CENTRAL VALLEY POSTHARVEST NEWSLETTER

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RIPENING GUIDELINES FOR KIWIFRUIT HANDLERS

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To assure fruit quality and consumer satisfaction, we recommend to start picking kiwifruit when they reach a minimum of 6.5% SSC measured in the field or 14% SSC after a forced ripening. Make sure to check the refractometer and standardize it against distilled water (0%) and/or a 20% sucrose solution.

Ethylene pre-conditioning treatment (100 ppm/12 hours) is only effective on kiwifruit that have been in cold storage for 5 weeks or less, or kiwifruit picked with a flesh firmness higher than 8 pounds.

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

Place warm or cold palletized kiwifruit in a room with a temperature setting and high relative humidity control. The type of kiwifruit container such as tray pack, volume fill package, or tri-wall container with polyliner does not interfere with the preconditioning treatment. We recommend use of polyliners. The ripening room should be located far away from any packing facilities to avoid ethylene contamination of long-term storage kiwifruit. High relative humidity is especially recommended when ripening is carried out at temperatures higher than 45F. **We enforce pre-cooling kiwifruit before preconditioning treatment to reduce potential decay, shrivelling problems and undesirable fast fruit softening during postharvest handling.**

Ethylene applied at 100 ppm for 12 hours within a 32-68F temperature range will induce uniform kiwifruit softening and starch conversion into sugars (ripening). The temperature setting during treatment and shipment should be adjusted according to the anticipated consumption schedule using 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

If shipping is delayed after treatment, fruit will reach 3 pounds within six days when held at 32°F. In this case, the temperature setting during storage and shipping should be close to 32°F.

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

Place **cooled** kiwifruit in any type of container but with polyliners at 32°F. Kiwifruit treated at near 32°F and maintained at near 32°F may be held up to 5 weeks. **After being transferred to 68°F, kiwifruit will reach 3 pounds in 2 to 3 days.** The temperature should be set near 32°F during shipping.

TIPS TO REDUCE INTERNAL BREAKDOWN INCIDENCE IN STONE FRUIT

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Based on our knowledge of this problem, we give the following recommendations:

1) Market susceptible cultivars according to their potential market life (See page 7).

2) Segregate fruit according to their market potential postharvest life.

3) Pick fruit "well matured" or even higher maturity.

4) Enforce proper postharvest handling during transport and at the retailer.
   a) Cool fruit as soon as you can.
   b) Keep fruit near 32°F during storage and transportation.
   c) Avoid 36-46°F temperatures during transportation and retail handling.

5) Educate warehouse and retail managers on Internal Breakdown.

DELAYING HARVEST TO PRODUCE A HIGH QUALITY STONE FRUIT

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There are two possible ways to produce high quality stone fruit: using production techniques such as training systems, pruning, thinning (crop load), good irrigation and fertilization practices, etc. to assure high quality and/or harvesting fruit after it reaches the "well mature" stage. Right now, at the Kearney Agricultural Center, we are investigating these two possible ways to improve quality in stone fruit.

In general, a fruit picked later than "well mature" will have larger size and higher SSC but be softer than the same fruit picked earlier. In addition, fruit drop, high bruising and decay susceptibility are the main concerns of this practice. Based on Mitchell's work, some recommendations for producing and handling high eating quality peaches, plums and nectarines for a late harvest have been developed:

1) Based on the limited information

available, taster acceptance of stone fruits increased as soluble solids content (SSC) levels increased, especially, when they exceeded 11%. Cultural practices and growing conditions strongly affect fruit SSC level.

2) Cultivars presenting high soluble solids content levels, relatively low susceptibility to impact bruising, and with relatively slow rates of softening should be used for late harvest. 'Flavorcrest,' 'Elegant Lady,' 'O'Henry,' 'May Grand,' 'Fantasia,' 'September Red,' 'Black Amber,' 'Friar,' and 'Angelino' cultivars are suitable for late harvesting. There are other cultivars which can also be used but we have not tested them yet.

3) Impact bruise susceptibility in peach and nectarine fruit does not increase until fruit soften to near the 8-10 lbf level. This bruising susceptibility varies among species, cultivars and impact force magnitudes in each postharvest operation. More detailed information for each cultivar should be developed before establishment of this technique. Flesh firmness variability among fruit on the tree/orchard on any harvest date must to be taken into consideration when we are working with averages.

