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Central Valley POSTHARVEST newsletter

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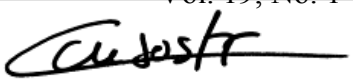

Carlos H. Crisosto, Editor

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INSTRUMENTS FOR MEASURING FRUIT AND VEGETABLE ENVIRONMENT

James F. Thompson and Carlos H. Crisosto
University of California
Davis, California

Environmental storage conditions, particularly air temperature, relative humidity and air velocity, have a major role in maintaining fruit and vegetable quality during cold storage. The constant low temperature, high relative humidity (RH) and moderate air flow are important to limit perishable quality. Storage temperature controls must be well calibrated to maintain a precise level of control. The temperature in a storage facility normally should be kept within ± 1ºC (2ºF) of the desired pulp temperature for the commodities being stored depending on temperature monitoring and degree of precision capabilities.

Several instruments are necessary to monitor environmental conditions during postharvest handling. Details on the instruments and sources can be found on the Postharvest Technology Center website which is updated frequently (http://postharvest.ucdavis.edu/phd/directorymain.cfm).

Temperature Measurements

Accurate temperature management and constant monitoring are essential for the success of storage operations. A wide range of instruments is available to measure this critical environmental factor during cooling, storage and transportation. The most suitable one will depend upon the degree of precision that is needed, the need for automated recording, whether a number of locations must be measured at the same time, how large the sensing probe should be, resistance to sulfur dioxide, and degree of technical skill required for operation and maintenance of the instrument.

Wall-mounted alcohol-filled thermometers provide good temperature measurements at low cost; long stem types can be read more accurately. Electronic thermometers with long lead wires allow measurements of coolant temperatures in inaccessible locations. Thermocouple wires cost $0.10 to 0.15 per foot, and readout devices cost as little as $100. Thermistor sensors, which are more accurate than thermocouples, cost more, but allow the use of less expensive copper lead wires. Both of these devices can be connected to data logging equipment and allow temperatures to be recorded. Monitoring equipment costs about $100 per recording channel. Recently, several manufacturers have developed self-contained temperature monitors and recorders, which are small, can be packed in the box and/or inserted in the produce and cost as little as $50 per unit. Data is read by connecting the unit to a computer or through a satellite connection.

Produce Temperature Measurement

Temperature-monitoring equipment should be installed in the facility, and portable measuring instruments should be available for cooling and storage personnel. These instruments respond quickly, and the probes in different sizes and lengths are suitable to reach the air, and individual berries, even in the middle of a pallet without disturbing the containers. Thermometers placed in the open cold air and shielded from any heat source are suitable to measure air temperature. When a thermometer probe is inserted in a berry it will measure pulp temperature. In both cases, temperature readings can be expressed in Fahrenheit or Celsius degrees. Sometimes these air temperature readings can be called *dry bulb temperature* after the temperature measured by the uncovered thermometer in a wet and dry bulb psychrometer.

Measuring pulp temperature Cold produce may absorb enough heat from a thermometer to warm the flesh near the probe, resulting in an erroneously high temperature reading. This error can be prevented by probing the produce once to cool the thermometer and then reinserting it in another area to take the actual reading. Some probes, usually dial thermometers, have an immersion depth marked on the stem. All of the probe length from the tip to the immersion mark must be within the product for an accurate temperature reading. Punctured product should be discarded if the puncture damage is the portion of the fruit that will be eaten.

Bimetallic, dial, and pocket-sized electronic thermometers, which cost from $5 to $30, are inexpensive devices for measuring produce temperature. Bimetallic thermometers can easily be calibrated with an adjusting nut located behind the dial. Bimetallic thermometers can be purchased with dials large enough for accurate reading. Because both types of units tend to respond slowly to produce temperature, operators need to determine the response time of their equipment.

Electronic thermometers (thermocouple and thermistor units) can be purchased with a very thin, strong probe for fast response, providing an accurate reading in about 8-10 seconds. Most units currently cost from $200 to $300 and can be purchased with lighted readouts for operation in dark areas. Most electronic thermometers must be replaced if they go out

of calibration but they are easily read under difficult light conditions. Most units display both Fahrenheit and Celsius temperature scales.

Infrared thermometers give instantaneous response but cost from $400-$1,000. They measure the surface temperature of the produce in front of them. Surface temperature equals produce pulp temperature if the produce has been in a constant ambient temperature for many hours, as in the case of produce in long-term storage. As the temperature readings depend on a property of the surface called emissivity, it has to be adjusted according to measuring surface. High water content fruits and vegetables usually have an emissivity near 0.95. These units work very well for rapidly surveying the temperature of the produce coming out of refrigerated vehicles. During and shortly after initial cool down, the produce's surface temperature is usually the coldest and is not a good indicator of the average pulp temperature.

Calibrating Temperature Measuring Equipment

Continuous and proper monitoring of the temperature-measuring system must be maintained and calibrated so that the indicated temperatures are indeed within the level of accuracy needed. All temperature equipment should be calibrated at least once a year. Accuracy can be checked by submerging the sensing unit in an ice bath, which has a temperature of 0°C or 32°F. The bath should contain both ice and water, should be continuously stirred and should be free of contaminants (distilled ice and water are best). The sensing unit should be in the water until it reaches a constant temperature, but should not be touching the container. Many instruments have an adjustment to allow recalibration. If adjustment is not possible, purchase a new instrument or mark the error on the unit.

Relative Humidity Measurements

Relative humidity is defined as the amount of water vapor, measured as water vapor pressure, in the air divided by the maximum amount of water vapor the air could hold if it were saturated. Relative humidity is expressed as a percent and is a good measure of conditions that allow mold and bacterial growth. Relative humidity should be monitored closely in a grape-handling facility, especially in the storage rooms. Many instruments measure relative humidity; however, the instrument selected should be accurate, dependable, and simple to operate to have much practical value.

Electric humidity sensors are based on substances whose electrical properties change as a function of their moisture content. As the humidity of the air around the sensor increases, its moisture increases, affecting the sensor's electrical properties. An accuracy of less than 2.0% of the actual humidity is often obtainable. Sensors lose their calibration if they become contaminated, and a few older devices lose calibration if water condenses on them. As most sensors have a limited life, accuracy of the sensor should be periodically checked with a calibration kit that can usually be purchased from the company marketing the sensor. Accuracy of the temperature sensor built into the unit should be checked using a calibrated thermometer.

Wet- and dry-bulb psychrometers with thermometer temperature divisions of 0.1°F will be sufficiently accurate to measure relative humidity to 1.0% in a cold storage atmosphere. Precautions should be taken that the indicated readings are reliable. There should be no fluid in the safety cavity at the top of the thermometer, and the column in the stem should be continuous with the reserve in the bulb at the base. The cotton *sock* on the wet bulb should be soaked thoroughly with distilled or deionized water. Relative humidity is determined from the wet bulb and dry bulb temperatures using a psychrometric chart or an analog slide rule provided with the instrument.

Mechanical hygrometers usually employ human hairs as a sensing element. Hair changes in length in proportion to the humidity of the air. The response to changes in relative humidity is slow and is not dependable at very high relative humidity. These devices are acceptable as an indicator of a general range of humidity but are not suitable for accurate measurements.

It is difficult to obtain accurate determinations in a cold storage room with a sling-type unit that must be swung in the air. Heat from the operator's body can be a significant factor, and the time needed for a precise reading can be quite long, especially in the cold uncomfortable storage room. Both problems of the sling psychrometer may be eliminated by use of an aspirated psychrometer that has a battery operated fan to draw the air past the bulbs at a velocity of at least 300 fpm. The motor of the fan should be downstream from the bulbs, so that heat from the motor does not cause a false reading. A reading should be taken every few minutes or so until a constant difference between wet- and dry-bulb temperature is obtained. This may take as long as 15 minutes if ice forms on the wet bulb. During ice formation, misleading readings are possible because heat is released during solidification of the water into ice. If ice forms the web-bulb thermometer reads the ice-bulb temperature of the air and relative humidity is determined from an ice-bulb/dry-bulb temperature chart. Special care must be taken when using a wet-bulb thermometer when the wet-bulb temperature is near freezing. Most humidity tables and calculators are based on a frozen wick at wet-bulb temperatures below 0°C (32°F). At temperatures below 0°C, touch the wick with a piece of clean ice or another cold object to induce freezing, because distilled water can be cooled below 0°C without freezing. The psychrometric chart or calculator must use frost-bulb, not wet-bulb, temperatures below 0°C to be accurate with this method.

Air Velocity

Air velocity is an important factor affecting cooling rates and water loss from grapes. An anemometer is used to measure air velocity. This is a common instrument used in a weather station. A rather inexpensive instrument for measuring this parameter is the pin-wheel anemometer; however, it cannot measure air velocities dependably below about 50 fpm. Unfortunately, air velocities, as low as 10-20 fpm are desired during cold storage.

Hot-wire anemometers use a very fine wire (on the order of several micrometers) heated to above the ambient. Air flowing past the wire has a cooling effect on the wire. As the electrical resistance of most metals is dependent upon the temperature of the metal (tungsten is a popular choice for hot-wires), a relationship can be obtained between the resistance of the wire and the flow velocity. The hot-wire anemometer is relatively inexpensive ($400) and it is being used effectively in cold storages. The hot-wire anemometer can reliably read air velocities as low as 10 fpm. In addition, the probe is very small and can be inserted into very narrow channels for measurements.

