CENTRAL VALLEY POSTHARVEST NEWSLETTER

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Editor

Contents

TIPS FOR REDUCING INKING/STAINING OF PEACHES AND NECTARINES

After three years of research funded by the California Tree Fruit Agreement, we have demonstrated that the two requirements for inking development are:

1) physical injury (abrasion), and
2) heavy metal contamination.

Through anatomical studies we confirmed that fruit abrasion is consistently associated with inking development. Unfortunately, abrasion injury is always occurring during the fruit harvesting/hauling operation, and it is very difficult to completely eliminate this type of physical damage.
We also found that various heavy metals such as iron, copper, and aluminum readily induced inking on fruit which had been abraded. A solution concentration of 5-10 parts per million (ppm) iron was sufficient to induce inking. Our work demonstrated that preharvest sprays which contain heavy metals (such as fertilizers and/or contaminants) can contribute to inking development.

To help reduce the possibility of fruit inking we recommend the following:

1. **Reduce fruit abrasion damage:**
   - Treat fruit as gently as possible.
   - Avoid long hauling.

2. **Reduce fruit contamination:**
   - Keep picking and bin containers clean and dry.
   - Avoid picking fruit with dew on it.
   - Avoid dust contamination.
   - Check water used for spraying for possible heavy metal contamination. Well water may contain iron concentrations high enough to induce inking/staining, especially, late in the season when water supply decreases and salts

and metals concentrate in the water. An approximate water iron concentration can be easily measured by using a kit similar to those used for chlorine in swimming pools/hydrocoolers.

- Do not spray foliar nutrients which contain heavy metals while fruit is on the trees.
- Avoid any unnecessary sprays prior to harvest.
- If preharvest sprays are necessary, apply them as far before harvest as possible. We developed the following tentative preharvest fungicide intervals: Funginex = 3 days, Rovral 50%WP = 7 days, Benlate = 12 days and Ronilan = 1 day. Fungicides applied according to this spray schedule are equally effective to prevent decay as when they were sprayed the same date of harvest. Following this spray schedule these fungicides do not act as contaminant(s) for inking development. As we have identified (botrytis) gray mold damage early in the season, it is important to point out that Funginex does not control Botrytis as well as Rovral as shown in previous studies done by Ogawa.

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PRECONDITIONING KIWIFRUIT

Most consumers prefer to purchase kiwifruit which are near full ripeness. On the other hand, when consumers buy unripe kiwifruit, they usually don't know how to properly ripen them, creating a response of "oh, it is sour" and thus fail to repurchase kiwifruit. To ensure good tasting, ready-to-eat fruit, kiwifruit can be legally ripened with ethylene treatment at shipping points. This is especially useful for early season, freshly-harvested fruit.

- **Maturity at harvest**

Kiwifruit should be picked according to the soluble solids content (SSC) determined with a well calibrated refractometer. In accordance with the California Kiwifruit Marketing Order, kiwifruit must be picked with a minimum maturity index of 6.5% SSC when inspected at the shipping point.

To assure good flavor of kiwifruits when ripe, we recommend picking them when they reach at least a minimum of 6.5% SSC measured in the field or 14% SSC after the accelerated ripening test. Make sure to check the refractometer and standardize it against distilled water (0%) and a 20% sucrose solution.

Ethylene pre-conditioning treatment is only effective on freshly-harvested kiwifruit or those that have been in cold storage for less than 5 weeks. Fruits kept in cold storage for longer than 5 weeks will ripen upon transfer to ripening temperatures of 59^{o}-70^{o}C (15-21^{o}F).

- **Pre-conditioning treatment**

Place kiwifruit in a room with good temperature and high relative humidity controls. The type of kiwifruit container such as tray pack, volume fill package, or tri-wall container with polyliner does not interfere with our preconditioning treatment. The ripening room should be located far away from any packing facilities to avoid ethylene contamination of long-term storage kiwifruit. High relative humidity (90-95%) is especially recommended when ripening is carried out at temperatures higher than 7.5^{o}C (45^{o}F).

