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## Contents:

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- Elevate Registered on Kiwifruit for Management of Gray Mold Caused by *Botrytis cinerea*
- Abstracts – from the 5th International Postharvest Symposium, Verona, Italy, June 6-11, 2004

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## ELEVATE REGISTERED ON KIWIFRUIT FOR MANAGEMENT OF GRAY MOLD CAUSED BY *BOTRYTIS CINEREA*

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The “reduced-risk” fungicide Elevate® 50WDG (fenhexamid) was fully registered in September 2004 as a postharvest treatment on kiwifruit to control postharvest gray mold caused by

*Botrytis cinerea*. This is the first time a postharvest fungicide has been registered on kiwifruit and the “reduced-risk” United States Environmental Protection Agency (EPA) classification represents one of the safest categories of pesticides. The Section 3 full registration of the fungicide was successfully done in cooperation with the IR-4 minor crop pesticide registration program. Furthermore, the new tool for managing kiwifruit decay represents a culmination of research supported by the California Kiwifruit Commission to identify new materials (1999-2000), develop efficacy data (2000-2003), and conduct residue field trials through the IR-4 program (2000-2001). An emergency registration was approved in the fall of 2003 for Elevate and the

fungicide was very successful in reducing gray mold under commercial practices in the first year of commercial use.

A “reduced risk” classification of a pesticide by EPA promotes integrated pest management practices and products that are effective against a specific target organism (i.e., *B. cinerea*) with minimal impact on other organisms or the environment while being one of the least toxic pesticides to animals and people available. Elevate has a very low mammalian toxicity and thus accommodates packinghouse workers’ and consumers’ safety. Furthermore, fungicide usage on kiwifruit is considered of low risk because the peel is rarely consumed. Based on these residue studies, the residue tolerance (or maximum residue limit – MRL) was set at 15 ppm.

As a review of the pathology of gray mold, the fungal pathogen *B. cinerea* depends on wounds as entry points or, alternatively, on dead or senescent tissue that is colonized before healthy tissue is being invaded. On kiwifruit, most infections originate at the wound where the stem was broken or snapped off during harvest. Some infections may also originate from colonized sepals. Although preharvest fungicide treatments may reduce total spore inoculum of *B. cinerea* in the kiwi vineyard, the stem-end of the harvested kiwifruit is still very susceptible to gray mold. The stem-wound (where the stem was removed) of the harvested kiwifruit is unprotected because most fungicides (including Elevate®) are not systemic. Elevate is highly effective as a protective treatment of non-wounded plant surfaces and as a wound (stem-wound) protection fungicide of harvested fruit. Only high-volume postharvest fungicide applications that are done after harvest are completely effective in protecting the stem-wound from infection. Thus, the application method is the most important parameter determining the efficacy of a postharvest fungicide treatment for kiwifruit.

Our research over the last several years has demonstrated that postharvest applications of Elevate® or Scholar® (also planned for registration later this year), are the most effective ways to prevent postharvest losses of kiwifruit from decay caused by *Botrytis cinerea*. In all experimental trials, decay was reduced to zero levels when applied as a dip, flood, or other high volume application. Applications of the fungicide in low-volume systems have also been effective in reducing decay but not completely. The labeled postharvest application rate for Elevate® is 24 oz of the product per 200,000 lb of fruit. Low volume applications of 8-25 gal are applied with controlled droplet or air-nozzle systems, whereas high volume applications (e.g., dip or drench treatments) apply the fungicide in 100 gal. Residues of 4 to 7 ppm should be targeted to obtain excellent decay control.