POSTHARVEST ABSTRACT UPDATES

Cherry

Effectiveness of a short hyperbaric treatment to control postharvest decay of sweet cherries and table grapes

Postharvest Biology and Technology, Volume 49, Issue 3, September 2008, Pages 440-442 Gianfranco Romanazzi, Franco Nigro, Antonio Ippolito Abstract

The effectiveness of short hyperbaric treatments to control postharvest decay of sweet cherries (*Prunus avium* L., cv Ferrovia) and table grapes (*Vitis vinifera* L., cv Italia) was investigated. Sweet cherries and table

grape berries were exposed to the pressure of 1140 mmHg (1.5 atm) for 4 and 24 h, respectively, in 64 L gas-proof tanks. Fruit kept at ambient pressure (near 760 mmHg, 1.0 atm) served as a control. Postharvest rots of sweet cherries arose from naturally occurring infections, whereas table grape berries were artificially wounded, exposed to the hyperbaric treatment, then the wounds inoculated with 20 μL of a *Botrytis cinerea* conidial suspension (5×10^4 spores mL^{-1}). Sweet cherries were stored at 0 ± 1 °C for 14 d, followed by 7 d at 20 ± 1 °C. Table grapes berries were kept at 20 ± 1 °C for 3 d. On sweet cherries, hyperbaric treatment reduced the incidence of brown rot, grey mould, and blue mould, with respect to the control. Similarly, on treated table grapes a significant reduction of lesion diameter and percentage of *B. cinerea* infected berries was observed. Induced resistance was likely to be responsible for the observed decay reduction. To our knowledge, this is the first report on the effectiveness of short hyperbaric treatments in controlling postharvest decay of sweet cherries and table grapes.

Detecting internal insect infestation in tart cherry using transmittance spectroscopy

Postharvest Biology and Technology, Volume 49, Issue 3, September 2008, Pages 411-416
Juan Xing, Daniel Guyer Abstract

This paper introduces an application of using transmittance spectroscopy to identify the infestation in tart cherry resulting from past or present insect activities. The spectra were recorded within a wavelength region between 550 and 980 nm with a FieldSpec spectroradiometer. The fresh tart cherries were hand harvested from different orchards in Michigan in 2004–2007. The samples included intact as well as infested cherries with different damage levels. The spectral analysis indicates that the maturity of tart cherry has effects on the classification accuracy. The intact cherries harvested late in the season (over-ripened) have similar spectral characteristics as the infested tissues. The classification accuracy for the samples harvested at normal time is better than that for the late harvested samples. Depending on the arrangement of the samples into *non-infested* or *infested* classes, the total classification accuracy varies from 82% to 87%. These findings and results demonstrate that transmittance spectroscopy has strong potential to detect the internal insect infestation within a tart cherry fruit.

Real time polymerase chain reaction for rapid and quantitative determination of Cystofilobasidium infirmominiatum on the surfaces of apple, pear, and sweet cherry fruit

Spotts, Robert A., Wallis, Kelly M., Serdani, Maryna, O'Gorman, Daniel T., Sholberg, Peter L.

The objectives of this study were to develop primers and a real time PCR protocol for the postharvest biocontrol yeast Cystofilobasidium infirmominiatum (Cim). The application of this technology was developed to quantify Cim on the surfaces of apple, two pear cultivars, and sweet cherry fruit treated over a range of concentrations. Statistically significant relationships were observed between Cim DNA on fruit surfaces, expressed as og/mpo, and CFU/L of dip suspensions for apple, pear, and sweet cherry. In addition, the relationship for each fruit was significantly different from the other three fruits. Threshold values of concentrations of Cim DNA on the fruit surface were calculated based on regression equations and a dose of 2.0x10p#p# CFU/L of dip suspension, the dose for optimum decay control, and were 4.8, 7.0, 16.5, and 25.2og/mpo for Bosc pear, Lapins sweet cherry, d'Anjou pear, and Golden Delicious apple, respectively. Monitoring Cim DNA concentration on fruit surfaces will assure that Cim is being properly applied to fruit and that a sufficient number of cells are present for optimum decay control.

Detecting internal insect infestation in tart cherry using transmittance spectroscopy

Xing, Juan, Guyer, Daniel

This paper introduces an application of using transmittance spectroscopy to identify the infestation in tart cherry resulting from past or present insect activities. The spectra were recorded within a wavelength region between 550 and 980nm with a FieldSpec spectroradiometer. The fresh tart cherries were hand harvested from different orchards in Michigan in 2004-2007. The samples included intact as well as infested cherries with different damage levels. The spectral analysis indicates that the maturity of tart cherry has effects on the classification accuracy. The intact cherries harvested late in the season (over-ripened) have similar spectral characteristics as the infested tissues. The classification accuracy for the samples harvested at normal time is better than that for the late harvested samples. Depending on the arrangement of the samples into non-infested or infested classes, the total classification accuracy varies from 82% to 87%. These findings and results demonstrate that transmittance spectroscopy has strong potential to detect the internal insect infestation within a tart cherry fruit.

Salicylic acid alleviated pathogen-induced oxidative stress in harvested sweet cherry fruit

Xu, Xiangbin, Tian, Shiping

The role of exogenous salicylic acid (SA) in regulating an antioxidative defense response of sweet cherry (Prunus avium L. cv. Hongdeng) fruit inoculated with Penicillium expansum was investigated by immunodetection of carbonylated proteins. After inoculation with P. expansum, carbonylated proteins accumulated to a lesser extent in SA-treated fruit than in control fruit, ranging from molecular mass 29-45kDa. Higher activities of catalase (CAT), glutathione peroxidase (GPX), chitinase and o-1,3-glucanase were observed in SA-treated fruit. Similarly, the expressions of CAT, GPX and o-1,3-glucanase genes were also stimulated by SA treatment. Moreover, 2mM SA did not inhibit P. expansum growth in vitro. These results indicate that SA activated antioxidant defense responses of sweet cherry fruit, which may play a role in the resistance against P. expansum.

Integrated control of postharvest diseases of sweet cherry with yeast antagonists and sodium bicarbonate applications within a hydrocooler

Karabulut, O.A., Arslan, U., Ilhan, K., Kuruoglu, G.

In vitro experiments showed that sodium bicarbonate (SBC) was effective in inhibiting the growth of Botrytis cinerea and Penicillium expansum. Radial growth of B. cinerea and P. expansum was completely inhibited at 0.12 M (1%) SBC. Spore germination of B. cinerea and P. expansum was completely inhibited in PDA containing 0.03 M (0.25%) SBC. Three storage experiments were conducted to investigate the effect of two yeast antagonists alone or in combination with SBC to control postharvest diseases of sweet cherry. In all experiments, treatments were applied to fruit within a hydrocooler prototype. Treatments with Kloeckera apiculata, Metschnikowia fructicola, SBC or their combinations significantly reduced the total decay incidence and the decay incidence caused by B. cinerea and P. expansum. The efficacy of SBC treatments at 0.12 and 0.24 M (2%) was equal. The total decay incidence of fruit treated with K. apiculata, M. fructicola, at 0.12 M and 0.24 SBC, and control was 56.6, 49.5, 56.8, 47.2 and 87.3%, respectively. M. fructicola and K. apiculata populations changed little during 60 days of storage at 0 pC. The population of K. apiculata on fruit treated with the combination of yeast and 0.12 and 0.24 M SBC was significantly lower than a stand-alone treatment of K. apiculata. Similar results were recorded on fruit treated with the combination of M. fructicola and 0.24 M SBC. Yeast antagonists did not harm the appearance of fruit while 0.24 M SBC caused a slight injury on stems of fruit.

Use of hot water treatment to control codling moths in harvested California 'Bing' sweet cherries

Feng, X.Q., Hansen, J.D., Biasi, B., Tang, J.M., Mitcham, E.J.

Preharvest gibberellic acid-treated California 'Bing' sweet cherries (Prunus avium L.) were treated with hot water baths (46-58 pC for 0.25-18 min), followed by hydrocooling. The fruit were then stored to simulate either air shipment or sea shipment to overseas markets, both followed by 15 h of shelf life at 20 pC. In separate experiments, cherries were also infested with codling moth larvae and subjected to similar hot water bath heating. The quality attributes showed different sensitivity to the combinations of temperature and time used for hot water bath treatment. Pitting was more common in fruit treated at lower temperatures for longer times, while stem browning was more common in fruit treated at high temperatures. Berry browning, stem color, and pitting were the quality attributes most affected by heat treatment. Browning of cherry stem color was a crucial factor in determining whether a combination of temperature and time for hot water bath treatment was successful. All cherries stored at 0 pC for 14 days to simulate sea shipment were of unacceptable quality after shelf life. Hot water bath treatments that provided 100% codling moth mortality and maintained overall acceptable fruit quality were very limited and included treatments at 50 pC for 10 min and at 54 pC for 6 min. Delaying the hot water bath treatment after fruit harvest, even if the cherries were kept at 0 pC, resulted in a greater loss in fruit quality compared with those treated on the harvest day. Using hot water baths as a quarantine treatment for codling moths (Cydia pomonella) on sweet cherries may be feasible if fruit are air shipped at 5 pC for 2 days, but not suitable if fruit are sea shipped at 0 pC for 14 days.

Quarantine treatment of cherries using 915 MHz microwaves: temperature mapping, codling moth mortality and fruit quality

Ikediala, J.N., Tang, J., Neven, L.G., Drake, S.R.