Ethylene applied at 100 ppm by using the "shot system" for 12 hours within a 0 to 20^{o}C (32-68^{o}F) temperature range will induce ripening as indicated by uniform kiwifruit softening and starch conversion into sugars. Ethylene exposures can be shortened to 6 hours by using the generator (C_2H_4) flow application system. The temperature setting during treatment and shipment should be adjusted according to the anticipated consumption schedule using Table 1.

If shipping is delayed after treatment, preconditioned fruit will reach a firmness of about 3 pounds-force within six days when held at 0^{o}C (32 ^{o}F). In this case, the temperature setting during storage and transportation should be close to 0^{o}C (32^{o}F).

Table 1. Rate of kiwifruit softening after ethylene treatment at 20 ^{o}C (68 ^{o}F).

Temperature ^{o}C	Temperature ^{o}F	Rate of softening lbs/day
0	32	1.7
7.5	45	1.9
20	68	3.4 - 3.7

To prevent softening due to delayed shipments, apply ethylene to cold kiwifruit. Cold kiwifruit treated at near 0^{o}C (32^{o}F) and maintained at that temperature may be held up to 5 weeks. These kiwifruit will reach a firmness of about 3 pounds-force in 2 to 3 days after being transferred to 20^{o}C (68 ^{o}F). The temperature should be set near 0^{o}C (32^{o}F) during transportation.

- **Management of pre-conditioned kiwifruit at the warehouse/store**

1. Pre-conditioned 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 18-14 lbs-force (hard). Pre-conditioned kiwifruit should arrive at destination warehouses with a firmness near 10-12 lbs-force but never lower than 5 lbs-force.

3. Kiwifruits should always be kept at low temperatures (below 7.5^{o}C) and enclosed with liners, except if they are going to be consumed within 3 days.

4. Cooled kiwifruit enclosed with liners should be moved to the retail market before they reach a firmness of lower than or equal to 5 lbs-force to avoid vibration and impact bruising damage during transportation and handling. Ripe kiwifruit (ready to eat) will register a flesh firmness of 2-3 lbs-force.
5. After delivery to the retail store, when kiwis reach the room temperature of 20-25^{o}C (68-77^{o}F), pre-conditioned kiwifruit will lose nearly 3 lbs-force per day until reaching about 2-3 lbs-force (optimum eating stage). If kept at 7.5 to 0^{o}C (45 to 32^{o}F), kiwifruit will soften at a rate of »2.0 lbs-force per day (Table 1). As kiwifruit continues to deteriorate during display (warm rack), kiwifruit can be placed in a cool room overnight to prolong their postharvest life. Frequent rotation and placing the softest kiwifruit at the front of the display are advised.

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

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STONE FRUIT INTERNAL BREAKDOWN

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 in apricots, peaches, nectarines, and plums. These symptoms are a consequence of internal breakdown also called chilling injury, dry fruit, mealiness, 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 consumer, not the grower and/or packer. This disorder is the main limitation in the shipping of some plums and late California peaches and nectarines. The intensity and time of appearance during the postharvest life varies according to cultivar, cultural practices, and postharvest handling.

Tips to Reduce Internal Breakdown Incidence in Stone Fruit

Based on our knowledge here are some recommendations:

1) Avoid cultivars susceptible to I.B.
2) Market susceptible cultivars according to their potential postharvest life.
3) Segregate fruit according to their potential postharvest life.
4) Pick fruit "well matured".
5) Follow UCD stone fruit cooling recommendations (fast cooling).
6) Enforce proper postharvest handling during transport and at the retailer.
   a) Keep fruit near 32^{o}F during storage and transportation.
   b) Avoid 36-46^{o}F temperatures during retail handling.
7) Educate warehouse and retail managers on I.B.