Because kiwifruit are traditionally kept dry during postharvest handling, the wetting of the fruit is of concern to some packers because of potential fruit staining. Two types of fruit staining are known: water and sooty mold stains. In laboratory studies by other researchers and by us, water staining occurs only on a small percentage (< 1%) of fruit treated in water application systems. Still, water staining may be a problem when large amounts of kiwifruit are treated in a high-volume fungicide application system. Elevate is not effective against sooty molds (a group of fungi that occur on the surface of fruit that cause dark staining of the fruit surface without causing decay). In some lots of fruit the amount of sooty mold staining can be very high. Thus, it is important to wash fruit on a brush bed using chlorinated water (100 ppm free chlorine) to eliminate surface contamination prior to the fungicide application. We will continue to evaluate fungicide-treated fruit using high-volume application systems for staining problems during the cold-storage period (2004-2005). High-volume applications are the best way to ensure that the fungicide is effectively covering

the stem wound. Before packing, excess wetness on the fruit surface can be removed by brushing or by using sponge rollers. Another strategy is to store fungicide-treated and graded fruit in bins until orders are received from retailers, thus allowing time for drying. Damp fruit that is put into storage should dry within a few days.

Elevate is the second fungicide that has ever been registered for gray mold control. Following the cancellation of Ronilan<sup>®</sup> (vinclozolin) on kiwifruit in December 2002, however, no registered fungicide or other treatment in the limited pesticide arsenal for kiwifruit was available that is effective for the management of gray mold. In our studies, preharvest treatments with Ronilan<sup>®</sup>, Elevate<sup>®</sup>, or other fungicides only partially reduced postharvest gray mold decay. Still, this is a valid integrated approach. To that end, we are continuing to develop “reduced risk” fungicides for preharvest use on kiwifruit. In the last several years, we evaluated preharvest applications of Vanguard<sup>®</sup> (cyprodonil) and demonstrated that it is effective similar to Elevate<sup>®</sup> in reducing postharvest gray mold. Currently, Vanguard is in the IR-4 residue program and thus, we plan to have this fungicide available and possibly Elevate<sup>®</sup> as a direct preharvest replacement for Ronilan<sup>®</sup>. Elevate<sup>®</sup> (registered 2004) and Scholar (planned for the 2005 season) as postharvest fungicides and Vanguard (planned for the 2007 season) as a preharvest fungicide will complete the fungicide program for kiwifruit. All of these materials are “reduced-risk” fungicides and all belong to different classes that should help prevent resistance from developing in the pathogen population.

Treatment of kiwifruit with the new fungicide Elevate<sup>®</sup> should keep postharvest decay losses caused by *B. cinerea* to a minimum. An important consideration before treating fruit with a postharvest application of Elevate<sup>®</sup> is to select fruit identification code stickers with the proper adhesive for wet fruit. Furthermore,

because different export markets have their own regulations for acceptance of pre- and postharvest treatments of fruit, the use of Elevate<sup>®</sup> should be considered based on specific requirements of the export destinations. Many countries default to US-EPA established tolerances, however, some countries do not. Therefore, the importer or the country that the kiwifruit shipment will be exported to should be consulted. For further information contact the California Kiwifruit Commission.

### **ABSTRACTS**

*from the 5<sup>th</sup> International Postharvest Symposium, Verona, Italy, June 6-11, 2004*

#### **The Use of Molecular Genetics to Improve Peach and Nectarine Post-Storage Quality**

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Internal breakdown (IB), also known as chilling injury, is the collective term for various disorders that occur during prolonged cold storage and/or after subsequent ripening of stone fruit. Symptoms include mealiness, flesh browning, loss of flavor, and red pigmentation (bleeding). The symptoms are usually not noticed until fruit reaches consumers, and therefore affects consumer consumption. Certain pectin-degrading enzymes appear to play a role in the development of mealiness.

To date, our program had evaluated approximately 133 peach and nectarine varieties for their susceptibility to IR. Some cultivars tend to be more susceptible than others, indicating that the trait has a genetic component. However, the genetic mechanisms by which low susceptibility genotypes avoid IB symptoms are not clear. Using two related and genetically variable populations of peach, we have undertaken a classical and molecular genetics approach to gain a better

understanding of the genetic control of IB and lay the foundation for marker-assisted selection (MAS) for these traits. A partial genetic linkage map was constructed, based on random SSR and RAF markers, candidate gene markers, and gene-targeted SRAP markers. Segregating morphological markers were also mapped, including the Freestone (F), Melting flesh (M), and Flesh color (Y) loci. QTL analysis was performed on the linkage groups, using phenotypic data collected for three seasons. QTLs for flesh mealiness, browning, and bleeding were located.

