CENTRAL VALLEY POSTHARVEST NEWSLETTER

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Editor

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JEFF MITCHELL NEW TO ACADEMIC STAFF AT KEARNEY

Taken from South Central Region News
Winter 1995 Issue

Three years as a Peace Corps school teacher in Botswana, Africa, convinced Jeffrey Mitchell to return to the United States and study agricultural science.

Those studies resulted in his appointment in October as the UC Davis extension specialist for vegetable crops based at the Kearney Ag. Center.

In his new position Jeff said he plans to use a team approach to identify research priorities in San Joaquin Valley vegetable crop production and enlist the participation of team members in conducting research.

"I would like to involve farmers with Extension and research staff from the ground floor," he said.

POSTHARVEST DECAY CONTROL

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Postharvest decay control depends on an integrated management approach based on: (1) harvest and handling processes that reduce injuries; (2) sanitation practices in the packinghouse (e.g., fruit disinfestation using chlorinated water, fruit grading or culling, sanitization of equipment); (3) postharvest fungicide treatments; and (4) modified environments that minimize fungal growth and changes in fruit physiology (e.g., temperature management and modified atmospheres). Major postharvest decays of stone fruit crops in California and effective postharvest management practices are listed in Table 1.

Sanitization. Sanitization of the packinghouse is one of the most important aspects of postharvest decay management. Picking containers, fruit bins, and dump tanks must also be washed, cleaned, and surface sterilized. Fruit lines including belts, rollers, and sizers must be kept washed, cleaned, and kept free of plant debris. Chlorine is often used in dump tanks or in hydrocoolers to surface sterilize fruit and equipment. The active ingredient is hypochlorous acid (HOCl) and it can be generated from chlorine gas or from sodium or calcium hypochlorite (50 to 100 ppm). Critical factors in the proper use of chlorinated water include monitoring HOCl concentration and acidity or pH. Hypochlorous acid becomes unstable as pH decreases and the result is the liberation of chlorine gas from the solution. Under alkaline conditions (high pH), little to no hypochlorous acid is formed. Thus, the pH of chlorinated water is usually buffered between 6.8 to 7.4 pH. Another potential problem is the accumulation of organic material that also inactivates the hypochlorous acid. The efficacy of chlorinated water is also dependent on the contact time. Higher concentrations are generally required for shorter contact periods. This treatment reduces the viable inoculum (fungal spores) in water or on fruit surfaces. Limitations of this treatment, however, are its ineffectiveness in sterilizing fungal spores in fruit wounds and its inability to penetrate fruit tissue to eradicate quiescent infections.

Fungicide Treatments. The efficacy of postharvest fungicide treatments depends on several factors including chemical structure, formulation, systemic action, residual half-life, and mixing properties with wax/oil emulsions. Currently, two postharvest fungicides are registered for use on stone fruit crops: dichloran (Botran 75WP or Allisan) and iprodione (Rovral 50WP). These fungicides can be applied as spray or dip treatments. Iprodione is effective against decays caused by *Monilinia*, *Botrytis*, *Alternaria,* and *Penicillium* species; whereas dicloran is highly effective against *Rhizopus stolonifer* but not other *Rhizopus* species. Dicloran has been registered for control of *R. stolonifer* on peaches, plums, nectarines, apricots, and sweet cherries for over 30 years. This fungicide has been used in combination with benomyl (Benlate 50WP), thiophanate methyl (Topsin M), or triforine (Funginex) and more recently with iprodione (Rovral 50WP) as a postharvest treatment of stone fruit crops. Both fungicides penetrate into fruit tissue. Fungal resistance to dicloran or iprodione has not occurred although selection for resistant strains in laboratory tests has been reported.

Previously, no alternatives to dicloran were available for effective control of *R. stolonifer*. Iprodione (Rovral 50WP) can provide some control but its efficacy is significantly less than that of dicloran. In fall 1991, we conducted preliminary studies to enhance the activity of iprodione. Our results in 1992-94 indicated that the performance of iprodione could be enhanced with the addition of wax/oil emulsions for postharvest control of *Rhizopus* rot on stone fruits. Subsequently, our research has also shown reductions in the natural incidence of most postharvest decays caused by *Monilinia, Botrytis, Alternaria,* and *Penicillium* spp. with the use of iprodione-wax/oil mixtures.

In laboratory and packinghouse tests, iprodione mixed with one of several wax/oil emulsions (i.e. Decco 251, 255, Brogdex Peach Wax, Brogdex 522M, and other similar commercial and laboratory preparations) effectively controlled *R. stolonifer*, as well as brown rot, gray mold, and other decays. Optimum concentrations of most waxes evaluated were between 20-50%. Quantitative analytical chemistry indicated that the solubility of iprodione was increased in specific wax/oil formulations (e.g. Decco 251, 255, and Brogdex); whereas residues on fruit only slightly increased compared to treatments with only iprodione and they did not exceed established tolerance. Thus, the improved efficacy of iprodione is attributed to improved solubility and coverage on fruit surfaces. Preliminary studies have also indicated improved efficacy of dicloran in wax/oil combinations. Iprodione-wax/oil mixtures can be used as an alternative to dicloran or in combination mixtures with dichloran for maximum decay control.

In 1994, controlled droplet applications of fungicides were introduced into the stone fruit industry. Preliminary comparisons of high volume (T-Jet) and controlled droplet (CDA) applications of postharvest fungicides indicated the advantages of CDA systems in minimizing excess fungicide application and fungicide waste. Critical control of fungicides and wax/oil volumes applied, however, were required in our studies to equal decay control efficacy of a high volume, T-Jet fungicide application. Two critical factors determining the efficacy of iprodione and dicloran in CDA systems are the amount of fungicide applied to fruit (lb of fungicide/lb of fruit treated) and the coverage of the fungicide preparation on treated fruit.