Sweet cherries (Prunus avium L.) were treated by 915 MHz microwaves in a pilot-scale multimode microwave system with an auxiliary hot air heater to determine heating characteristics and the effect of treatments on insect mortality and fruit quality. Quality parameters of the microwave-treated 'Bing' cherries were compared with control fruit and those subjected to methyl bromide fumigation. When heating cherries to average pit temperatures of 45, 50 and 55 degrees C, the cherry pits heated faster than the surface, and larger cherries heated more quickly than smaller ones. Cherry temperature increased linearly with time with heating rates dependent on the microwave power, sample weight, cherry size and radial location inside the cherry. With a 2 min holding and 5 min hydrocooling protocol after microwave treatments, adjusted percentage 3rd instar codling moth (Cydia pomonella L.) mortality ranged from 5 to 62% and 39 to 98% without and with 1-2 days cold storage, respectively. A higher mortality rate was obtained for insects in 'Bing' than 'Rainier' fruit. Firmness, percentage soluble solids content, titratable acidity, fruit weight, and objective fruit colour of microwave-treated 'Bing' fruit were comparable with these properties of control fruit and to those of cherries fumigated with methyl bromide. Stem greenness colour was reduced after the microwave and dry hot air combined treatments. Microwave energy may provide an alternative non-chemical quarantine treatment against codling moth in export cherries, but further study is needed to optimize the treatment protocol for insect control and fruit quality.

Postharvest sweet cherry quality and safety maintenance by Aloe vera treatment: a new edible coating

Martinez-Romero, D., Alburquerque, N., Valverde, J.M., Guillen, F., Castillo, S., Valero, D., Serrano, M.

A novel edible coating based on Aloe vera gel, accordingly to our developed patent (SP Patent Filed P200302937), has been used as postharvest treatment to maintain sweet cherry quality and safety. During cold storage, uncoated fruit showed increases in respiration rate, rapid weight loss and colour changes, accelerated softening and ripening, stem browning and increased microbial populations, these processes being more intense during the shelf life periods. On the contrary, sweet cherry treated with A. vera gel significantly delayed the above parameters related to postharvest quality losses, and storability could be extended. The sensory analyses revealed beneficial effects in terms of delaying stem browning and dehydration, maintenance of fruit visual aspect without any detrimental effect on taste, aroma or flavours. As far as we aware, this is the first time A. vera gel is used as an edible coating in fruit, which would be an innovative and interesting means for commercial application and as alternative of the use of postharvest chemical treatments.

Seasonal changes in the abscission site in bunch tomatoes and differential response to 1-methylcyclopropene

Lichter, A., Guzev, L., Dvir, O., Farber, I., Danshin, A., Pressman, E., Ganz, S., Beno-Moualem, D.

Cherry tomatoes harvested as bunches are susceptible to abscission during storage. Two abscission zones are present in the bunch: the joint (AJ) in the middle of the pedicel and the receptacle (AR), which connects the fruit to the pedicel. It is demonstrated in the present study that during the temperate winter, after storage at 12 pC abscission commences through the AJ and that during the spring there is a transition to AR. Fruit harvested in the summer mostly underwent the AR type. It has been shown that 1-methylcyclopropene (1-MCP) can prevent abscission in cv. R-819. It is now shown that in early winter lower doses of 1-MCP are required to suppress abscission than during the warmer season. Of three cultivars tested, cvs. Shiren and Conchita had less abscission after storage than R-819, and 1-MCP could suppress abscission in all of them to various extents. Exposure of cv. Shiren to 50 ol l-1 of ethylene for 3 h did not induce abscission whereas 1-MCP reduced both AJ and AR abscission, and delayed ripening, as indicated by fruit color and firmness. Delay of red color development required lower doses of 1-MCP than inhibition of abscission. The variability in abscission of bunch tomatoes during the season indicates that multiple environmental signals determine the final quality of the produce.

Induction of H2O2-metabolizing enzymes and total protein synthesis by antagonistic yeast and salicylic acid in harvested sweet cherry fruit

Chan, Z., Tian, S.

The immersion of sweet cherry fruit in Pichia membranefaciens at a concentration of 5 x 107 cells ml-1 or in salicyclic acid (SA) at 0.5 mM for 10 min reduced the incidence of decay and lesion size caused by Penicillium expansum. Without pathogen inoculation, peroxidase (POD) activity was enhanced in yeast-treated fruit, but activities of catalase (CAT) and superoxide dismutase (SOD) showed a decrease in the same fruit. SA-treatment significantly inhibited CAT activity, but stimulated SOD and POD activities. After inoculation with P. expansum, CAT activity decreased and SOD activity increased in both yeast- and SA-treated fruit. No obvious difference was found in POD activity between treatments and water control. Treatments with yeast and SA changed the expression of POD isozymes. In addition, yeast and SA treatment increased total protein content of sweet cherry and up-regulated 33 and 47 kDa protein bands

shown by SDS-PAGE. These results indicated that yeast- and SA-treatments induced synthesis of anti-oxidant enzymes and specific proteins, which may play a role in the resistance against postharvest blue mold.

Efficacy of 1-MCP treatment in tomato fruit: 2. Effect of cultivar and ripening stage at harvest

Guillen, F., Castillo, S., Zapata, P.J., Martinez-Romero, D., Valero, D., Serrano, M.

Four cultivars of tomato fruit ('Cherry', 'Daniela', 'Patrona' and 'Raf') were harvested at two ripening stages (S1 and S2), treated with 0.5 (So(Bl l-1 of 1-methylcyclopropene (1-MCP) for 24 h and stored at 10 degrees C for 28 days. For all cultivars, control fruit deteriorated very rapidly (due to weight loss, softening, colour changes and decay) with an estimated shelf life of 7 days ('Cherry' and 'Patrona') and 14 days ('Daniela' and 'Raf'), independently of the ripening stage at harvest. All quality parameters for all cultivars were delayed and/or inhibited in treated fruit, the efficacy of 1-MCP being higher in tomatoes harvested at the S2 ripening stage. At this stage, the organoleptic properties had already developed in fruit on the plant and tomatoes could thus reach consumers with optimal postharvest quality.

Studies on water transport through the sweet cherry fruit suface. 10. Evidence for polar pathways across the exocarp

Weichert, H., Knoche, M.

Water uptake through the fruit surface is considered as an important factor in cracking of sweet cherry (Prunus avium L.) fruit. Uptake may occur by diffusion and/or viscous flow along a polar pathway. To establish the mechanism of water uptake, the effects of viscosity and molecular weight of selected osmotica on water uptake into detached sweet cherry fruit were investigated. In addition we investigated the effect of temperature on penetration of 2-(1-naphthyl)[1-14C]acetic acid ([14C]NAA; pK(a) = 4.2) as a molecular probe in the nondissociated (pH 2.2) and dissociated (pH 6.2) forms. Rates of water uptake were linearly related to the inverse viscosity of gum arabic solutions (range of concentrations and dynamic viscosities 10-300 g L(-1) and 1.3 x 10(-3) to 115.9 x 10(-3) Pa s, respectively). When fruit was incubated in solutions of osmotica of differing molecular weight that were isotonic to the fruit's water potential, water uptake depended on the molecular weight of the osmoticum [range 58-6000 for NaCl to poly(ethylene glycol) 6000 (PEG 6000)]. There was no uptake from PEG 6000 solutions, but rates of water uptake increased as the molecular weight of the osmotica decreased. Apparent water potentials of sweet cherry fruit, determined by incubating fruit in concentration series of selected osmotica, increased as the molecular weight of the osmotica increased up to 1500 and remained constant between 1500 and 6000. Reflection coefficients (sigma) estimated from this relationship were closely related to hydrodynamic radii (r) of the osmotica [sigma = 1.0(+/-0.0) - [10.9(+/-0.9) x 10(-11)][r(-1) (m(-1))], R2 = 0.97, P < 0.0001]. The permeability of the sweet cherry fruit exocarp to NAA (pK(a) = 4.2) and temperature dependence of NAA permeability (P(d)) as indexed by the energy of activation (E(a), temperature range 5-35 degrees C) were significantly higher for the nondissociated NAA (pH 2.2, P(d) = 10.2(+/-0.8) x 10(-8) m s(-1), E(a) = 67.0 +/- 1.7 kJ mol(-1)) than for the dissociated NAA (pH 6.2, P(d) = 1.1(+/-0.2) x 10(-8) m s(-1), E(a) = 51.8 +/- 1.9 kJ mol(-1)). The activation energy for penetration of the dissociated NAA was closely related to the stomatal density (R2 = 0.84***, P < 0.0001) but less so for the nondissociated NAA (R2 = 0.30*, P < 0.03). These data provide evidence for the presence of polar pathways through the sweet cherry fruit exocarp that allow water uptake by viscous flow. These pathways offer a potentially useful target for strategies to reduce water uptake and fruit cracking, provided that a technique is identified that selectively "plugs" these pathways.

Modified atmosphere packaging of sweet cherry (Prunus avium L., ev. 'Sams') fruit: metabolic responses to oxygen, carbond dioxide, and temperature

Petracek, P.D., Joles, D.W., Shirazi, A., Cameron, A.C.

