county. This project updated the FNRIC website to include a Pomology Weather Services web page. The web page provides a practical interface with the California Irrigation Management Information System (CIMIS) and selected weather stations to provide direct access to the chilling accumulation information on the World Wide Web, 24 hours a day, seven days a week. Researchers, growers and industry can now access real time chill hours and historic data for comparison. The Web page is located at <http://fruitsandnuts.ucdavis.edu>.

PREDICTION OF BROWN ROT, EVALUATION OF CHEMICALS FOR PRE- AND POSTHARVEST MANAGEMENT OF BROWN ROT AND FUMIGATION OF FRESH MARKET STONE FRUITS

Themis Michailides,
Plant Pathology Department,
UC Davis/Kearney Ag Center, Parlier
James Adaskaveg,
Plant Pathology Department, UC Riverside

Themis Michailides

Principal objectives of our brown rot project were to develop a disease warning system using latent infection as a predictor and to research alternative strategies for current chemical control of pre- and postharvest brown rot. Latent infection of stone fruits by *Monilinia fructicola* was detected using the overnight freezing technique (ONFIT) in 24 of 29 sampled orchards. Preharvest brown rot was observed in the 25 orchards. Monthly data of latent infection are being related to preharvest and postharvest brown rot.

This year we investigated a number of alternative strategies including suppression of secondary inoculum produced on thinned fruit on the ground, biocontrol, fumigation and new chemicals. Since thinned fruit is a significant source of secondary inoculum, we investigated three alternatives for the removal of thinned fruit from orchard floor.

First, sporulation of *M. fructicola* was observed only on 1 of 3,000 thinned fruit in the three orchards. Second, rototilling the orchard floor twice buried 95% of the thinned fruit spread on the ground. And third, cover spray of Rovral at 1 pound a.i. with 50 gallons of water/acre suppressed the sporulation (incidence and intensity) and spore germination of *M. fructicola* on thinned fruit in two of four orchards (no sporulation developed in the other two orchards). However, pre- and postharvest brown rot was low in the two orchards, which might have been due to frequent protective sprays of fungicides.

Nine of more than 35 isolates (mainly *Trichoderma* spp.) tested at 107 spores/ml reduced brown rot severity by 90% on plums.

Fumigants such as acetic acid and propionic acid significantly reduced postharvest brown rot on naturally infected nectarines and peaches. Acetic acid gave better control of brown rot (by 72-93%) than propionic acid (by 18-85%). However, there were no significant differences in postharvest brown rot between fumigated and non-fumigated plums and prunes. This is due to low natural infection of these fruits. New chemicals tested reduced postharvest brown rot at all concentrations tested.

James Adaskaveg

Brown rot blossom blight, quiescent and internal brown rot of fruit, and gray mold of mature fruit caused considerable losses of fresh market stone fruit crops in 1998. High rainfall that extended into late spring and early summer and warm temperatures provided conducive conditions for pre- and postharvest fruit decay. With loss of Rovral (iprodione) as a preharvest treatment on peaches and a postharvest treatment on all stone fruit crops, the only highly efficacious treatment for preharvest management of brown rot are the DMI class of fungicides. Thus, we continued to elucidate quiescent

fruit infections in the life cycle of *M. fructicola* and to develop rapid methods for detection of brown rot of fruit before symptoms are visible to improve timing of management practices and to develop methods for a brown rot risk assessment program for an orchard during the growing season.

A. Epidemiology and management of blossom and preharvest brown rot of stone fruit

New preharvest fungicides that have been recently registered have limited efficacy against gray mold caused by *Botrytis cinerea*. Additionally, because of their rapid degradation and reduced penetration into fruit tissue as compared to older fungicide chemistries, their suppressive activity against brown rot is reduced. Thus, more frequent applications are generally required under conducive environments. New materials are currently being evaluated as protective and suppressive treatments for management of blossom and preharvest fruit diseases of fresh market stone fruit crops. These include strobiluring (e.g., Abound and Flint), hydroxylanilides and DMI compounds (Elite, Break, Rally and Indar). Indar, or fenbuconazole, is expected to be registered in 1999 for preharvest use. Efficacy data is currently being summarized. Other new materials representing new classes of materials are also being evaluated as numbered compounds in laboratory studies. In 1999, EPA plans to restrict all preharvest fruit applications of iprodione on stone fruit crops. Thus, without the development of new classes of fungicides, the potential of resistant populations to develop to the solely registered DMI fungicides is greater than ever.