Based on information from the Rovral 50WP label, 2 lb of Rovral should be mixed in 100 gal of water and applied to 200,000 lb of peaches, plums, or nectarines. This is equivalent to 0.5 lb ai/100,000 lb of fruit. If the average peach weighs 0.25 lb, then two peaches are treated for every milliliter of fungicide preparation. Based on the FIFRA 2(ee) recommendation for Allisan (Sept. 1994), concentrate applications of the fungicide are for 1 gal/30,000 lb of fruit. Again if the average peach weighs 0.25 lb, then 30 peaches are treated for every milliliter of fungicide preparation. If the dilute application is based on 100 gal/300,000 lb of fruit, again using the same average weight of a peach (0.25 lb), then 3 peaches are treated for every milliliter of fungicide preparation. The latter application method is similar to the Rovral label. In a liquid application system, regardless of the redistribution of fungicide using brushes, fungicide efficacy is dependent on adequate coverage by the carrier medium. Furthermore, brush application has never equaled the efficacy of 'T-Jet' spray application of dicloran for Rhizopus decay control of peaches. Thus, rate of fungicide delivery should be based on amount of fruit being treated. Decay control failure in CDA systems or any application system may result when the amount of fungicide used is diluted by the amount of fruit treated or by improper fruit coverage to below adequate residue levels that prevent fungal decay.

Temperature management and modified atmospheres. Temperature management is critical in postharvest handling of stone fruit crops. Cold temperatures slow the growth of fungal decay organisms and maximize the postharvest life of fruit by reducing the rate of respiration. Stone fruit crops can generally be stored at 30-32 F. Some decay fungi, however, have a minimum growth temperature less than 32 F. At these temperatures, several fungi such *as M. piriformis*, *B. cinerea, P. expansum, A. alternata*, and *C. herbarum* can grow over extended storage periods of 3-4 weeks. *M. fructicola* can also grow at these temperatures but the rate is so slow that decay is only seen after excessive storage periods. Other fungi have a minimum temperature of 41 F or higher. Fungi such as *R. stolonifer, G. persicaria,* and *A. niger* are sensitive to low temperatures. For cold storage of stone fruit crops, temperatures should be lowered to below the minimum growth temperatures of these fungi. This can prevent spore germination of cold-sensitive fungi and delay the rapid growth phase of fungal mycelium that has initiated growth and decay. Often the ideals of cold temperature management, however, are not attainable for the duration of storage, transportation, and marketing. Nevertheless, cold temperatures reduce fruit respiration, delay fruit senescence, and maintain fruit physiology that also prevents fungal decay. Thus, harvested fruit should be cooled without delay to 32 F or the lowest temperature tolerated by the crop.

Atmospheres around fruit in storage or transit may be continuously controlled (CA) or modified (MA) without continuous adjustment. Air contains approximately 21% oxygen (O_2) and 0.03% carbon dioxide (CO_2). Generally, in CA or MA systems O_2 is lowered to 2-5%, CO_2 is increased to 10-15%, or both. The addition of 10-15% CO_2 to fruit stored at 41 F affects both host and decay fungus similar to fruit storage at 32 F.

Carbon dioxide is often added to sweet cherries in transit to suppress gray mold and brown rot. Thus, the purpose of CA or MA storage is to slow the rate of fruit respiration and suppress decay. Effects on decay include delaying ripening, senescence, and maintaining fruit health, as well as reducing fungal respiration (similar to the effect on fruit respiration). Often the combination of low O_2 and high CO_2 suppresses respiration, delays fruit ripening, and slows fungal growth more effectively than by the regulation of either gas concentration alone. If oxygen levels are to a low (<2%) or CO_2 levels too high, however, anaerobic conditions may cause fermentative respiration that results in the development of off-flavors in the fruit.

Table 1. Major postharvest decays, causal fungi, and activity of postharvest fungicide treatments for decay control of stone fruit crops.

		Fungicidal treatment				
		HOCl				
Postharvest decay	Decay fungus	Non-wounded	Wounded	Dicloran	Iprodione	Iprodione-oil
Black mold	*Alternaria alternata*	+	-	-	++	++
Gray mold	*Botrytis cinerea*	+	-	+	++	++
Cladosporium decay	*Cladosporium* spp.	+	-	-	++	++
Gilbertella decay	*Gilbertella persicaria*	+	-	-	-	?
Brown rot	*Monilina fructicola, M. laxa*	+	-	+	++	++
Mucor decay	*Mucor* spp.	+	-	-	-	+
Blue-green mold	*Penicillium expansum*	+	-	-	++	++
Rhizopus rot	*Rhizopus stolonifer*	+	-	++	+	++
	Other *Rhizopus* species	+	-	-	-	?

MANAGEMENT OF STONE FRUIT HARVEST AND FIELD OPERATIONS

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The goal of fruit harvesting should be to:

1) Pick fruit at optimum maturity.
2) Transport fruit to the packing facility with no deterioration in fruit quality.

To do this requires proper coordination between human resources, fruit maturity, environmental factors, and technical resources and equipment. An understanding of these factors and their relationship is essential to making the proper management decisions for a given orchard situation.

Harvest Operations

Fruit maturity can be measured by a number of different methods. Unfortunately, many of these methods are destructive, and therefore are of little value in field situations. Fruit background color is a useful, nondestructive method of estimating fruit maturity, and is most easily employed and understood by field workers. Since the proper background color for estimating optimum harvest maturity varies by variety, experience with a particular variety is helpful in making the correct decision.

At the start of a block or variety, accurate, easily understood directions for estimating maturity should be given to the workers. By selecting a few fruit of varying maturity, and demonstrating what maturity level is acceptable or unacceptable, many mistakes can be eliminated. It is good to leave these samples with the crew boss as a reference throughout the day. The value of a good crew boss cannot be overemphasized. This person should be considered essential and integral in the harvesting process. He should be instructed to continually monitor the fruit being picked, as well as the fruit remaining on the tree, to determine if the correct balance is achieved.