4) Peach and nectarine fruit harvested at lower flesh firmness should be cooled down to 38F within 8 hours to reduce the rate of flesh softening. This short cooling delay should be emphasized when we are working with cultivars susceptible to internal breakdown.

5) Plum softening for the varieties tested, 'Black Amber,' 'Friar,' and 'Angelino,' appeared to be unaffected by a 24 hour cooling delay.

6) Fruit characteristics varied greatly between fruit located inside and outside of the canopy. Fruit located outside the canopy showed considerably higher levels of SSC than fruit located inside of the canopy.

MAINTAINING POSTHARVEST QUALITY OF PERSIMMONS

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Minimum maturity is based on skin color changes from green to orange or reddish-orange for 'Hachiya' or to yellowish-green or yellow for 'Fuyu,' 'California Fuyu,' and 'Jiro.' Optimum storage conditions are 32 $\pm$ 2^{o}F fruit temperature and 90-95% air relative humidity. Postharvest life under optimum **ethylene-free** air storage conditions can be up to 3 months vs. 5 months in optimum, ethylene-free CA conditions. 'Fuyu' and similar non-astringent cultivars are chilling-sensitive at temperatures between 41^{o} and 59^{o}F (5^{o} and 15^{o}C) and will exhibit flesh browning and fast softening. Persimmons are very sensitive to ethylene action and exposure to ethylene aggravates chilling injury at these temperatures. Exposure to 1 ppm and 10 ppm ethylene at 20^{o}C (68^{o}F) accelerates softening to less than 4 lb-force (limit of marketability) after 6 and 2 days, respectively. Thus, ethylene removal and/or exclusion from transport and storage facilities is highly recommended.

Our last seasons' work showed that `Hachiya' fruit firmness went down from 9 pounds to 1. 2 pounds in 3 weeks when they were held at 41F. The use of ethylene absorber pads did not make any difference in the rate of softening.

HOW TO AVOID INTERNAL BROWNING

OF 'YA LI' AND 'SEURI' CHINESE PEARS

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Our last two years of work showed that brown discoloration of the core, carpels and flesh areas of 'Ya Li', 'Tsu Li' and 'Seuri' Chinese pears was dependent upon harvest date. This physiological disorder can be avoided by harvesting fruit earlier than is presently being done commercially in the San Joaquin Valley. In our trials, fruit harvested no later than 180 days after full bloom (before August 30th) did not develop the disorder. In both cultivars, the onset of internal browning was observed after storage in fruit that had been harvested when skin color had changed from green to light green-yellow. Thus, changes in skin color can be used to determine harvest date to avoid internal browning incidence during storage of 'Ya Li' and 'Seuri' Chinese pears.

To avoid this disorder fruit should be picked when most of the pears on the tree are still green and only a few exposed top fruit are beginning to show yellow spots. Flesh and core browning will affect Chinese pears which are starting to show some yellow spots when cooling is delayed. Green Chinese pears will turn yellow during storage or postharvest handling depending on temperature.

Fruit picked when the skin is completely yellow will develop internal browning within one month after harvest.

We suggest growers keep records of the number of days after full bloom needed for their Chinese pears to turn yellow in order to help them to decide when to pick without reducing fruit size in subsequent years.

POMEGRANATE STORAGE TEMPERATURE

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To ensure pomegranate best eating quality for consumers, pomegranates should be picked when fully ripe because they do not ripen off the tree. Ethylene exposure to pomegranate during postharvest handling will not reduce their quality. Pomegranates are susceptible to chilling injury if stored longer than **one month** at temperatures between the freezing point 26°F (-3°C) and 41°F (5°C). The minimum safe temperature for storage for up to **two months** is 41°F (5°C). Longer storage should be at 50°F (10°C) to avoid chilling injury but decay and weight loss become problems. Maintenance of a relative humidity near 95% minimizes weight loss during storage. This information was extracted from an article published in the 1984 July-August California Agriculture written by A.A. Kader and cooperators.

