CENTRAL VALLEY POSTHARVEST NEWSLETTER

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Editor

Contents

PRECOOLING BEFORE LOADING

(Extracted from Loading Makes the Difference, Jim Thompson)

Most temperature management problems during transport could be reduced with the use of improved design refrigerated trailers that have deep floors, recessed-groove sidewalls, high capacity fans, pressure bulkheads, and solid state temperature controllers. These features are used in modern marine container vans in which fresh produce is transported for transit times much longer than those occurring in domestic shipments in the United States. A few U.S. truckers now have trailers with these advanced design features. However, problems related to the extra weight of deep floors, the reduced inside width of recessed-groove walls, and their extra susceptibility to damage during loading and unloading have prevented most truckers from purchasing these improved-design trailers. Hopefully, these design and handling problems can be solved. Meanwhile, truckers can contribute to better product transit temperatures and fewer losses by following these recommendations:

Trailers should be precooled to remove the heat contained in the walls, ceiling, floor, and doors before loading with already cooled products. If not removed, this heat would be rapidly conducted to the load. The disadvantage of precooling a trailer before loading is that during loading some warmer air may enter the trailer, resulting in condensation on the trailer's inner surfaces.

A useful trailer precooling guide is as follows:

1. Precool trailers, especially during warm weather.

   a) Trailers to be loaded at refrigerated docks should be precooled to their desired thermostat set point.

   b) Trailers to be rapidly loaded (15 to 20 minutes) at non-refrigerated docks should be cooled to about 5°F above their desired thermostat set point.

c) Trailers that will be loaded slowly (30 minutes or more) at non-refrigerated docks should be precooled to about 5°F lower than a temperature half way between the ambient air temperature and the desired thermostat set point. For example, if the ambient air temperature is 75°F and the desired set point is 34°F, the trailer should be precooled to 49.5°F.

$$\frac{75^{o}F - 34^{o}F}{2} = 20.5^{o}F$$

and $75^{o}F - 20.5^{o}F = 54.5^{o}F$

and $54.5^{o}F - 5^{o}F = 49.5^{o}F$

This will prevent accumulation of excess moisture on the trailer's inner surfaces and subsequent extensive cycling of the refrigeration unit.

2. Determine and record product pulp temperatures during loading.

3. Load the product away from sidewalls and on pallets or racks, especially during very hot or very cold weather exposure during the trip.

4. Do not load so high that the air delivery chute is collapsed or blocked.

5. Do not load all the way to the rear doors, leave at least 4 inches between the rear of the load and the rear doors.

6. Secure loads properly by bracing or with load-locks.

7. Make sure lengthwise air channels are not blocked in mixed loads.

8. Keep the trailer in optimum condition with regular checks and maintenance.

   - Refrigeration unit operative.
   - Walls, doors, and air delivery chute in good repair.
   - Floor grooves cleaned out.

9. Keep transit times to an absolute minimum by avoiding unnecessary delays en route.

10. When mixed loads of fresh fruits and vegetables are shipped, it is important that the various commodities are compatible with one another with respect to their requirements for temperature, modified atmospheres, relative humidity, and protection from odors or physiologically active gases (ethylene).

11. Load extra packages at the rear end of a palletized or racked load on short pallets or racks to provide air circulation under the load.

EXPORT OF CALIFORNIA GRAPES

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For several years quality problems have continued to occur with California grapes more than with other California horticultural crops. In 1992, California exported 8676 metric tons of grapes to the EEC. These problems include residues (mostly dust) on grapes, black widow spiders in packages of grapes and condition problems.

The condition problems are bruising, crushing, shatter, senescent and excessively dry looking stems, and decay of grapes. The bruising and crushing (split berries) of grapes is caused by packing too many grapes within a given size box and the shocks and vibrations during transit. We have observed five kilo (11 lb) boxes packed with six or seven kilos (13-15 lb) of grapes and 11 kilo (23 lb) boxes packed with 12-13 kilos (24-27 lb) of grapes. Most grapes grown in Europe and those imported from Southern hemisphere countries are not packed as tightly as U.S. grapes. Consideration should be given to developing a new grape package, particularly for export.

Observations indicate that grapes shipped across the U.S. by rail to the East Coast for export to Europe seem to have more bruising and shatter than grapes shipped through the Panama Canal to Europe. California grapes also arrived with dried-out brown stems. This problem may be related to transit temperatures somewhat higher than recommended. Even though the thermostat setting may be correctly set at 0-1EC (32 to 34EF), poor air circulation in the van containers result in actual grape temperatures being 3 to 4EC (38 to 40EF) during transit.

For the export of grapes, the following specifications should be followed:

1. Season. The harvest of table grapes begins in southern California and Arizona in mid May and ends in central California in early November. Early cultivars such as `Thompson Seedless', `Perlette' and `Flame Seedless' are best shipped immediately after harvest and precooling. Late season cultivars such as `Ruby Seedless', `Emperor', `Ribier', `Red Globe' and `Calmeria' may be shipped after short duration (∃ 3 weeks) storage.

