



CENTRAL VALLEY POSTHARVEST NEWSLETTER

COOPERATIVE EXTENSION • University of California
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July 2006

Vol. 15, No. 3

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HEALTH BENEFITS – EXCITING EARLY RESULTS FOR KIWIFRUIT

Taken from *The Orchardist* (Journal of Horticulture New Zealand), March 2006, Vol. 79, No. 2, page 43. From the International Kiwifruit Symposium.

Kiwifruit may have potential to reduce cancer risk and cardiovascular (heart) disease, say researchers from the University of Oslo in Norway.

Their presentations were highlights of the International Kiwifruit Symposium in Rotorua, New Zealand.

A. R. Collins explained that damage to DNA was the originating event in the process of carcinogenesis. “The damage can be caused by environmental or endogenous (produced within the body) processes, and oxidative damage caused by reactive oxygen molecules released during cellular respiration is thought to make a significant contribution.

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“There are two lines of defense against oxidation of DNA. Damage is limited to antioxidants – enzymes and biomolecules, including many different kinds derived from the diet, that quench the reactive oxygen before it reaches the DNA. Of the damage that does occur, almost all is repaired by a very efficient set of cellular enzymes constituting the base excision repair (BER) pathway.”

He reported preliminary results of a trial that set out to evaluate the antioxidant properties of kiwifruit by giving volunteers a single dose of kiwifruit juice and testing the resistance of white blood cells against oxidative attack on the DNA by H₂O₂. For at least 24 hours, DNA was protected.

Subsequently, volunteers were given 1, 2 or 3 kiwifruit daily for three weeks.

“As well as H₂O₂ protection, we found a reduction in endogenous DNA oxidation. Unexpectedly, there was also a significant increase in the capacity of lymphocytes (type of white blood cell formed in lymphatic tissue) for BER – suggesting that kiwifruit may have a dual benefit in terms of reducing cancer risk, and emphasizing the importance of fruit in the diet.”

A. K. Duttaroy said the results of a human trial provided evidence that kiwifruit have potential for increasing the effectiveness of thrombosis prophylaxis (heart disease prevention).

This researcher concentrated on the activation of blood platelets not only in haemostasis but in the pathological development of several arterial disorders, including strokes and myocardial infarction (heart attack).

Because of the significance of strokes and heart attacks in industrialized societies, a key focus of research on cardiovascular disease was in the development of new, better tolerated and more effective anti-platelet drugs. “Fruits and vegetables have been thought to be beneficial in cardiovascular disease. The beneficial

effects of fruits and vegetables may be explained by the antioxidants and other components contained therein.”

A trial looked at eating kiwifruit modulated platelet activity and plasma lipids in human volunteers.

“We report that consuming two or three kiwifruit per day for 28 days reduced platelet aggregation response to collagen and ADP by 18% compared with the controls. In addition, consumption of kiwifruit lowered blood triglycerides levels by 15% compared with control, whereas no such effects were observed in the case of cholesterol levels.”

NEW OPPORTUNITIES FOR KIWIFRUIT IN POSTHARVEST TECHNOLOGIES

Taken from *The Orchardist* (Journal of Horticulture New Zealand), March 2006, Vol. 79, No. 2, pages 39-40. From the International Kiwifruit Symposium.

SmartFreshSM is the most promising of several breakthrough postharvest technologies evaluated at HortResearch, says Dr. Nagin Lallu of the Mt Albert (Auckland) research centre.

He said kiwifruit biology and SmartFreshSM technology appeared to be reasonably well matched, making the ethylene inhibiting action technology appropriate for the industry.

Dr. Lallu explained the way in which SmartFreshSM worked. It arrested the operation of ethylene, which accelerates the change from a mature but unripe fruit at harvest to an edible ripe fruit. SmartFreshSM slows the ripening process down, leads to the fruit ripening, creating the color, texture and aroma present at maturity. It is a powder which when mixed with water produces a gas.

Trials have shown that SmartFreshSM leads to greater firmness retention of fruit held in storage, using either conventional air cooling or controlled atmosphere. It also reduces the incidence of over soft fruit and rots associated with soft fruit.

“Results indicate that SmartFreshSM treatment prior to coolstorage retards the softening rate of ‘Hayward’ and ‘Hort16A’ fruit during both storage and shelf life without detrimental effect on rots and disorders, or the taste acceptability of the fruit.

“Several options for the use of SmartFreshSM on kiwifruit can be identified and include: use for short- to medium-term bin storage of ‘Hayward’ and ‘Hort16A’ fruit.

Management of fruit losses during storage of packed fruit

Management of fruit condition at the time of shipment and/or arrival in the market.

Use for the transport of bins of fruit

When combined with CA storage, use for reducing fruit losses from medium-term bin storage.

Nagin Lallu said that SmartFreshSM would be a competitive advantage in relation to untreated kiwifruit.