Orchard managers should involve the crew boss in all stages of the decision-making process when determining optimum harvest maturity. Doing so will give him greater understanding and experience in the process. More importantly, it will solidify in his mind the importance of his role in harvesting fruit at the proper maturity.

A number of factors can affect how quickly fruits ripen. Trees tend to ripen from top to bottom. This is probably related to the amount of sun they receive. Consequently, fruit on weak trees tend to ripen earlier than on strong trees, as does fruit on summer pruned trees. Fruit on girdled trees ripen earlier than fruit on ungirdled trees. These fruit also tend to ripen more uniformly within the tree from top to bottom. A skillful manager will consider these factors, as well as others, and judge when an orchard should be harvested, and how much fruit can be removed in any one picking.

Because of the complexity of these factors, there is no substitute for experience in making these decisions. This process involves as much art as it does science. Strategies that are effective for one grower may be entirely incorrect for another due to different organizational and marketing situations and tactics. An example of differing strategies is demonstrated by the grower who prefers to harvest five to eight times for each variety, with each harvest 2 to 3 days apart. This is in contrast to the grower who prefers to pick only two or three times, with a longer interval in between. The first grower may decide that he doesn't mind spending the extra money on increased labor because he is getting greater packouts. The second grower may not mind throwing away greater amounts of fruit because he is saving so much on labor.

Most stone fruit operations use picking bags and bins in their harvest operations. There are still a number of growers who pack directly from buckets or field boxes. These growers feel that they can more easily handle fruit of higher maturity through this method. Regardless of the system used, a number of precautions should be taken with any harvest operation.

Pickers should be instructed to treat the fruit as gently as possible at every stage of the harvest process. When emptying bags into the transport bins, care should be taken to ensure that the fruit are not dumped into the bin from a high height. Again, this is where the crew boss is helpful in reducing problems.

Picking bags and buckets should be kept clean. There appears to be a relationship between "ink staining," dirt, and surface abrasion. Washing picking bags at regular intervals may be helpful in reducing this problem.

After harvest, but while still in the field, fruit should be protected from heat and direct sunlight. Insulated bin covers are the most helpful, but any type of shading is beneficial. Some growers use cloth coverings to protect the fruit. On very hot days, cloth coverings should be supported above the fruit because direct contact can allow enough heat to pass through to cause fruit scald.

Transport Operations

Tractor drivers should be instructed to drive slowly and smoothly. Severe fruit damage can result from poor driving practices, especially on turns and starts. It appears to be beneficial to use "suspension-type" bin trailers instead of solid axle trailers. These trailers tend to ride more smoothly. Similar results can be obtained to a lesser degree by lowering tire air pressure. Both of these procedures are probably more helpful for road transport conditions than for field transport.

Unloading of trailers should also be performed as gently as possible. Care should be taken to educate workers as to the importance of this process. It is helpful if the unloading area is smooth and spacious to eliminate bumping and jarring.

After harvest, fruit should be transported to a cooling facility as quickly as possible. If there is a delay in transportation, fruit should be stored in a cool, shaded area. Temporary structures near the harvest location are often constructed from shade cloth material. Care should be taken while the harvested fruit is being loaded for transport to the packing facility. Forklift drivers should be informed of the importance of treating fruit gently when loading and unloading.

During transport, drivers should do everything possible to reduce and eliminate jarring and bouncing. By choosing proper routes, and avoiding rough, bumpy roads, transportation injury can be better controlled. Position of fruit on the trailer is also important. Vibration levels within the bin are highest at the front of the trailer, intermediate in the rear, and lowest in the middle of the trailer. The addition of air-suspension systems to trailers has been shown to be of tremendous value in reducing this type of fruit damage. Plastic bin liners and padded bin covers have also been demonstrated to reduce transport injury. Research has shown that thick bubble padding is more beneficial than thin, and that larger bubbles are preferred to small.

There are three types of damage which can occur during harvest and transport: impact bruising, compression bruising, and abrasion/vibration bruising. Impact bruising is the result of dropping, bouncing, or jarring. Compression bruising occurs primarily when bins are overfilled and stacked, and fruit is "crushed" against each other. Abrasion bruising results from fruit rubbing against each other or against container surfaces. Proper fruit handling and transport will reduce these types of injury, and contribute to the production of a high-quality final product.

Suggested practices

The results discussed above coupled with other work and observations have led to the following suggestions:

1. Avoid extended forklift movement of bins through the field from point of harvest to loading site.

2. Supervise truck or trailer loading to avoid rough handling or dropping of bins or lugs.

3. Grade farm roads to eliminate ruts, potholes, and bumps.

4. Where necessary, route truck movement to avoid public roads that are in poor conditions.

5. Restrict transport speeds to a level that will avoid free movement of fruit. This may require different speed limits on different roads.

6. Use suspension systems on all transport equipment. Consider installing air suspension systems on all axles of transport equipment--tests have shown that this reduces damaging motion as well as fruit damage by more than 50 percent.

7. Reduce tire air pressure on transport vehicles to reduce motion transmittal to the fruit.

8. Install plastic liners inside the bin. Bottom liners are not needed. Plastic bubble liner material, fastened to bin sides with bubbles facing the fruit, performs well. Side vents can be cut in the liners to match those on the bin sides.

9. In difficult situations, such as long-distance transport, top bin pads can further reduce damage. These are pieces of light (3/8 inch or 10 mm) plywood cut to fit inside the bin, faced with a double layer of 2-inch (13-mm) thick bubble liner, and held against the fruit by short rubber trucker straps.

REDUCING CHERRY DAMAGE IN PACKINGHOUSE OPERATIONS

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Laboratory Tests:
Carefully controlled experiments showed that as flesh temperature decreases, Bing cherries are more susceptible to pitting (caused by impact to a rough surface) and bruising (caused by slowly pushing a steel sphere against the fruit). Fruit treated with gibberillic acid was more susceptible to pitting and bruising than untreated fruit. A test in a single growing region in Washington showed that cherries vary greatly in their susceptibility to pitting damage.

