Postharvest IPM Research Summaries: April 2002

Objective 1: Influence of preharvest factors on postharvest susceptibility to decay and insects.

- Laboratory rearing of codling moth on cherries
- Survival of walnut-strain codling moth on sweet cherries
- Use of aggregation pheromone and mass trapping for reduction of driedfruit beetle damage in dried figs
- Use of mating disruption for reduction of navel orangeworm damage in dried figs

Objective 2: Benefits of postharvest temperature management or temperature treatments for control of decay and insects.

- Evaluation of hot water and chemical treatments for decay control on inoculated tomatoes
- Stress-related genes as indicators of freeze damage in citrus fruits
- Increasing tomato fruit resistance to decay by temperature conditioning (curing)
- Heat tolerance of navel orangeworm and Indianmeal moth
- Commercial cold storage to control cowpea weevil in organic garbanzo beans
- Forced hot air for control of arthropods in harvested chrysanthemum cuttings
- High temperature forced air/controlled atmosphere quarantine treatments for peaches and nectarines

Objective 3: Influence of atmospheric modification or fumigation with safer materials on decay and insect control (CA, MA, CO, acetaldehyde, ozone, etc.)

- Disinfest Lettuce of Insects through Postharvest Treatments and Pre-harvest IPM
- Maximizing thiabendazole effectiveness for the control of green mold of

citrus
- Effects of continuous 0.3 ppm ozone exposure on decay development and physiological responses of peaches and table grapes in cold storage
- Continuous exposure to exogenous ethylene does not affect brown rot development on cold-stored stone fruits
- Effect of gaseous ozone exposure on the development of green and blue molds on cold stored citrus fruit
- Effects of Silwet L-77 on several arthropod pests of table grapes
- Further exploration of ethyl formate as a fumigant for arthropod pests associated with table grapes
- Effects of acetaldehyde on fruit quality and target pest mortality for harvested strawberries
- Ethyl formate for postharvest control of arthropods on harvested strawberries
- Postharvest insect control on harvested *Dendrobium* orchids
- Mode of action of elevated CO_2 atmospheres
- Propylene oxide/carbon dioxide mixture for control of postharvest insect pests of dried fruits and nuts
- Susceptibility of pink hibiscus mealybug to methyl bromide
- Toxicity of sulfuryl fluoride (Profume) to fruit flies
- Effect of modified atmospheres on microflora and respiration of California prunes
- Response of postharvest insects to vacuum
- Potential postharvest fumigants on fruit phytotoxicity and insect mortality
- Use of ozone to control postharvest insects
- Testing of 2 additional prune plum varieties for export to Japan.
- The sorption of phosphine by whole walnuts.
- The use of aeration to alleviate phytotoxicity of methyl iodide on lemons.

Objective 4: Methods to improve postharvest handling or sanitation procedures to reduce susceptibility to decay or insects..
- Efficacy of alternative antimicrobials for decay and human pathogen disinfection
- Sampling apple culls to support the systems approach for quarantine

Objective 5: Influence of energy wave inputs such as irradiation, UV, or microwave on postharvest decay and insect infestations.
- Heat as a quarantine treatment against codling moth in cherry
- Use of radio frequency energy to control navel orangeworm
- Use of radiofrequency energy and hot water as an alternative to methyl bromide fumigation for California 'Bing' sweet cherries

- Application of Radio Frequency Treatments to Control Insects in Walnuts
- Use of Radio Frequency Energy to Control Insects and Microorganisms in Harvested Almonds
- Use of Radio Frequency Energy to Control Insects in Harvested Pistachios.

Objective 6: Use of natural enemies for biological control and increased understanding of basic biology of postharvest insect pests and decay organisms.

- Controlled atmosphere, temperature management and granulosis virus for Indian mealmoth control
- Recovery of *Habrobracon hebetor* in dried fruits and nuts by DFA inspectors
- Effect of Combinations of Hot Water Dips, Biological Control and Controlled Atmospheres for Control of Gray Mold on Harvested Strawberry

---

Objective 1: Influence of preharvest factors on postharvest susceptibility to decay and insects.

Laboratory rearing of codling moth on cherries - *James D. Hansen, USDA ARS, Wapato, WA*

Tests were conducted to determine codling moth survival on California sweet cherries. Previous studies with cherries from the Pacific Northwest indicate less than 10% survival from newly hatched larvae to adult under controlled laboratory conditions. Codling moth development from first instar to adults was observed in three California cultivars ('Bing,' 'Brooks,' and 'Tulare') with cohort survival equal or less than 2.5%. Thus, there is no indication that California cherries are more susceptible to codling moth infestation than Pacific Northwest cherries.