2. Quality. Table grapes for export to Europe, Japan and some other countries must meet the requirements of the U.S. Fancy grade. For export, the grapes must be free of dust, spiders, decay and serious damage. When selecting grapes particularly for the European market, select lots that are free of dust and other residues as European health inspectors may reject importation of grapes having any type of residue. Grapes for export should be dry when packed, mature with high soluble solids content, well-colored as characteristic of the cultivar with green and turgid stems. Quality of grapes is judged by stem freshness by most receivers. For Europe, grape bunches must weigh about 200 (1/2 lb) grams each for Category No. 1. Grapes harvested after rain should not be exported as they may be susceptible to decay. Early season cultivars should be shipped as soon as possible after harvest since their shelf life is only 4 to 6 weeks. Late season cultivars may be shipped from storage, but storage conditions must be optimal [0EC (32EF) and 90-95 percent relative humidity].

3. Pre-transit treatment. Recommended preharvest, harvest and packing procedures should be thoroughly followed with extra care for grapes destined for export. Grapes should be thoroughly precooled immediately after harvest using forced-air cooling before storage and/or shipment. Grapes are also fumigated with sulfur dioxide (SO_2) immediately after packing to help control decay and to maintain the light-green stem color. Grapes destined for export are best precooled and fumigated in a single operation promptly after harvest. Pressure or forced-air cooling speeds cooling and enhances gas penetration into packages. A label for SO_2 fumigation was finalized by the EPA in 1992 and approved by Cal EPA in 1993. It states requirements for safety, maximal dosages, number of fumigations, labeling and other aspects of SO_2 use. Regulations allow up to 10,000 ppm (1.8 lb. per 1000 cu. ft.)

SO_2 for the first fumigation. All subsequent fumigations cannot exceed 5000 ppm. SO_2 generating pads are often used in export packages. If export of these packages is delayed and they are repeatedly fumigated, injury and excessive residues can result. If SO_2 fumigation is done in van containers, it should be done 20-30 minutes with doors closed and the refrigeration unit operating for thorough circulation. After fumigation, the doors can be opened with the refrigeration unit operating and ventilated for 15 minutes before shipment to reduce the chances of SO_2 injury to the berries. Plant health inspectors in Europe check for sulfur dioxide injury and have refused entry for such injury and/or sulfur residue.

4. Packaging. Most European receivers prefer a 5 kilo (11 lb) fiberboard box for grapes. The grapes should be carefully place-packed in the box without overpacking the bunches. Fiberboard boxes must be strong enough to withstand the long transit times to export markets. Some receivers prefer the polystyrene foam box for grapes, but some disposal problems may arise in the future with this box. Polystyrene boxes offer the advantages of minimizing quality deterioration by not absorbing moisture from the grapes and absorbing some of the vibration during transit. Boxes should be palletized on a 120 by 100 cm approved wooden pallet and adequately secured to the pallet with strapping or netting.

5. Pre-transit Vehicle Check. Check the transport vehicle before loading to be sure it is clean, check doors for proper closure and that floor drains are clean and operable. The transport vehicle should be precooled to desired transit temperature. Keep loading time to a minimum.

6. Transit Environment. The optimum transit temperature for table grapes is 0EC (32EF) and the desired relative humidity is 90 to 95 percent. The air exchange or venting system should be set at 15-18 CFM for fresh air.

7. Loading Pattern and Bracing. Most van containers used for export of grapes are equipped with state of the art refrigeration systems with bottom-air delivery. Since most export shipments of grapes are palletized, the pallets should be loaded against each sidewall of the van container leaving a void channel down the center of the van container or two pallets stacked alternately against each sidewall (Fig. 1). For maximum air circulation, the void floor space should be covered with fiberboard and the ends or entry of the last two pallets should be covered with fiberboard. If four-way entry pallets are used, the openings for the forklift entry must also be covered on the side facing the void space. If the floor at the rear of the van container is not covered with a metal plate, then any floor space at the rear of the van container not covered with pallets should also be covered with fiberboard. It is also recommended that the load be braced with either an air bag or wood bracing to maintain pallet stack placement.

8. Vehicle Routing. For early season grape cultivars, route the shipment by the fastest combination of overland and ocean routes to keep transit time to a minimum. Late season cultivars may be routed by the fastest ocean routes which for European shipments may be through the Panama Canal instead of overland to the East Coast of the U.S.

9. Care of Product upon Arrival. The quality and shelf life of table grapes are highly dependent upon storage temperature at 0EC (32EF) and relative humidity at 90 to

95 percent. Upon arrival, grapes should be kept under refrigeration and moved to retail outlets as quickly as possible under refrigeration.

<u>EXPORT OF CALIFORNIA PLUMS</u>

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In the past several years many quality and condition problems have been reported with California plums. In 1992, the U.S., mostly from California, exported 5740 metric tons of plums to the EEC. Many receivers state that they would import more plums if consistent quality can be assured. The principal problems with California plums were internal browning and decay.

This past year six shipments of 'Roysum' plums were destroyed because of internal browning. In addition to the costs of plums and transport, there is the cost for the removal and the destruction of the plums. Fourteen other van container shipments of plums had varying degrees of decay and internal browning with 50 percent losses. Most problems with plums are related to maintenance and setting of the proper transit temperature and the length of time from harvest to destination. Temperature control at 0EC (32EF) is of utmost importance in the control of internal browning of plums. Most plum cultivars are susceptible to internal browning at temperatures of 2EC (36EF) and above. A temperature setting at 4EC (40EF) is particularly detrimental depending upon exposure time. The temperature setting of most van containers was 0-1EC (32-34EF), but due to loading technique and inadequate air circulation within the van container, actual plum temperatures during transit averaged about 4EC (40EF). In the case with the 'Roysum' plums, which were harvested in early October and stored until shipment in late October, the time from harvest to arrival in Europe was six to eight weeks. The maximum recommended storage/transit time (shelf life) for 'Roysum' plums is only four weeks.