APPLE RUSSETING

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Russeting is a fairly new condition in the Central Valley of California, but is by no means unknown to other apple growing regions. Experience elsewhere has shown that there are a number of things which can cause russeting including disease, frost, or damage by chemical sprays.

Another cause of russeting and the most difficult to control is weather-induced and is associated with free moisture, spring rains, and wet weather conditions during the early growing season. Genetic, environmental, and cultural factors influence the degree of weather-induced russeting. By understanding these factors, effective control strategies can be developed.

Genetic Factors

Genetics control the internal susceptibility of any particular apple variety to russet formation. There are both sensitive and resistant varieties including sports, or mutations, which may exhibit more or less russeting than their parent.

Russet develops when the cuticle and epicuticular waxes are damaged. This can be caused by either outside forces such as frost, chemical, or disease damage, or by internal forces such as rapid epidermal growth which causes the protective cuticle to rupture. If either occurs, a layer of cork cambium develops, pushes outward, and replaces the cuticle as the outer protective layer of the fruit. Unlike the smooth, waxy cuticle, the cork cambium is rough in texture and gives the fruit a russeted, scabby appearance.

Cuticle thickness is very important and anything which reduces or damages cuticular development tends to cause russeting. Apple varieties which are sensitive to russeting usually have thin cuticles. The period of susceptibility is usually recognized as the first 4 to 6 weeks after petal-fall. This timing coincides with cuticle development and division of epidermal cells.

Environmental Factors

The major cause of weather-induced russeting is moisture. Rain, dew, or high humidity during the sensitive period, the first 4 to 6 weeks following petal-fall, initiates russeting. In experiments preformed in the eastern United States apple trees were covered during the critical period to protect the fruit from rain. Fruit from uncovered trees russeted heavily, while fruit from protected trees were russet free. Similar experiments have been performed elsewhere and have further demonstrated the relationship between rain and russeting.

High relative humidity either within a tree or orchard tends to increase russeting. Under experimental conditions, apple fruits enclosed in paper bags which allowed for air movement did not develop russet. Apple fruits enclosed in plastic bags which maintained a high relative humidity around the fruit were russeted uniformly from blossom to stem end.

Dew during the critical period also influences the development of russet. Heavy dew often causes water to accumulate in the stem cavity of fruit, a location where russeting is often severe.

Development of russeting is believed to be increased when overnight temperatures during the critical period are warm. Temperatures in the 40s are reportedly less harmful than those in the high 50s and 60s.

Fruit position and exposure can also affect sensitivity to russeting. Lateral fruits generally have more russeting than "king" or terminal fruits because lateral fruits have thinner epidermal cells and cuticles.

Cultural Factors

Fruit from vigorous rootstocks tend to develop less russeting than fruit from weaker rootstocks. Because these fruits are more shaded, they develop a more elastic, resilient cuticle which is less susceptible to russeting. Under high humidity conditions, however, a dense canopy can trap moisture, causing increased russeting.

Nutrition can also play a role in russet development. Excessive amounts of nitrogen tend to cause increased russeting, possibly by affecting nutrient "balance" within the tree. Phosphorus deficiency may lead to increased russeting. Currently, these interactions are not well understood.

Unnecessary irrigation should be avoided during the critical period of 4 to 6 weeks after bloom to help keep down free moisture in the orchard. If winter rains are lacking, supplemental irrigation to fill the soil profile should be applied prior to bloom. Overhead sprinkler irrigation should not be used during the critical period since it duplicates ideal conditions for russet development. Large soil moisture fluctuations can affect epidermal cuticle growth and should be avoided during the critical period. Since russeting can be more severe on heavy, waterlogged soils, adequate drainage should be provided.

Pesticides and nutritional sprays may increase russeting and should not be applied to the fruit during the critical period, especially at night or when drying conditions are slow. Reports indicate that emulsifiable materials are more likely to cause russeting than wettable powders.

Control

Growers should focus on cultural strategies to reduce russeting. Proper nutrient status should be maintained. Nitrogen should not be excessive and phosphorus levels (usually not a problem in most areas) should be maintained. Tree training and pruning to encourage air flow through the canopy should be performed, proper irrigation techniques followed, and all unnecessary sprays should be avoided during the critical period.