The influence of O2, CO2 partial pressures (pO2(pkg) and pCO2(pkg), respectively), and temperature on sweet cherry (Prunus avium L. cv. 'Sam') fruit respiration was examined in modified atmosphere (MA) packages. Ranges of pO2(pkg) and pCO2(pkg) were created by sealing 2-20 fruit in 76.6 micrometer (3 mil) low-density polyethylene (LDPE) packages stored at 0, 5, 10, 15, 20, or 25 degrees C. Steady-state pO2(pkg) and pCO2(pkg) were attained within 2 (25 degrees C) to 10 (0 degrees C) days. Respiration rates were calculated based on polymer film permeability, thickness, and surface area, steady-state pO2(pkg) and pCO2(pkg), and packaged fruit mass. The Michaelis-Menten equation combined with Q10 was used to model steady-state O2 uptake as a function of temperature and pO2(pkg). Estimated maximum respiration at 0 degrees C (rO2(max,0)), Q10, and k(1/2) values for a combined model (0, 5, 10, 15, and 20 degrees C) were 36 nmol kg(-1) s(-1), 2.5, and 0.3 kPa O2, respectively. Estimated k(1,2) values increased slightly from 0.3 kPa at 0 degrees C to 1.0 kPa at 25 degrees C. The fermentation induction point (FIP), as determined by a specific increase in respiratory quotient (RQ) and ethanol production, also increased from under 1 at 0 degrees C to over 4 kPa at 25 degrees C. Removing CO2 from the package did not influence pO2(pkg), respiration rates or headspace levels of ethanol or acetaldehyde. Shelf life, as determined by visual appearance, principally decay incidence, was an inverse function of temperature, but was not related to package pO2(pkg), pCO2(pkg), or respiration rate. CO2 levels usually considered fungistatic (pCO2(pkg) over 10 kPa) were attained in LDPE packaging of sweet cherries only when fruit were anaerobic.

Integrated control of brown rot of sweet cherry fruit with a preharvest fungicide, a postharvest yeast, modified atmosphere packaging, and cold storage temperature

Spotts, R.A., Cervantes, L.A., Facteau, T.J.

An integrated approach was studied for control of postharvest brown rot of sweet cherry fruit. System components included a preharvest application of propiconazole, a postharvest application of a wettable dispersible granular formulation of the yeast Cryptococcus infirmo-miniatus (CIM) Pfaff and Fell, storage in modified atmosphere, and storage at 2.8 degrees C for 20 days or -0.5 degrees C for 42 days. Preharvest propiconazole and postharvest CIM were similarly effective for control of brown rot. A significant propiconazole-CIM synergism was observed. Modified atmosphere significantly reduced brown rot compared to air-stored fruit. The storage temperature regime effect was inconsistent. This integrated decay control approach was effective and is especially relevant since postharvest fungicide options for cherry are limited.

Quarantine treatment of cherries using 915 MHz microwaves: temperature mapping, codling moth mortality and fruit quality

Ikediala, J.N., Tang, J., Neven, L.G., Drake, S.R.

Sweet cherries (Prunus avium L.) were treated by 915 MHz microwaves in a pilot-scale multimode microwave system with an auxiliary hot air heater to determine heating characteristics and the effect of treatments on insect mortality and fruit quality. Quality parameters of the microwave-treated 'Bing' cherries were compared with control fruit and those subjected to methyl bromide fumigation. When heating cherries to average pit temperatures of 45, 50 and 55 degrees C, the cherry pits heated faster than the surface, and larger cherries heated more quickly than smaller ones. Cherry temperature increased linearly with time with heating rates dependent

on the microwave power, sample weight, cherry size and radial location inside the cherry. With a 2 min holding and 5 min hydrocooling protocol after microwave treatments, adjusted percentage 3rd instar codling moth (Cydia pomonella L.) mortality ranged from 5 to 62% and 39 to 98% without and with 1-2 days cold storage, respectively. A higher mortality rate was obtained for insects in 'Bing' than 'Rainier' fruit. Firmness, percentage soluble solids content, titratable acidity, fruit weight, and objective fruit colour of microwave-treated 'Bing' fruit were comparable with these properties of control fruit and to those of cherries fumigated with methyl bromide. Stem greenness colour was reduced after the microwave and dry hot air combined treatments. Microwave energy may provide an alternative non-chemical quarantine treatment against codling moth in export cherries, but further study is needed to optimize the treatment protocol for insect control and fruit quality.

Peach

Selection and evaluation of new antagonists for their efficacy against postharvest brown rot of peaches

Zhang, Dianpeng, Spadaro, Davide, Garibaldi, Angelo, Gullino, Maria Lodovica

During the growing seasons 2007 and 2008, 210 isolates of yeasts or yeast-like fungi were obtained from the carposphere of temperate fruit collected from organic orchards in Northern Italy. Through six rounds of in vivo screening, three isolates showing the highest biocontrol efficacy against Monilinia laxa on peaches were selected. By using molecular and morphological tools, the strain AP6 was identified as Pseudozyma fusiformata, the strain AP47 as Metschnikowia sp., and the strain PL5 as Aureobasidium pullulans. This research represents the first evidence about the potential use of P. fusiformata to control postharvest diseases of fruit. By co-culturing in vitro M. laxa in the presence of the three antagonists, neither the inactivated cells nor the culture filtrate of the three isolates had any significant effect on spore germination or germ tube elongation, allowing exclusion of the production of secreted toxic metabolites. The antagonistic activity of A. pullulans PL5 and P. fusiformata AP6 was dependent on the cell concentration. Metschnikowia sp. AP47 significantly inhibited spore germination at the three concentrations tested (10e cells/mL, 10" cells/mL, and 10i cells/mL). The efficacy of the three strains was tested on peaches stored at three different temperatures, and their effectiveness was higher at 1pC than at 8pC or 20pC. In trials carried out in semi-commercial conditions with peaches inoculated by spraying 10e spores/mL of M. laxa and stored for 21d at 1pC and 96% RH, a cell concentration effect on the control of brown rot incidence was observed. AP6 and PL5 showed no significant differences in efficacy when applied at 1c10i cells/mL or at 1c10" cells/mL, indicating that they could be used at a lower concentration in potential biofungicide formulations. Finally, in an experiment in semi-commercial conditions on fruit not inoculated with the pathogen with 21d storage at 1pC and 96% RH, the evaluation of postharvest quality parameters, including firmness, total soluble solids, ascorbic acid content, and titratable acidity, showed that none of the three screened antagonists impaired peach quality, when applied before storage. The present study identified three antagonistic microorganisms with potential exploitation as active ingredients for the development of products for postharvest control of brown rot on peaches.

Control of Monilinia spp. on stone fruit by curing treatments. Part II: The effect of host and Monilinia spp. variables on curing efficacy

Casals, C., Teixidcd, N., Viclas, I., Cambray, J., Usall, J.

In previous experiments, we identified that a postharvest curing treatment (50pC for 2h and 95-99% RH) satisfactorily controlled brown rot on several peach and nectarine varieties. In the

present complementary study, the effect of fruit maturity, fruit with natural infection, time of infection and inoculum concentration on the curing efficacy was investigated. Different maturity levels affected curing efficacy. As fruit maturity increased, the efficacy of a postharvest curing treatment decreased from 95% control of brown rot (harvest mature fruit) to 65% (the most advanced mature fruit). The effect of Monilinia fructicola infection time prior to treatment also affected the curing efficacy. When the infection time was increased from 0 to 48h, brown rot control decreased from 90% to 64%. A factorial experiment design was used to investigate the effect of M. fructicola conidial concentrations (10pd, 10t, 10e and 10e conidiamLp#) at different exposure times (1, 2, 3 and 4h) on curing efficacy. Overall, longer curing exposure times (3 or 4h) were required when higher conidial concentrations were applied to the wounded fruit. At the lowest M. fructicola conidial concentration tested (10pd conidiamLp#), 2h of curing exposure resulted in 100% and 94% brown rot control in Andros' peaches and Flames Kid' nectarines, respectively. A high level of brown rot control was also achieved when naturally infected fruit with Monilinia spp. were cured. When fruit with natural inoculum were surface sterilized prior to the curing treatment, complete brown rot control resulted. This findings support our earlier demonstration that a postharvest curing treatment is an attractive non-chemical strategy for use in conventional and organic stone fruit brown rot management.

Control of Monilinia spp. on stone fruit by curing treatments Part I. The effect of temperature, exposure time and relative humidity on curing efficacy

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Monilinia spp. are the most important cause of brown rot on peaches and nectarines. In many countries, no postharvest chemical treatments of stone fruit are allowed and alternative postharvest treatments are urgently required. The effect of curing treatments at different temperatures, exposure times and relative humidity (RH) to control brown rot was studied. Three curing temperatures were tested (40, 45 and 50pC) at different exposure times (ranging from 30min to 6h). Curing at 50pC for 2h successfully increased brown rot control (95%) after fruit were incubated at 20pC and 85% RH for 5 d after treatment. Longer exposure time was required to achieve the same level of brown rot control at lower curing temperatures. Four relative humidity (RH) levels (60%, 80%, 90% and 99%) were also tested during curing at 50pC for 1, 2, 3 and 4h. Brown rot control at 99% or 90% RH for 3 or 4h were the same, achieving control at higher than 95%. At lower RH levels (60% and 80%), more exposure time was required to achieve the same control as at the highest RH (90% and 99%). Complete control of disease development was achieved when four varieties of peach and nectarine fruit artificially inoculated with either Monilinia laxa or Monilinia fructicola were cured at 50pC for 2h and 95-99% RH. Curing at 50pC for 2h and 95-99% RH had a positive effect on fruit quality, with significantly ($P < 0.05$) lower firmness loss in comparison with uncured fruit. No adverse effects were observed on fruit acidity and colour index. Postharvest curing of peach and nectarine fruit may be a suitable alternative to synthetic fungicides for postharvest brown rot control.