More research was needed in terms of the timing of applications, and the changing sensitivity of fruit to ethylene harvest issues in relation to the use of SmartFreshSM treatment.

He also discussed Near Infra Red (NIR) technology and HarvestWatchTM, concluding that these were less well matched to the kiwifruit industry and there could be a need for further development for comparable benefits to be achieved.

Dr. Lallu said NIR was currently used by three postharvest kiwifruit companies. The aim was to eliminate low dry matter kiwifruit. In that sense NIR was being used as a grading technique.

However, for early harvested crops there was the alternative of achieving better taste by leaving the fruit on the vine longer for dry matter to accumulate further.

It was assumed that there was a simple relationship between dry matter, Brix level and good tasting fruit. Taste was a complex issue involving factors like sweetness, acidity, aroma and texture. NIR segregation still results in fruit with a range of tastes.

Currently there were calibration issues with NIR in terms of taking readings and using the technology in the context of taste evaluation.

HarvestWatchTM is a system involving the use of a sensor that measures the fluorescence emitted by chlorophyll. By measuring the physiological response of the fruit in coolstorage this system gives an oxygen level and effectively creates a dynamic controlled atmosphere system. Once a low oxygen threshold is indicated by a ‘spike’ in the fluorescence, a new oxygen level can be set to give a safety margin.

HarvestWatchTM is installed in two controlled atmosphere facilities in New Zealand where the reliance on high CO₂ levels during CA storage has been reduced by using much lower O₂ levels, and can facilitate lower CO₂ densities and rates.

Dr. Lallu commented that there were dangers in marketers trying to drive dry matter requirements up to levels out of keeping with the natural biology of kiwifruit.

SMARTFRESHSM WORKSHOP

**Taken from *The Orchardist* (Journal of Horticulture New Zealand), March 2006.
From the International Kiwifruit Symposium.**

Recent trials with kiwifruit using SmartFreshSM have confirmed the value of this new product in enhancing the quality of kiwifruit.

Several studies were reported at a workshop held during the International Kiwifruit Symposium in Rotorua last month.

In an overview Giovanni Regioli of AgroFresh in Italy, the subsidiary of Rohm and Hass that handles the product, said SmartFreshSM brought benefits to both green and gold kiwifruit varieties.

“It complements and elevates current storage technologies to the next level so that fruits can maintain their fresh-picked quality during and after storage – through the whole supply chain.”

Advantages include:

- Fruits remain firmer during storage and shelf life with no negative effect on physiological disorders and rots
- Reduced fruit losses due to soft fruit and other soft fruit-related disorders in both packed and bin-stored fruit
- Replacement of CA storage for medium-term storage and shipment
- Fruits ripen normally during shelf life with no negative effect on taste
- Fruits have an extended storage and marketing window.

“SmartFreshSM has been granted registration on kiwifruit in New Zealand, Chile, USA, China, South Africa and it is under advanced registration process in various countries including Italy and France.”

The product is nontoxic.

He cautioned that SmartFresh could not save poor fruit. “Quality can be maintained, not created.”

A HortResearch study has concluded that the volatile levels and profiles in SmartFreshSM-treated kiwifruit are likely to be within the range of levels and profiles found in untreated fruit. “SmartFreshSM treatment does not result in any unpleasant odors in kiwifruit.”

Jem Burdon, of the HortResearch Mt Albert research centre, said kiwifruit from four orchards had been used in the study.

A study in Chile compared SmartFreshSM in combination with or as an alternative to actual postharvest treatments consisting of modified atmosphere packaging and controlled atmosphere storage.

“There was very little softening of kiwifruit stored under controlled atmospheres and firmness was similar to SmartFreshSM-treated fruit. Evaluation of fruit after ripening at 20°C demonstrated that application of 1-MCP consistently kept fruit firmer for longer than the respective control fruit.”

A study done in Greece on Hayward kiwifruit found that use of SmartFreshSM drastically reduced ethylene production during shelf life and significantly inhibited ripening during storage and shelf life. “When fruit were removed from storage after 10 weeks, it is estimated that SmartFreshSM prolonged the wholesale market period for 1.4 weeks and the retail market period for 13.9 days; when removed after 20 weeks storage the wholesale market period was prolonged by 3.8 weeks and the retail market period by 4.1 days.”

Peter Vriends, general manager for AgroFresh, Europe – Middle East, Africa, Asia and Pacific, said the impact of the product on bananas giving an extra four-five days shelf life was significant for consumers. They could now select a yellow banana and not be concerned that it would rapidly pass ripeness.

The company is now working more proactively with consumers to explain what SmartFreshSM is. It has been found that once they realize the advantages of the product and the fact it leaves no residues they are happy with the breakthrough.

“We are doing a lot of work with retailers in Europe.”