Packinghouse tests:
Cherry damage tests were conducted in ten Bing cherry packinghouses during the 1993 and 1994 seasons. Houses were located in California, Oregon and Washington. The results allowed us to make the following conclusions:

1. Most cherry bruising occurs before the fruit reach the packinghouse. An average of 19% of the fruit was bruised when it arrived at the packinghouse. Packing operations bruised 10% of the fruit.
2. An average of 35% of the fruit arriving at the packinghouse was pitted.

3. Packing operations caused more pitting than bruising damage and pitting levels varied greatly depending on the design and operation of the packinghouse equipment.

4. Cluster cutter pitting damage can be reduced by slowing the belt speed or increasing the fruit throughput. Installing variable speed controller would allow the cluster cutter operator to minimize the speed and still obtain good fruit throughput. Saw type cutters should be operated at high capacities whenever possible.

5. Shower type hydrocoolers with high water drop heights cause fruit pitting and bruising. Hydrocoolers should be designed to minimize the distance between the shower pan and the fruit.

6. Immersion type hydrocoolers do not cause significant amounts of pitting damage.

7. Diverging roll sizers cause little pitting damage but may cause some bruising damage to small sized fruit.

8. Cherries falling 10" to a cleated conveyor belt are subject to pitting.

9. In all packinghouse operations except for the cluster cutter, fruit throughput rate is not correlated with pitting damage.

KIWIFRUIT TEMPERATURES AND RIPENING

Taken from Ripening Guidelines
for Kiwifruit Receivers
Research conducted by the
University of California, Davis/KAC
for the California Kiwifruit Commission.

If you receive kiwifruit which has not been pre-conditioned, but their firmness is below 10 lbs. and/or held in cold storage longer than 5 weeks, fruit softening (ripening) can be handled just by temperature management. Temperature conditions for kiwifruit during storage treatment should be adjusted according to your anticipated marketing/selling schedule. The fruit flesh softening rate of kiwifruit which has not been pre-conditioned is about 2.0 lbs. per day when exposed to 68^{o}F. Softening can be slowed down when fruit is stored at temperatures below 45^{o}F.

STEPS TO RIPEN PEACHES AND NECTARINES FOR RECEIVERS

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Because stone fruit are a climacteric fruit, they are harvested when they reach a minimum or higher maturity, but are not completely ripe. Completion of the ripening process must occur before consumption to satisfy consumers. Most consumers will be satisfied after eating ripe peaches and nectarines and they will return to buy again, thus, increasing your sales. However, when consumers eat even high quality but unripe peaches and nectarines, they will not be satisfied and the consumers will wait a long time before buying again, therefore, your sales will not increase.

In response to this important industry concern, the California Tree Fruit Agreement (CTFA) in cooperation with the Pomology Department (UC-Davis/Kearney Agricultural Center) have prepared this protocol designed to properly ripen peaches and nectarines for warehouse and produce managers. We do not recommend carrying out ripening at the production point because of rapid softening, water loss, bruising and disease susceptibility of stone fruits.

1. Checking the Initial Fruit Ripeness

Flesh firmness is the best indicator of stone fruit ripening and one predictor of their potential shelf life. A penetrometer is a quick and simple device to determine fruit firmness. Either a hand-held or drill press-mounted instrument can be used. The drill press-mounted instrument is recommended for accuracy and consistency. Fruit which reach 2-3 pounds flesh firmness are considered ripe, therefore, "ready-to-eat." Fruit which arrives in your warehouse or retail store should be tested for flesh firmness using a standard fruit penetrometer with an 8.0 millimeter (5/16 inch) tip. This initial firmness value and your fruit rotation will determine your ripening management.

A) Upon arrival to the warehouse, select twenty fruits and place them to warm up at 68°F (room temperature) before taking flesh firmness readings.

B) Remove a nickel-sized slice of skin on each side-cheek of the fruit with a knife or potato peeler. Hold the fruit against a hard, stationary surface such as a table top or, if you are using the drill press-mounted system, the base.

C) Slowly and constantly force the pressure tester tip into the fruit to the depth of the inscribed line on the end of the tip. Measurements are more consistent when the same person always performs the firmness tests. Reset the tester gauge and record each reading to the nearest half pound.

2. Communicating with Your Merchandisers

Find out the anticipated consumption schedule (fruit turning schedule) for these arriving fruit before starting your fruit ripening and/or establishing your temperature conditions. Establish your ripening protocol according to this anticipated consumption schedule.

3. Determining the Rate of Softening

The rate of fruit softening (lbs firmness lost/day) varies among peach and nectarine cultivars and is controlled by temperature. A high rate of softening is achieved at 68° to 77°F and a low rate of softening is accomplished by using lower temperatures (Table 1). Temperatures higher than 77°F will reduce the rate of softening, induce off flavors and irregular ripening. This general guideline information (Table 1) was developed under our experimental conditions, therefore, these softening rates may vary according to physiological maturity stage and environmental conditions during ripening.

4. Fruit Ripening Conditions

Peaches and nectarines harvested at or higher than the "California Well Mature Stage" do not need ethylene exposure to ripen properly because fruit softening is temperature dependent. In fact, exogenous ethylene application will not accelerate California well mature peach and nectarine fruit ripening.

Adequate air circulation within the room to assure uniform fruit temperature is desired. Pallets should be placed at least 18 inches from the room walls and six inches from each other to provide good air circulation. High humidity around the fruit during the ripening process, preferably 90%, to prevent fruit shrivel is necessary. It is also important to assure that carbon dioxide produced by the fruits does not accumulate in the room by using continuous air exchange or by opening the room for an air change.