Comparative studies on nanostructures of three kinds of pectins in two peach cultivars using atomic force microscopy

Yang, Hongshun, Chen, Fusheng, An, Hongjie, Lai, Shaojuan

Firmness is an important postharvest quality property of fruit. To investigate the reasons for firmness differences between soft and crisp fruit cultivars, two peach (Prunus persica L. Batsch) cultivars (soft and crisp) were selected to compare the nanostructures of pectins. Water-soluble pectin (WSP), chelate-soluble

pectin (CSP) and sodium carbonate-soluble pectin (SSP) were extracted and nanostructures were conducted and analyzed using atomic force microscopy (AFM). The results show that SSP chain lengths were different between the two cultivars with average SSP lengths of 249nm and 57nm for fruit of the crisp and soft cultivars, respectively, while the WSP and CSP chain lengths were not much different. There were no statistical differences for chain heights and widths in the three kinds of pectins between fruit of the two cultivars. All the chain heights were about 1-5nm. The results indicate that neutral sugar-rich pectins from the primary cell wall of peach flesh might be the cause of the main differences in pectin nanostructures between the two cultivars. The neutral sugar-rich pectins in primary cell walls of peach might also be the reason for firmness differences.

A combination of hot air and methyl jasmonate vapor treatment alleviates chilling injury of peach fruit

Jin, Peng, Zheng, Yonghua, Tang, Shuangshuang, Rui, Huaijin, Wang, Chien Y.

Peaches (Prunus persica Batsch cv Baifeng) were harvested at the firm-mature stage and treated with various combinations of methyl jasmonate (MJ) and hot air (HA). Severity of internal browning and flesh mealiness, firmness, extractable juice, total soluble solids (TSS), total acid, vitamin C and total phenolic contents were measured after 3 and 5 weeks of storage at 0pC plus 3d at 20pC for shelf-life. The activities of phenylalanine ammonia-lyase (PAL, EC 4.3.1.5), superoxide dismutase (SOD, EC 1.15.1.1), polyphenol oxidase (PPO, EC 1.10.3.1), peroxidase (POD, EC 1.11.1.7), pectin-methylesterase (PME, EC 3.1.1.11) and polygalacturonase (PG, EC 3.2.1.15) were analyzed during the cold storage period. The results showed that fruit treated with 1omolLp# MJ vapor at 38pC for 12h (HMJ), and heat treatment at 38pC for 12h and then treated with 1omolLp# MJ vapor at 20pC for 24h (HA+MJ) had the highest quality and lowest percent of chilling injury symptoms. HA treatment alone significantly inhibited internal browning, but caused more severe flesh mealiness than other treatments. This side effect was counteracted by MJ. The percent of extractable juice in combined treatments was higher than that in the control, however, no significant effect was found on firmness. TSS was 23% and 25.3% higher and total acid was 59.4% and 62.5% higher in treatments of HMJ and HA+MJ, respectively, than those in control fruit after storage for 5 weeks. Vitamin C and total phenolic contents were also maintained at higher levels in combined treatments. In addition, the combined treatments resulted in higher activities of PAL, SOD and PG, and lower activities of PPO, and POD than the control. The combination of HA and MJ vapor treatment might be a useful technique to alleviate chilling injury and maintain peach fruit quality during cold storage.

Quantitative determination of flesh mealiness in peach [Prunus persica L. (Batch.)] through paper absorption of free juice

Infante, R., Meneses, C., Rubio, P., Seibert, E.

A simple and rapid method was developed for quantitative determination of juiciness in peach flesh based on the absorption of free juice with ordinary absorbent paper after a flesh sample is squeezed by two metallic rolling cylinders. Juiciness data were compared with trained panel determinations on three peach cultivars kept at 4pC and 90% RH for 7, 14 and 21 d plus a ripening period at 20pC and 65% RH until the flesh reached 19.6pl9.2N. There was a high correlation between panel judgment and paper absorption (r po =0.75 in 'Elegant Lady', 0.77 in 'O'Henry' and 0.93 in 'Ross'). A sub-sample of the juiciest and the mealiest fruit also were sorted after 14 and 21 d in cold storage. 'Ross', a non-melting peach cultivar, did not develop flesh mealiness during any evaluation period. During storage, there was a reduction in juiciness reaching 15% less after 21 d. Mealy fruit were exclusively observed with melting cultivars exposed to cold storage. The proposed

method for determining juice content is easily executed and shows a high association with human perception of juiciness and mealiness in peach.

Regulation of stony hard peach softening with ACC treatment

Hayama, Hiroko, Tatsuki, Miho, Yoshioka, Hirohito, Nakamura, Yuri

Controlling the rate of fruit softening in melting-flesh peaches is a primary goal of the fruit industry. Stony hard (SH) peach varieties lack the ability to synthesize 1-aminocyclopropane-1-carboxylic acid (ACC), the precursor of ethylene, which is required for fruit maturation. SH peaches thus have crisp flesh that remains firm during ripening. In this study, we developed a simple technique to stimulate fruit softening by a single spray application of ACC at a concentration of 10-20mM, which was sufficient to allow ethylene synthesis and fruit softening. Higher concentrations of ACC increased ethylene production, and made the fruit softer. Ethylene synthesis was limited to the first 2-3d after ACC treatment, after which fruit ceased softening and retained its remaining firmness. These results indicate that a single application of ACC solution can be used to regulate the process of fruit softening in SH peaches.

Combined treatment of aminoethoxyvinylglycine (AVG) and 1-methylcyclopropene (1-MCP) reduces melting-flesh peach fruit softening

Hayama, Hiroko, Tatsuki, Miho, Nakamura, Yuri

The effects of postharvest application of aminoethoxyvinylglycine (AVG) and 1-methylcyclopropene (1-MCP) on ethylene production and fruit quality, and thus on transportation and shelf-life, were evaluated in melting-flesh peaches. AVG (150mgLp#) significantly reduced ethylene production, and the effect was enhanced in combination with 1-MCP (1oLLp#). However, fruit treated with AVG alone softened to untreated control levels 2d after harvest (DAH). Treatment with 1-MCP significantly reduced the rate of softening until 2 DAH, but the fruit rapidly softened thereafter, and reached untreated control levels by 4 DAH. A combination of AVG and 1-MCP significantly reduced fruit tissue softening throughout ripening. The effect of each chemical on flesh firmness indicated that 1-MCP affected fruit response in the early stages of ripening up to 4 DAH, and AVG significantly reduced softening in the latter stages from 4 to 9 DAH. Peaches treated with AVG and 1-MCP retained their ground color during ripening, but the effect of each chemical on color is unclear. The present study indicates that combined treatment with AVG and 1-MCP significantly delays the ripening of melting-flesh peaches.

A new index based on vis spectroscopy to characterize the progression of ripening in peach fruit

Ziosi, V., Noferini, M., Fiori, G., Tadiello, A., Trainotti, L., Casadoro, G., Costa, G.

In peach fruit (Prunus persica L. Batsch), establishing the optimal harvest time is a crucial issue, since fruit shelf-life potential and quality are closely related to the ripening stage at harvest. In order to develop a non-destructive index for monitoring the progression of ripening, the difference in absorbance between two wavelengths near the chlorophyll-a absorption peak (670 and 720nm; index of absorbance difference, I AD) was related to the time course of ethylene production during on-tree ripening of peaches (cv. 'Fayette') and nectarines (cvs. 'Laura' and 'Stark Red Gold'). For each variety, consecutive stages of ripening, as defined according to ethylene production (pre-climacteric, climacteric, post-climacteric), occurred in the same ranges of I AD in different years (2003 and 2004). In 2005, the relationship I AD/ethylene production was used to classify fruit at harvest according to their ripening stage (class 0: pre-

climacteric; class 1: onset of climacteric; class 2: climacteric). For each cultivar, the transition from class 1 to 2 was marked by increased ethylene production, and reduced flesh firmness (FF) and titratable acidity (TA). In contrast, fruit quality traits did not discriminate between fruit belonging to classes 0 and 1. In 'Stark Red Gold' nectarines, the robustness of the I AD was further corroborated by changes in transcript levels of genes which are either up- or down-regulated during peach fruit ripening. Class 0 fruit had the lowest transcript amount of the up-regulated genes and the highest of the down-regulated ones, while the opposite occurred in class 2 fruit. Moreover, mRNA abundance of some marker genes discriminated class 0 and 1 fruit. Peaches and nectarines graded at harvest according to the I AD also differed in their postharvest ripening behaviour: fruit with higher I AD produced lower amounts of ethylene, began to soften later, and maintained higher TA than those with lower I AD. Present data demonstrate that the I AD identifies physiological changes occurring during ripening regardless of the fact that they might have or not led to appreciable modifications in fruit quality. Therefore, the I AD can be regarded as a very promising tool both for practical and scientific applications, since it allows to monitor on-tree fruit ripening, to establish accurately the optimal harvest time, and to reduce the variability which is present in fruit batches.