For the export of plums the following specifications should be used:

1. <u>Season.</u> The harvest of plums begins in California and moves to Oregon, Washington and Idaho. The harvesting season starts in early May and continues through early October. There are over 140 varieties of fresh plums available in the U.S. but they are not all adapted to long term storage/transit. Some varieties have a longer shelf life and store and ship better than others. Plums are susceptible to internal browning or breakdown with some varieties more susceptible than others. For export, select only varieties which have a long shelf life of 3 or more weeks and are less susceptible to internal breakdown.

2. <u>Quality.</u> Export only freshly harvested plums with high quality, well-colored and a high soluble solids content. They should be U.S. Fancy or U.S. No. 1 grade.

3. <u>Pretransit Treatment.</u> Recommended harvest and packing procedures should be thoroughly followed with extra care for plums that are to be exported. Plums should be precooled immediately after packing. The time between harvesting and precooling should be kept to a maximum of a few hours. Precool plums by hydro-cooling and/or forced-air cooling to 0EC (32EF) as soon as possible and maintain this temperature prior to shipment.

4. <u>Packaging.</u> Plums for export should be

place-packed or tray packed one or two layers in fiberboard boxes. European receivers prefer boxes with 5 to 6 kilos (11 to 13 lb) net weight. Fiberboard boxes must be strong enough to withstand the rigors of export. Boxes should be palletized on a 120 by 100 cm approved wooden pallet and adequately secured to the pallet with strapping or netting.

5. Pretransit Vehicle Check. Check the transport vehicle before loading to be sure it is clean, check doors for proper closure and that floor drains are clean and operable. The transport vehicle should be precooled to desired transit temperature before loading. Keep loading time to a minimum.

6. Transit Environment. The recommended transit temperature is -0.5 to 0EC (31-32EF) and relative humidity 90 to 95 percent. The air exchange or venting system of the van container should be set to allow 40-50 CFM. Some cultivars of plums may benefit from modified or controlled atmosphere during transit.

7. Loading Pattern and Bracing. Most containers used for export of plums are equipped with state of the art refrigeration systems with bottom-air delivery. Since most export shipments of plums are palletized, the pallets should be loaded against each sidewall of the van container leaving a void channel down the center of the van container or two pallets may be stacked alternately against each sidewall (Figure 1). For maximum air circulation, the void floor space should be covered with fiberboard and the ends or entry of the last two pallets should be covered with fiberboard. If four-way entry pallets are used, the openings for the forklift entry must also be covered on the side facing the void space. If the floor at the rear of the van container is not covered with a metal plate, then any floor space at the rear of the van container not covered with pallets should also be covered with fiberboard. It is also recommended that the load be braced with either an air bag or wood bracing to maintain pallet stack placement.

8. Vehicle Routing. Route the shipment by the fastest overland and ocean routes possible to keep transit time to a minimum. For shipment to Europe, overland shipments to Gulf or East Coast ports should be by truck or unit train to keep total transit time from packing to arrival in Europe to three weeks or less.

9. Care of Product upon Arrival. On arrival at destination, plums should be marketed rapidly since most of their market life has been exhausted. Plums should be ripened at retail or by the consumer at 18EC (65EF). Plums should not be stored after arrival in export markets for more than a few days at about 1EC (34EF).

CONTROL OF POSTHARVEST BROWN ROT OF STONE FRUIT

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DISORDER:

Brown rot diseases of stone fruit are caused by fungi in the genus *Monilinia.* In North America, *M. fructicola* and *M. laxa* are the causal agents.

OCCURRENCE:

The disease is cosmopolitan occurring on stone fruits (peaches, nectarines, plums, prunes, cherries, apricots), and occasionally apples.

IMPORTANCE:

Brown rot is the most destructive of the postharvest diseases of stone fruit, primarily because infections can start in the field and continue to develop after harvest and the fungus can develop quickly at ripening temperatures 72 to 75 EF (23 to 25EC), causing significant economic losses yearly.

SYMPTOMS:

Brown rot of fruit starts as small, circular brown lesions that break down the skin and flesh of the fruit as the disease extends outwards. As the disease progresses under high humidity, thread-like hyphal filaments come through the fruit surface and masses of buff colored spores (conidia) develop. Conidia are often arranged in concentric bands. The decay is soft but firm in comparison to other "soft rots" such as decay caused by *Rhizopus stolonifer*. Before the production of spores the fruit skin will slip easily away when rubbed during handling. Infections from one fruit can spread to other fruit if fruit are in contact.

LIFE CYCLE:

In the orchard, *Monilinia fructicola* survives the winter in infected twigs and in mummified fruit (mummies) hanging in trees or fallen on the ground. However, in surveys done from 1994 through winter 1996, Michailides et al. were unable to find infected twigs with sporulation of *M. fructicola* in peach, nectarine, and plum orchards. Furthermore, no fresh sporulation was observed on mummies hanging on trees, instead these mummies were covered by sporulation of *Cladosporium* species. In contrast, it was consistently found that apothecia produced from mummies survived on the orchard floor. Apothecia are cup-like structures that produce millions of ascospores that are actively released into the air in the spring when stone fruit trees are in bloom. Among 36 orchards (peach, nectarine, plum, and prune) surveyed, apothecia were only found in those with no cultivation (natural vegetation in the orchards) but were not found in disked orchards. Although disking in late winter to early spring is not recommended, because it may create difficulties in driving through the orchard spray rigs, our results show that disking at least disrupts the process of apothecia development. Consistently, more apothecia were found on the north side than the south side of trees.