5. Calculating the Number of Days to the Transfer And/or "Ready to Eat" Points

For example, if your 'O'Henry' fruit arrived at your warehouse with a cheek firmness of 12 pounds and according to your merchandiser department they need to be "Ready to Eat" in 6 days. Because 'O'Henry' has a rate of softening of 3.7 lbs/day at 77°F, 2.2 at 68 °F and 1.5 at 59°F (Table 1), by using the formula below you will find out that, it will take close to 3.0 days at 77°F, 4.5 at 68°F or 7.0 days at 59°F.

$$\text{Number of Days at (F) to Reach the Transfer Point} = \frac{\text{Initial firmness (lbs) - Transfer point (lbs)}}{\text{Rate of softening at (F) (lbs/day)}}$$

As the relationship between fruit firmness and bruising indicate that soft fruit are more susceptible to bruising than hard fruit, to reduce physical damage occurring during the transportation and handling at the retail point, we recommend moving fruit to the retail store before fruit reaches 6 pounds (Transfer Point). The establishment of 6 pounds as the Transfer Point is based only on our previous experience with fruit damage during harvesting, hauling, and packaging and in our laboratory tests. As bruising incidence varies among different retailer operations and among cultivars, you should develop your own Transfer Points for your conditions.

Thus, to meet your merchandiser department's request, these 'O'Henry' fruit should be delivered to the retail store by 2 days after arrival if they were placed at 77°F, 3 days if they were at 68°F and 4 days if they were at 59°F.

6. Controlling the Rate of Softening

Careful temperature and flesh firmness control are the key to success in this ripening program. If you want to slow down your ripening because of changes in your rotation time, place your fruit at a lower temperature. For example, moving your 'O'Henry' to 68 or 59°F, they will reach 6 pounds by 5 and 7 days, respectively.

7. Keeping Record

Start to develop your own information for your specific cultivars, ripening conditions and stores. Write down your rates of softening, transfer points, fruit arrival to your different stores, decay incidence, physical damage, consumer reaction to "Ready to Eat" fruit etc. This information will be extremely valuable to improve your ripening program in the future.

Table 1. Rate of fruit softening for different peach and nectarine cultivars grown in California.

Cultivar	Rate of Softening (lbs/day)		
	59°F	68°F	77°F
NECTARINE			
Armking	2.2	>3.3	4.4
Armqueen	2.2	>3.3	4.4
August Red	0.9	1.3	1.7
Aurelio Grand	2.2	>3.3	4.4
Autumn Grand	1.0	1.5	2.0
Early Sungrand	2.2	3.3	4.4
Fairlane	1.5	2.2	2.9
Fantasia	1.5	2.2	2.9
Firebrite	1.5	2.2	2.9

Flamekist	1.3	2.0	2.7
Flaming Red	1.1	1.7	2.3
Flavortop	1.5	2.2	2.9
Gold King	0.9	1.4	1.9
Granderli	1.5	2.2	2.9
Independence	1.5	2.2	2.9
July Red	1.3	2.0	2.7
June Glo	1.7	2.5	3.3
Late Le Grand	0.9	1.4	1.9
Le Grand	1.5	2.2	2.9
May Diamond	1.7	2.5	3.3
May Glo	2.2	3.3	4.4
May Fair	1.5	2.2	2.9
May Grand	1.7	2.5	3.3
Moon Grand	1.5	2.2	2.9
Red Diamond	0.5	0.8	1.1
Red Free	1.5	2.2	2.9
Red Grand	1.5	2.2	2.9
Red June	1.5	2.2	2.9
Regal Grand	0.5	0.7	0.9
Royal Giant	1.5	2.2	2.9
September Grand	2.2	>3.3	4.4
September Red	0.6	0.9	1.2
Sparkling Red	1.7	2.5	3.3
Spring Grand	1.5	2.2	2.9
Springred	1.7	2.5	3.3
Summer Diamond	2.2	3.3	2.9
Summer Grand	0.5	0.7	0.9
Summer Red	0.9	1.4	1.9
Sun Grand	2.2	>3.3	4.4
PEACH			
Angelus	1.5	2.2	2.9
Autumn Gem	0.5	0.7	0.9
Belmont	1.3	2.0	2.7
Calred	1.5	2.2	2.9
Carnival	1.5	2.2	2.9
Cassie	3.4	5.0	6.6
Coronet	2.2	>3.3	4.4
Early Coronet	1.5	2.2	2.9
Early Fairtime	2.2	>3.3	4.4
Early O'Henry	1.5	2.2	2.9
Elegant Lady	1.7	2.5	3.3
Fairtime	2.2	>3.3	4.4
Fay Elberta	1.5	2.2	2.9
Fayette	1.5	2.2	2.9
Firered	0.5	0.7	0.9
Flamecrest	0.5	0.7	0.9
Flavorcrest	1.5	2.2	2.9
Fortyniner	2.2	>3.3	4.4
June Lady	1.5	2.2	2.9
Kings Lady	2.2	3.3	4.4
Lacey	1.1	1.7	2.3
Maycrest	1.5	2.2	2.9
Merricle	1.5	2.2	2.9
Merrill Gemfree	1.3	2.0	2.7
O'Henry	1.5	2.2	2.9
Pacifica	1.5	2.2	2.9
Pageant	1.5	2.2	2.9
Parade	1.5	2.2	2.9
Redcal	1.5	2.2	2.9
Redtop	1.9	2.9	3.8
Regina	1.5	2.2	2.9
Royal Gold	2.2	>3.3	4.4
Ryansun	1.7	2.5	3.3
Sparkle	1.7	2.5	3.3
Springcrest	1.3	2.0	2.7
Springold	2.2	>3.3	4.4
Spring Lady	1.3	2.0	2.7
Summer Lady	1.1	1.7	2.3
Summerset	0.5	0.7	0.9
Suncrest	2.2	>3.3	4.4
Windsor	0.5	0.7	0.9

STEPS TO RIPEN PLUMS FOR RECEIVERS

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Because plums are a climacteric fruit, they are harvested when they reach a minimum or higher maturity, but not completely ripe. Completion of the ripening process must occur before consumption to satisfy consumers. Most consumers will be satisfied after eating ripe plums and they will buy again, thus increasing your sales. However, when consumers eat even high quality but unripe plums they will not be satisfied and the consumers will wait a long time before buying plums again, therefore, your sales will not increase.