Different postharvest conditions modulate ripening and ethylene biosynthetic and signal transduction pathways in Stony Hard peaches

Begheldo, Maura, Manganaris, George A., Bonghi, Claudio, Tonutti, Pietro

Stony hard (SH) peaches are characterized, at ripening, by the maintenance of flesh firmness and the lack of ethylene production due to a reduced expression of Pp-ACS1. In a trial comparing melting flesh (MF, cv. 'Summer Rich') and SH ('IFF331' selection) fruit at two different postharvest temperatures (10 and 20pC), unexpected behaviour was observed in SH peaches that displayed an increase in ethylene production and a decrease in flesh firmness when stored at 10pC, a temperature regime basically ineffective in delaying ripening in MF fruit. This appeared to be the result of an induction of Pp-ACS1 transcription, making this genotype of particular interest for studying temperature stress physiology and ethylene-related ripening processes in peaches. Comparative expression analyses of genes involved in cell wall metabolism pointed out the presence of a negative (Pp-EG4), positive (Pp-endoPG) or no (one member of the PL family) relationship with ethylene at ripening. Results clearly showed that the last stage of firmness decrease (melting) only occurs in fruit producing ethylene and is associated with Pp-endoPG transcript accumulation. The expression of genes involved in ethylene biosynthesis and signalling pathways was evaluated using QRT-PCR. Pp-ACO1 appeared to be induced in SH kept at 10pC but not at 20pC. Transient increases in Pp-CTR1 and Pp-EIN2like gene expression have only been detected at the early stages of ripening in samples producing ethylene, indicating that a causal relationship might exist between ethylene and elements of its transduction pathway during peach fruit ripening.

The effect of heat treatment on quality retention of fresh-cut peach

Koukounaras, Athanasios, Diamantidis, Grigorios, Sfakiotakis, Evangelos

This work investigates the effect of short-term heat treatment on quality of fresh-cut peach. Different parameters of heat treatment (intensity, duration, time of application) were evaluated. A clear beneficial effect of 4 h pre-cutting heat treatment at 50pC for 10 min on postharvest quality of fresh-cut peach was found. In order to study the effect of that treatment on visual quality as well as on the nutritional value, peach slices were stored in modified atmosphere packaging for 6 days at 5pC. Fruit treatment at 50pC for 10 min 4 h

before cutting effectively controlled browning and retained firmness during storage. Significantly lower concentrations of CO and ethylene in the package atmosphere were recorded for heat-treated slices. In contrast, an insignificant effect of heat treatment on chemical composition (ascorbic acid, total soluble phenols and total antioxidants) was observed. However, this treatment increased the total carotenoids loss and reduced the chroma values of the slices. Pectinmethylesterase activity was significantly higher in the first 2 days of storage for heat-treated slices, while no difference was observed in polyphenoloxidase activity for the control and the heated slices.

Stone fruit injuries and damage at the wholesale market of ScDo Paulo, Brazil

Amorim, Lilian, Martins, Marise C., Lourenço, Silvia A., Gutierrez, Anita S.D., Abreu, Fabiana M., Gonçalves, Fabrício P.

Mechanical injuries and diseases in stone fruit are important causes for market rejection. The objectives of this research were to quantify and characterize the mechanical injuries and diseases in peaches, nectarines and plums at ScDo Paulo's wholesale market, the largest in Brazil. Incidence of injuries was assessed weekly in 1% of the marketed fruit (2973 fruit/week), from September to December in 2003 and 2004. Mechanical injuries were the most frequent injuries in both years, ranging from 8.73% (plum) to 44.5% (nectarine) of injured fruit. There was a significant positive correlation between the incidence of postharvest mechanical injuries and postharvest diseases. Incidence of postharvest diseases varied from 2.5% to 6.6%. Cladosporium rot (Cladosporium sp.) and brown rot (Monilinia fructicola) were the most frequent diseases, and were mostly detected in the apexes of nectarines and peaches. Aurora (peach), Sunraycer (nectarine) and Gulfblaze (plum) varieties were the most susceptible to injuries and diseases.

Control of brown rot on stonefruit by synthetic and glucosinolate-derived isothiocyanates

Mari, M., Leoni, O., Bernardi, R., Neri, F., Palmieri, S.

The potential use of five isothiocyanates (ITCs) (allyl, butenyl, benzyl, 2-phenylethyl and 4-methylthiobutyl-ITC) to control Monilinia laxa was tested by in vitro and in vivo trials. In in vitro trials, ITC activity on spore germination and mycelial growth was evaluated. The 4-methylthiobutyl-ITC was more efficient in controlling M. laxa than the other ITCs, showing the lowest values of ED50 and ED95, respectively, 0.04 and 0.10 mg L-1 for conidia germination and 0.30 and 0.52 mg L-1 for mycelial growth. In addition, a significant reduction in conidia germination was observed after only 90 min of ITC vapour exposure. In in vivo trials, artificially infected nectarines and peaches were exposed for 3-6 h in an ITC-enriched atmosphere, resulting in a substantial difference in the pathogen control from the in vitro tests. Among the 5 ITCs tested, only allyl and butenyl-ITC reduced brown rot by more than 85% after 3-4 days of fruit incubation at 20 pC but in the case of butenyl-ITC, some phytotoxic effects can occur. Similar results were obtained in further experiments with allyl and butenyl-ITC vapours produced in situ from defatted meal of Brassica carinata and Brassica rapa, respectively. Although further studies are necessary to exclude any detrimental effects on fruit quality, this study provides experimental evidence that supports the use of biofumigation based on ITCs, allyl-ITC in particular, as a technique to control postharvest brown rot in nectarine and peach fruit.

Nectarine

Control of Monilinia spp. on stone fruit by curing treatments. Part II: The effect of host and Monilinia spp. variables on curing efficacy

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In previous experiments, we identified that a postharvest curing treatment (50pC for 2h and 95-99% RH) satisfactorily controlled brown rot on several peach and nectarine varieties. In the present complementary study, the effect of fruit maturity, fruit with natural infection, time of infection and inoculum concentration on the curing efficacy was investigated. Different maturity levels affected curing efficacy. As fruit maturity increased, the efficacy of a postharvest curing treatment decreased from 95% control of brown rot (harvest mature fruit) to 65% (the most advanced mature fruit). The effect of Monilinia fructicola infection time prior to treatment also affected the curing efficacy. When the infection time was increased from 0 to 48h, brown rot control decreased from 90% to 64%. A factorial experiment design was used to investigate the effect of M. fructicola conidial concentrations (10pd, 10t, 10e and 10e conidiamLp#) at different exposure times (1, 2, 3 and 4h) on curing efficacy. Overall, longer curing exposure times (3 or 4h) were required when higher conidial concentrations were applied to the wounded fruit. At the lowest M. fructicola conidial concentration tested (10pd conidiamLp#), 2h of curing exposure resulted in 100% and 94% brown rot control in Andros' peaches and Flames Kid' nectarines, respectively. A high level of brown rot control was also achieved when naturally infected fruit with Monilinia spp. were cured. When fruit with natural inoculum were surface sterilized prior to the curing treatment, complete brown rot control resulted. This findings support our earlier demonstration that a postharvest curing treatment is an attractive non-chemical strategy for use in conventional and organic stone fruit brown rot management.

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Non-destructive determination of quality parameters in nectarines during on-tree ripening and postharvest storage

Pérez-Marín, Dolores, Sánchez, María-Teresa, Paz, Patricia, Soriano, María-Auxiliadora, Guerrero, José-Emilio, Garrido-Varo, Ana

Changes in physical-chemical properties of nectarines (Prunus persica (L.) Batsch cv. Sweet Lady) were studied during on-tree ripening and postharvest refrigerated storage, using near-infrared (NIR) spectroscopy. Two commercially available spectrometers were evaluated for this purpose: a handheld micro-electro-mechanical system (MEMS) spectrometer of 1600-2400nm and a diode-array Vis-NIR spectrophotometer of 400-1700nm. Analysis covered a sample of 144 nectarines during on-tree ripening, and another one of 220 nectarines during postharvest storage (0pC, 95% RH). Spectra and analytical data were used to develop MPLS (modified partial least squares) calibration equations to quantify changes in soluble solids content (SSC) (%), flesh firmness (N), fruit weight (g) and diameter (equatorial diameter; cm), these being the major parameters used to chart ripening and measure shelf-life in this fruit. Both NIRS instruments provided good precision for SSC (r po =0.89; SEP=0.75-0.81%) and for firmness (r po =0.84-0.86; SEP=11.6-12.7N). The diode-array instrument predicted well the two other physical parameters tested (r po =0.98 and SEP=5.40g for fruit weight; and r po =0.75 and SEP=0.46cm for diameter), while the handheld MEMS instrument proved less accurate in this respect. The results show that changes in nectarine quality parameters can be measured non-destructively, with a single spectrum measurement and in a matter of seconds, during both on-tree ripening and postharvest storage, paving the way for using the handheld instruments to assist growers in making harvesting decisions in the field.

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Relationship between nondestructive firmness measurements and commercially important ripening fruit stages for peaches, nectarines and plums

Valero, C., Crisosto, C.H., Slaughter, D.

Fruit firmness measurement is a good way to monitor fruit softening and to predict bruising damage during harvest and postharvest handling. Ripening protocols traditionally utilize a destructive penetrometer-type fruit firmness measure to monitor ripening. Until recently, methods of assessing fruit texture properties nondestructively were not commercially available. The nondestructive Sinclair iQ firmness tester was investigated to monitor ripening and predict bruising susceptibility in stone fruit. This work was carried out on four peach, three plum, and five nectarine cultivars over two seasons. The correlations between destructive and nondestructive firmness measurements were significant (p-value = 0.0001), although too low for commercial applications as they varied from r2 = 0.60-0.71 according to fruit type. Using a different approach, the relationship between destructive and nondestructive firmness measures was characterized in terms of segregating these fruit according to their stages of ripening. This was done by using discriminant analysis (66-90% agreement in ripeness stage classification was observed in validation tests). Discriminant analysis consistently segregated nondestructive firmness measured fruit into commercially important classes (ready to eat, ready to buy, mature and immature). These represented key ripening stages with different bruising potentials and consumer acceptance. This work points out the importance to relate nondestructive measurements directly to important commercial physiological stages rather than to correlate them with the current standard penetrometer values. Thus, destructive and nondestructive firmness measurements can be directly used to identify the stage of ripeness and potential susceptibility to bruising during postharvest changes. Further work is recommended to evaluate the performance of this nondestructive sensor in segregating fruit according to their stage of ripeness under packinghouse or processing plant conditions.