Back to Objectives

Survival of walnut-strain codling moth on sweet cherries - *James D. Hansen, USDA ARS, Wapato, WA*

Walnuts are a unique host for codling moth because they belong the Juglandaceae family whereas most hosts of codling moth are fruits of Rosaceae, the rose family. The objective of this study was to determine if cherries were more inclined to be hosts of the walnut strain than other Rosaceous hosts. Field-collected codling moth pupae from a California walnut orchard were used to test if a laboratory

colony could be established. Initially, it was difficult for the moths to reproduce because they were not predisposed to laboratory conditions. After a reliable colony was establish on artificial rearing diet, codling moth development from first instar to adults was observed on three cultivars of sweet cherries ('Bing,' 'Rainier,' and 'Sweetheart'). The levels of adult emergence (equal or less than 4.5%) were consistent with previous observations. Thus, there is no indication that the walnut-strain codling moth survives better in cherries than the laboratory reared colony.

Table 1. Emergence of the walnut-strain codling moth genotype from mature cherry cultivars and their apple controls. Study in progress and the numbers of infested fruits containing immature insects are listed for future observations.

	Cherry			
Cultivar	No. Fruits Recorded	No. Adults	% Adults	No. Fruits to be Observed
'Bing'	200	1	0.5	300
'Rainier'	474	18	2.9	14
'Sweetheat''	450	21	4.5	50

	Apple			
Cultivar	No. Fruits Recorded	No. Adults	% Adults	No. Fruits to be Observed
'Bing'	64	44	68.8	186
'Rainier'	342	231	67.5	43
'Sweetheat''	204	139	68.1	46

1. Currently conducting tests to determine survival of walnut strain codling moth on California and Pacific Northwest cherries. The biology of this strain is poorly known, particularly on non-preferred hosts. The tests have been designed to determine if this strain can switch to cherries and survive.
2. Have been in consultation with USDA-APHIS on the use of cold storage to eliminate oriental fruit moths from apples. This is an area concern for domestic apples exported to Mexico and is now part of current negotiations.

Back to Objectives

Use of aggregation pheromone and mass trapping for reduction of driedfruit beetle damage in dried figs - *Charles Burks and L.P.S. Bas Kuenen, San Joaquin Valley Agricultural Sciences Center, USDA-ARS, Parlier, California*

Treated and untreated comparison blocks were used to examine the efficacy of pheromone-augmented mass trapping for *Carpophilus hemipterus, C. mutilatis*, and *C. freemani* (Coleoptera: Nitidulidae). Effects were assessed by monitoring traps in the orchard during the growing season, and by sampling fruit from windrows at the time of harvest. Significantly fewer nitidulids were captured in monitoring traps while mass-trapping was being conducted. There were fewer damaged fruit in the mass trapping area compared to the control area. Both reduction in insect damage and in mold contributed to this difference, which was significant both statistically and economically. Current research is examining how to achieve this efficacy in a more labor-efficient manner.

Back to Objectives

Use of mating disruption for reduction of navel orangeworm damage in dried figs - *Charles Burks and L.P.S. Bas Kuenen, San Joaquin Valley Agricultural Sciences Center, USDA-ARS, Parlier, California*

The Paramount Puffer System (Suterra LLC) was used to examine the effect timed release of 11,13-hexadecadianol, a component of the sex pheromone of the navel orangeworm *Amyelois transitella*, on insect damage in figs. Female-baited flight traps were monitored during the growing season, and fruit collected from windrows at time of harvest was examined for damage. Few or no male insects were captured in the pheromone treated areas while males were seasonally abundant in control areas, indicating that mating disruption occurred. There were significantly fewer insect-infested fruit in the pheromone-protected area, but the difference was small and not economically important. We are currently collecting another season of data and examining treatment timing.

Back to Objectives

Objective 2: Benefits of postharvest temperature management or temperature treatments for control of decay and insects.

Evaluation of hot water and chemical treatments for decay control on inoculated tomatoes - *Marita Cantwell, Trevor Suslow and Xunli Nie, Dept. Vegetable Crops, UCDavis*

We used high quality summer fruit as well as weaker late-season and winter fruit in these tests. Sodium and calcium hypochlorite solutions (200 ppm) at commercial dump tank temperature (104° F [40°C]) or ambient temperature (68°F [20°C]) were not effective in reducing decay from wound infections. Higher temperature water dips, with and without chemical disinfectants were compared over a range of inoculum loads of *Botrytis* and *Geotrichum*. Hot water treatments (126-131°F [52.5-55°C]) for 6 to 8 minutes were generally very effective in reducing growth of wound-inoculated *Botrytis*. These treatments did not affect ripe fruit quality. Addition of calcium hypochlorite (200 ppm, pH 7.0) to hot water generally improved control of *Botrytis, Geotrichum* and *Alternaria*. Other calcium-containing compounds (calcium metalosate, calcium chloride) and other chemicals including sodium bicarbonate, acetic acid, surfactant Tween, and SunRider vegetable wash, did not improve decay control over the hot water treatments alone or in combination with calcium hypochlorite. Complete control of *Geotrichum* was extremely difficult and only achieved in one of five experiments.