Currently in California there are no registered chemicals for control of weather-induced russeting. There are a few compounds which have shown promise in other regions. Most of these work by either toughening or increasing cuticle thickness. Some of these compounds are currently being tested in California and preliminary results are encouraging.

In summary, weather-induced russeting occurs when there are wet conditions during the critical period, the first 4 to 6 weeks after petal-fall. During the 1991 season most apple growing regions in California were subjected to such conditions by the record-setting March rains. Increased plantings of varieties with greater susceptibility and lack of suitable control methods made the problem even more significant.

SKIN DISCOLORATION ON PEACH AND NECTARINE FRUIT

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

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

We found that iron was more effective than aluminum, copper, tin, zinc, or sodium in inducing inking on abraded fruit. In fact, 10 ppm iron was enough to induce inking at the physiological cell pH.

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

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

Tips to reduce inking on peaches and nectarines

Based on our knowledge we suggest the following practices:

1. Reduce abrasion damage
   a. Treat fruit gently during harvesting operations (orchard).
   b. Avoid long hauling.
   c. Reduce vibration damage during hauling.

2. Reduce contamination of fruit
   a. Keep harvesting equipment clean.
   b. Avoid dust.
   c. Eliminate any foliar nutrient sprays during the growing season (iron, aluminum, tin or copper).
   d. Do not spray fungicides 5-7 days before harvest.
   e. Avoid insecticide or miticide sprays before harvest.

MARKET LIFE OF STONE FRUIT

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Some of the most frequent complaints by consumers and wholesalers are the presence of flesh browning, flesh mealiness, black pit cavity, flesh translucency, red pigment accumulation (bleeding), and loss of flavor on apricots, peaches, nectarines, and plums. These symptoms are a consequence of chilling injury also called, internal breakdown, internal browning, mealiness, dry fruit, or woolliness. These symptoms normally appear after placing fruit at room temperature while some ripening is occurring, following cold storage. For this reason, this problem is usually experienced by the consumers, and not by the growers, packers and/or shippers. This disorder is the main limitation to the market life, and therefore, shipping of some plums and late California peaches and nectarines. The symptom intensity and time of appearance during the postharvest life varies according to cultivars, cultural practices, postharvest handling, growing location and seasons. Stone fruit cultivars vary greatly in susceptibility to internal breakdown injury (Table 1). Among peaches and nectarines; early season cultivars are least susceptible, late-season cultivars most susceptible. Among plums, there is no seasonal pattern of susceptibility.

Among stone fruits the greatest internal browning symptom development occurs at temperatures between about 36°F and 46°F (2.2° and 7.8°C). While symptoms will still develop at 32°F (0°C) or below, they develop more slowly and normally become less intense than at higher temperatures. Even under the best storage and marketing handling conditions, stone fruit have a limited market life. An evaluation of the market life of stone fruit grown under California conditions is presented in Table 1. Market life means the number of weeks for each of the cultivars under a continuous exposure to 32°F (0°C) and 90% RH which their fruit can be kept until at least 85% remain marketable. As perfect 32°F (0°C) conditions rarely occur during the storage, transportation and handling at the retail end, this potential postharvest life of stone fruit cultivars never is reached. In fact, when fruit from different cultivars are exposed to 41°F (5°C), their market life is shorter by nearly half (Table 2).

I have observed that some non susceptible California cultivars became more susceptible when they are grown under cooler summers (Chile and South Africa) than those in California.
The best long term solution to this problem would be to breed high quality cultivars not susceptible to this problem. We hope that the level of physiological understanding of the cause(s) of this problem will improve in the near future, thus, allowing plant breeders and molecular geneticists to eliminate this stone fruit postharvest problem.

It has been claimed that different treatments such as pre-warming, high temperature, CA during storage/transportation can reduce internal breakdown, thereby, extending the postharvest life of stone fruit cultivars. Use of controlled atmosphere (CA) conditions has shown some beneficial effect on extending the postharvest life of 'Angeleno' and 'Friar' but not 'Casselman' plums grown in California (Table 3). However, when some benefits of these treatments were observed, they were overcome by post-treatment temperature exposure to near 41°F (5°C).