Candidate gene analysis identified that a gene encoding the cell wall degrading enzyme, endopolygalacturonase, pleiotropically controls the F and M loci. A large genetic effect on mealiness was detected for this locus, reflecting the observation that mealiness occurred only in some freestone melting flesh progeny and was entirely absent in clingstone non-melting flesh progeny. The use of MAS in breeding for low susceptibility to internal breakdown symptoms appears to be an achievable goal for peach.

### **Storage and Shelf Life of Venus Nectarine Cultivar**

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The objective of this study was to determine storage and shelf life of Venus nectarine cultivar grown in Mersin (Tarsus/Yenice). Fruits were kept at 0°C and 85-90% relative humidity for 2 months to determine cold storage conditions. In addition, three replicates of fruits taken from storage room at a week interval were kept at 20°C and 65-70% relative humidity for 6 days to determine shelf life.

Percent weight loss, skin color (L, a, b), flesh color (L, a, b), fruit flesh firmness (kg force), total soluble solids (%), pH, titratable acidity (g malic acid 100 ml<sup>-1</sup>), physiological and fungal disorders were determined in the fruit samples

taken during cold storage at a week interval and those kept at 20°C at a two-day interval. Weight loss increased during storage and reached about 5% at the end of storage. Fruit flesh firmness decreased, but still remained above 4 kg-force at the end of 2-month storage. Total soluble solid (%) and pH increased while titratable acidity (%) decreased. As the storage period was extended the shelf life was observed to be shortened.

### **Postharvest Calcium Chloride Dips for Increasing Peach Firmness**

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Postharvest bruising of peaches might be reduced by increasing fruit firmness. This study evaluated changes in firmness resulting from dipping peaches in a calcium solution soon after harvest. Cartons of 'Harvester' and 'Juneprince' peaches were obtained from a commercial packinghouse from three harvests each. Half were dipped for 30 minutes at room temperature in a 1% calcium chloride solution and held at 0, 4, and 10°C and 95% relative humidity. Nondestructive tests (firmness, mass, and color) were made five or more times during 21 days of storage on 180 fruits from the two varieties (30 fruits x 3 temperature x 2 calcium levels). Firmness was from parallel plate deformations at 10 N. Mass was measured to a resolution of 0.001 g. Color was measured with a Minolta color comparator in L, a, b units. Destructive tests were made on 15 fruits from each treatment: total soluble solids (% Brix), acidity (pH), firmness (Magness-Taylor), and taste. Firmness (nondestructive and destructive) during storage was higher for fruit treated with calcium than for untreated fruit. However, temperature affected firmness more than the calcium treatment. Calcium treatments increased mass loss only on 'Harvester' fruit

stored at 10 degrees and lowered hue angle only in a few cases near the end of storage.

The main differences in TSS were due to days of storage with little influence caused by the calcium treatments. An undesirable taste was noted in the fruit that was treated. A study is needed to determine if a lower concentration of calcium chloride could provide beneficial increases in firmness without changing the taste of the fruit. The effect of temperature on calcium absorption should also be studied.

### **The Effect of 1-MCP on Storage Potential of Plum (*Prunus domestica*) & Greengage**

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Victoria plums were harvested on one date, from two different agri-climatic areas, with Margorie and Greengage harvested from one location at a later date. Samples of the fruit were treated with 1-MCP (Smartfresh™) within 12 h of harvest, prior to storage in air. The 1-MCP was applied at 650 nL L<sup>-1</sup> for 24 h at 1°C.

All fruit was stored in air at 1°C for 28 days. Fruit was removed from the cold store at 7 day intervals, with each sample having an untested subsample transferred to 20°C for 7 days. The fruit quality was tested by colorimeter (Minolta a\* reading), the presence of decay, pressures and soluble sugars. For both cultivars the most notable effect of 1-MCP was the improved firmness of fruit both from cold storage and after 7 days at 20°C. The agri-climate region had an effect on the fruit pressure in Victoria, with a 7 day benefit over the untreated sample for the firmness to drop below 4 kg cm<sup>-2</sup>. There was a similar benefit for greengage.