During questions, the issue of cost of using SmartFreshSM was raised. Jane Turner, manager Australia and New Zealand for AgroFresh Inc., said the cost was generally 12-15 c a tray for kiwifruit, but there were rebates. HortResearch postharvest scientist Dr. Nagin Lallu said cost would vary according to the size of the room treated, but the range would be about 11-16 c a tray.

Jane Turner said the product was of value right in enhancing the product and eliminating or reducing problems as it moved through the value chain from grower to consumer. One example was to reduce the repacking of fruit in-market. Another advantage was increased consumer confidence in buying the product.

EVALUATION OF POSTHARVEST TABLE GRAPE STORAGE QUALITY FOR DIFFERENT CULTIVARS PACKED IN THREE BOX TYPES UNDER COMMERCIAL CONDITIONS – 2005 SEASON

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It has been reported that design and materials of inner packaging and box types can influence the concentration of SO₂ surrounding grapes inside the boxes, therefore affecting the success of the fumigation. Commercial evaluations using different boxes for the protocol have been

carried out during the last 5 years. As a result of these studies, standard corrugated boxes are not approved for use in the black widow spider (BWS) protocol. This is because BWS populations were not completely killed in corrugated boxes using the official protocol. The explanation for this is that standard corrugated boxes have a high rate of SO₂ and water absorbance associated with the box material, which reduces the amount of SO₂ available to control BWS inside the box.

Recently, a new coating technology has been applied in the manufacturing of corrugated boxes with the goal to reduce water uptake, decrease rate of SO₂ absorbance, increase SO₂ within the box to kill BWS and improve decay control. This MAXCO corrugated box is coated with a proprietary aqueous-based material (Maxgard), which is manufactured by Texcoat, a division of Corrugated Services, L.P. This new, recyclable corrugated box is called LTS System.

During this season, we conducted several studies to evaluate LTS System box performance in relation to BWS control and table grape quality. We carried out controlled laboratories box water gain loss, laboratory forced air cooling evaluations, commercial forced air cooling evaluations, commercial postharvest quality evaluations, and commercial BWS mortality studies. These studies are being repeated during the 2006 season.

This preliminary report covers a detailed postharvest quality evaluation before storage on grapes commercially packed using three types of boxes including the new LTS System box.

Material and Methods

We evaluated box water uptake, grape cluster weight loss, temperature during fast cooling and SO₂ penetration initially and during storage on boxes packed with ‘Autumn Royal,’ ‘Thompson Seedless,’ ‘Crimson Seedless’ and ‘Redglobe.’ Grapes were packed in five each

of standard “Display-Ready Corrugated” (DRC), foam “Expandable Polystyrene” (EPS), coated “Long Term Storage” (LTS System), and LTS System + box liner (1/4” holes diameter 3” center) box types.

This preliminary report only covers quality performance after handling, fumigation and cooling.

Results and Discussion

‘Autumn Royal’ – In this harvesting-cooling operation (Table 1), the LTS box gained ~51.0 g of water and grapes packed in that box lost ~ 1.3% of weight in relation to their initial weight while the EPS box did not gain any weight. Grapes packed in the EPS box lost 1.0%. The LTS + box liner only gained 38.7 g of water per box and grapes packed in this system lost 1.0% of their initial weight. The DRC box gained ~74.8 g of water and grapes packed in that box lost ~ 2.0% of weight measured after cooling and fumigation in relation to their initial weight.

SO₂ penetration during the initial fumigation using forced air systems was satisfactory in all four box types (Table 1). In general, the 5DH and 5D dosimeters were max-up after initial fumigation in all types of boxes. During storage, under this commercial situation, SO₂

fumigation penetration was also above the requirement, reaching ≥ 480 ppm-hour detected on 5DH dosimeters measured 36 hours after the application. These values are within the recommended specification, >250 ppm-hour. It is important to point out that SO₂ fumigation penetration, although sufficient, was low (~20%) on the LTS + box liner compared to other box types. This situation may become a problem in other cold storages so it is important to keep measuring SO₂ fumigation penetration when a box liner is being used in combination with any box type.

For grapes packed in EPS, LTS, or DRC, it took ~5-6 hours for grapes to reach their 7/8 half-cooling and these grapes attained temperatures near 32°F upon removal of the tunnel (Table 1). For grapes packed in the LTS + box liner, the calculated 7/8 half-cooling was ~24 hours and in fact, these grapes never reached temperatures below 43°F. This rate of cooling and grape temperature values are outside the standard California table grape operations. Under these conditions, decay and deterioration can occur very quickly during storage and transportation. However, at this point because pallets with different box types were mixed in the tunnel, the actual cooling rate may be lower than our results. A cooling test will be carried out this season at this location to resolve this issue.

Table 1. Influence of type of container on postharvest box water uptake, cluster water loss, SO₂ penetration and cooling rate of ‘Autumn Royal’ table grapes measured after harvesting, fumigation, and forced air cooling.