In laboratory experiments, apothecia of the brown rot fungus discharged ascospores for at least 20 days with a daily maximum of 9 million ascospores per apothecium (Hong et al. 1996). Depending on the stage of bloom, ascospores can infect blossoms causing blossom blight, and/or young developing green fruit causing latent or quiescent infections. Latent infections can also be caused by conidia produced on blighted flowers during the season or conidia produced on sporulating green fruit on trees or on the ground after fruit thinning. Latent infections are very common in years with rainy springs when infections of blossoms are common, and primary spore inoculum (ascospores) or secondary spore inoculum (conidia from sporulating blossoms and twigs which were blighted during the current season) are abundant. Infections of mature fruit come about either from continued development of latent infections or from secondary infections by conidia produced on infected green fruit, thinned fruit on the ground, or conidia carried to fruit on the trees by orchard insects (nitidulid beetles and drosophilid flies). In California, fruit infection is most common during the last four weeks before harvest. Fruit infections may result from direct penetration of conidia in conducive environments, however, infections commonly occur through wounds. Natural wounds occur from fruit cracking during maturation and ripening and from insect damage. Injuries may occur during harvest, transportation, and packing that also provide entries for infection.

MANAGEMENT:

BEFORE HARVEST

Keep soil in the orchard free of vegetation when trees are in bloom to reduce apothecia development, disk or rototill to disrupt the development of apothecia.

Be conservative when you fertilize with nitrogen. The more nitrogen that is applied the more brown rot that will develop (Daane et al. 1995).

By applying the recommended bloom sprays (Funginex, Rovral, or Bravo), growers can lower the incidence of blossom blight and thus reduce the spore inoculum produced in blighted blossoms.

Continue with a second or third spray as recommended by the pest management guidelines, if weather continues to be rainy when trees are in bloom. Recent work in both our laboratories showed that spring and early summer sprays of green fruit (including prunes) reduce both the incidence of disease in the field and postharvest.

Apply preharvest sprays (1-2 weeks or 1-3 days before harvest) as recommended for registered fungicides to reduce postharvest decay and increase storability of fruit.

AT HARVEST

Harvest, transport, and package fruit with excessive care, avoiding the creation of bruises or wounds.

Use clean picking bags and harvest bins that have protective pads on the sides and bottom to avoid fruit bruising or wounding.

After a rain, allow fruit to dry on the trees and then harvest.

Do not delay harvests; mature fruit are very susceptible to infection.

AFTER HARVEST

Cool fruit as soon as possible after harvest; forced-air or hydrocooling is efficient in precooling the fruit before postharvest treatment and packaging.

Wash fruit with chlorinated water to remove soil dust, disinfect fruit surfaces, and prevent contamination of other fruit with fungal inoculum in the wash water (Adaskaveg 1995).

Apply registered postharvest treatments. Currently, with the cancellation of iprodione (Rovral 50WP), no postharvest fungicide is registered for brown rot control. Iprodione, however, can be used for brown rot control until supplies are exhausted. Dicloran (Botran or Allisan) is the only fungicide currently registered for postharvest use against Rhizopus rot and gray mold on stone fruit crops (Adaskaveg and Michailides 1996).

Use boxes for packing fruit with the necessary ventilation openings to help maintain the fruit in cold storage without excessive loss of moisture.

Use small samples of fruit from various fruit lots or varieties maintained at room temperature to determine levels of decay and to help make decisions on which fruit should be sent to the market first.

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CONTROL OF POSTHARVEST GRAY MOLD ON TABLE GRAPES

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DISORDER:

Gray mold, caused by the fungus *Botrytis cinerea*.

OCCURRENCE:

Table grapes. Gray mold is among the most common and widely distributed of diseases of fruits, vegetables, and greenhouse crops worldwide.

IMPORTANCE:

It is the most destructive of the postharvest diseases of table grapes, primarily because it develops at temperatures as low as 31°F (-0.5°C) and grows from berry to berry.

SYMPTOMS:

Gray mold first turns berries brown, then loosens the skin of the berry, its white, thread-like hyphal filaments errupt through the berry surface, and finally masses of gray colored spores develop. Before spores are produced, infections can be diagnosed easily by their "slipskin" condition; brown areas of berry skin infected with the fungus will slip freely away when rubbed with the fingers, leaving the firm underlying pulp exposed. In darkness and under humid conditions, abundant gray to white aerial hyphal filaments spread rapidly from berry to berry. An uncontrolled infection from a single berry can spread to an entire package of grapes. Pockets of decayed grapes resulting from berry-to-berry spread are called "nests."

LIFE CYCLE:

In the vineyard, Botrytis cinerea survives the winter on mummified berries and tar-colored, long-lived resistant bodies called "sclerotia". When moist, these produce masses of gray-colored spores that infect newly emerging shoots, flowers, and berries. Infection of wet berries occurs after only 4 hours at 54 - 86°F, while flowers can become infected after only two hours under similar conditions. Later, additional spores are produced from bunch rot infections and other infected plant parts, increasing the density of spores as the season progresses. Spores can infect berries in several ways. Early season infection of the stigmata of opening grape flowers will leave behind fungus-infected fragments of the flower that increase the subsequent inoculum level inside the developing cluster. Some evidence shows that these stigmal infections remain on the berry as it develops, but become inactive (latent) and develop later when the berry matures. Other latent infections may arise when spores germinate and penetrate the berry surface, but then stop developing until the berry matures. Latent infections are especially troublesome because they reside within the grape tissue where they cannot be eradicated by preharvest fungicides or postharvest sulfur dioxide applications. Wounds near harvest caused by physiological cracking, tight clusters, insect or bird damage, or rough handling also provide opportunities for infections. No wound is required for infection when wet conditions occur.