The firmness for Margorie was around 3.5 kg cm<sup>-2</sup> at harvest, but the 1-MCP treatment sample did not decrease to below 3.5 until 35 days, with the control falling below this figure after 21 days.

### **Effect of the Rate and Duration of Forced Air Cooling on the Quality of Imperial Apricots and Pioneer and Songold Plums**

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Gel breakdown (GB) and overripeness (OR) remain the biggest internal problems with imperial apricots which makes the biggest contribution to the total volume of apricots exported from South Africa per annum. Pioneer, an early season South African plum cultivar, ripens quickly on and off the tree which results in rejections for soft fruit at packing and on arrival overseas. Songold, a yellow, midseason plum cultivar tends to develop GB and OR during cold storage in some seasons, which renders the fruit inedible and results in high rejection rates.

Prompt cooling and good temperature management are essential to lower the rate of physiological deterioration of stone fruit. In some instances, FAC can take as long as 48 to 72 h, depending on the type of packaging, in some of the commercial depots where FAC is applied on stone fruit in South Africa. The trial fruit was subjected to the following FAC rates at a delivery air temperature of -1.0°C to a pulp temperature of -0.5°C: 6 h, 12 h, 24 h stepwise cooling and 48 h stepwise cooling for the apricot, and 12 h, 24 h, 48 h stepwise cooling, and 72 h stepwise cooling for the two plum cultivars. The fruit was evaluated after a cold-storage and a simulated shelf-life period. The trial was conducted in two consecutive seasons.

Imperial apricots had the best internal quality after 8 h of FAC, Pioneer plums were not sensitive to FAC rate or duration, and Songold plums had the best internal quality when FAC was applied for 12 h and longer. This result on the plums demonstrates that cultivar differences

must be considered when drawing up handling protocols for stone fruit, as a blanket recommendation may lead to the induction of quality defects.

### **Commercialization of SmartFresh™ (1-Methylcyclopropene) in the South African Deciduous Fruit Export Market, and Its Effect on Post Harvest Handling and Fruit Quality**

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SmartFresh™ (1-methylcyclopropene), an antagonist ethylene inhibitor in horticultural products, is an exciting new breakthrough in the post harvest storage of fresh fruit. Due to its ethylene blocking effect, SmartFresh™ maintains the quality of fresh produce during cold storage and shelf life. Registered for application on apples since 2002, SmartFresh™ has been successfully applied commercially within the USA and South Africa. Consistent with findings of overseas researchers, SmartFresh™ treatment on South African apples enabled maintenance of flesh firmness, skin color and malic acid levels, and when applied under the recommended guidelines, complete superficial scald control. SmartFresh™ also extended shelf life and in some instances reduced greasiness.

From an extensive database of over 100 treatment rooms, the effects of commercially applied SmartFresh™ on fruit maturity at treatment, storage duration, RA vs. CA storage, and different apple cultivars, were determined. Using the database, maturity parameters at treatment were compared with quality responses after storage. It was immediately evident that the most important factors effecting SmartFresh™ efficacy were starch levels, followed by flesh firmness. When fruit were treated with less than 40% starch break down, flesh firmness improvement at the end of

cold storage was invariably greater than 1.0 kg. It was also evident that SmartFresh™ was no longer effective above a certain level of starch breakdown in the fruit.

Data was analyzed statistically in a forward stepwise regression procedure to develop a model to predict treatment outcome using maturity data at treatment. While still in the conceptual stage, results indicate promise, and the accuracy of this model should improve as additional data points are added. Extensive research on plums and pears resulted in SmartFresh™ registration for use on plums in 2003, and it is hoped that pear registration will follow shortly. The significance of these findings will be discussed.