Box Type	Box Water Uptake (g)	Box Water Uptake (%)	Grape Water loss (%)	SO ₂ Initial (CT)	SO ₂ Storage (CT)	Cooling Rate Hours to reach 7/8-Cooling and final temperature
DRC	74.8	10.0	2.0	600+	600	5.0-33°F
FOAM	0.0	0.0	1.0	600+	591	6.2-33.6°F
LTS	51.0	5.5	1.3	600+	598	6.0-31°F
LTS-LINER	38.7	4.2	1.0	600+	495	24.0-43°F

‘Thompson Seedless’ – In this harvesting-cooling operation, the LTS box gained ~70 g of water and grapes packed in this box lost ~ 1.2% of weight in relation to their initial weight, while the EPS box did not gain any weight. Grapes packed in the EPS box lost 0.8%. The LTS + box liner only gained 68 g of water per box and grapes packed in this system lost 0.9% of their initial weight. The DRC box gained ~73 g of water and grapes packed in that box lost ~ 1.1% of weight measured after cooling and fumigation in relation to their initial weight.

‘Crimson Seedless’ – In this harvesting-cooling operation, the LTS box gained ~53 g of water and grapes packed in that box lost ~ 1.5% of weight in relation to their initial weight while the EPS box did not gain any weight. Grapes packed in the EPS box lost 1.4%. The LTS + box liner only gained 49 g of water per box and grapes packed in this system lost 1.1% of their initial weight. The DRC box gained ~71.2 g of water and grapes packed in that box lost ~1.7% of weight measured after cooling and fumigation in relation to their initial weight.

‘Redglobe’ – In this harvesting-cooling operation, the LTS box gained ~45 g of water and grapes packed in that box lost ~ 0.5% of weight in relation to their initial weight while the EPS box did not gain any weight. Grapes packed in the EPS box lost 0.6%. The LTS + box liner only gained 38.7 g of water per box and grapes packed in this system lost 0.5% of their initial weight. The DRC box gained ~65 g of water and grapes packed in that box lost ~ 0.8% of weight measured after cooling and fumigation in relation to their initial weight.

Conclusions

For these four cultivars, the use of this new coated corrugated box LTS System reduced box water uptake in all the cultivars. Water uptake reduction of this new corrugated box during the harvesting-cooling period may

potentially decrease rate of SO₂ absorbance, increase SO₂ within the box to kill BWS and improve decay control during standard SO₂ fumigation operations. This potential benefit of the new corrugated box will be evaluated during a commercial mortality BWS test.

Grape water loss was also reduced in grapes packed in LTS and LTS + liner. Water loss measured after cooling and fumigation ranged from 0.5-1.5% in grapes packed in LTS while grapes packed in DRC ranged from 0.8 to 2.0%. Grape water loss in grapes packed in EPS or LTS + liner varied from 0.6 to 1.4% and 0.5 – 1.0%, respectively. Grape water loss values $\geq 1.0\%$ are considered a potentially negative influence on stem and berry condition after a cold storage period. Postharvest quality evaluations during storage will reveal if this initial reduction on grape water loss will maintain quality during cold storage.

For these four cultivars, the use of this new coated corrugated box LTS System did not interfere with cooling rate or final pulp temperature. Also SO₂ box penetration during initial and weekly fumigation was not reduced by the use of this LTS System box under these commercial cold storage conditions.

It is important to point out that SO₂ fumigation penetration during weekly cold storage conditions, although sufficient, was low (~20%) on the grapes packed with a box liner compared to boxes without liners. **This situation may become a problem in some cold storages so it is important to keep measuring SO₂ fumigation penetration when a box liner is being used in combination with any box type.** A similar situation was observed in cooling time for grapes packed using box liners. The rate of cooling and grape temperature values were outside the standard California table grape operations. Under these conditions, decay and deterioration can occur very quickly during storage and transportation. A further detailed evaluation of this cooling delay is under investigation.

TABLE GRAPE PACKAGING INFLUENCES 'FLAME SEEDLESS' AND 'REDGLOBE' STORAGE QUALITY (1999 SEASON)

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Table grapes are subject to serious water losses during postharvest handling. Rachis browning, which occurs as a consequence of water loss, reduces table grape postharvest quality. Cumulative water losses occurring during postharvest handling may lead to stem browning, berry shatter, and wilting and shriveling of berries during marketing. In our previous research, we developed critical cluster water loss threshold values for stem browning of 'Perlette', 'Thompson Seedless', 'Flame Seedless', 'Fantasy Seedless', and 'Redglobe' table grape cultivars. At the same time, our survey of potential cluster water loss during harvesting operations indicated that a short cooling delay at high air temperatures contributed to stem browning. These low critical cluster water loss threshold values, in combination with the high level of water loss measured during harvesting operations, illustrate the need to minimize cooling delays and the importance of developing techniques to reduce cluster water loss during harvest and/or postharvest handling.