CONTROL:

BEFORE HARVEST

By removing desiccated, infected grapes of the previous season from vines during winter pruning, growers can reduce the inoculum produced in the following season.

To minimize infections, use a leaf-removal canopy management program to produced an environment that will inhibit the fungus and facilitate fungicide coverage. Canopy management alone can control gray mold as well as the fungicides if the weather is dry. Fungicides are particularly important if rainfall or persistent humid weather occur. Benomyl plus captan, iprodione, captan alone, dichloran, and narrow range oil (acceptable for organic use) are currently registered for grapes. Fungicides will reduce the number of infected berries that develop in storage by about fifty percent. Recent South African work indicated near-harvest applications are most important, and that most infections of berries occurred during handling at harvest.

AT HARVEST:

Trim visibly infected, split, cracked, or otherwise damaged grapes rigorously before packaging. Do not block the box vents by over-filling, misalignment of the liner, or use of liners or pads that are not needed.

After a rain that thoroughly wets the clusters, allow a minimum of 3 days before harvest resumes. This will allow infections to develop so they can be visible for removal by trimmers at harvest. Prompt fumigation after harvest of rained-on grapes is particularly important. To maximize control of infections after a rain, packers should use a package or packaging that does not impede sulfur dioxide penetration, such as plain or naked pack. Even with these precautions, rained-on fruit should be segregated from fruit harvested in rain-free periods, and should be sold as soon as possible. If you suspect infections are numerous, you can sample berries to predict gray mold incidence (Harvey, 1984).

AFTER HARVEST:

Completely pre-cool and fumigate with sulfur dioxide as rapidly as possible after harvest. Forced-air fumigation, particularly when combined with pre-cooling, is superior to fumigating or cooling with circulating air.

Temperatures in storage should be maintained as close as possible to 31°F (-0.5°C), since temperatures 4° to 8°F (1.7° to 3.9°C) or higher can result in a 2- or 3-fold increase in decay development. Furthermore, sulfur dioxide recommendations were developed under conditions of good temperature management and could fail if the grapes are stored too warm.

Use total utilization fumigation, so no ventilation is required to remove surplus sulfur dioxide. The longer fumigation allows more time for the gas to penetrate throughout the packages.

Estimate the amount of sulfur dioxide needed based on: 1) number of boxes, their composition, and internal packaging; 2) capacity of the room; 3) number of boxes in the room; and 4) the dose tables on pages 20 and 21 of UC Bulletin 1932. Confirming the dosage of this estimate is adequate using dosimeters. Available from safety supply companies, these thermometer-like glass tubes change color to indicate sulfur dioxide dose. Place the dosimeters inside the packages within the clusters in locations, for example, in the middle of a pallet, where penetration may be low. The minimum dose is 100 parts per million-hour. This dose is expressed an average of 100 parts per million (ppm) of sulfur dioxide present for one hour. The same dose can be delivered over longer or shorter periods, for example; it can be achieved by 50 ppm for two hours, 25 ppm for four hours, or 200 ppm for thirty minutes.

Weekly fumigation is more effective than fumigation at longer intervals. Under refrigeration, gray mold infections can move from one berry to an adjacent berry in about eight days, therefore, a weekly fumigation interval is sufficient to stop it, and more brief intervals will not improve control.

During weekly fumigations, air speed past pallets during the first one or two hours of fumigation should be greater than 100 feet per minute (fpm). Stack pallets neatly with four inches between lanes, and use slotted air ducts or plenums to improve air distribution. High air speed in the room between fumigations is not needed and can accelerate drying of the berries.

When possible, store boxes with similar penetration characteristics in the same room because they share the same fumigation dose.

As inventory decreases, consolidate fruit in the least number of rooms and minimize open lanes. Air will move down open pallet lanes and leave the air velocity too low elsewhere.

Following fumigation, use gas monitoring equipment to verify appropriately low concentrations of sulfur dioxide are in the room before you allow personnel to re-enter.

Inspect the berries repeatedly during storage. High weekly doses (500 ppm-hour) increase the risk of high residues and bleaching injury to the berries. Bleaching usually occurs around cuts in the berry skin or on detached berries, but very high doses will cause bleached spots on uninjured berries. If nests of gray mold develop, the sulfur dioxide dosage is too low and/or unevenly distributed. If the number of individual decayed berries is high, but there are no nests of decay, this suggests many infections were present at harvest that developed within single berries during storage, but further spread was suppressed by sulfur dioxide. If re-packing to remove infected berries is done, it is critically important to promptly fumigate the re-packaged berries to eliminate gray mold inoculum distributed by workers' hands. Forced-air fumigation is recommended, since it will improve penetration and help dry any condensation that may have formed during re-packing operations.