In response to this important industry concern, the California Tree Fruit Agreement (CTFA) in cooperation with the Pomology Department (UC-Davis/Kearney Agricultural Center) have prepared this protocol designed to properly ripen plums for warehouse and produce managers. We do not recommend carrying out ripening at the production point because of rapid softening, bruising, water loss and disease susceptibility of plums.

1. Checking the Initial Fruit Ripeness

Flesh firmness is the best indicator of plum ripening and one predictor of their potential shelf life. A penetrometer is a quick and simple device to determine fruit firmness. Either a hand-held or drill press-mounted instrument can be used. The drill press-mounted instrument is recommended for accuracy and consistency. Plums which reach 2-3 pounds flesh firmness are considered ripe, therefore, "ready-to-eat." Fruit which arrives in your warehouse or retail store should be tested for flesh firmness using a standard fruit penetrometer with an 8.0 millimeter (5/16 inch) tip. This initial firmness value and your fruit rotation will determine your ripening management.

A) Upon arrival to the warehouse, select twenty fruits and place them at 68°F (room temperature) to warm up before taking flesh firmness readings.

B) Remove a nickel-sized slice of skin from each side-cheek of the fruit with a knife or potato peeler. Hold the fruit against a hard, stationary surface such as a table top or, if you are using the drill press-mounted system, the base.

C) Slowly and constantly force the pressure tester tip into the fruit to the depth of the inscribed line on the end of the tip. Measurements are more consistent when the same person always performs the firmness tests. Reset the tester gauge and record each reading to the nearest half pound.

2. Communicating with Your Merchandisers

Find out the anticipated consumption schedule (fruit rotation) for these arriving fruit before starting your fruit ripening and/or establishing your temperature conditions. Establish your ripening protocol according to this anticipated consumption schedule.

3. Determining the Rate of Softening

Temperature conditions for plums during ripening should be adjusted according to the anticipated consumption schedule. A high rate of softening is achieved at 68° to 77 °F and a low rate of softening is accomplished by using lower temperatures (Table 1). Temperatures higher than 77°F will reduce the rate of softening, and induce off flavors and irregular ripening.

The rate of fruit softening, number of days to reach 2 pounds flesh firmness ("ready to eat") varies among plum cultivars and can be controlled at your facilities according to the storage temperature. This general guideline information (Table 1) was determined under our experimental conditions, therefore, these rates of softening may vary according to physiological maturity stage and environmental conditions during ripening.

4. Fruit Ripening Conditions

Plum cultivars, picked at the "California Well Mature Stage", normally produce sufficient ethylene to initiate ripening upon arrival to the warehouse when they are exposed to higher temperatures, thus, plums harvested at or higher than the "California Well Mature Stage" do not need ethylene exposure to ripen properly.

Plums harvested at a lower maturity stage than the "California Well Mature Stage" will need exposure to 100 ppm ethylene for at least 12 hours to ripen evenly.

For the "very slow" ripening plum cultivars, without the ability to produce their own ethylene, such as Angeleno, Black Beaut, Casselman, Kelsey, Late Santa Rosa, Nubiana, Queen Ann, Red Rosa and Roysum, ethylene exposure induces and accelerates the ripening process. Ethylene exposure can be done using other ripening fruits or applied as a special treatment (exogenous ethylene application). Without giving special attention to ripening, these "very slow" ripening plum cultivars vary in performance, depending upon chance exposure to ethylene during handling. These fruits, especially, Roysum must be continuously exposed to ethylene (10 to 100 ppm) for several days (normally 3 to 4) at warm temperatures, about 68^o to 77^{o}F (20^o to 25^{o}C) to ripen properly.

Adequate air circulation within the room to assure uniform fruit temperature is desired. Pallets should be placed at least 18 inches from the room walls and six inches from each other to provide good air circulation. High humidity around the fruit during the ripening process, preferably 90%, to prevent fruit shrivel is necessary. It is also important to assure that carbon dioxide produced by the fruits does not accumulate in the room by using continuous air exchange or by opening the room for an air change.

5. Calculating the Number of Days to the Transfer And/or "Ready to Eat" Points

For example, your 'Friar' plums have arrived at your warehouse with a cheek firmness of 7 pounds and according to your merchandiser department they need to be "Ready to Eat" in 6 days. Because 'Friar' has a rate of softening of 1.7 lbs/day at 77^{o}F, 1.1 at 68^{o}F and 0.9 at 59^{o}F (Table 1), by using the formula below, it will take 3.0 days at 77^{o}F, 4.5 at 68^{o}F or 5.5 days at 59^{o}F.

Number of Days at (F)
to Reach the Transfer Point =

$$\frac{\text{Initial firmness (lbs) - Transfer point (lbs)}}{\text{Rate of softening at (F) (lbs/day)}}$$

As the relationship between fruit firmness and bruising indicates that soft fruit are more susceptible to bruising than hard fruit, to reduce physical damage occurring during the transportation and handling at the retail, we recommend moving fruit to the retail store before the fruit reaches 5 pounds (Transfer Point). The establishment of 5 pounds as the Transfer Point is based only on our previous limited experience with fruit damage during harvesting, hauling, and packaging and in our laboratory tests. As bruising incidence varies among different retailer operations and cultivars, you should develop your own Transfer Points for your conditions.

Thus, these 'Friar' plums should be delivered to the retail store by 1.0 day after arrival if they were placed at 77^{o}F, 1.8 days if they were at 68^{o}F and 2.2 days if they were at 59^{o}F.