During the 1999 season, 88% of the approximately 17.5 million boxes of 'Flame Seedless' grapes produced in California were packed using plastic cluster bags and approximately 32% (3.5 million boxes) of 'Redglobe' production were bagged. Based on this, one practical approach to limit water loss may be the use of restricted ventilation cluster bags (RVCB) and/or box liners (BL). In our previous work (Crisosto et al., 1994), we recommended the use of a ventilated box liner with or without a SO₂ pad as one successful

technique to reduce water loss during field packing and postharvest handling of grapes.

The use of a restricted ventilation cluster bag (RVCB) approach has been tested on several table grape cultivars (Davis, et al., 2000). For example, 'Ruby Seedless' grapes were packed by using the commercial cluster bag (CCB) with approximately 60% ventilation, or the restricted ventilation cluster bag (RVCB) with approximately 1.4% ventilation in foam boxes. During the storage period, grapes packed using the restricted ventilation and commercial cluster bags did not show excessive condensation. Under a high SO₂ application, SO₂ penetration was adequate in both types of cluster bags during the initial treatment and weekly fumigations. The results indicate that the RVCB was more effective to reduce water loss and maintain stem freshness without interfering with the SO₂ penetration than the currently used commercial cluster bag. The use of the RVCB with 1.4% ventilation reduced stem browning and increased the buyer's opinion grade without affecting decay or bleached berries as compared to grapes stored in bags with approximately 60% ventilation. During these trials, fruit packed with the restricted ventilation cluster bag (1.4% ventilation) had less shatter than fruit packed with the commercial bag (60% ventilation).

Based on these results we evaluated the performance of restricted ventilation cluster bags with a vented area of 0.5 to 1.2% on storage quality of 'Flame Seedless' and 'Redglobe' table grapes.

Materials and Methods

'Flame Seedless' and 'Redglobe' table grapes were commercially harvested and packed using different cluster bag types. To attain cluster bags with different venting areas (VA), bags with different sized holes (1/4" or 1/8" diameter holes) and number of ventilating perforations (16 – 70 holes per bag) were used. A box liner (BL) with a VA of 0.57% in

combination with the restricted ventilation cluster bag (RVCB) was also included in the treatments. In this treatment, a slow-release sulfur dioxide pad was placed over the grapes, and enclosed by the box liner (Table 1).

For 'Flame Seedless', each treatment consisted of 36 corrugated boxes. Grapes were picked and packed into nine cluster bags per 19-pound box. Harvesting was carried out during the hottest part of the day on July 12, 2000 in Ducor, California.

For 'Redglobe', 234 styrofoam boxes of grapes were harvested in a commercial vineyard on September 11, 2000 at Famoso, California, 20 miles north of Bakersfield. For each treatment a pallet of 78 styrofoam boxes was used and each box contained nine cluster bags. Grapes packed using a box liner were packed in RVCB-1.4% and placed inside the box liner (0.57% VA) using a bottom pad, and the slow-release sulfur dioxide pad was placed over the grapes and inside the box liner. For the other two treatments, grapes were packed using RVCB-1.4% and RVCB-0.8%. Each pallet had 13 tiers; those between position 3 and 9 (named from the bottom to the top) were used for data collection. In each of these tiers, three boxes were used for quality evaluation and three for nesting observation. A total of 42 boxes per pallet were used for observations. Additionally, 12 boxes per pallet were used for SO₂ readings and water condensation measurements.

For both cultivars, grapes were held at 33°F and 85% RH for a three-week period ('Flame Seedless') and 16 weeks ('Redglobe'), then moved to room temperature (68°F and 60% RH) for a 4-day period. SO₂ applications were carried out initially and weekly following Nelson's SO₂ fumigation protocol (Nelson, 1985). Sulfur dioxide penetration was measured initially and weekly placing sulfur dioxide reading tubes 5D and 5DH in box 6 of each treatment. Water condensation on the berries and/or inside polyethylene liners was measured under two temperature handling

conditions. The first temperature handling condition was on warm picked grapes after precooling and during cold storage period (cold storage). The second temperature handling condition was on cold stored grapes after being moved to warm room temperature (warm display).

Quality Evaluations. 'Flame Seedless' and 'Redglobe' storage and quality evaluations were carried out at the Kearney Agricultural Center, Parlier, CA. Quality evaluations included SSC, TA, rachis browning, berry shatter, bleached berries, and botrytis-induced decay development. Table grape stem condition and berry appearance were determined after cooling and also during the cold storage period. Stem browning symptoms were evaluated using the following scoring system: healthy = entire stem including the cap stems (merging point between berries and rachis) green and healthy; slight = only cap stems showing browning; moderate = cap stems and secondary stems showing browning; and severe = cap stems, secondary and primary stems completely brown (Crisosto et al., 2001).