Quantitative postharvest contamination and transmission of Penicillium expansum (Link) conidia to nectarine and pear fruit by Drosophila melanogaster (Meig.) adults

Batta, Y.A.

This research demonstrated the possibility of conidial transmission of Penicillium expansum by the adult flies of Drosophila melanogaster to mature, sound nectarine and pear fruit. This transmission was accomplished by inserting the fungal conidia adhering either to mouthparts of the contaminated flies or to their abdominal tip into mature, sound nectarine and pear fruit, while making punctures in the fruit skin either for feeding or for oviposition. Accordingly, the mean number of typical P. expansum lesions that appeared due to this transmission per one nectarine or pear fruit subjected to contaminated flies was 4.7 and 2.5,

respectively. Also, the mean diameter of these typical lesions was 5.3 and 3.2 mm on the same types of fruit, respectively. When the eggs laid by the contaminated females of D. melanogaster were left to develop until adult fly emergence, the mean number of the flies that emerged per fruit at the end of the life cycle was 48.3 and 24.3 on nectarine and pear fruit, respectively. Also, the mean life cycle duration for the emerged flies was 24.3 and 28.7 days on the same types of fruit, respectively. Moreover, viability of the pathogen conidia that either adhered externally to the various body parts of the contaminated flies or were introduced into their bodies was tested by plating the conidia onto oatmeal agar plates amended with chloramphenicol, following the release of the contaminated flies onto plates or the spread of their ground suspension in saline solution onto the same type of plates. The mean number of typical P. expansum colonies that appeared per plate was 5.3 for external contamination of the flies and 2.4 for internal contamination. The conidia of P. expansum adhering to the various body parts of contaminated flies were first localized on these parts and then photographed under the light microscope after they have been correctly identified. Overall results indicate the possibility of P. expansum conidial transmission by D. melanogaster adults into sound, mature nectarine and pear fruit through their feeding and oviposition punctures.

Pathogen aggressiveness and postharvest biocontrol efficiency in Pantoea agglomerans

Frances, J., Bonaterra, A., Moreno, M.C., Cabrefiga, J., Badosa, E., Montesinos, E.

Pathogen aggressiveness on the host was studied as one of the influencing factors in the variability of the efficiency of biocontrol by Pantoea agglomerans. The effect of the relative dose of the pathogen and biocontrol agent (BCA) on efficacy of biocontrol was analyzed in six postharvest pathogens (Rhizopus stolonifer, Botrytis cinerea, Penicillium expansum, Monilinia laxa, Penicillium digitatum and Penicillium italicum), five fruit types (apple, pear, nectarine, strawberry, orange) and two strains of P. agglomerans. Median effective dose (ED50) of the pathogens and of the BCAs was estimated by fitting data to a hyperbolic saturation model. The raw data required were either obtained from the literature or generated by the appropriate experiments. The ED50 of the pathogens covered a range from 1 to 475 spores/wound and of the BCA strains ranged from 207 to 30,000 cfu/wound. The efficiency of the P. agglomerans strains was estimated as the ratio between the ED50 for the BCA and the pathogen, and ranged from 7 to 25,000 cfu/spore. Low values indicate high efficiencies. A significant inverse relationship was observed between the efficiency of biocontrol and the ED50 of the pathogen on the corresponding host, indicating that the higher the aggressiveness of the pathogen the lower the efficiency of the BCA. It is expected that this relationship can be extended to other postharvest biocontrol-pathogen systems.

A comparison between intact fruit and fruit explants to study the effect of polyamines and aminoethoxyvinylglycine (AVG) on fruit ripening in peach and nectarine (Prunus persica L. Batch)

Bregoli, A.M., Ziosi, V., Biondi, S., Claudio, B., Costa, G., Torrigiani, P.

In order to establish whether in vitro model systems are suitable to study the reciprocal relationships between ethylene and polyamines (PAs) in peach fruit, whole detached fruit and fruit explants from Redhaven peaches and Stark Red Gold nectarines at two different ripening stages were subjected to in vitro treatments with 10 mM putrescine (Pu), 1 mM spermidine (Sd) or 0.32 mM aminoethoxyvinylglycine (AVG) in the presence or in the absence of labelled Pu or methionine. Labelled Pu uptake studies showed that, in the short-term, much more label was recovered in intact nectarines than in peaches. In fact, in the former, ethylene production was

strongly impaired by Pu and Sd at both stages, while it was substantially unaffected in the latter. In treated fruit, flesh firmness, soluble solids content and fresh weight were only sporadically affected. Under the same experimental conditions, AVG almost totally inhibited ethylene production although fruit quality was practically unaltered. In explants obtained from fruit at the firmer ripening stage, Pu and Sd did not alter and even enhanced methionine incorporation into ethylene, while in those from softer fruit only Sd was able to counteract ethylene biosynthesis. Also in this case, AVG dramatically reduced ethylene biosynthesis. Short-term treatments of fruit explants showed that only Sd and AVG counteracted ripening. Comparing results from intact fruit and fruit explants indicates that Pu and Sd exert a differential effect on ethylene and fruit quality, depending upon ripening stage and cultivar.

Chilling injury in peach and nectarine.

Lurie, S., Crisosto, C.H.

Peaches and nectarines ripen and deteriorate quickly at ambient temperature. Cold storage is used to slow these processes and decay development. However, low temperature disorders, chilling injury classified as internal breakdown, limit the storage life of peaches and nectarines under refrigeration. The onset of chilling injury symptoms determines the postharvest storage/shipping potential because their development reduces consumer acceptance. Chilling injury is genetically influenced and triggered by a combination of storage temperature and storage period. It manifests itself as fruit that are dry and have a mealy or woolly texture (mealiness or woolliness), or hard textured fruit with no juice (leatheriness), fruit with flesh or pit cavity browning (internal browning), or with flesh bleeding (internal reddening). In this review, we describe what is known about the etiology of each of these types of chilling injury symptoms as well as the biochemical processes in the fruit tissue responsible for their development. We also report on pre- and postharvest manipulations or treatments that can affect the time of appearance or severity of chilling injury symptoms.

The use of electrical impedance spectroscopy to assess the physiological condition of kiwifruit

Bauchot, A.D., Harker, F.R., Arnold, W.M.

The electrical impedance of kiwifruit [Actinidia deliciosa (A. Chev) C.F. Liang et A.R. Ferguson, cv. Hayward] was studied during fruit ripening. Measurements were made on whole fruit, and tissues excised from the outer pericarp, inner pericarp and core. Alternating current at frequencies between 50 Hz and 1 MHz was passed through fruit and tissue samples, and complex impedance spectra were separated into the resistances of the apoplast, cytoplasm and vacuole, and capacitances of the plasma membrane and tonoplast. The differences in R50 (Hz) and R1 (MHz) between tissues (representative of apoplast resistance and total tissue resistance, respectively) were explained in terms of the anatomy and composition of the respective tissues. Some variations were seen from one year to the other. During ripening, there was little change in the impedance characteristics of the fruit, despite a 10-fold decrease in firmness. This was unexpected since previous studies with nectarine, persimmon and tomato fruit have shown a considerable reduction in impedance during ripening. The failure to observe any impedance change was checked using a number of different methods for measuring impedance, by two different laboratories, and confirmed by measuring electrolyte leakage from tissue discs. All the results suggested that the mobility of electrolytes within the cell wall did not change during kiwifruit ripening. We speculate that physicochemical interactions that take place within the cell wall may have a major impact on the impedance of kiwifruit tissue.

Plum

Expression of sHSP genes as affected by heat shock and cold acclimation in relation to chilling tolerance in plum fruit

Sun, Ji-hao, Chen, Jian-ye, Kuang, Jian-fei, Chen, Wei-xin, Lu, Wang-jin

Three full-length cytosol small heat shock protein (sHSP) genes, including two class I sHSP (CI sHSP) and one class II sHSP (CII sHSP) cDNAs, termed Ps-CI sHSP1, Ps-CI sHSP2 and Ps-CII sHSP1 respectively, were isolated and characterized from plum fruit at harvest. Their expression in relation to heat shock and cold acclimation-induced chilling tolerance were investigated. Heat shock treatment by dipping the fruit in water at 55pC hot for 2min and cold acclimation by conditioning the fruit at 8pC for 5d prior to storage at 2pC could effectively reduce malondialdehyde (MDA) content and alleviate chilling injury. Furthermore, accumulation of Ps-CII sHSP1 mRNA transcripts in the fruit during the subsequent storage at 2pC was remarkably enhanced by heat shock and cold acclimation treatments. These data suggest that heat shock and cold acclimation treatments induced the expression of Ps-CII sHSP1, which may be involved in chilling tolerance of the fruit caused by these treatments.

Changes in hydrophilic and lipophilic antioxidant activity and related bioactive compounds during postharvest storage of yellow and purple plum cultivars

Dcaz-Mula, H.M., Zapata, P.J., Guillcbn, F., Martcnez-Romero, D., Castillo, S., Serrano, M., Valero, D.