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INTERNAL BROWNING OF FUJI: CENTRAL CALIFORNIA EXPERIENCES

Western apple growers and packers are learning quickly to grow, handle, and market high quality Fuji apples. Over the fifteen years Fuji has been commercially grown in California, a number of pre- and post-harvest problems have been encountered. Many have been successfully resolved; others remain as challenges for the future. Included among the latter is the problem of internal browning (IB) during controlled atmosphere (CA) storage.

Our experience with internal browning began in January, 1992, when a packer observed that some lots of Fuji apples held in controlled atmosphere storage from the 1991 harvest had moderate to severe browning upon removal from storage. The disorder was greatest in large fruit from late-harvested lots. Past research linked IB to high storage carbon dioxide (CO_2) levels in other varieties, so there was some question whether a failure to adequately monitor or control storage CO_2 levels may have contributed to the observed problem.

Apples with IB have patchy areas of dark brown flesh discoloration, often beginning near the core of the apple. IB-affected tissues are typically less firm than unaffected tissues, but are otherwise similar in texture and consistency to normal tissues. Margins of IB-affected tissues are smooth and distinct. Small air cavities are sometimes found associated with the brown tissues. When IB-affected fruit are cut lengthwise, the patchy brown areas are often found more frequently near the stem than the calyx end. Except in the most severely affected fruit, browning rarely extends into the core area or to the apple surface.

Since 1992, the reported incidence of IB has varied from year to year, but has been generally low. In 1994, there were many more reports of IB in CA-stored Fujis than in previous years. At least one packer observed initial signs of IB at harvest in 1994. Another reported observing a high incidence in packed air-stored fruit.

Laboratory IB Studies

Our experiments are based on the hypothesis that IB is caused by accumulation of injurious levels of respiratory CO_2 in fruit tissues. Factors which may contribute to increased internal CO_2 concentrations include high fruit respiration rates occasioned by high temperatures or other factors; reduced rates of CO_2 diffusion through the cortex, skin, and/or wax coating applied to apples, and high CO_2 in the surrounding air.

We initiated IB studies in 1992 and expanded those studies in 1993 and 1994. The objective of our studies was to explore the influences of harvest timing and CA CO_2 levels on IB incidence and severity.

In the three years' tests, we used apples from a well-managed commercial Fuji orchard near Modesto, California, with a history of IB. While our sampling procedures have varied slightly from year to year, we have harvested apples four times each year over a range of dates corresponding roughly to the grower's commercial harvest schedule. We made measurements of flesh firmness, % soluble solids, % titratable acidity, and starch-iodine maturity rating at harvest. We then stored apples from each harvest for four months at 32°F in air or in one of three controlled atmospheres: 2% O_2 + 0.5% CO_2, 2% O_2 + 1.5% CO_2, 2% O_2 + 3.0% CO_2. After storage, and 5 days at room temperature to simulate market handling conditions, apples were evaluated and rated as having no, slight, moderate, or severe IB.

In 1992, there was little or no IB in fruit from all but the last harvest. There was little IB in air-stored fruit from the last harvest, but IB increased with CA CO_2 level in fruit from the last harvest. IB incidence was lower in 1993 than 1992. It was low to nil in early-harvested fruit stored in air or low CO_2, but high in late-harvested fruit held at 3% CO_2. In 1994, IB incidence and severity was much higher than in previous years. As in 1992, IB was low in early harvested fruit stored in air or low CO_2, but was higher with later harvest dates and higher CA CO_2 levels.

Managing IB: Suggestions for 1995

There are many aspects of this problem which remain unclear and warrant further study. Year-to-year and orchard-to-orchard variability in IB incidence and severity suggest that orchard and/or environmental factors may play a role in predisposing fruit to brown. Preharvest factors are under preliminary investigation, but little is known about this aspect of IB. Alternative storage strategies also need to be investigated, including effects of storage O_2 levels other than 2% and temperatures other than 32°F.