Back to Objectives

Stress-related genes as indicators of freeze damage in citrus fruits - *Timothy Close, Raymond Fenton and Steve Wanamaker, Botany and Plant Sciences, UC Riverside*

The project members are Staff Research Associate Ray Fenton, Programmer Steve Wanamaker, and Geneticist Timothy Close. A standard set of methods of genomics: (1) cDNA library construction, EST sequencing, and sequence database analysis is being applied to the study of freeze damage in citrus fruits. The material is citrus fruits before and after damaging freeze treatments. The initial question is, "What genes are switched on in parallel with cold acclimation or the appearance of damage symptoms in freeze-damaged fruit". The practical benefits would be the development of inexpensive and reliable indicators of hardiness and damage of fruit. During the past three years the Close laboratory has produced more than 40 high quality cDNA libraries for federally funded wheat (NSF Plant Genome) and barley (USDA-NRI) projects. Recently the EST database viewing software "HarvEST" (see http://harvest.ucr.edu) has been developed as a user-friendly Windows software, and the intention is to apply the HarvEST shell also to citrus EST sequences that will be generated

from this and other citrus EST projects. This venture into citrus genomics is a new project that currently has no extramural funding, though it is related to an ongoing project on citrus stress proteins that was funded by the Citrus Research Board in the 2000/2001 year. The rate of progress and delivery of practical tools to the industry will depend on the level of funding and the interest of other potential research partners. This experimental approach to the development of indicators can potentially be applied to any post-harvest issue for any plant.

Back to Objectives

Increasing tomato fruit resistance to decay by temperature conditioning (curing) - *Marita Cantwell and Xunli Nie, Dept. Vegetable Crops, UCDavis*

A 2 or 3 day, but not a 1 day, curing treatment of mature-green fruit at 98.6°F (37°C) at high humidity (>98% RH; humidified air stream) was effective in reducing decay on wound-inoculated fruit. This treatment accelerated the wound healing process and did not reduce ripened fruit quality. Curing was not effective for control of *Geotrichum*, but was very effective in reducing *Botrytis* development. We also tested whether curing provided some benefit to tomatoes if stored at a chilling temperature of 41°F (5°C) for 10 days before ripening. The curing treatments did not provide protection against subsequent low temperature storage at 41°F (5°C).

Back to Objectives

Heat tolerance of navel orangeworm and Indianmeal moth - *Judy Johnson, USDA-ARS-HCRL, Parlier, CA*

Organic bean processors have used 30-day exposures to commercial cold storage temperatures (0°F, -18°C) to disinfest beans of cowpea weevils. We examined the response of cowpea weevils to cold storage in an attempt to shorten the exposure times needed for adequate control. Cowpea weevil eggs were the most cold-tolerant stage. Although the center of the bean bins were the most difficult to cool, no cowpea weevil eggs placed at the center of bean bins hatched after 2 weeks of exposure to commercial cold storage conditions.

Back to Objectives

Commercial cold storage to control cowpea weevil in organic garbanzo beans - *Judy Johnson, USDA-ARS-HCRL, Parlier, CA and Juming Tang,*

Washington State University

Using a heating block designed at WSU, relative heat tolerance of navel orangeworm and Indianmeal moth was determined. Fifth-instar lavae of the navel orangeworm was the most heat tolerant stage and species, and was nearly 5 times as tolerant as fifth instar Indianmeal moth. Diapausing Indianmeal moth larvae were more tolerant than non-diapausing Indianmeal moth larvae, but were still less tolerant than navel orangeworm.

Back to Objectives

Forced hot air for control of arthropods in harvested chrysanthemum cuttings - *Tiffanie Simpson, Veronique Bikoba and Elizabeth Mitcham, Pomology, UCDavis*

Commercially harvested and bagged chrysanthemum tip cuttings, western flower thrips, two-spotted spider mites, and melon aphids were exposed to hot air using a self-contained, computer-controlled atmosphere and temperature treatment system (CATTS). Temperatures between 45°C and 52°C were tested with exposure times from 15 minutes to 4 hours. Preliminary results indicated that western flower thrips and aphids were completely controlled at temperatures and exposure times well within the tolerance of mum cuttings. Two-spotted spider mites were tolerant of all temperatures and exposure times tested. Initially, cuttings showed little or no damage to treatments that resulted in significant insect mortality, even after 1 week of storage at 20°C. However, when a rooting trial was initiated, it became apparent that there was significant damage to most of the varieties tested. We are currently in the process of determining the tolerance of mum cuttings under different conditions such as using perforated bags to facilitate heat penetration. We are also examining more closely the temperature and exposure time necessary to completely control western flower thrips and melon aphids.