Detection systems are currently being developed using freezing and molecular techniques. Species-specific primers have been developed for *M. fructicola* and *B. cinerea*. These are currently being evaluated in fruit epidermal tissue. In last year's

studies, fruit extracts interfered with the detection method. Currently, we are developing several methods to circumvent this problem.

B. Postharvest management of brown rot, gray mold, Rhizopus rot and other decays of stone fruit with fungicides

We continue to develop new fungicides for postharvest management of fresh market stone fruit. In 1998, we successfully obtained a Section 18, emergency registration of fludioxonil (Medallion), for apricots, peaches, plums and nectarines in California. We also conducted the IR-4 residue studies for fludioxonil on peaches and nectarine that allowed the Section 18 to be approved by the US-EPA and California Department of Pesticide Regulation (CDPR). The 1998 IR-4 fludioxonil residue studies have been completed. Full registration is expected in one to two years for this "reduced risk" (EPA classification) pesticide. Additionally, we screened new fungicides and identified fenhexamide as an additional material for the IR-4 program to support postharvest use on stone fruit crops. Fenhexamide represents a very effective treatment against gray mold and is also effective against brown rot. Other new materials being evaluated included several strobilurin fungicides such as Abound, Flint and a BASF numbered compound. Although these materials are not as effective at the rates evaluated as other recent fungicides tested (e.g., tebuconazole and fludioxonil) they are effective as wound-protection treatments against other decay fungi such as *Rhizopus* and *Mucor*. Additional studies are currently being conducted in the laboratory to determine effective concentrations for in vitro growth reduction.

TOLERANCES FOR PESTICIDES ON PEACHES, NECTARINES AND PLUMS

Dr. Taka Shibamoto
Environmental Toxicology, UC Davis

This is the first year of an expected 1 year project. The Interregional Research Project No. 4 (IR-4) is an USDA sponsored program to conduct the field and laboratory trials necessary to support pesticide tolerances on minor crops.

The IR-4 has received requests from growers, farm advisors and commodity groups to conduct trials on various crops. IR-4 has determined that the uses of Clopyralid (a postemergence herbicide) and fludioxonil (Medallion, a postharvest fungicide) on peaches, plums and nectarines will address a number of pest management problems associated with these crops. Samples from the trials were harvested and laboratory residue analyses were completed for both materials in the Fall of 1998. Once the final laboratory report is issued, IR-4 headquarters will prepare the final tolerance petition package for submission to EPA to fulfill one of the requirements of the full registration process for these materials.

APRICOTS PRODUCE FACTS RECOMMENDATIONS FOR MAINTAINING POSTHARVEST QUALITY

Carlos H. Crisosto,
Pomology Department, UC Davis/
Kearney Ag Center, Parlier
Elizabeth J. Mitcham, Adel A. Kader
Pomology Department, UC Davis

Maturity Indices:

In California, harvest date is determined by skin ground color changes from green to yellow. The exact yellowish-green color depends on the cultivar. Apricots should be picked when still firm because of their high bruising susceptibility when soft. Most apricot cultivars soften very fast making them very susceptible to bruising and subsequent decay.

Quality Indices:

Fruit size, shape, and freedom from defects

and decay. High consumer acceptance is attained for fruit with high (>10%) soluble solids content (SSC) and moderate acidity (0.7-1.0%). Apricots with 2-3 pounds-force flesh firmness are considered "ready to eat". Apricot cultivars have a rapid rate of fruit softening (3 pounds force per day at 20 °C (68 °F)).

Optimum Temperature:

-0.5 to 0 °C (31-32 °F) is recommended. Susceptibility of cultivars to freezing injury depends on SSC, which may vary from 10-14%. Highest freezing point = -1.0 °C (30.5 °F).

Optimum Relative Humidity:

90 to 95%

Rates of Respiration:

<u>Temperature</u>		ml CO ₂ /kg X hr*
°C	°F	
0	32	2-4
10	50	6-10
20	68	15-25

*To calculate heat production, multiply ml CO₂ kg X hr by 440 to get BTU/ton/day or by 122 to get kcal/metric ton /day.

Rates of Ethylene Production:

Ethylene production rates increase with ripening and storage temperature [$<0.1 \mu\text{l/kg X hr}$ at 0 °C (32 °F) to $4-6 \mu\text{l/kg X hr}$ at 20 °C (68 °F) for firm-ripe apricots and higher for soft-ripe apricots].

Responses to Controlled Atmosphere (CA):

The major benefits of CA during storage/shipment are to retain fruit firmness and ground color. CA conditions of 2-3% O₂ + 2-3% CO₂ are suggested for moderate benefits; extent of benefits depends on cultivar. Exposure to <1% O₂ may result in development of off-flavors and >5% CO₂ can

cause flesh browning and loss off flavor.