From results of our studies to date, we suggest the following provisional guidelines for managing IB:

1. Begin and end harvest as early as possible. Results of our studies suggest that IB incidence and severity are low in fruit harvested before 180-190 days after bloom.
2. Sample, cut and inspect fruit during harvest, especially in known IB orchards.
3. CA store only early harvested fruit free of IB.
4. Expedite handling of late-harvested lots: Do not CA store.
5. Keep CA CO_2 levels as far below 0.5% as possible.

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PESTICIDE LAW HINDERS HEALTH BENEFITS OF PRODUCE

The produce message is clear -- eating five servings of fruits and vegetables per day can significantly reduce the incidence of many types of cancer. However, an outdated law, the Delaney Clause, and recent lawsuits concerning its strict implementation could jeopardize the future availability and cost of these simple cancer-fighting produce items.

The Delaney Clause is the 1958 federal legislation that said any pesticide found to cause cancer in test animals must be banned from the food supply even if residues are so tiny they can barely be measured. In 1958, measurements to detect residues were at one part per million. Any level below that was considered "zero." In 1965, one part per billion was possible; in 1975, one part per trillion; and today, science is working to reach one part per quadrillion. As "zero" disappears, Congress has an opportunity to modernize this now-outdated law.

The Environmental Protection Agency (EPA) has been utilizing a risk factor of one in a million, meaning that over a 70-year estimated life span, consumption of any food product possibly containing a pesticide residue will not result in deaths greater than one in a million. This is compared with cancer deaths from other causes, which total 237,000 per million. However, environmentalist lawsuits have caused EPA to revert to the old Delaney Clause standard.

The Senate has already approved a reform bill that would replace the Delaney Clause. In the House of Representatives, HR 1627, also titled "The Food Quality Protection Act," was introduced. It, too, would repeal the Delaney zero-risk food safety clause.

This bill is being sponsored by Rep. Pat Roberts, R-Kansas, chairman of the House Agriculture Committee, and Tom Bliley, R-Virginia, chairman of the House Commerce Committee. The new proposal directs EPA to determine what is prudent, using the best available science, and then to regulate accordingly.

If the Delaney Clause is not reformed, it will result in the eventual cancellation of crop-protection tools and ultimately in the decline of the wonderful variety of fruits and vegetables, available at the lowest per capita cost, that we enjoy today. And as costs skyrocket to grow what little will be available, the consumer will ultimately pay for it in the end.

The benefits of farm chemicals in the production and distribution of healthenhancing fruits and vegetables should not be jeopardized by the folly of the outdated Delaney Clause and the actions of a regulatory, proliferating agency.

Article written by Richard Matoian, Farm View Column, The Fresno Bee

PREDICTING KIWIFRUIT BOTRYTIS (GRAY MOLD) IN COLD STORAGE

Approximately 6,300 acres of kiwifruit (*Actinidia deliciosa*) are presently grown in California producing 10 to 11 million boxes of fruit valued at 100 to 110 million dollars annually (source: California Kiwifruit Commission). Initially, kiwifruit was regarded as a "disease-free" crop in California, but with increasing acreage and expanding exports during the past 10 years, the quantity of fruit in cold storage has increased, and post-harvest rotting due to Botrytis gray mold of kiwifruit has become a potentially serious problem.

Gray mold storage decay, caused by *Botrytis cinerea,* is the most important disease of kiwifruit, even though *B. cinerea* does not develop in the field in California. However, postharvest decay by gray mold, commonly responsible for large losses during long-term cold storage of kiwifruit, is a direct result of *B. cinerea* infections that occur in the field but remain latent in the senescent floral parts (sepals and stamens), stem-end scars, or small wounds created during fruit harvest. Then, during long-term cold storage, kiwifruit become physiologically susceptible to the pathogen, which usually invades the fruit tissues starting from the stem end.