Eight plum cultivars (four dark-purple and four yellow) were harvested at the commercial ripening stage, and changes of fruit quality properties were evaluated during cold storage and subsequent shelf-life, with special emphasis on bioactive compounds (phenolics, anthocyanins and carotenoids) and antioxidant activity (TAA). From the eight plum cultivars, four showed the typical climacteric ripening pattern ('Blackamber', 'Larry Ann', 'Golden Globe' and 'Songold') while four behaved as suppressed-climacteric types ('Golden Japan' 'Angeleno', Black Diamond' and 'TC Sun'), the latter being described for the first time. At harvest, large variations in phytochemicals and antioxidant activity were found among cultivars in peel and pulp tissues, although phytochemical concentration and antioxidant activity were higher in the peel than in the flesh (2-40-fold depending on the bioactive compound). During storage, increases in total phenolics for all cultivars (peel and pulp), in total anthocyanin content in the peel of the dark-purple plums, and total carotenoids in the peel and pulp of the yellow cultivars were observed. This behaviour of the bioactive compounds was reflected in TAA changes, since hydrophilic-TAA (H-TAA) was correlated with both phenolics and anthocyanins, while lipophilic-TAA (L-TAA) was correlated with carotenoids. L-TAA comprised about 30-50% of the TAA in plum tissues. Carotenoids and phenolics (and among them the anthocyanins) could be the main lipophilic and hydrophilic compounds contributing to L-TAA and H-TAA, respectively. No significant loss of bioactive compounds and TAA occurred during prolonged plum storage. Moreover, for a better evaluation of the antioxidant potential of plums, the contribution to carotenoids should not be overlooked.

Novel 1-methylcyclopropene immersion formulation extends shelf life of advanced maturity 'Joanna Red' plums (Prunus salicina Lindell) [Erratum: 2008 Oct., v. 50, issue 1, p. 107.]

Manganaris, G.A., Crisosto, C.H., Bremer, V., Holcroft, D.

A postharvest application, by immersion, of a new 1-methylcyclopropene (1-MCP) formulation delayed ripening changes and extended the shelf life period of plum fruit

(Prunus salicina Lindell cv. Joanna Red) harvested at an advanced maturity stage when ripened immediately after harvest or after cold storage. Fruit were either immersed in a water solution (control) or in an aqueous solution of a formulation containing 10, 100, 1000 and 10,000ngkgp# of 1-MCP. The fruit were allowed to ripen at 23pC after 5-m immersion or after immersion and subsequent cold storage (5pC, RH 90%) for 10d, prior to being evaluated for quality attributes. 1-MCP immersion treatments reduced firmness loss, skin color changes, fruit weight loss and respiration rate. Furthermore, a pronounced suppression of ethylene production in fruit treated with 1000 and 10,000ngkgp# 1-MCP was detected. All fruit ripened normally and did not show any chilling injury (CI) symptoms when ripe fruit were evaluated after cold storage. Overall, 1-MCP concentration of 1000ngkgp# was the most effective in controlling fruit ripening changes and extending the shelf life of this advanced maturity (tree ripened), low CI susceptible plum. This is the first study, to the best of our knowledge, reporting the successful application of 1-MCP by immersion on the postharvest performance of fleshy fruit.

Cell wall modifications in chilling-injured plum fruit (Prunus salicina)

Manganaris, G.A., Vicente, A.R., Crisosto, C.H., Labavitch, J.M.

The aim of this study was to analyze the changes in cell wall pectins in normally ripening (juicy) and in chilling-injured plum fruit (Prunus salicina cv. Fortune) showing mealiness. Total cell wall neutral sugars and uronic acids, solubilization and depolymerization of pectins in water-, CDTA- and NaCO-soluble fractions of the cell wall (WSF, CSF and NSF, respectively), non-cellulosic neutral sugar compositions of these fractions, and the activities of the cell wall-degrading enzymes polygalacturonase (PG), pectin methylesterase (PME), 1,4-o-d-glucanase/glucosidase and o-galactosidase (o-gal) were determined. No differences in the total content of pectin and neutral sugars between normally ripening and chilling-injured fruit were detected. However, the mealy plums presented a higher level of tightly bound pectin (NSF) and a lower proportion of loosely bound pectin (WSF) than the juicy controls. Lower pectin depolymerization and reduced solubilization of neutral sugars in the WSF and CSF were also detected in the chilling-injured tissues, confirming an alteration in the normal ripening-associated pattern of polyuronide disassembly. While no differences were found in the activities of PG, PME and 1,4-o-d-glucanase/glucosidase between normally ripening and mealy fruit, the latter had reduced o-gal activity. This might have led to differential solubilization of polymers with galactan side chains, but further studies are required to determine if there is a causal relationship between these events. Overall, results indicated that the development of chilling injury symptoms in 'Fortune' plums is associated with abnormalities in cell wall metabolism, including a reduction in pectin solubilization and depolymerization and decreased ripening-associated modification of galactose-rich pectin polymers.

Stone fruit injuries and damage at the wholesale market of São Paulo, Brazil

Amorim, Lilian, Martins, Marise C., Lourenço, Silvia A., Gutierrez, Anita S.D., Abreu, Fabiana M., Gonçalves, Fabrício P.

Mechanical injuries and diseases in stone fruit are important causes for market rejection. The objectives of this research were to quantify and characterize the mechanical injuries and diseases in peaches, nectarines and plums at São Paulo's wholesale market, the largest in Brazil. Incidence of injuries was assessed weekly in 1% of the marketed fruit (2973 fruit/week), from September to December in 2003 and 2004. Mechanical injuries were the most frequent injuries in both years, ranging from 8.73% (plum) to 44.5% (nectarine) of injured fruit. There was a significant positive

correlation between the incidence of postharvest mechanical injuries and postharvest diseases. Incidence of postharvest diseases varied from 2.5% to 6.6%. Cladosporium rot (Cladosporium sp.) and brown rot (Monilinia fructicola) were the most frequent diseases, and were mostly detected in the apexes of nectarines and peaches. Aurora (peach), Sunraycer (nectarine) and Gulfblaze (plum) varieties were the most susceptible to injuries and diseases.

Effect of harvest date on cold storage and postharvest quality of plum cv. Green Gage
Guerra, M., Casquero, P.A.

European plums (Prunus domestica L.) cv. 'Green Gage' were harvested on several dates before the commercial harvesting date. After cold storage for 10, 20, 30 and 40 days at 2pC, the fruit was analysed for weight loss, flesh firmness, total soluble solids (TSS), titratable acidity (TA) and skin ground colour. Plums were ripened for 3 days at 20pC after storage and were investigated at 10 examination stages during storage and after ripening. Significant differences were found in fruit mass, weight loss, skin colour, firmness, TSS and TA between harvest dates during storage and after ripening. An increase in fruit mass, TSS and skin colour was observed in plums during the harvesting period, whereas flesh firmness decreased significantly during the same period. Significant changes were also noted in fruit mass, skin colour, firmness and TSS during ripening. In general, at room temperature TSS increased, whereas firmness decreased. Less mature fruit withstood cold storage better than more mature fruit. However, less mature fruit had lesser quality when ripened than mature fruit. It is suggested that the best poststorage quality of 'Green Gage' plums would be obtained when fruit were harvested with a skin ground colour between -12 and -13 measured with a colorimeter as a * and a flesh firmness between 35 and 40N. A lesser degree of harvest maturity was associated with inability of fruit to ripen because fruit picked too early stayed firmer over the whole storage period.

FUTURE DATES

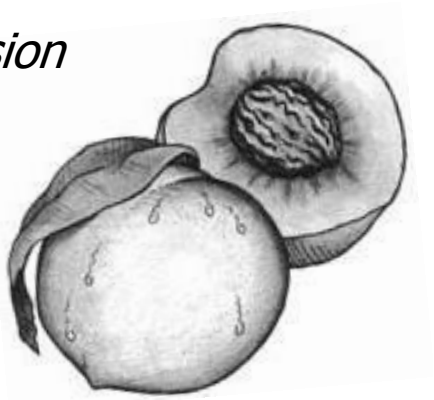
First Winter Postharvest Short Course. February 21 to 25, 2011 at the Kearney Agricultural Center, Parlier, CA. For further information contact Carlos H. Crisosto at carlos@uckac.edu or (559) 646-6596.

Upcoming events are posted on the Postharvest Calendar at the UC Agriculture and Natural Resources, website at: http://ucce.ucdavis.edu/calendar/calmain.cfm?calowner=5423&group=w5423&keyword=&ranger=3650&calcat=0&specific=&waste=yes

Information about upcoming events can also be found on the Postharvest Technology Research and Information Center website at http://postharvest.ucdavis.edu/

University of California Cooperative Extension
and the
Kearney Agricultural Center

present



2010
VARIETY DISPLAY AND RESEARCH UPDATE SEMINAR SERIES

8:00 am – 9:00 am	Variety display by stone fruit nurseries, breeders, and the USDA
9:00 am – 10:00 am	Research Update Topic and discussion in the field

Mark your calendars for these dates:

Friday, June 4
Friday, July 2
Friday, August 6

Topics to be discussed will include:

Stone Fruit Rootstocks, Pedestrian Orchards,
Fruit Quality, Tree Nutrition

at the

Kearney Agricultural Center
9240 S. Riverbend Avenue
Parlier, CA 93648

For more information contact:
Scott Johnson (559) 646-6547; sjohnson@uckac.edu
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Bob Beede (559) 582-3211, Ext. 2737; bbeede@ucdavis.edu

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