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KEEP STONE FRUIT COLD IN TRANSPORT

James Thompson and Tom Hinsch

The refrigeration unit on a trailer will keep precooled stone fruit below 36°F only if cooled air can flow around the load to prevent outside heat reaching the fruit. Product loaded against the walls and floor will warm during summer transit. Tests with well-cooled strawberries showed that boxes touching a side wall were 5°F warmer than center load boxes. If pallets are center line loaded with at least a 1- to 2-inch gap between boxes and a smooth side wall, boxes close to the wall are the same temperature as center load boxes.

Center line loading requires that pallets are braced away from walls at the top and bottom. Small, air-filled bags, about the size of a pillow, can be taped near top boxes and inflated to stabilize the tops of pallets. Wedges cut to length, are placed between the duct floor and the wood pallet to brace the pallet bottom. Proper loading will require an extra person on the dock to install braces, but in the heat of summer, stone fruit will usually arrive below 36°F at destination.

Proper loading also requires that loading personnel and truckers:

< precool the trailer before loading
< turn off refrigeration unit while the doors are open if loading from a warm dock
< use floor racks or load on pallets unless the floor has deep channels
< do not block the air chute or load up to the ceiling
< load away from the rear doors and brace the load
< keep iced products away from dry products but do not allow divider to block floor air flow
< set thermostat below 36°F
< load only product cooled to below 34°F

RIPENING GUIDELINES FOR KIWIFRUIT HANDLERS

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Most consumers prefer to purchase kiwifruit which are near full ripeness. In fact, featuring ripe kiwifruit in your stores has proven to increase shelf turns at retail -- a key component in produce department profits. On the other hand, when consumers buy mature, but not ripe kiwifruit, they usually don't know how to properly ripen them, creating the usual response of "oh, it is sour" and thus, decline to repurchase.

In response to these important industry concerns, the California Kiwifruit Commission, in cooperation with the Pomology Department (UC-Davis/Kearney), have prepared two kiwifruit ripening protocols. These protocols are designed to assist in handling and ripening kiwifruit at different points during the postharvest handling. This protocol will deal specifically with preconditioning at shipping point. In this case, fruit ripening is triggered by an ethylene treatment but ripening changes are slowed down by decreasing fruit temperature. As the fruit warm up at the warehouse/retailer stores, ripening will continue. A second protocol dealing with handling preconditioned kiwifruit and ripening at the retailer is contained in the "Ripening Guidelines for Kiwifruit Receivers."

Since growers, packers and shippers are important players in this ripening program, we would like to instruct them on how to precondition kiwifruit.

This protocol is a comprehensive guide for handlers interested in providing receivers with preconditioned fruit. Information contained in this protocol addresses the following items:

I. Pre-Conditioning
II. Ethylene Treatment Systems
III. Ethylene Sources
IV. Safety Precautions
V. Storing Treated Fruit

I. <u>Pre-conditioning</u>

Harvest: Kiwifruit should be picked according to soluble solids content (SSC). In accordance with the California Kiwifruit Marketing Order, kiwifruit must be picked to correspond with the actual minimum maturity index of at least a 6.5% SSC when inspected at the shipping point.

To assure fruit quality and consumer acceptance, we recommend picking kiwifruit when it reaches a minimum of 7.0% SSC measured in the field or 14% SSC after forced ripening. Research clearly states that higher sugars at harvest increases the consumer acceptance, storage, and shelf-life of kiwifruit. Make sure to check the refractometer and standardize it against distilled water (0%) and/or 20% sucrose solution.

To precondition kiwifruit, 100 ppm ethylene exposure for 12 hours is recommended. A short ethylene exposure of 6 hours is enough to precondition kiwifruit which have been in storage for one week. This preconditioning treatment is only necessary on kiwifruit that have been in cold storage for less than 4 weeks.

! **Pre-conditioning for Long Distance Shipping (2-3 weeks)**

Place cooled kiwifruit in any type of container with polyliners at 32^{o}F in a 40 foot truck or room with a temperature setting control. The type of kiwifruit container such as tray pack, volume fill packages, or tri-wall containers with box polyliners does not interfere with the preconditioning treatment. We recommend use of polyliners to protect fruit from water loss and premature shriveling. The ripening treatment should take place far away from any packing facilities to avoid ethylene contamination of long-term storage kiwifruit. Ethylene applied at 100 ppm for 12 hours within 32°F-68°F temperature range will induce uniform kiwifruit softening and starch conversion into sugars (ripening). A 6-hour ethylene treatment is enough to precondition kiwifruit which have been in storage for at least one week. After venting, cold ethylene treated kiwifruit can be stored back in your cold storage but must be separated from your long-term storage kiwifruit room. Kiwifruit treated at near 32°F and maintained at near 32°F may last up to 3 weeks for weak kiwifruit and up to 6 weeks for strong kiwifruit. After being transferred to higher temperatures, kiwifruit will soften according to flesh temperature (Table 1).

Table 1. Rate of kiwifruit softening after ethylene treatment at 68°F.

Temperature	Number of days to reach 3 pounds
32°F	6.5 to 7.0
45°F	6.0 to 7.0
68°F	3.0 to 4.5

! Pre-conditioning for Short Distance Shipping (4-7 days)

Place warm or cold palletized kiwifruit in a 40 foot truck or room at 68°F and high relative humidity. The type of kiwifruit container such as tray pack, volume fill packages, or tri-wall containers with box polyliners does not interfere with the pre-conditioning treatment. We recommend use of polyliners to protect fruit from water loss and premature shriveling. The ripening treatment should take place far away from any packing facilities to avoid ethylene contamination of long-term storage kiwifruit. The temperature during shipping should be set near 32°F. We recommend precooling kiwifruit before preconditioning to reduce potential decay, shriveling and undesirable fast fruit softening during postharvest handling.