Research in 1983 at UC Davis by Dr. N. F. Sommer (*California Agriculture* 37(1-2):16-18) showed that bloom and preharvest sprays with vinclozolin (Ronilan 50W), which is registered for control of Botrytis rot of kiwifruit, decrease significantly the incidence of postharvest gray mold. Although best control has been achieved with two bloom and two preharvest sprays, there are still problems with disease in the majority of the vineyards. Disease reduction achieved by four fungicide applications may not be economic because the cost of four fungicide applications may exceed the loss from rot. In addition, four applications per year of Ronilan also increase the risk of developing resistant strains of the pathogen. As a result of these problems, along with environmental issues and a great and ever-growing public concern that many pesticides may be carcinogens, efforts are being made to discover alternatives to the use of pesticides or, at the least, ways to reduce the use of pesticides.

Marketing of kiwifruit requires that fruit be placed in storage, particularly since the use of controlled atmospheres has extended the storage life of kiwifruit from a few weeks to 5 or 6 months. Although near-optimum conditions for quality maintenance can be achieved in commercial storage designed for the special needs of kiwifruit, conditions during transport to distant export markets may be far less than optimum. Since transit times are frequently as long as 30 days, there is a potential for considerable loss of fruit quality and for gray mold decay during shipments from California to European markets. These losses represent direct loss of the product and additional costs for re-sorting and re-packing labor, which increase considerably the price of the final, marketable product. Unfortunately, the incidence of Botrytis gray mold is unpredictable since it is highly variable from year to year and from vineyard to vineyard. Up to 20% incidence of primary Botrytis stem-end rot has been recorded in California and a range of 32 to more than 50% for kiwifruit from Italy and New

Zealand. In California kiwifruits the decay has been limited to fruit in storage or in marketing channels. It is apparently the environmental conditions and field location that influence the severity of the damage caused by *B. cinerea* in stored fruits. Vineyards having the highest levels of infection of floral parts also had the highest fruit rot after six and a half months storage.

In order to develop more efficient methods for controlling gray mold, it is necessary to understand the relationship of Botrytis infections in the field (latent infections) and the incidence of gray mold in storage. Presently, there is no method for predicting the incidence of gray mold that develops during cold storage of kiwifruit and growers routinely apply bloom and preharvest sprays of Ronilan regardless of the expected levels of disease. Furthermore, when kiwifruit are removed from storage and are ready to be sent to market, shippers lack criteria on which fruit to sell first and which to keep for longer storage. An empirical, indirect criterion used by shippers is the historical background of fields in relationship to Botrytis gray mold. Therefore, if the incidence of kiwifruit sepals or stem ends colonized by *B. cinerea* is an indicator and a correct predictor of anticipated decay in storage, it is possible 1) to send to market first those fruit which are expected to have higher incidence of gray mold and keep in storage longer those lots expected to have lower incidence of gray mold; 2) to spray with vinclozolin only those fields which are expected to produce fruit with high potential for disease; 3) to reduce the number of fungicide applications in fields with medium disease potential; or 4) to not spray at all in fields with low or nil disease potential. In 1993, we initiated a study to determine the relationship between colonization of kiwifruit sepals and receptacles by *B. cinerea* and incidence of gray mold in cold storage and 2) to determine when the applications of vinclozolin sprays in kiwifruit vineyards are justified.

We developed a field-monitoring system that can be used to predict the incidence of Botrytis gray mold of kiwifruit in cold storage. Sampling 60 fruit from vineyards 4 months after fruit set, plating their sepals or stem ends in plates with acidic potato-dextrose agar, and recording the incidence of Botrytis colonization proved to be a reliable field-monitoring method to predict the incidence of kiwifruit Botrytis gray mold after 3 or 5 months in cold storage. There was a significant correlation ($r \geq 0.95$) between the levels of infection of sepals and stem ends of kiwifruit collected from nine fields in both 1993 and 1994 and the incidence of gray mold in cold storage after 3 or 5 months storage. Our research showed that for growers planning to sell their fruit within 3 months of storage one spray of vinclozolin (Ronilan) one week before harvest is sufficient to reduce significantly the levels of gray mold decay in cold storage. Those growers, however, who anticipate to keep their fruit for a 5 - month storage, need to spray their vineyards twice, both two and one week before harvest in order to reduce the levels of gray mold in cold storage. In addition, our research in 1993 and 1994 showed that when the field-monitoring system predicts a very low level of gray mold (1-2%) preharvest sprays of vinclozolin do not reduce significantly the Botrytis mold in storage. Therefore, these sprays will be unnecessary and increase the cost of the fruit production. In general, the preharvest fungicide treatments with vinclozolin (Ronilan 50WP) one and/or two weeks before harvest, respectively, significantly reduced postharvest gray mold after 3 or 5 months storage only in vineyards with a high (above 6%) incidence of gray mold while preharvest sprays were not needed when incidence of gray mold was low (below 6%). The developed method for predicting Botrytis gray mold in storage can be used successfully by growers to make decisions on the need for preharvest sprays, sorting, re-packing, and timing for marketing and shipping fruit.