### **Evolution of the Allergenic Potential in Peach and Nectarine Fruits During Ripening**

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According to recent epidemiological studies, food allergies enhanced during recent decades in many countries. Allergies to fruits represent also an increasing problem and studies should be addressed to produce hypoallergenic fruits. In peach the major allergen has been identified as a Lipid Transfer Protein (LTP) and in the present research the evolution of the allergenic potential of different peach and nectarine varieties has been monitored throughout ripening and in relation to postharvest treatments. Fruits of peach cv Royal Gemm, Zorzi, of nectarine cv Rita Star, Early Giant and Mariadorata, and of flat type (Platicarpa), were harvested in correspondence of commercial ripeness (TO) and maintained in

air for few days at room temperature to reach the full ripe stage or at 4°C for 3 weeks. Treatments with propylene were also performed. Northern blot analyses were carried out on total RNA extracted from epicarp and mesocarp to study Pp-LTP1 gene expression. Immunological studies were performed by means of a polyclonal antibody raised against the purified protein.

Expression analysis showed that Pp-LTP1 transcripts accumulated only in the epicarp. With the exception of cv Rita Star the strongest accumulations have been detected in epicarp of all varieties at TO. A decreasing trend of expression was observed in all fruits kept in air and at 4°C, but not in Platicarpa. Excluding Mariadorata fruits, propylene treatment did not appear to affect Pp-LTP1 gene expression. Western blots revealed the presence of LTP only in epicarp of all varieties, but not in Rita Star, and showed that the protein markedly increased in full ripe fruits maintained in air: this might indicate the presence of a lag between gene transcription and accumulation of secreted functional LTP. According to these results, Rita Star appears to be a variety with a low allergenic potential.

### **Alternatives to Sulphur Dioxide in Table Grape Storage: Potentials for Ethanol Vapors**

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Experiments have been conducted over three years to optimize the application of ethanol vapors in order to prevent *Botrytis* development and stem browning, two of the major problems in postharvest quality of table grapes. Various strategies have been tested: modified atmosphere packaging, several concentrations of ethanol in the vapor phase, combination of sulphur dioxide or modified atmosphere with

ethanol. Results show that small doses of ethanol alone (around 2 ml per kg of grapes) gave a sufficient control of *Botrytis* development to replace SO<sub>2</sub>, without a concomitant increase in stem browning. Other results, e.g. berry shatter and consumer acceptability, will be discussed.

### **Changes in Fruit Quality, Phenolic Compounds and Antioxidant Capacity of Fresh Prune during Storage**

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Phenolic compounds, anthocyanins and some factors related to the quality of fresh prune were analyzed and their changes during storage at 1°C and 5°C were investigated. The fruit quality was maintained within 15 days at 5°C but remarkable internal browning was observed after 21 days.

The fruit stored at 1°C showed less internal browning than at 5°C, however dehydration and softening were severe at this temperature. The increase of soluble solids and the decrease of titratable acid were observed at both temperatures. Total phenolics content of flesh decreased slightly at 5°C but increased at 1°C after 15 days of storage. Total phenolics and anthocyanins content in peel increased at both storage temperatures. 3-Caffeoylquinic acid was the major compounds in flesh while 3-caffeoylquinic acid, 5-caffeoylquinic acid (chlorogenic acid) and two major anthocyanins (cyaniding-3-glucoside and peonidin-3-glucoside) were major phenolics in peel. Cyanidin-3-rutinoside and peonidin-3-rutinoside were also detected in peel. DPPH radical scavenging activities of peel and flesh were higher than chlorogenic acid standard and remained stronger during storage period.

## High CO<sub>2</sub> Treatment to Control Decay on Peach Fruits

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This study was conducted to investigate the effects of short term treatment (24-72 hours) with high CO<sub>2</sub> concentrations (35, 60, or 100%) on growth of *B. cinerea* isolated from naturally infected peach fruit and decay of peach fruits at 25%. CO<sub>2</sub> concentrations at 35-100% provided a reduction in growth of *B. cinerea* and, at 100%, significantly delayed the lesion formation during the treatment periods. Decay of peach fruits was controlled by use of high CO<sub>2</sub> concentrations at 100% for 24 or 48 hours and 60% for 48 hours. Short term treatment of high CO<sub>2</sub> concentrations 35-100% did not affect SSC, but increased firmness and color preference. In certain cases, off-flavors were noted in fruits after treatment with 100% CO<sub>2</sub> for more than 24 hrs. CO<sub>2</sub> concentration of 60%, therefore, was the most effective to control decay and preserve freshness of peach fruits.