Physiological Disorders:

Gel Breakdown or Chilling Injury: This physiological problem is characterized in the earlier stages by the formation of water-soaked areas that subsequently turn brown. Breakdown of tissue is sometimes accompanied by sponginess and gel formation. Fruit stored between 2.2-7.6 °C (36-46 °F) have short market life and lose flavor. Market life is also related to cultivar.

Pathological Disorders:

Brown Rot: Caused by *Monilia fructicola* is the most important postharvest disease of apricot. Infection begins during flowering. Fruit rots may occur before harvest, but often occur postharvest. Orchard sanitation to minimize infection sources, pre-harvest fungicide application and prompt cooling after harvest are among the control strategies.

Rhizopus Rot: Caused by *Rhizopus stolonifer* occurs frequently in ripe or near ripe apricot fruits held at 20 to 25 °C (68 to 77 °F). Cooling the fruit and keeping them below 5 °C (41°F) is very effective against this fungus.

SWEET CHERRY RECOMMENDATIONS FOR MAINTAINING POSTHARVEST QUALITY

Elizabeth J. Mitcham, Adel A. Kader
 Pomology Department, UC Davis
 Carlos H. Crisosto
 Pomology Department, UC Davis/
 Kearney Ag. Center, Parlier

Maturity Indices:

Skin color and soluble solids content (SSC) are the main criteria used to judge fruit maturity. Minimum maturity in California requires that the entire cherry surface have a minimum of light red color and/or 14 to 16% SSC, depending on the variety. The bright, solid red mahogany stage is

recommended for harvest of 'Brooks', 'Garnet', 'Ruby', 'Tulare' and 'King' varieties.

Quality Indices:

Taste is related to SSC, titratable acidity (TA) and the ratio of SSC/TA. Freedom from cracks, bird pecks, shriveling, decay or misshapen fruit (doubles, spurs). Green fleshy stems are often associated with freshness and quality.

Optimum Temperature:

-0.5 ± 0.5 °C (31 ± 1 °F)

Optimum Relative Humidity:

90-95%; high humidity is particularly important to maintain green stem color.

Rates of Respiration Production:

Temperature		ml CO ₂ /kg X hr*
°C	°F	
0	32	3-5
5	41	5-9
10	50	15-17
20	68	22-28

*To calculate heat production, multiply ml CO₂ kg X hr by 440 to get BTU/ton/day or by 122 to get kcal/metric ton /day.

Rates of Ethylene:

< 1 µl/kg X hr at 20 °C (68 °F)

Responses to Ethylene:

Cherry response to ethylene is minimal. Ethylene does not accelerate cherry ripening.

Responses to Controlled Atmospheres (CA):

CA reduces respiration rate and thereby increases postharvest life. Elevated CO₂ suppresses decay development. Modified atmosphere packaging within boxes has been very successful. Successful atmospheres are generally within the following ranges:

3 to 10% O₂

10 to 15% CO₂

< 1% O₂ (can result in skin pitting and off-flavors)

> 30% CO₂ (can result in brown skin discoloration and off-flavors)

Flavor volatiles may be reduced following several weeks of CA storage resulting in fruit of good visual quality but poor sensory quality.

Physiological & Physical Disorders:

Pitting: An indentation in the surface of the fruit caused by the collapse of cells under the skin. Thought to result from impact injury.

Bruising: Results from compression and impact of the fruit.

Postharvest life is closely related to respiration rate. Respiration rate increases as a result of increased temperature and physical injury.

Pathological Disorders:

Brown Rot: Caused by *Monilinia fructicola*, disease can begin in the orchard or postharvest. Pre and postharvest control measures are necessary.

Grey Mold: Caused by *Botrytis cinerea*, a fungus that continues to grow slowly at 0 °C (32 °F).

Rhizopus Rot: Caused by *Rhizopus stolonifer*, a fungus that is found in fruit exposed to temperatures of 5 °C (41 °F) or greater.

Proper temperature management (rapid cooling to optimum storage temperature) can completely control Rhizopus Rot and significantly reduce Brown Rot and Grey Mold. Eliminating injured and diseased fruit from the packed box is important. Fungicide treatments, pre and postharvest are often

beneficial.