Conclusions:

1. **A field-monitoring system has been developed to predict the levels of Botrytis gray mold of kiwifruit in storage. This system involves plating the sepals or stem ends from 60 fruit on acidic potato-dextrose agar and recording the incidence of colonization by *Botrytis cinerea,* the fungus which causes gray mold in cold storage.**

2. **Sixty fruit per vineyard are sufficient for the field-monitoring system to predict Botrytis gray mold in storage.**

3. **Plating the stem ends (60 in total from 60 fruit) on media is simpler, less expensive, and a more accurate method than plating the sepals (more than 300 from 60 fruit).**

4. **The best timing for sampling the 60 fruit is 4 months after pollination.**

5. **Preharvest spray(s) with vinclozolin are needed when the field-monitoring system predicts more than 6% gray mold in storage and they are not necessary when less than 6% gray mold is predicted.**

6. **Kiwifruit growers who anticipate to sell their fruit within 3 months can spray with vinclozolin one week before harvest but those who plan to store the fruit for 5 months need to spray both two and one week before harvest in order to reduce significantly the storage decay.**

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WHEN IS THE BEST TIME TO HARVEST CALIFORNIA APPLES?

In 1993, a study was initiated to learn more about the proper harvest time for Gala, Sommerfeld and Fuji apples grown in Stanislaus County. This study was continued in 1994 and expanded to include Fuji apples from Fresno and Kern counties as well as Stanislaus County. We have learned a lot about California apples over the last two years. The following is a summary of what we know so far.

Harvest and Storage of Apples

Apples are generally harvested before they are ready to eat to allow for successful long-term storage. Unlike some fruit which do not improve in eating quality after harvest, apple fruit have the ability to ripen to good eating quality after harvest because of the starch reserves, normally present in the fruit at the time of harvest, which convert to sugar as the fruit ripens. Only fruit which will be immediately marketed are allowed to remain on the tree until ripe. For best storage life of apples, they should be picked before they begin the climacteric, i.e., the period of increased respiration and ethylene production and rapid ripening.

The optimum harvest maturity of a given apple variety provides for successful long-term storage and good eating quality after storage. To determine optimum maturity, fruit are harvested at one to two week intervals and placed into storage. The fruit quality after storage in air or CA is related to the harvest maturity. Fruit quality is assessed as absence of defects and disorders, such as internal browning, checking, bitter pit and storage scald, as well as eating quality which is related to firmness, soluble solids and acidity contents and flavor components. The apple characteristics at harvest, such as starch content, ground color and firmness are monitored to determine if a notable change in one of these characteristics can be related to the optimum harvest period. A close relationship between ground color changes or starch content changes with optimum harvest maturity, for example, can provide an index for growers to use to judge optimum harvest maturity in future years. With these guidelines in mind, let's summarize what we know about Gala, Sommerfeld and Fuji apples.

Gala

It is important to note that all the work with Gala apples thus far has been conducted in Stanislaus County. In the future, it will be important to look at other growing areas.