## Consumer Expectations and Soluble Solids, Acidity and Firmness of Plums

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Soluble solids content, acidity and firmness are important factors determining eating quality of fruit. Tests with consumers confirmed that acceptance can be predicted by instrumental measurements of total soluble solids (refractometer), titratable acidity and firmness measurements for plums. The variety 'Cacaks Schöne' of acceptable eating quality should attain a minimum of 13.8°Brix. Acidity should be less than 10 g L<sup>-1</sup> (malate) and firmness should not exceed 35 Durofel units. A sugar acid ratio ranging between 16 and 18 seemed

most acceptable. Soluble solids content and acidity of plums were related to crop load. Furthermore, acidity and firmness were dependant of picking time or ripening stage of plums. Plums picked at an early stage of ripeness and stored for four weeks were not liked by consumers, although firmness and acidity decreased during storage. Hence control of crop load and picking at the optimal ripeness stage are decisive for the eating quality of plums.

## Control of Postharvest Diseases of Sweet Cherry with Ethanol and Hot Water

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Complete inhibition of the spores of *P. expansum* occurred after a 10 s exposure to 40% ethanol or more at ambient temperature, while spores of *B. cinerea* were completely inhibited by 30% ethanol or more. Mortality of the spores of *P. expansum* and *B. cinerea* in heated 10% ethanol was higher than in water at the same temperatures. Immersion of naturally inoculated fruits in 20, 30, 40, or 50% ethanol reduced the decay present after storage for 10 days at 20°C similarly and by about 60 to 85%. Immersion of fruit that had been inoculated with the spores of *P. expansum* and *B. cinerea* reduced decay by both pathogens after storage for 30 days at 0°C and 5 days at 20°C when 30% or higher concentrations of ethanol were used.

The incidence of decay after immersion in water alone for 30 seconds at 24, 50, 55, or 60°C was 57.8, 44.8, 46.3, and 35.7%, respectively, while 10% ethanol at these temperatures the decay incidence to 52.3, 33.9, 32.8, or 14.8%, respectively. Water treatments at 50, 55, or 60°C alone were not effective against *P. expansum*, while their efficacies were significantly increased by the addition of

10% ethanol. The most effective treatment was immersion in 10% ethanol at 60°C. Ethanol treatments at 20, 30, 40, or 50% and water treatments at 55 or 60°C significantly reduced natural fungal populations on the surfaces of fruits in all of the experiments. Addition of 10% ethanol to water significantly increased the efficacy of water in reducing the fungal populations at elevated temperatures. None of these treatments caused surface injuries to the fruit or adversely affected stem color.

### **On-Orchard Factors that Influence the Level of Storage Rots on *Actinidia chinensis* ‘Hort16a’ In New Zealand**

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ZESPRI GOLD kiwifruit (*Actinidia chinensis* var *chinensis* ‘Hort16a’) can experience fungal rots in storage. The prevalence of these rots is influenced by the susceptibility of the fruit, the presence and amount of inoculum, and the harvest and storage regime. This abstract reports research on on-orchard factors that influence fruit susceptibility and the prevalence of the fungal pathogens. Fifteen orchards within the North Island of New Zealand were included in this trial.

Necrotic leaf discs and last season’s fruit peduncles were collected from each orchard and assessed for the presence of rot fungi. Information on shelter type, canopy structure and rating, orchard layout, irrigation, and contour in each orchard was also collected. Immediately after clearance to pick, 500 fruit were harvested from each orchard and placed into storage. The fruit were assessed regularly for rots and other storage disorders. Fruit with rots were removed and the causal pathogen(s) identified. The mean °Brix, flesh color,

firmness, dry matter, and mineral composition were also determined for each orchard. There were considerable differences in the incidence of the various fungi on the orchards sampled. The range of fungi was greater on leaf discs than on peduncles.