Back to Objectives

High temperature forced air/controlled atmosphere quarantine treatments for peaches and nectarines - *David Obenland, USDA/ARS Parlier and Lisa Neven, USDA/ARS Wapato*

High temperature forced air with and without a controlled atmosphere (CA) of 1% oxygen and 15% carbon dioxide was tested as a possible method of achieving insect quarantine security for

peaches and nectarines. All heating rates were 12°C/hour and treatment durations ranged from one to four hours. Eight cultivars representing mid- and late-season peach and nectarine varieties were treated and evaluated for surface injury, percent juice (a measure for flesh mealiness), internal browning, firmness, acidity, brix, and external color after a storage period of two to three weeks. Increased surface injury was sometimes noticeable following 3 hours or more at 44°C or 2 hours or greater at 46°C. The injury, however, was generally slight and only in the case of the heat+CA treatments was the fruit significantly damaged, and this only in three of the eight cultivars. Percent juice was enhanced by heat treatment and not generally affected by CA. None of the other quality factors evaluated showed any consistent changes as a result of treatment. Those treatments that resulted in no loss of quality for any of the eight cultivars will be evaluated for their effect on Oriental Fruit Moth mortality to determine the suitability of these treatments as insect quarantine treatments.

Back to Objectives

Objective 3: Influence of atmospheric modification or fumigation with safer materials on decay and insect control (CA, MA, CO, acetaldehyde, ozone, etc.)

Disinfest Lettuce of Insects through Postharvest Treatments and Pre-harvest IPM - *Yong-Biao Liu, USDA, ARS, US Agricultural Research Station, Salinas, CA*

Insect infestation hinders export of U.S. lettuce to markets that have strict phytosanitary regulations such as Japan. Postharvest disinfestation with methyl bromide or hydrogen cyanide fumigation injures lettuce and results in degraded or unsalable products. Methyl bromide will be phased out in 2005. Better alternatives for postharvest insect control are needed for lettuce. Disinfesting lettuce of insects requires effective pre-harvest management to minimize infestation by insects and effective postharvest treatments to kill live insects. This project deals with both postharvest and pre-harvest insect control. Post-harvest research aims to explore and develop alternative vacuum-based postharvest disinfestations techniques and will focus on understanding basic mechanisms of vacuum effects on insects and interactions of vacuum with other factors, determining effects of vacuum and combinations of vacuum and controlled atmosphere treatments on insects, and determining effects of

vacuum-based insecticidal treatments on storage and shelf life, and quality of different types of lettuce. The research will advance our understanding of mechanisms of effects of vacuum on insects and of potential of vacuum-based postharvest disinfestation for lettuce. Pre-harvest research will focus on understanding host colonization process of iceberg lettuce by the lettuce aphid, *Nasonovia ribisnigri*, a new and major pest of lettuce in U.S. and its population dynamics, and developing tools for monitoring aphids and other insects. The pre-harvest research will provide applied knowledge and techniques that are needed for effective management of lettuce aphid and other pests.

Back to Objectives

Maximizing thiabendazole effectiveness for the control of green mold of citrus - *Joe Smilanick, USDA-ARS, Frenso, CA*

Thiabendazole (TBZ) has been used to control postharvest decay of citrus since 1970. It is usually used at rates of 2000 to 4000 ppm in fruit waxes. We attempted to reduce this rate and TBZ residues by applying it in water, immersing the fruit in the solution rather than spraying the material on, combining it with chlorination (Cl2) and sodium bicarbonate (SBC), or heating the solution. After a series of empirical tests with each of these elements, we were able to reduce the TBZ rate to 400 ppm while retaining excellent activity, even against TBZ resistant strains of the green mold pathogen that normally cannot be controlled by TBZ. In the fall and winter of 2001, green mold losses were particularly high on navel oranges in central California. This was probably a consequence of many split fruit within the canopy of the trees, moderate temperatures, and early rains, which together provided conditions conducive to early infections and a build-up of inoculum. Because navel oranges are often de-greened with ethylene gas before they are processed and treated with fungicides in the packinghouse, decay among them can be particularly severe. A TBZ/SBC/Cl2 combination was applied by drenching field bins immediately after harvest before de-greening, and the addition of this treatment reduced losses during de-greening more than 80% compared to the conventional practice of no treatment before de-greening in several large commercial tests.