6. Controlling the Rate of Softening

Careful temperature and flesh firmness control are the keys to success in this ripening program. If you want to slow down your ripening because of changes in your rotation time, place your fruit at a lower temperature or even place it back at 32 ^{o}F.

7. Keeping Record

Start to develop your own information for your specific cultivars, ripening conditions and stores. Record your rates of softening, transfer points, fruit condition upon arrival to your different stores, decay incidence, physical damage, consumer reaction to "Ready to Eat" fruit, etc. This information will be extremely valuable to improve your ripening program in the future.

Table 1. Rate of fruit softening for several plum cultivars at different fruit temperatures.

	Rate of Softening (lbs/day)		
Cultivar	59°F	68°F	77°F
PLUM			
Ambra	0.8	1.0	1.5
Angeleno	0.4	<0.5	0.8
Black Amber	1.0	1.3	2.0
Black Beaut	0.4	<0.5	0.8
Black Diamond	0.4	<0.5	0.8
Casselman	0.4	<0.5	0.8
Catalina	0.8	1.0	1.5
Durado	0.6	0.7	1.0
El Dorado	0.6	0.7	1.0
French Prune	0.5	0.6	0.9
Friar	0.9	1.1	1.7
Frontier	1.4	1.7	2.6
Grand Rosa	0.6	0.8	1.2
July Santa Rosa	0.6	0.8	1.2
Kelsey	0.4	<0.5	0.8
Laroda	0.9	1.1	1.7
Late Santa Rosa	0.4	<0.5	0.8
Moyer	0.4	<0.5	0.8
Nubiana	0.4	<0.5	0.8
President	0.6	0.7	1.0
Queen Ann	0.4	<0.5	0.8
Queen Rosa	0.9	1.1	1.7
Red Beaut	0.6	0.7	1.0
Red Rosa	0.4	<0.5	0.8
Rosemary	0.4	0.5	0.8
Roysum	0.4	<0.5	0.8
Royal Diamond	0.5	0.6	0.9
Santa Rosa	0.6	0.7	1.0
Simka	0.6	0.7	1.0
Spring Beaut	0.4	<0.5	0.8
Wickson	0.9	1.1	1.7

RESEARCH UPDATE

compiled by Scott Johnson

Project Title:
Management of Pre- and Postharvest Diseases of Fresh Market Peaches, Plums, and Nectarines
Project Leader:
James E. Adaskaveg

Objectives of the 1994 project were: 1) Continue studies on preharvest control of brown rot blossom blight and fruit rot with fungicide protectants and suppressants; 2) Continue research to improve preharvest iprodione treatments with tank mixtures of iprodione and summer oils; 3) Continue development of non-fungicidal, nutritional materials for control of brown rot; and 4) Complete commercial evaluation studies on iprodione-oil mixtures as a postharvest treatment to control Rhizopus rot without the use of dicloran. Supplemental to these objectives, research was initiated to determine the efficacy of controlled droplet application of postharvest fungicides and to evaluate new alternative methods to chlorine as postharvest sanitation treatments of fruit.

Highlights of 1994 Preharvest Disease Control

1. One application of iprodione (Rovral 50WP), myclobutanil (Rally 40W), and propiconazole (Orbit 3.6EC, 45WP), as well as the experimental compounds TD2350 and CG219417 applied at pink bud were effective in reducing brown rot blossom blight to less than 0.5%

compared to non-treated on Red Diamond nectarine (5.8%), Elegant Lady (3.2%), and Fairtime (1.2%) peach. Iprodione and iprodione-oil mixtures were the most consistent of the treatments with 100% blossom blight control for all of the varieties evaluated. Similarly, iprodione-oil mixtures, propiconazole (Orbit 3.6), and the experimental compounds ABG8006 and CG219417 were consistently and highly effective on all cultivars evaluated as a preharvest treatment for control of pre- and postharvest brown rot of stone fruits.

2. For control of brown rot of fruit, iprodione (Rovral 50WP) in mixtures with summer oils (e.g. Omni Supreme Spray, Gavicide Ultra 90, Volk Supreme) at a maximum rate of 2% were extremely effective on nectarines and peaches. Furthermore, a 0.5 lb ai/A of iprodione in mixtures with oil was equivalent to 1.0 lb ai/A of iprodione without oil for brown rot control. Improved efficacy is attributed to increased solubility of the fungicide and improved coverage on fruit surfaces and suppression of quiescent infections. No phytotoxicity was observed from these treatments. For fruit sprays, the most effective treatments were high volume applications (100-200 gal/A) of iprodione-oil mixtures (1 lb ai/A - 2% oil). Furthermore, for the first time, we have shown that preharvest application of iprodione-oil is effective for control of postharvest Rhizopus rot even after commercial postharvest chlorination and detergent washing (Decco 241).

3. Nonfungicidal, nutritional (calcium formate and calcium acetate) preharvest treatments of blossoms and fruit were compared to non-treated blossoms and fruit for control of brown rot caused by _M. fructicola_. These treatments were shown to be effective in reducing brown rot blossom blight and fruit rot, as well as improving color, soluble solids, and firmness of some varieties, as well as improving the cold storage of fruit. Responses in fruit quality (color, soluble solids, and firmness) to calcium treatments, however, were variety specific. For example, Elegant Lady responded to preharvest applications (3, 2, & 1 wk PHI) of calcium acetate, whereas Fairtime did not respond.

Highlights of 1994 Postharvest Control of Rhizopus Rot

1. In extensive laboratory and commercial evaluations 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 522M formulations) to effectively control Rhizopus rot, as well as brown rot, gray mold, blue mold, and Alternaria decay of stone fruits. Control of Rhizopus rot was similar or equivalent to control obtained using dicloran (Botran 75WP, Allisan 75W).