The optimum harvest period for Gala apples in Stanislaus County appears to be near **115 days from bloom**. However, because of the spread of bloom in California, this is not the most accurate means of determining the exact harvest date but can be useful as a guide. In the two years we have studied Gala apples, both **ground color and starch content** began to change near the optimum stage for harvest. The initial change of ground color from green to light green and the initial starch degradation, as determined by the iodine potassium iodide staining method (see recipe below), may prove to be useful indicators that it is time to initiate the first pick. In both seasons, Gala apples in Stanislaus County had 60% or greater blush at 115 days from bloom.

The optimum harvest period for Gala apples has been determined from storage studies and taste tests. Fruit harvested later than 115 days from bloom (later than the period when ground color and starch content began to change) did not maintain firmness in storage and were considered somewhat mealy and not crisp by taste panelists. Many tasters said they would not buy the Gala apples which had been picked after 115 days from bloom and stored only 2 months in air or 4 months in CA.

CA storage with 1.5% oxygen and 1.5% carbon dioxide reduced the loss of firmness in storage considerably. After 5 months in CA storage, fruit had not lost more than 2 lbs. of firmness. CA also maintained higher titratable acidity which can be very important for flavor. Soluble solids also remains higher in CA stored fruit.

Gala apples can develop storage scald after only 2 months in air storage although symptoms are usually slight. CA storage eliminated the occurrence of storage scald in our studies but further work is needed to determine if CA can be 100% effective against scald under commercial conditions. Galas are also and postharvest dips are recommended.

Sommerfeld

This apple matures **between Gala and Fuji** (approximately 145 days from bloom) and has characteristics of both apples. Like the Gala, Sommerfeld has a moderately high acid content (0.50%) at the time of harvest. In addition it has an intermediate soluble solids content (15%) between Gala and Fuji giving it a **nice blend of sugar and acid** similar to

Braeburn apples. Many of our tasters really liked this apple. Sommerfeld also seems to develop red color with no checking at a time appropriate for harvesting according to its maturity.

It is difficult to comment on the storage characteristics of this apple because of the limited availability of commercially produced fruit. In our studies, most fruit was obtained from budwood trees under less than ideal cultural conditions for the apple fruit. Because of the growing conditions, fruit condition was not near its full potential. Based on our limited work, it appears that storage at 32°F in air is appropriate. We recommend that CA storage be used on a trial basis only until fruit tolerance to CA atmospheres has been tested.

Fuji

One of the greatest challenges to growing Fuji apples in California, especially the Central Valley, is poor red color development. Because market prices are geared towards red color in red and striped apples, many growers pick Fuji apples well beyond the optimum harvest maturity as they wait for red color which may or may not develop. Problems with checking (cracking of the skin of the apple) have been shown to increase with time as apples hang on the tree. This past season, many Fuji growers had problems with internal browning developing in their fruit, particularly in CA storage. This problem was found almost exclusively in later harvested, high maturity fruit. Because Fuji apples maintain their firmness on the tree and in storage, the main risks of late harvesting are the development of checking on the skin and the risk of internal browning in storage. In addition, the longer the fruit is on the tree the less acidity is present. For some consumers, acidity balanced with sweetness is important for apple flavor.

Data from the last two years indicate that Fuji apples should be harvested at approximately 180 to 190 days from bloom to minimize problems with checking and internal browning. By this stage of maturity in Fuji apples, much of the starch has already been converted into sugars, but a small amount of starch usually remains as shown by staining with iodine potassium iodide solution (15 to 25% of the cut surface stained black). Based on our limited data, the change in ground color from green to light green appears to coincide with the recommended stage of maturity (180 to 190 days from bloom). Additional seasons of data are necessary to determine if ground color or starch content can be useful indicators of harvest date for Fuji apples.

Most California Fuji growers know that red color development is generally not good at 180 to 190 days from bloom. To continue to have a successful Fuji industry in California we need to continue to develop methods to improve color development such as summer pruning or use of reflective materials as have been studied by Harry Andris and Mario Viveros, farm advisors in Fresno and Kern Counties, along with Carlos Crisosto at Kearney.