Back to Objectives

Effects of continuous 0.3 ppm ozone exposure on decay development and physiological responses of peaches and table grapes in cold storage- *Lluís Palou, Carlos H. Crisosto, Pomology, UC Davis, Kearney Ag. Center, Parlier;*

Joseph L. Smilanick, USDA-ARS, Parlier; James E. Adaskaveg, Plant Pathology, UC Riverside; Juan P. Zoffoli, Pontificia Universidad Católica, Santiago, Chile.

FContinuous ozone exposure at 0.3 ppm (v/v) (US-OSHA Threshold Limit Value for short term exposure) inhibited aerial mycelial growth and sporulation on 'Elegant Lady' peaches wound inoculated with *Monilinia fructicola, Botrytis cinerea, Mucor piriformis*, or *Penicillium expansum* and stored for 4 weeks at 5°C and 90% relative humidity (RH). Aerial growth and sporulation, however, resumed afterward in ambient atmospheres. Ozone exposure did not significantly reduce the incidence and severity of decay caused by these fungi with the exception of brown rot. Gray mold nesting among 'Thompson Seedless' table grapes was completely inhibited under 0.3 ppm ozone when fruit were stored for 7 weeks at 5°C. Gray mold incidence, however, was not significantly reduced in spray inoculated fruit. Continuous ozone exposure at 0.3 ppm increased water loss after 5 weeks of storage at 5°C and 90% RH in 'Zee Lady' peaches but not after 4 weeks of storage in 'Flame Seedless' grapes. Respiration and ethylene production rates of 'O'Henry' peaches were not affected by previous exposure to 0.3 ppm ozone. In every test, no phytotoxic injuries of fruit tissues were observed in ozonated or ambient atmosphere treatments.

Back to Objectives

Continuous exposure to exogenous ethylene does not affect brown rot development on cold-stored stone fruits- *Lluís Palou, Carlos H. Crisosto, Lisa M. Basinal. Pomology, UC Davis, Kearney Ag. Center.*

The influence of continuous exposure to exogenous ethylene during long-term cold storage on the development of postharvest brown rot was investigated during three seasons on selected cultivars of climacteric (peach, plum, nectarine, and apricot) and non-climacteric (sweet cherry) stone fruits. Fruit were wound inoculated with *Monilinia fructicola* and placed in plastic cavity trays in 7.8-L plastic containers. The containers were connected to an ethylene flow-through system inside standard cold storage rooms at each desired temperature. Depending on the experiment, climacteric stone fruit were exposed to ethylene concentrations of 0, 0.1, 1, 3, 10, or 100 $\mu L\ L^{-1}$ during storage at 0, 5, or 10°C for up to 28 days; sweet cherries were exposed to 0, 0.01, 0.1, or 1 $\mu L\ L^{-1}$ ethylene during storage at 0 or 5°C for 21 days. In every test, neither brown rot incidence nor severity were significantly affected by constant ethylene exposure. Therefore, no benefit in decay reduction can be expected from actively removing ethylene from commercial cold storage rooms

containing stone fruits.

Back to Objectives

Effect of gaseous ozone exposure on the development of green and blue molds on cold stored citrus fruit - *Lluís Palou, Pomology, UC Davis, Kearney Ag. Center, Parlier; Joseph L. Smilanick, USDA-ARS, Parlier; Carlos H. Crisosto, Pomology, UC Davis, Kearney Ag. Center, Parlier; Monir Mansour, Menofiya University, Shebin El-Kom, Egypt.*

The effects of gaseous ozone exposure on in vitro growth of Penicillium digitatum and Penicillium italicum and development of postharvest green and blue molds on artificially inoculated citrus fruit were evaluated. Valencia oranges were continuously exposed to 0.3 ± 0.05 ppm (vol/vol) ozone at 5°C for 4 weeks. Eureka lemons were exposed to an intermittent day-night ozone cycle (0.3 ± 0.01 ppm ozone only at night) in a commercial cold storage room at 4.5°C for 9 weeks. Both oranges and lemons were continuously exposed to 1.0 ± 0.05 ppm ozone at 10°C in an export container for 2 weeks. Exposure to ozone did not reduce final incidence of green or blue mold, although incidence of both diseases was delayed about 1 week and infections developed more slowly under ozone. Sporulation was prevented or reduced by gaseous ozone without noticeable ozone phytotoxicity to the fruit. A synergistic effect between ozone exposure and low temperature was observed for prevention of sporulation. The proliferation of spores of fungicide-resistant strains of these pathogens, which often develop during storage, may be delayed, presumably prolonging the useful life of postharvest fungicides. In vitro radial growth of P. italicum, but not of P. digitatum, during a 5-day incubation period at 20°C was significantly reduced by a previous 0.3 ± 0.05 ppm ozone exposure at 5°C for 4 days. Inoculum density did not influence the effect of gaseous ozone on decay incidence or severity on oranges exposed to 0.3 ± 0.05 ppm ozone at 20°C for 1 week. Susceptibility of oranges to decay was not affected by a previous continuous exposure to 0.3 ± 0.05 ppm ozone at 20°C for 1 week. A corona discharge ozone generator was effective in abating ethylene in an empty export container.