The incidence of post-harvest rots was low, with the majority of rots being associated with chilling injury. The main fungi associated with rots were *Phomopsis* spp. and *Cryptosporiopsis actinideae*. In some cases, the incidence of storage rots and the incidence of *Phomopsis* spp. on necrotic leaf discs were related. In general orchards with higher levels of rots had denser canopies. Further analysis also suggested linkages between a higher prevalence of rots and particular shelter species, warmer temperatures, higher rainfall and specific fruit nutrient levels. In addition more mature fruit tended to be less susceptible to rots associated with chilling injury.

### **Integrated Control of Sweet Cherry Storage Rots by Pre- and Postharvest Applications of *Aureobasidium pullulans*, Calcium Chloride, and Sodium Bicarbonate**

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Calcium chloride (CC) and sodium bicarbonate (SB) were selected among 17 salts as the most effective against *Botrytis cinerea* in in vivo trials on wounded sweet cherries. Under the same conditions, the combination of CC and SB with a known biocontrol agent (*Aureobasidium pullulans*, strain L47) reduced Botrytis rot by 98 and 94% respectively.

Tests with pre and postharvest treatments were conducted in 2000 and 2001 using CC, SB, and L47, alone or in combination. In both year trials, postharvest treatments gave significant

reductions of rot incidence compared to the control. In particular, the combinations L47+CC and L47+SB were the most effective with a reduction of total rots ranging from 62 to 75%. The application of Limpel's formula proved the presence of a synergistic effect of combined applications of antagonist and salts.

Compared to the untreated control, preharvest applications of the antagonist and salts alone resulted in a significant reduction of rots ranging from 24 to 58%; however, their combined application did not improve the level of control. CC and SB did not show any in vitro toxic effect on *A. pullulans* and did not modify the epiphytic population of yeasts, yeast-like fungi, and filamentous fungi on fruit surface. In postharvest applications, the population of the antagonist was not reduced by the presence of salts, whereas, on fruits treated before harvest the colony forming units (CFU) of yeast-like fungi were lower on fruits treated with a combination of antagonist and salts, compared to fruits treated with the sole antagonist.

#### **Biocontrol Activity of Bio-Coat and Biocure against Postharvest Rots of Table Grapes and Sweet Cherries**

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The efficacy of two postharvest biocontrol products under commercial development was determined in semi-commercial tests on table grapes and sweet cherries. The products consist of the yeast *Candida saitoana* combined with either chitosan (Bio-Coat) or an antifungal, lytic enzyme (Biocure).

On table grape (cv Italia) field applications of the two biocontrol products 21 days and 1 day

determined significant reduction of grey mold rots after storage and shelf-life ranging, from 33 to 46%. Field rots (mainly sour rot) were also reduced on bunches of grapes treated 21 days before harvest. The level of control was comparable to that of a conventional chemical fungicide (Mepanypirim). On sweet cherries (cv Lapins) postharvest dipping treatments significantly reduced total rots (mainly grey and brown mold) by 59% (Bio-Coat) and 64% (Biocure). Similar results were obtained on sweet cherries cv Moreau.

The two biocontrol products did not cause any phytotoxic effect and did not modify the fruit appealing on both table grapes and sweet cherries.

#### **Effect of 1-Methylcyclopropene on Kiwifruit Softening**

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Premature softening induced by ethylene is a serious commercial problem limiting storage life of kiwifruit. The objective of this study was to evaluate the effectiveness of 1-MCP in extending storage and shelf life and preventing postharvest softening of kiwifruit. Exposure to 100 nl L<sup>-1</sup> 1-MCP at room temperature for 12 h or at low temperature (<5°C) for 24 h was applied with a single or double treatment before or/and after storage. Fruit were also treated with a single application at 250 nl L<sup>-1</sup> 1-MCP. Following storage at 0°C fruit were kept at 20°C. The results show that exposure to 100 and 250 nl L<sup>-1</sup> 1-MCP delayed softening in kiwifruit after shelf life. An application before storage was more effective than treatment after storage. Double treatment was slightly more effective compared to single application. Furthermore, a single application of 1-MCP at

room and low temperature was equally effective in delaying the loss of firmness.