Decay Evaluation. A controlled decay incidence test was performed on 'Redglobe' by using inoculated berries ("bombers"). Each "bomber" was internally inoculated with 10 µl of a suspension containing 10⁶ spores ml⁻¹ of *Botrytis cinerea* with a Hamilton™ syringe. Before their use in the experiment, inoculated berries were incubated at 68°F and 95% RH for 3 days. One "bomber" was placed in the center of each cluster bag. Each box contained nine cluster bags, and three boxes per each of the three treatments were inoculated. One box for each treatment was placed in each tier of each pallet. Three pallets with a total number of 21 boxes per pallet per treatment were used.

Decay was evaluated by counting the number of berries per box (excluding "bombers") showing gray mold (nesting). Bleached berries were evaluated by counting the number of berries per box showing bleaching symptoms.

Data was collected every 3 weeks during a 16-week cold storage period.

Results and Discussion

Condensation under Warm to Cold Conditions. The amount of condensation varied among the different cluster bag treatments for 'Flame Seedless' packed in corrugated boxes. The RVCB-1.4% treatment had the lowest condensation level measured immediately after forced air-cooling. After 7 and 14 days of cold storage, the level of condensation decreased in all of the treatments but still it was the lowest in the RVCB-1.4% after forced air-cooling and 7 days of cold storage. RVCB-1.4% also had significantly lower moderate plus severe condensation levels than the other treatments measured immediately after forced air-cooling and 7 days of cold storage (Table 2). Immediately after cooling, RVCB-1.4% had 44% of moderate plus severe condensation in comparison to 81-98% for the rest of the treatments. By one week of cold storage, grapes packed in the RVCB-1.4% treatment had 15% of moderate plus severe condensation while it ranged from 56 to 74% in the other treatments. Among the other treatments, grapes packed under treatment RVCB-0.7% and RVCB-0.6% showed the lowest condensation. By 14 days, moderate plus severe condensation was very low (0-4%) except for RVCB-0.5% and RVCB-1.4%+BL with 11% and 6% levels, respectively.

Amount of condensation varied among the different cluster bag treatments for 'Redglobe' packed in foam boxes. Grapes packed using the RVCB-1.4% treatment did not show any condensation problems immediately after forced air-cooling and during the 42 days cold storage. There were no significant differences in condensation appearance and amount between grapes packed in the RVCB-0.8% and the RVCB-1.4%+BL within this evaluation period (Table 3). Twenty-four hours after packing, under cold storage (33°F and 85%

RH), the lowest significant value of condensation was shown by RVCB-1.4%.

RVCB-1.4% also had significantly lower moderate plus severe condensation levels than the other two treatments measured immediately after forced air-cooling and during the 42 days cold storage period (Table 4). Immediately after cooling, RVCB-1.4% did not show any grapes with moderate plus severe condensation in comparison to approximately 60% for the rest of the treatments. By 21 days of cold storage, condensation was not observed in any of the three treatments.

Condensation under Cold to Warm Conditions: When 'Flame Seedless' grapes from these different cluster bag treatments were moved to warm conditions, high condensation (condensation score of approximately 3.5) quickly developed in all treatments. However, there were no significant differences in condensation scores among RVCB treatments. Condensation remained high during the first 3 days after removal to warm conditions. By day 4, these condensation scores decreased close to 1.2 (data not shown).

Approximately 90% of the grapes packed in the different cluster bags had moderate plus severe condensation by the first days at warm temperature. High percentages of grapes (69-98%) packed in the different cluster bags had moderate plus severe condensation by two days at warm temperature. Grapes within the moderate plus severe condensation category decreased to 4-24% by day 4. Despite no significant differences in condensation measurements, it appears that condensation disappeared faster in grapes packed by using the RVCB-1.4% treatment than in any of the other RVCB treatments (data not shown).

Grape Quality Evaluations. After three weeks of cold storage, there were no significant differences in 'Flame Seedless' stem condition, berry shatter, bleached berries, and berry decay between treatments. The same situation occurred during the 4 day warming period,

except by day 4 of warming, grapes packed using RVCB-1.4% had a more severe stem browning (2.4 score condition) than grapes packed in the RVCB-0.7% treatment (2.0 score condition). However, after 4 days at warm temperature, stem condition on grapes from all of the RVCB treatments was acceptable (approximately 2.0 score condition). Stems only showed the first symptoms of dehydration at the cap stems.