As with Gala apples, Fujis are susceptible to storage scald but symptoms are slight. Under laboratory conditions, CA storage in 1.5% oxygen and 1.5% carbon dioxide eliminated storage scald. It is not yet known if CA can provide this level of control under commercial conditions. CO2 levels in CA storage should be kept as low as possible to avoid internal browning, particularly if fruit is picked beyond 180 days from bloom.

Research in 1995-96, sponsored by the California Apple Commission, will explore the causes of Fuji checking. The role of oxygen concentration and temperature on fruit susceptibility to internal browning and the reasons for seasonal variability in susceptibility to internal browning will also be studied. We will also continue to increase our knowledge of the optimum maturity for harvest of Gala and Fuji apples.

Recipe for Iodine Solution for Starch Testing

58.1 grams	potassium iodide
14.5 grams	iodine
2 liters (½ gallon)	distilled water

Dissolve potassium iodide in water (this will take a lot of mixing and time). Add the iodine and mix well. Storein a brown or foil-covered bottle. Place cut surface of apple in solution for 1 minute, observe pattern of black staining indicating presence of starch.

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TROUBLE SHOOTING HYDROCOOLERS

Good hydrocooler operators regularly measure the temperature of product entering and leaving the cooler. Occasionally an operator will notice that a product is not cooling as fast as expected. Water temperature in the distribution pan above the product and water temperature in the reservoir under the product are clues to the poor performance.

Symptom 1: Water temperature increases in the distribution pan and the reservoir during a cooling cycle or increases as air temperature increases during the day.

Cause: Inadequate refrigeration capacity.

Solutions:

- Put less product on a batch cooler or slow the product conveyor in a continuous cooler.
- Reduce external heat gain by 1) insulating cooler, 2) protecting it from the sun, 3) installing plastic flap curtains, or 4) install the cooler in a cold room. Heat entering the cooler from air infiltration and conduction across the walls can equal 25% to 30% of the refrigeration requirements of a hydrocooler installed in the open.
- Reduce incoming product temperature by initial cooling with high quality well water. Water is showered over product only once and then used for irrigation. This initial cooling also precleans the fruit, reducing trash build up in the cooler.
- Check refrigeration maintenance.
- Install more refrigeration capacity.

Symptom 2: Water temperature increases in the reservoir during a cooling cycle but remains cold in the distribution pan.

Cause: Inadequate water flow. A continuous belt cooler for unpackaged product (as is used for cherries) needs about 7 to 10 gallons per minute per square foot of shower pan area, a cooler for pallet bins of stone fruit requires about 20 to 25 gpm/ft^2.

Solutions:
- Check water pump.
- Check reservoir screens.
- Install more pump capacity and may need to increase number of holes in the water distribution pan.
- Put less product on the cooler.

Symptom 3: Water temperature remains cold in the reservoir and in the distribution pan but product cools slowly or nonuniformly.

Cause: Inadequate water flow through packages.

Solutions:
- Increase top and bottom package vent area.
- Insure that package vents align if packages are stacked in the cooler.
- Leafy products may shed water like shingles on a roof. This may be solved by developing a new packing method for the product.
- Inspect distribution pan for trash and leaves.
- Insure that water is supplied uniformly to the distribution pan.

Cause: Trying to cool faster than heat can be removed from product interior. Large diameter products take longer to cool than small products. For example cooling cherries takes 7 to 10 minutes, stone fruit takes 20 to 30 minutes and melons may require more than 45 minutes.

Solutions:
- Leave in cooler longer (this may require additional hydrocooler capacity).
- Reduce incoming product temperature by 1) using shades in receiving area, 2) harvesting earlier in the day or at night, 3) quickly transporting product to the cooler after harvest.

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PRECOOLING BEFORE LOADING

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^{o}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^{o}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^{o}F and the desired set point is 34^{o}F, the trailer should be precooled to 49.5^{o}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 pulp product 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.

(Extracted from Loading Makes the Difference, Jim Thompson)