The post treatment temperature management should be adjusted according to the anticipated consumption schedule using Table 2.

Table 2. Rate of kiwifruit softening after warm ethylene treatment (68°F).

Temperature	Pounds lost per day
32°F	1.5
45°F	2.0
68°F	3.0 to 4.0

If shipping is delayed after treatment, fruit will reach 3 pounds within approximately six days when held at 32°F. To assure reaching maximum storage potential, the kiwifruit temperature during storage and shipping should be close to 32°F.

II. <u>Ethylene Treatment Systems</u>

The "Shot" and "Flow-Through" systems are the two techniques by which ethylene can be applied to kiwifruit. In either case, make sure your ripening room or truck are well sealed. These two ethylene application systems can be done by using compressed ethylene from a cylinder. The ethylene generator can only be used for the "Flow-Through" system.

- **The Shot System**

A measured amount of ethylene is introduced into the room. The room can be completely full. Ethylene shots from a cylinder may be applied by flow using a gauge that registers the discharge of ethylene in cubic feet per minute. The required ethylene application is made by adjusting the regulator to give the appropriate flow rate, then timing the delivery of gas. The amount of gas needed for a room is calculated by using the following information:

C= ppm of ethylene required (100 ppm)
V= volume of room in cubic feet
F= flow rate of gas (measured from flow meter) in cubic feet per minute (CFM)
T= time (in minutes) for which gas is allowed to flow

Insert this information into the following formula:

$$T = (C \times V) / (F \times 1,000,000)$$

For a 48-foot trailer (2,825 cubic feet), a desired ethylene concentration of 100 ppm and an ethylene flow rate of 0.018 CFM, (or approximately 0.5 liters per minute), the equation would be as shown below:

$$(100 \times 2,825) / (0.018^* \times 1,000,000) = 15.7 \text{ minutes}$$

* *To convert the above equation from cubic feet per minute to milliliters per minute, multiply by 28.32.*

Flow time is easily measured with a stopwatch. The room should be ventilated before each application by opening the doors for at least one-half hour. Kiwifruit just harvested or stored for less than a week, should be treated for at least 12 hours. If kiwifruit have been in cold storage for more than a week, a 6-hour ethylene treatment will trigger ripening. In both cases, a ventilation fan should be provided.

- **The Flow-Through System**

With the "Flow-Through" system, ethylene is introduced into the room continuously, rather than intermittently, by using compressed ethylene from a cylinder or ethanol from a catalytic generator. The room can be filled to capacity with fruit. The flow of ethylene is very small and it must be regulated carefully. Regulate ethylene by reducing pressure using a two-stage regulator and passing the gas into the room through a metering valve and flowmeter. To prevent buildup of CO_2 or C_2H_4, fresh air is drawn into the ripening room at the rate which ensures a change of air every six hours (360 min.). The air should be vented through an exhaust port in the rear of the room. Fan size or Ventilation Fan Delivery, (measured in cubic feet per minute), is calculated using the following formula:

$$\text{Ventilation Fan Delivery} = \text{Volume of Room (cubic feet)} / 360$$

The ethylene flow rate (in CFM) needed to maintain 100 ppm in the room is calculated as follows:

$$\text{Ethylene Flow Rate (CFM)} = \text{Ventilation Fan Delivery (CFM)} \times 100/1,000,000$$

In milliliters per minute, the flow rate is:

$$\text{Ethylene Flow Rate (ml/min.)} = \text{Ventilation Fan Delivery (CFM)} \times 2.8$$

Monitoring gas in a "Flow-Through" system can be done with a "sight glass" in which ethylene bubbles through a water trap on its way to the ripening room.

III. <u>Ethylene Sources</u>

Presently, there are two sources to commercially apply ethylene to kiwifruit: ethylene generated from alcohol as the ethylene source (catalatic) and compressed ethylene from a cylinder.

Ethylene Generator: The ethylene generator is a machine in which a liquid (ethanol and catalyst agent) produces ethylene when heated. The generator combines a simple heater with a system for attaching a bottle of a generator liquid. Ethylene can be applied by using ethylene generators in position 1 in a well sealed 48 foot-trailer (2,825 cubic feet) or position 2 in a trailer not well sealed. We recommend measuring ethylene levels initially in the season for each operation.

There are two companies who have included kiwifruit on their California labels:

Precision Generators Inc.
905 Washington Ferry Road
Prattville, AL 36067
Phone 1-800-337-1777

American Ripener Company Inc.
803 Pressley Road, Suite 106
Charlotte, NC 28217
Phone 1-800-338-2836

Ethylene Cylinder: Use only explosion-proof mixtures. Check with your provider.

Dual Stage Regulator: Ethylene tanks require a regulator with a CGA-350 fitting. Regulator delivery pressure should not exceed 250 psi.

Product Example: Matheson Model 3122

Flowmeter: Two types are available; both meters measure only air content.

1. Direct read, scaled in liters per minute of air.
2. Flow rate determined by chart, scaled in millimeters.

Product Example: Matheson (ordered as separate components)

TTube Cube Model J409, 0.5 - 5.0 liter/min. (0.018-0.18 CFM)

TFlowmeter FM-1000S-HA with 1/8" FPT fittings

Connecting Fittings: Flowmeter must be securely attached to the regulator. It must be oriented vertically to operate properly.