In a separate experiment, kiwifruit were treated three days after harvest, after curing, with 100 nl L<sup>-1</sup> 1-MCP at room temperature for 12 h and stored in air at 0°C with or without ethylene absorber. Following storage fruit were kept at 20°C. 1-MCP treated fruit were significantly firmer than untreated fruit after storage and shelf life. Kiwifruit treated and stored without ethylene absorber had comparable or superior value of firmness to untreated stored with ethylene absorption.

In both trials, 1-MCP had no effects on soluble solids content and acidity. No significant differences in fruit rot, caused by *Botrytis cinerea*, were observed.

### Radio Frequency Heating of Walnuts and Sweet Cherries to Control Insects after Harvest

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Radio frequency (RF) heating has been explored as a potential non-chemical method to control insects in harvested walnuts and as a quarantine treatment for 'Bing' sweet cherries. Walnuts (2.5 kg) were heated until the walnuts reached 50 to 90°C. Heating walnuts to 55°C or higher resulted in 100% mortality of navel orangeworm. Heating walnuts with RF energy to 80°C had no negative effects on walnut quality. Moisture content had a significant influence on the heating rate of the walnut kernels. For industrial applications, walnuts could move on a conveyor through one or more RF systems with mixing of nuts between systems.

'Bing' sweet cherries (50) were heated in a polyethylene container holding 10 L of circulating distilled water with 2.3 g of NaCl. Fresh fruit must be treated in a saline solution to prevent burning at fruit contact points, and circulation improves heating uniformity within the RF field. Cherries were equilibrated in 35°C water for 6 minutes, then heated with RF energy to target temperatures between 50 and 54.5°C and held for 0.5 to 6 min. before hydro-cooling. Fruit were stored for 1 day at 5°C or 14 days at 0°C to simulate air or sea shipment, respectively. Shorter treatments at higher temperatures were better tolerated than longer treatments at lower temperatures. Cherry fruit infested with codling moth larvae were subjected to the same treatments. Mortality was 100% in all treatments except those at 50°C. However, fruit quality was unacceptable following sea shipment and marginal following air shipment. Treatment times would be significantly longer to provide for Probit 9 security (99.9968% population mortality) required for export to Japan and therefore RF treatments do not appear promising for sweet cherry fruit.

### Time-Resolved Reflectance Spectroscopy as a Non Destructive Tool to Assess the Maturity at Harvest and to Model the Softening of Nectarines

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The quality (flavor, texture) of peaches and nectarines is dependent on harvest maturity, related to background color. In the new cultivars the background color is masked by blush, preventing the identification of the maturity stage. A new non-destructive technique, Time-Resolved Reflectance

Spectroscopy (TRS), can measure separately the optical properties of absorption and scattering at selected wavelengths in diffusive media. In a previous trial with nectarines, the absorption coefficient at 670 nm (ma670) measured at harvest was correlated to fruit maturity and to softening after harvest. The aim of this research was to model the softening during shelf-life of 'Springbright' nectarines measured by TRS. Fruits of two sizes were picked on 16 July 2003, and ranked by decreasing ma670 (increasing maturity). Ranked nectarines were randomly assigned to each sample for analysis at harvest and during shelf-life, in order to ensure that fruit from the whole range of ma670 were available in each sample. Fruit were stored at 0°C for 3 or 10 days, then at 20°C for 5 days. Firmness was

measured destructively (pressure test) twice a day during shelf-life. Firmness did not change significantly during cold storage. Softening during shelf-life after cold storage was modeled by non linear regression analysis. Softening followed a logistic model in function of ma670 at harvest and of time at 20°C ( $R^2=0.89$ ).

The results of the previous trial were fully confirmed. The effects of fruit size and of cold storage were not significant. The logistic model had already been used to model the color evolution in horticultural products, but not yet, in our knowledge, to model fruit softening. By using this model and knowing the ma670 at harvest of nectarines, it is possible to predict their softening rate at 20°C, and so to choose their marketing destination.

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