Under low SO₂ application, there were differences in sulfur dioxide penetration measured during the initial fumigation among the treatments. Percentages of SO₂ penetration were calculated based on the highest penetration. The RVCB-1.4%, RVCB-1.4%+BL, RVCB-1.2% had the highest SO₂ penetration (100%), followed by the RVCB-0.5% and RVCB-0.7% with approximately 80% SO₂ penetration. The lowest SO₂ penetration (60%) was measured on the grapes packed in RVCB-0.6%. During poor SO₂ fumigation conditions, the RVCB-1.4%, RVCB-1.4%+BL, RVCB-1.2% had the highest SO₂ penetration (100%), followed by the RVCB-0.5%, RVCB-0.7% with approximately 57% of SO₂ penetration. A very low SO₂ penetration of only 16% was measured on the grapes packed in RVCB-0.6%.

During 12 weeks of cold storage, there were no significant differences in 'Redglobe' stem condition, berry shrivel, and berry shatter among the three packaging treatments. After 9 weeks of cold storage, the stem condition of grapes from all of the treatments was acceptable (approximately 2.0 score condition). By 12 weeks, stems only showed the first symptoms of dehydration at the cap stems especially in grapes from the RVCB-1.4% and RVCB-0.8%.

Under high SO₂ application, there were no differences in SO₂ penetration measured during the initial and weekly fumigation among the treatments. In most of the cases the dosimeter tubes were over 600 C.T., thus, it was impossible to collect reliable data.

Bleached Berries and Decay Development. Bleached berries became important by 9 weeks of storage, reaching its maximum expression by 16 weeks. Bleaching damage was nearly three times greater on grapes packed in the RVCB-1.4% than grapes packed in RVCB-0.8% or RVCB-1.4%+BL. Reduction of SO₂ by the RVCB-0.8% was determined in our previous test using 'Flame Seedless'. Even though RVCB-1.4%+BL had a low SO₂ penetration, botrytis was controlled as well as with RVCB-1.4%.

Initial and periodic sulfur dioxide fumigations, and low storage temperature were very effective in preventing gray mold development and nesting from the "bombers" on grapes packed using the three packaging systems (Table 5). Botrytis became visible after 9 weeks of storage in two of the three treatments but the amount of botrytis was not related to the treatments until week 16. By week 16, grapes packed using the RVCB-0.8% had the highest botrytis incidence. Grapes packed in RVCB-1.4% and RVCB-1.4%+BL had the lowest botrytis development. Grapes packed with the RVCB-0.8% that were exposed to a high and long condensation period after forced air-cooling had the highest decay development. However, grapes packed using the RVCB-1.4%+BL were also exposed to a high and long condensation period but did not show high decay development. This may be explained by the use of a SO₂ pad, which should have provided a constant SO₂ application during storage, which may have compensated for the poor room SO₂ penetration into the boxes. The influence of inner packaging on free water inside the package may have also been influenced in a different way by this packaging system. We cannot conclude that high decay development was solely due to the fact grapes were exposed to a long condensation period because these grapes also had the poorest SO₂ penetration.

Conclusions

- There were differences in the time and length of condensation period between the different restricted ventilation cluster bags. The RVCB-1.4% had the least condensation after forced air-cooling and during cold storage conditions without limiting SO₂ penetration (warm to cool test).
- There were no differences in condensation among grapes packed with different cluster bags that were warmed up after 21 days in cold storage. Under these conditions, all of the RVCB treatments had high condensation (cold to warm test).
- In general, table grape stem and berry quality attributes were not affected by any of these RVCB packaging treatments, except for decay incidence.
- The most condensation and poorest SO₂ penetration was found on grapes packed in RVCB-0.6% (cluster bags with 70 1/8" holes) after forced air-cooling and cold storage conditions (33°F and 85% RH).
- Under a long commercial storage period, grapes packed using the RVCB-0.8% were exposed to a high amount of condensation and a long condensation period on the surface of the berries. Grapes packed with the RVCB-0.8% also had low SO₂ penetration ending with high decay development.
- This work demonstrates that reducing the venting area of packaging components is a good approach to maintain green rachises but its relationship to SO₂ penetration, cooling operations, and condensation should be studied in detail. Development and implementation of new restricted ventilation packaging (cluster bags and box liners) systems should be carefully evaluated before any commercial implementation.
- This work points out that packaging ventilation affects both the amount and

length of the condensation period and the penetration of SO₂ to the grapes, and it is associated with decay development expressed later during cold storage and postharvest handling.

- These results also suggest that number, size and location of holes in cluster bags influence potential decay in table grapes. Further studies must be carried out varying number, size and hole placement on the cluster bags.

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Table 1. 'Flame Seedless' table grape cluster bag specifications.