2. For iprodione-wax/oil emulsions: optimal concentrations of wax/oil emulsions (Decco, Brogdex Stone Fruit Waxes) were $\geq$20%; whereas an iprodione concentration of 1 lb ai/100 gal was effective for control of Rhizopus rot. Solubility of iprodione was increased in specific wax/oil formulations (including Decco 251, 255, and Brogdex); whereas residues on fruit were similar to residues when iprodione was used alone.

3. Preliminary comparisons of high volume (T-Jet) and controlled droplet application (CDA) systems of postharvest fungicides indicated the advantages of CDA systems in minimizing excess fungicide application and fungicide waste. Critical control of

fungicides and wax/oil volumes (in a liquid carrier), however, was required to obtain decay control efficacy similar to high volume, T-Jet fungicide application. A critical factor determining the efficacy of iprodione and dicloran in CDA systems is the amount of fungicide applied to the fruit (lb of fungicide/lb of fruit treated). This is determined by the amount of fruit being treated (bins/hr), rate of fungicide application using a liquid carrier to provide uniform coverage, and concentration of the fungicide in a tank mixture. Based on the Rovral label information (2 lb product/100 gal/200,000 lb fruit), ideal parameters for the application of iprodione are 0.5 ml/fruit and 0.5 lb ai/100,000 lb of fruit. Thus, regulated pumps for iprodione and wax/oil reservoirs are suggested for application systems to maintain proper application of fungicides by adjusting rate of fungicide delivery based on amount of fruit being treated. Decay control failure in CDA systems or any application system may result when the amount of fungicide used is diluted by the amount of fruit treated or by the lack of uniform coverage to below adequate fungicide residue levels that prevent decay.

4. A new alternative chemical sanitation treatment to chlorine is currently being developed. The new material, PHMB, surpasses the efficacy of chlorine by disinfecting non-wounded and wounded fruit. PHMB represents a new class of water sanitation treatments and is already registered with the EPA for swimming pools in the United States except California. Potentially, this new treatment could replace chlorine as a postharvest sanitation treatment. Additional studies are required.

<u>Project Title</u>:
Studies on Stone Fruit Internal Breakdown
<u>Project Leader</u>:
Carlos H. Crisosto

Studies focusing on the role of preharvest factors and temperature regimes on the incidence of internal breakdown in nectarines and peaches are being carried out at the F. Gordon Mitchell Postharvest Laboratory. Our work investigated the influence of "orchard factors" such as crop load, fruit canopy position and nitrogen on internal breakdown (IB). These preharvest factors and temperature regimes affected internal browning and mealiness incidence differently. Bleeding was not a problem in the peach and nectarine cultivars tested. Mealiness was expressed earlier than internal browning for each cultivar and temperature studied.

Based on our first season's work, the erratic and unreliable benefit of the CA technique in delaying IB symptoms appears to be related to preharvest factors. The segregation of fruit according to canopy position to reduce variability is necessary in further research. Maximization of the CA benefits may be accomplished by using outer canopy fruit (high quality).

Our preliminary work indicates that internal browning and mealiness symptoms are related to preharvest factors. This points out the need for continuing studying these factors to maintain quality and extend the market life.

<u>Project Title</u>:
Peach and Nectarine Skin Discoloration
<u>Project Leader</u>:
Carlos H. Crisosto

Inking on peach and nectarine fruits 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, Argentina, and Chile.

Inking symptoms appear as discolored brown and black spots but are restricted to the skin.

After our three years of study, we have demonstrated that physical injury and contamination are essential for inking development. Unfortunately, physical injury constantly occurs during harvest and hauling operations within the orchard. Through our anatomical studies, we determined that the type of physical injury associated with inking is abrasion. The skin cells, where the anthocyanin/phenolic pigments are located, were collapsed while the underlying fleshy cells (mesocarp cells) remained intact.

We also found that iron, copper and aluminum were the most deleterious contaminants among those studied in inducing inking formation on abraded fruit. In fact, only 5-10 ppm iron was enough to induce inking at the physiological fruit pH. Our studies focused on the role of exogenous contamination indicated that black and brown spot formation required exogenous chemical contaminants. This contamination can generally occur within 15 days before harvest, during harvesting or packing operations. Our 1993 and 1994 California and Chilean seasons' data indicated that foliar nutrient, fungicide and insecticide preharvest sprays may act as sources of contamination for inking development depending on the application time. At the same time, we also evaluated the influence of time and type of fungicide application on postharvest decay control.

We completed our inking research by developing safe application times (low inking incidence) for Rovral7 (iprodione), Funginex7 (triforine), Ronilan7 (vinclozolin) and Benlate7 (benzimidazole) which are still effective in controlling brown rot.

As a short term solution, I advise chemical companies (foliar nutrients, fungicides and insecticides) to develop recommendations for their users of preharvest application intervals to avoid inking without losing decay control.

As a long term solution, I suggest chemical manufacturers attempt to identify and remove the possible sources of contamination from their chemicals that may cause inking before distributing them.

<u>Project Title</u>:
Preharvest Factors Affecting Fruit Quality at Harvest and in Storage
<u>Project Leader</u>:
Kevin R. Day

Training and thinning studies showed that both the two leader Kearney Perpendicular AV@ (403 trees per acre) and the four leader Quad AV@ (269 trees per acre) were equal with respect to fruit production and sizing potential for May Glo nectarine. The study also showed that fruit quality was inversely related to crop load. Regression formulas were developed which can be used to estimate the effect of crop load on fruit quality parameters.

Preharvest summer pruning of August Red nectarine, consisting of both watersprout removal and leaf pulling, was effective in increasing fruit surface color. Fruit size and fruit soluble solids concentrations were reduced by summer pruning. Fruits from summer pruned trees tended to have reduced amounts of internal browning after 5 weeks in cold storage. However, the results were inconsistent leading to the conclusion that summer pruning can only be relied upon to improve fruit color, not overall fruit quality or storage potential.