Product Example: Sunnyvale Valve and Fitting Company

Brass 4" hex long nipple (B-4-HLN-4.00)
Reducing street elbow (B-4-RSE-2)
1/8" NPT to 1/4" ID hose connector (B-4-HC-1-2)

IV. Safety Precautions

Mixtures of ethylene gas and air are potentially explosive when the concentration of ethylene rises above 3.1 percent by volume, which is **30,000 times** greater than the concentration required to initiate kiwifruit ripening.

1. Do not permit open flames, spark-producing devices, fire, or smoking in a room containing ethylene gas or near the generator.

2. All electrical equipment, including lights, fan motors, and switches should comply with the National Electric Codes for Class 1, Group D equipment and installation.

V. Storing Treated Fruit

Based on our knowledge, cold ethylene treated kiwifruit does not produce more ethylene than untreated kiwifruit. In both cases, the level of ethylene production of cold kiwifruit is extremely low. Thus, cold ethylene treated kiwifruit can be transported with any type of commodity.

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Featuring "ready to eat" (ripe) kiwifruit in your stores has proven to increase shelf turns at retail. This is a key component in produce department profits. A number of California kiwifruit growers and shippers are using our preconditioning protocols to supply you with ripe fruit in the early season.

To inform you of the new available technology, the California Kiwifruit Commission and the Pomology Department, University of California, Davis prepared this brochure designed to help you deal with ripe kiwifruit. This brochure has been developed based on the last 5 years of research. It includes a simple guide to handling the preconditioning of kiwifruit and information on how to ripen kiwifruit yourself at the warehouse or store levels.

This easy-to-follow format outlines the following items:

- Determining stage of ripening
- Handling preconditioned kiwifruit
- Temperature ripening
- Ethylene ripening

Determining Stage of Ripening

Fruit firmness is the best measurement of ripeness. We define fruit firmness as the force necessary to break the flesh tissues and we relate this to different stages during the ripening process. For example, fruit firmness of a mature fruit varies from 12-18 pounds. During ripening, softening occurred, thus, fruit firmness decreases, reaching values of 2-3 pounds. When fruit reaches these values it is considered ripe or "ready-to-eat." This is the level at which fruit will achieve its best eating characteristics. Fruit firmness of 4-5 pounds is defined as the shipping point. Fruit with firmness below this level become more susceptible to physical abuse during transportation and handling.

To determine ripening stage, fruit which arrives at your warehouse should be tested for flesh firmness using a standard fruit penetrometer with 8.0 millimeter tip (5/16"). Fruit firmness should be measured on warm fruit (55-77^{o}F).

As a general rule, non-preconditioned kiwifruit received in your warehouse which have been in storage less than 4 weeks or have a flesh firmness level of 8-10 pounds or greater should be treated further by using ethylene treatment to enhance ripening at the warehouse or store levels. Fruit which has been in storage equal to or longer than 4 weeks or have a flesh firmness of less than 8 pounds can be ripened to optimum levels by temperature management.

Handling Preconditioned Kiwifruit at the Warehouse/Store

1. Preconditioned kiwifruit firmness must be tested upon arrival to the warehouse or retail store and handled according to its rate of softening (Table 1) and your rotation time.

2. Fifteen kiwifruit may be taken from the upper corner box in the pallet. A mature

kiwifruit is usually harvested and shipped with a flesh firmness of 14-18 lbs-force (hard). Preconditioned kiwifruit should arrive at destination warehouses with a firmness near 6-12 lbs/force but never lower than 4-5 lbs-force. Fruit arrival temperature should be lower or equal to 50°F.

3. Kiwifruit should always be kept at low temperatures (below 45°F), except if they are going to be consumed within 3 days. Keep kiwifruit enclosed with liners as long as you can.

4. Cooled kiwifruit enclosed with liners should be moved to the retail market before they reach a firmness of lower than or equal to 4-5 lbs-force to avoid vibration and impact bruising damage during transportation and handling (shipping point).

5. After delivery to the retail store, when kiwis reach the room temperature of 20-25°C (68-77°F), preconditioned kiwifruit will lose nearly 3 lbs-force per day. If kept at 7.5 to 0°C (45-32°F), kiwifruit will soften at a rate of .2.0 lbs-force per day (Table 1). As kiwifruit reach 2-3 pounds and start to deteriorate during display (warm rack), kiwifruit can be placed in a cool room overnight or transferred to a cold rack if it is available to prolong their postharvest life. Frequent rotation and placing the softest kiwifruit at the front of the display are advised.

6. Consumers should be informed that preconditioned kiwifruit or "ready-to-eat" (2-3 lbs) kiwifruit must be refrigerated if they are not eaten immediately.

Temperature and Ripening

If the flesh firmness is more than 5 pounds, but less than 10 pounds, its ripeness can be triggered and controlled at your warehouse by temperature management.

The fruit temperature should be adjusted according to the anticipated consumption schedule (Table 1).

Table 1. Rate of kiwifruit softening after ethylene treatment.

Temperature	Number of days to reach 3 pounds
32°F	6.5 to 7
45°F	6.0 to 7
68°F	3.0 to 4.5

Ethylene and ripening

Kiwifruit can be treated in existing banana or tomato ripening rooms using 10-100 ppm of ethylene per 6 hours. To avoid or reduce fruit shriveling, kiwifruit should be place in ripening rooms in tray pack or volume fill packages with poly liners. Temperature setting will be according to predicted fruit consumption (Table 1).