TREATMENTS	CLUSTER BAG SPECIFICATIONS					
	Holes Location	Cluster Bag Area (Sq. inches)	Hole diameter (inches)	Number of Holes	Area of Holes (Sq. inches)	Venting Area Percentage (VA)
RVCB-1.4%	Top/Bottom	162	1/4	46	2.26	1.4
RVCB-1.4%+BL ^z	Top/Bottom	162	1/4	46	2.26	1.4
RVCB-1.2%	Top/Bottom	162	1/4	40	1.96	1.2
RVCB-0.5%	Top/Bottom	162	1/4	16	0.79	0.5
RVCB-0.7%	Top/Bottom	162	1/4	24	1.18	0.7
RVCB-0.6%	Top	151	1/8	70	0.859	0.6

^z Box liner: Chilean standard box liner, 1/4" holes on 4" centers was used in combination with the RVCB. Treatments 1-5 used bags vented equally top and bottom. Treatment 6 included holes on the top and sides of the cluster bag only.

Table 2. Berry condensation scores of 'Flame Seedless' table grapes packed in six different types of cluster bags evaluated after forced air-cooling and then 7 and 14 days cold storage (warm to cold).

TREATMENTS	MEAN CONDENSATION SCORE ^z			MODERATE PLUS SEVERE CONDENSATION (%)		
	After forced air cooling	COLD STORAGE		After forced air cooling	COLD STORAGE	
		7 days	14 days		7 days	14 days
RVCB-1.4%	2.4	1.7	1.1	44	15	0
RVCB-1.4%+BL	3.6	3.0	1.5	98	70	6
RVCB -1.2%	3.4	2.9	1.6	92	74	4
RVCB -0.5%	3.7	3.3	1.7	94	83	11
RVCB -0.7%	3.1	2.6	1.6	81	56	4
RVCB -0.6%	3.7	2.6	1.1	94	57	0
P-value	<.0001	<.0001	<.0005	<.0001	.0002	.0245
LSD 0.05	0.46	0.53	0.37	21	27	6.8

^z Condensation score: 1=none, 2=slight, 3=moderate, and 4=severe.

Table 3. Berry condensation scores of 'Redglobe' table grapes packed in three different types of cluster bags evaluated after forced air-cooling and during cold storage (warm to cold).

TREATMENT	MEAN CONDENSATION SCORE ^z					
	DAYS AFTER COOLING					
	0	1	2	3	21	42
RVCB-1.4%	1.07	1.02	1.00	1.00	1.00	1.00
RVCB-0.8%	2.63	2.72	2.70	2.13	1.26	1.05
RVCB-1.4%+BL	2.59	2.81	2.83	2.37	1.40	1.13
P-value	.0014	.0001	<.0001	.0001	.0104	.1222
LSD 0.05	.83	.725	.718	.6671	0.2447	NS

^zCondensation score: 1=none, 2=slight, 3=moderate, and 4=severe.

Table 4. Percentage of 'Redglobe' table grape boxes showing moderate plus severe condensation when packed in three different types of cluster bags evaluated after forced air-cooling during cold storage (warm to cold).

TREATMENT	MODERATE PLUS SEVERE CONDENSATION (%)					
	DAYS AFTER COOLING					
	1	2	3	4	21	42
RVCB-1.4%	0	0	0	0	0	0
RVCB-0.8%	59	57	54	43	2	0
RVCB-1.4%+BL	52	65	65	52	4	0
P-value	.0044	.0003	.0004	.0021	.3419	-
LSD 0.05	34.49	28.30	28.30	27.06	NS	-

Table 5. Number of berries per bag showing symptoms on 'Redglobe' table grapes stored at 32°F under commercial conditions.

Symptom	Treatment	Number of berries per box ^z				
		Storage period (weeks)				
		3	6	9	12	16
Botrytis (Gray mold)	RVCB-1.4%	0	0	1	3	21 b
	RVCB-0.8%	0	0	1	1	65 a
	RVCB-1.4%+BL	0	0	0	0	24 b
	<i>P</i> -value	-	-	0.2295	0.1270	<0.0001
Bleached berries	RVCB-1.4%	0	0	12	14	130 a
	RVCB-0.8%	0	0	13	16	49 b
	RVCB-1.4%+BL	0	0	0	19	50 b
	<i>P</i> -value	-	-	0.2040	0.1392	<0.0001

^zValues are the means of nine bags per each of the three boxes.

FUTURE DATES

Friday, September 8, 2006 – Variety Display and Research Update Seminar at the Kearney Agricultural Center, 9240 S. Riverbend Avenue, Parlier, CA. Sponsored by University of California Cooperative Extension and the Kearney Agricultural Center.

8:00 – 9:00 a.m. Variety display by stone fruit nurseries, breeders and the USDA

9:00 – 10:00 a.m. Soil Fumigation Considerations (research update and discussion in the field)

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Wednesday, December 6, 2006 – Winter Tree Fruit Meeting in Dinuba. Save the date.

Other upcoming events posted on the Postharvest Calendar at the ANR website can be found at: <http://ucce.ucdavis.edu/calendar/calmain.cfm?calowner=5423&group=w5423&keyword=&ranger=3650&calcat=0&specific=&waste=yes>

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