Back to Objectives

Effects of Silwet L-77 on several arthropod pests of table grapes - *Christopher Tipping and Elizabeth Mitcham, Department of Pomology, UCDavis*

WSurfactants, or surface acting agents, are often used in conjunction with many classes of pesticides as adjuvants to facilitate

the dispersing, spreading, or wetting of active ingredients. Although the exact nature of the toxic effects of surfactants has not been adequately determined, insecticidal and acaricidal effects of soaps and oils as surfactants have been noted for over 80 years. Because organosilicones have superior wetting properties, they most likely disrupt a variety of arthropod systems that depend on specific water relationships including cuticular and respiratory functions. Silwet L-77, an organosilicone surfactant, was applied to several arthropod pests of California table grapes.

For each treatment, approximately 0.15 g of dH_2O or Silwet L-77 solutions of 0.1, 0.25, 0.5, or 1.0% (v/v, pH 7) were applied with a glass chromotography sprayer. Eggs of grape mealybug, Pseudococcus maritimus (Ehrhorn), and omnivorous leaf roller, Platynota stultana Walsingham, were resistant to 0.1, 0.25, and 0.5% (v/v) treatment solutions; however, eggs of Pacific spider mite, Tetranychus pacificus McGregor, were highly susceptible with mortality >99.4 % for the 0.1% Silwet L-77 treatment. Mortality of larval and adult stages of cotton aphid, Aphis gossypii, F. occidentalis, and T. pacificus was >93.8, >98.5, and >99.4% for 0.1, 0.25 and 0.5% Silwet L-77, respectively. Grape mealybug crawlers had 100% mortality when treated with 0.5 and 1.0% Silwet L-77 solutions; however, mortality was only 6.7% when 0.1% Silwet L-77 was applied. When Silwet L-77 was applied to the upper surface of cotton leaves with the lower surfaces infested with A. gossypii, mortality was 24.9, 24.0, and 35.8 % for 0.1, 0.5, and 1.0% Silwet L-77, respectively, indicating that coverage during application is important. 'Thompson Seedless' table grapes did not appear damaged when treated with up to 1% of Silwet L-77 and as compared to untreated controls; however, grapes treated with the 0.5 and 1.0% solutions appeared wetted after removal from cold storage. Grapes dried with the normal bloom on the berries when they reached room temperature.

Surfactants have been used successfully as a postharvest disinfectant for apples infested with two-spotted spider mite, Tetranychus urticae Koch and asparagus infested with western flower thrips, Frankliniella occidentalis (Pergande). Otherwise, the application of organosilicones as postharvest pesticides has been largely unexplored. Further investigations into the toxicological effects as well as its potential as a postharvest disinfestation treatment for other commodities may prove beneficial due to increased interest in alternatives to methyl bromide.

Back to Objectives

Further exploration of ethyl formate as a fumigant for arthropod pests associated with table grapes - *Christopher Tipping, Veronique Bikoba, Elizabeth Mitcham, Department of Pomology, UCDavis*

Investigations into the use of naturally occurring plant volatiles as potential fumigants for postharvest treatment of arthropods has increased due to tighter restrictions governing the use of methyl bromide. Plants naturally produce many volatile compounds that are not only important for aromatic and flavor characteristics, but have the additional benefit of offering resistance to pathogens and arthropod pests. Ethyl formate (EtF) occurs naturally in a large variety of products including essential oils of grasses, beer, rice, beef, cheese, grapes, and wine. One important advantage of using volatiles for fumigation is that the residues found on treated commodities are often in trace amounts. The FDA has reviewed the use of ethyl formate and has characterized this compound as generally regarded as safe (GRAS). Ethyl formate was previously registered in California for control of several stored product pests including confused flower beetle, Tribolium confusum and raisin moth, Ephestia figulilella. Ethyl formate is currently registered for insect control in Australia.