WAYS TO REDUCE I.B. INCIDENCE

Carlos H. Crisosto,
Pomology Department, UC Davis/
Kearney Ag. Center, Parlier

One of the most frequent complaints by consumers and wholesalers is the presence of flesh browning, flesh mealiness, black pit cavity, flesh translucency, red pigment accumulation (bleeding), and loss of flavor in apricots, peaches, nectarines, and plums. These symptoms are a consequence of internal breakdown complex (IB) which is also called chilling injury, dry fruit, mealiness, or woolliness. Internal breakdown normally appears during prolonged cold storage and/or after ripening at room temperature following cold storage. For this reason, the problem is usually not noticed until the fruit reaches the retailers and consumers and it is, therefore, affecting the reputation of the California Stone Fruit Industry. We are attempting to establish the appropriate delayed cooling temperature conditions for popular peach cultivars to minimize internal breakdown symptoms.

The main objective was to develop the best "preconditioning/preripening" treatment for the most important peach cultivars. A series of experiments were carried out on 'Elegant Lady' and 'O'Henry' peaches. These are our findings so far:

1. Temperature management is the most important, current commercial tool for reducing IB. Holding/storage at 5°C can result in a significant reduction in peach market life as compared to immediate cooling and storage at 0°C.
2. This work also points out an important loss of market life due to IB symptoms resulting from uncontrolled temperature exposure (delayed cooling) prior to storage at 0°C.

3. Controlled delayed cooling treatments (preconditioning) reduced mealiness and flesh browning development after postharvest handling. However, decay development and excessive softening may be a problem.
4. This preliminary work suggests that delayed cooling should be done at 20°C for the shortest possible, yet still effective length of time, with fruit protected to avoid decay.
5. The length of this preconditioning treatment is perhaps cultivar and seasonally dependent. Thus, further detailed studies on the ideal recipe for other peach cultivars must be pursued before utilizing this technique commercially.
6. Studies on the relationship between delayed cooling and fruit quality with an emphasis on decay incidence and fruit softening must be pursued during a "normal" season.
7. This work in progress points out the importance of peach temperature management very early during postharvest handling (within the first 48 hours).

INFLUENCE OF POSTHARVEST HANDLING TEMPERATURE ON DECAY

Carlos H. Crisosto, David Garner
Pomology Department, UC Davis/
Kearney Ag. Center, Parlier,
Jim Adaskaveg,
Plant Pathology, UC Riverside,
David Parker,
California Tree Fruit Agreement, Reedley

Abstract

Final decay incidence was not affected by the post-packaging temperature regime (transportation/buyer handling). However, the onset of decay was related to the post-packaging temperature. Decay incidence was depending on factors such as orchard management, postharvest handling, postharvest fungicide application and other

practices.

Introduction

The 1998 season was marked by high decay pressure. Due to this, we decided to investigate whether changes in retail temperature management were affecting decay incidence. Also, we wanted to determine whether there was anything packinghouses could do to improve the decay situation.

Materials and Methods

Size 48-60 commercially packed 'O'Henry' peaches were collected from 21 different shippers in Fresno, Kings and Tulare Counties. Twelve shippers contributed both volume fill and 2-layer tray packed fruit. Seven shippers contributed just tray packed fruit, and two shippers just volume fill. Three boxes of fruit from each source and pack type were collected. Boxes of fruit were transported to the F. Gordon Mitchell Postharvest Building at Kearney Agricultural Center for treatment and analysis.

Four fruit from each source and pack type plus control samples were sent to a commercial laboratory (Pent-A-Vate Biological Testing & Research Laboratory, Lindsay, Calif.) for iprodione (Rovral) and dichloran (Botran) analysis. The remaining fruit were separated into the following three temperature treatment regimes:

- A. 32°F for 2 days (simulates shipping facility) + 37°F for 3 days (simulates transportation + 34°F for 3 days (simulates distribution center protocol) + 50°F for 2 days (simulates display on store cool tables) + 68°F for 2 days (simulates home kitchen).
- B. 32°F for 2 days (simulates shipping facility) + 37°F for 3 days (simulates transportation + 50°F for 3 days (simulates distribution center protocol) + 68°F for 2 days (simulates display on store warm tables) + 68°F for 2 days

(simulates home kitchen).

- C. 32°F for 2 days (simulates shipping facility) + 37°F for 3 days (simulates transportation) + 68°F for 3 days (simulates distribution center protocol) + 68°F for 2 days (simulates home kitchen).

Decay incidence was measured at the end of each step of each of the three temperature regimes.

Results and Discussion

Postharvest Temperature Management After Domestic Shipment. Postharvest temperature affected the time of decay expression. Less than 1.0% of the fruit showed signs of decay after simulated domestic shipment (Table 1).