Detailed research on these different pre-conditioning treatments and CA during transportation are being studied for California conditions at the F. Gordon Mitchell Postharvest Center. In the meantime, temperature management is the only tool commercially available to delay the onset of internal breakdown. Storage near or below 0°C (32°F) but above the freezing point is beneficial to delay chilling injury symptoms and extend the market life.

Table 1. Postharvest performance rating of various stone fruit cultivars grown in California.

	Postharvest performance	
Variety	Internal Breakdown[z] @41°F	Market life wks @ 32°F
NECTARINE		
August Red	M	3
Autumn Grand	H	2-3
Fairlane	H	3
Fantasia	M	4-6
Flamekist	M	3
Flaming Red	M	3
Flavortop	L	4-5
Independence	L	5-6
July Red	L	6
June Glo	L	6
May Diamond	L	6
May Glo	L	4
May Fair	L	6
May Grand	L	6
Red Free	L	6
Red Grand	M	3-5
Royal Giant	M	4
September Grand	M	3-4
September Red	M	3
Sparkling Red	M	5
Springred	L	6
Summer Grand	L	5
Summer Red	M	5
PEACH		
Autumn Gem	H	1
Belmont	H	1
Calred	H	2

Carnival	H	2
Cassie	H	2
Early Fairtime	H	2
Early O'Henry	H	4
Elegant Lady	H	4
Fairtime	H	2
Firered	H	2
Flamecrest	L	3
Flavorcrest	H	4
June Lady	M	3
Kings Lady	H	2
Lacey	M	6
Merrill Gemfree	L	6
O'Henry	M	4
Parade	H	3
Redcal	H	2
Redtop	L	4
Regina	L	3
Sparkle	M	3
Springcrest	H	3-4
Springold	H	3
Spring Lady	L	5
Summer Lady	H	5
Suncrest	M	2
Windsor	H	2
PLUM		
Ambra	H	2
Angeleno	M	8-10
Black Beaut	L	3
Casselman	M	5-6
Catalina	L	6
El Dorado	M	3-5
French Prune	L	>8
Friar	M	3-4
Frontier	H	4+
Grand Rosa	H	3
July Santa Rosa	H	3
Kelsey	H	2
Laroda	L	4
Late Santa Rosa	L	3
Moyer	L	5
Nubiana	H	2
President	L	3
Queen Ann	M	4
Queen Rosa	M	4
Red Beaut	H	1-2
Red Rosa	H	4
Rosemary	L	4
Roysum	M	4
Royal Diamond	M	6
Santa Rosa	L	3-5
Simka	M	3
Spring Beaut	L	2
Wickson	L	4

[z] Rankings are summarized from detailed test results. Market life is the length of time for which fruit could be stored with at least 85% of the fruit remaining marketable. Market life varies according to initial maturity, orchard influence, and conditions during growing season and storage period.

Table 2. Percent of marketable stone fruit after two different temperature regimes.

	% of Juicy Fruits	
Variety	32F/6 weeks	41F/3 weeks
Peaches		
Spring lady	80	17
Springcrest	95	35
Flavorcrest	85	42
Redtop	42	27
O'Henry	67	14
Fairtime	67	23
Nectarines		
June Glo	100	100
Sparkling June	86	100
Fantasia	91	40
September Rose	49	13
Fairlane	50	9

Table 3. Estimating market life of three plum cultivars as influenced by storage conditions.

	Postharvest (months)			
	Air		Ca[z]	
Cultivar	-1.1°C	0.6°C	-1.1°C	0.6°C
Angeleno	4	2	1-2	5
Casselman	2-3	1	1	2-3
Friar	1	<1	2	2

[z] Market life is the length of time for which fruit could be stored with at least 85% of the fruit remaining marketable.

Tips to Reduce Internal Breakdown Incidence in Stone Fruit

Based on our knowledge here are some recommendations:

1) Segregate fruit according to their postharvest market life.

2) Pick fruit "well matured" or even higher in maturity.

3) Enforce proper postharvest handling during transport and at the retailer.
   a) Cool fruit as soon as you can (fast cooling).
   b) Keep fruit near 32°F during storage and transportation.
   c) Avoid 36-50°F temperatures during postharvest handling including retail operation.

4) Educate warehouse and retail managers on internal breakdown.