Previous studies have indicated that the eggs of the grape mealybug are the most difficult stage to control for all of the arthropod groups we are presently studying. Fumitoria for all EtF tests were sealed, one-gallon glass jars. Ethyl formate was injected through an airtight rubber septum connected to the lid of the fumitoria onto filter paper where it rapidly volatilized. Mealybug eggs were treated with 0.8, 1.6, 2.4, 3.2, or 3.9% ethyl formate for 1, 2, or 3 hours at 0 or 24°C, followed by post-treatment exposure to air (2°C, >90% RH) or CA (45% CO_2, 2°C, >90% RH) for 5, 8, 11, or 14 days. Eggs treated with EtF at both 0 and 24°C showed a trend of increasing mortality with higher concentrations and longer periods of exposure to EtF. Overall, mealybug eggs treated with EtF at 0oC were more resistant to fumigation than those treated at 24°C, most likely due to reduced metabolic activity of the developing ova at lower temperatures. At 24°C, mortality was >99% for eggs treated at with 2.4, 3.2, and 3.9% EtF for one hour followed by 5-14d of CA. Eggs treated for 3h had 100% mortality when 3.2 or 3.9% EtF was applied followed by as little as 5d in air. Unlike the egg stage, the crawler stage of the grape mealybug was highly susceptible to EtF treatments with 100% mortality when treated with only 0.8% EtF for one hour.

In subsequent tests with mealybug eggs, the most promising treatments were 2.4% for 3 hours, 3.9% for 1 hour or 5.5% for 0.5

hours, but post-treatment exposure to cold or CA was sometimes necessary for 100% mortality. The presence of grapes during fumigation had little effect on the efficacy of the treatment as grapes appear to absorb EtF slowly.

Other pests of table grapes were more susceptible to EtF. Larval, pupal, and adult stages of western flower thrips, Frankliniella occidentalis (Pergande), were killed by a one hour exposure to less than or equal 0.8% EtF. Omnivorous leaf roller, Platynota stultana Walsingham, egg and pupal stages were killed by exposure to 2% EtF for 3h or 3.9% for 1 hour. We plan to treat different aged eggs to determine if there is a critical time in development that could influence efficacy of EtF. Pacific spider mite, Tetranychus pacificus McGregor, lifestages were also killed by exposure to 3.9% EtF for one hour. The egg stage has not yet been tested. We are continuing to determine the lowest concentration of EtF required to control these arthropods as well as the potential synergistic effects of CO_2 exposure prior to and during EtF fumigation.

Finally, we have treated several varieties of table grapes with various concentrations of EtF that have shown potential for grape mealybug egg control. Preliminary results with table grapes indicate that some of the higher treatment concentrations cause obvious visible damage to the stems and rachis of grapes not previously treated with sulfur dioxide. Berry damage has never been observed. This season, we plan to treat grapes that have been previously fumigated with recommended commercial levels of SO_2, as SO_2 has been demonstrated to protect grape stems and rachis from browning. Emphasis will be on the EtF treatment of 2.4% for 3h, because this treatment generally had 100% mortality of mealybug eggs without a post-treatment exposure to cold or CA.

Back to Objectives

Effects of acetaldehyde on fruit quality and target pest mortality for harvested strawberries - *Tiffanie Simpson, Veronique Bikoba and Elizabeth Mitcham, Pomology, UCDavis*

Strawberry fruit and western flower thrips were exposed to 1, 2, 3, or 4% acetaldehyde (Aa) for 2 h in air or in 20 kPa CO_2. Following treatment, fruit were stored at 0°C or 20°C for 4 days or 2 days, respectively. Acetaldehyde treatment did not significantly impact fruit firmness, color, or soluble solids content; however, calyx damage

increased with increasing concentration of Aa. Strawberry fruit tolerated exposure to 1% or 2% Aa with little or no damage to the fruit calyx. Fruit acetaldehyde, ethanol, and ethyl acetate concentrations increased initially, but decreased over time; the decrease being greater in fruit stored at 20°C as compared to 0°C. Methanol and acetone levels were lower in treated than untreated fruit. Western flower thrips were not completely controlled by any of the treatments, but >95% mortality was achieved by a 2 h exposure to 3 or 4% Aa. The presence of 20 kPa CO_2 enhanced mortality of western flower thrips at lower concentrations of Aa. Strawberry fruit, western flower thrips and two-spotted spider mites were also exposed to multiple applications of Aa over time. Strawberry fruit exposed to low concentrations of Aa in repeated doses showed higher tolerance than fruit exposed to the same dose as a single exposure. While repeated exposure to 1 or 2% Aa resulted in greater mortality than a single exposure to 1 or 2% Aa, mortality was significantly lower with repeated applications of low doses as compared with a single application of the accumulated dose (1%, 1%, 1% vs. 3% Aa). None of the treatments resulted in complete control of either target pest.