Postharvest Temperature Management After Warehouse Storage. After three days storage at 34°F (Regime A), 50°F (Regime B) or 68°F (Regime C), simulating handling at the distribution center/retail warehouse decay incidence reached 0.9%, 1.6% and 19.3%, respectively (Table 1). At this point in the postharvest handling, moving the fruit to 68°F induced softening as well as decay (19%). There was not a significant difference in the incidence of decay of fruit stored for three days at 50°F versus 34°F (0.9% v/s 1.6%).

Postharvest Temperature Management During Retail Handling. When fruit were transferred from 34°F to 50°F (Regime A), 50°F to 68°F (Regime B) or kept at 68°F (Regime C), simulating retail display, decay increased to 1.4% (Regime A), 11.8% (Regime B), and 42.6% (Regime C), respectively (Table 1). Fruit held at 50°F (Regime A), simulating a back room or cold table remained hard and had a low incidence of decay (1.4%). Fruit that were moved from 50°F to 68°F (Regime B) began the ripening process and decay started to develop slowly (11.8%). For the fruit that

were already ripe (Regime C), decay incidence was very high (42.6%). At this point, lower postharvest temperatures reduced the expression of decay in comparison to the higher temperature regimes. Fruit handled under postharvest temperature Regime A were still hard at this point.

Postharvest Temperature Management During Consumption. When fruit were transferred to a home kitchen situation (68°F), those from Regime B had 42.8% decay and were soft. Fruit handled according to Regime A had only 19.0% decay, but were hard (Table 1). Two days later, fruit handled according to Regime A were soft and decay increased from 19.0% to 45.8%.

Effect of Temperature Regime on "Final" Fruit Decay. The incidence of decay on ripe fruit was not affected by the postharvest temperature regime. Approximately 45% of very soft fruit had decay without regard to any of the three postharvest temperature handling regimes (Table 1). Thus, when fruit were soft, the preceding postharvest temperature regime did not make any difference in decay incidence.

It is important to point out that even though the average rate of decay for the industry was high (45%), 6-12% of the shippers had decay rates of <3.0% on very soft fruit (Table 2). Only 6% of the shippers had decay rates of $\leq 3.0\%$ on fruit handled under Regime A and B, while 12% of the shippers had decay rates of <3.0% on fruit handled under Regime C (fast ripening). When fruit were starting the softening process (step 4), 27% of cold storage samples handled under Regime A had a low incidence of decay. In fruit from Regime B, 42% of the shippers had a low incidence of decay. Finally in fruit from the rapid ripening treatment (Regime C), less than 27% of the shipper's samples did not show decay.

Fruit Fungicide Residues. There was a large variability in iprodione (Rovral) residues among peach samples from the different shippers. Only 18% of the samples (6 samples) were over the 1.5 ppm iprodione residue suggested as a minimum by UC guidelines. Only 33% of the samples (11 samples) were over 1.0 ppm. A similar situation occurred with dichloran (Botran) residues. In this case 27% (9 samples) had ≥ 1.0 ppm residue suggested by UC guidelines as a minimum.

Relationship Between Residues and Decay Incidence. There was a highly significant (P-value = 0.0048) relationship between fruit residues and decay incidence (Table 3). However, fruit residues only accounted for 47% ($r^2 = 0.47$) of the association with decay. This means that fruit residues are important, but other factors are also affecting decay. The fact that fludioxonil (Medallion) was used by some of the packinghouses does not explain this low association. In fact, this 47% association between fruit residues and decay incidence points out the importance of others factors in decay development such as orchard decay control, careful harvesting and handling, good temperature management during packaging, avoiding physical abuse during packaging, maintaining good packinghouse sanitation, etc.

Table 1. Incidence of decay measured at different stages of the three postharvest temperature management regimes.

Regime	Stage	Treatment	Decay
A	1	2 days at 32°F + 3 days at 37°F	0.7
	2	plus 3 days at 34°F	0.9
	3	plus 2 days at 50°F	1.4
	4	plus 2 days at 68°F	19.0
	5	plus 2 days at 68°F	45.8
B	1	2 days at 32°F + 3 days at 37 °F	0.3
	2	plus 3 days at 50°F	1.6
	3	plus 2 days at 68°F	11.8
	4	plus 2 days at 68°F	42.8
C	1	2 days at 32°F + 3 days at 37°F	0.6
	2	plus 3 days at 68°F	19.3
	3	plus 2 days at 68°F	42.6

Table 2. Percentage of packinghouses having $\leq 3\%$ of decay.

Stage	Incidence of Non-decayed Fruit (%)		
	Regime A	Regime B	Regime C
1	93.9	97.0	90.9
2	87.8	81.8	27.3
3	75.8	42.4	12.1
4	27.3	6.0	--
5	6.1	--	--