Back to Objectives

Ethyl formate for postharvest control of arthropods on harvested strawberries - *Tiffanie Simpson, Veronique Bikoba and Elizabeth Mitcham, Pomology, UCDavis*

Strawberry fruit and western flower thrips were exposed to ethyl formate (EF) at 0.8, 1.6, and 2.4% with an exposure time of 1 h. Strawberry fruit and pests were also exposed to 0.8 % EF for 60, 90, and 120 minutes. For treatments requiring multiple applications of EF, berries thrips and mites were fumigated at 24°C with 0.8% two (0.8%-0.8%) or three (0.8%-0.8%-0.8%) times with 1 h ambient air between the repeated exposures. In order to test the effects of increased levels of CO_2 in the presence of EF, jars containing pests were flushed with an atmosphere of 5, 10, 20, 40, 80, or 95% CO_2 in air until the desired level of CO_2 was reached, then sealed and injected with 0.3% EF. Strawberry fruit showed no significant differences between treated and untreated fruit for firmness, color, berry damage, or soluble solids. Strawberry fruit sustained less damage when exposed to lower concentrations of EF for longer exposure times or to repeated exposure, as indicated by increased calyx damage in treatments with higher concentrations. Acetaldehyde content of strawberry fruit increased with increased cumulative

exposure to EF either by extended exposure time, multiple exposure, or by exposure to higher concentrations of EF. Fruit exposed to a single, high dose of EF exhibited higher Aa concentrations than fruit exposed to the same cumulative dose in successive exposures. Methanol levels in treated fruit were slightly decreased compared with the control. Acetone levels were relatively similar for treated and untreated fruit. Ethanol and ethyl acetate concentrations increased in treated fruit, increasing with longer exposure times and increased concentrations. Ethyl formate concentrations in treated fruit were slightly elevated above that of the control fruit, with a slight trend toward increased concentrations at higher cumulative concentrations. All EF treatments resulted in significant western flower thrips mortality, however, complete mortality was achieved only in the treatments with the highest cumulative exposures; 0.8%-0.8%, 0.8%-0.8%-0.8%, and 2.4% EF. Two spotted spider mites were less susceptible to EF. The treatments with the highest cumulative exposures, 0.8%-0.8%-0.8b% and 2.4%, resulted in 57 and 66% mortality, respectively. Thrips mortality increased slightly in CO_2 concentrations of 5% and 10% CO_2 over that of air and declined when CO_2 concentrations reached less than or equal to 40%. Two-spotted spider mites showed a sharp increase in mortality at 5% and 10% CO_2 over that of EF in air. Mortality then rapidly declined at 20% CO_2 and continued to fall as concentrations of CO_2 were increased.

Back to Objectives

Postharvest insect control on harvested Dendrobium orchids - *Tiffanie Simpson, Veronique Bikoba and Elizabeth Mitcham, Pomology, UCDavis*

A number of control methods were tested on harvested Dendrobium orchids against western flower thrips including ethyl formate, methyl formate, acetaldehyde, hot air (35°C), low O_2 (1.0% or 1.5%) and high CO_2 (55%). In addition, combinations of acetaldehyde, hot air and low O_2 were tested. Orchid inflorescences were placed in plastic sleeves and exposed to the treatments described above in large PVC tubes that had been modified to be used as airtight treatment chambers. Treatments with ethyl formate, methyl formate and 55%

CO_2 resulted in significant damage to flowers, including burned pollen caps, and water-soaking and browning of petals. Hot air, acetaldehyde, and low O_2 treatments were well tolerated by the orchids but did not result in complete mortality of thrips as stand-alone treatments. Combined treatments using a pre-treatment of 1.0% acetaldehyde, followed by exposure to 1.5% O_2 at 35°C for up to 24 h resulted in high insect mortality with little impact on orchid vase life. We are in the final stages of testing the most promising combination treatments to verify our mortality results and vase life studies.

Back to Objectives

Mode of action of elevated CO2 atmospheres - *Tunyalee Martin and Elizabeth Mitcham, Pomology, UCDavis*

We recently completed a study of the response of omnivorous leafroller pupae to low O_2 and high CO_2 atmospheres using microcalorimetry to better understand how these atmospheres affect insect metabolism. We are continuing this work to better understand the mode of action of CO_2 atmospheres. One idea is that CO2 affects metabolism. In mammals and plants, an increase in internal CO_2 decreased internal pH. Termed acidosis, it is unknown if this phenomenon occurs in insects. Acidosis affects a number of metabolic processes that lead to a decreased metabolic rate (observed from our previous work) and death. A second idea we would like to test is if increased CO_2 compromises membrane permeability by affecting ATP production. In mammals, it is suggested that reduced ATP production causes a disruption in the cell membrane potential and eventually cell damage or death. We would like to determine if the same events occur in insects and if cell membrane leakage could explain mortality due to elevated CO_2. In addition, we would like to look at energy charge (the ratio of ATP/ADP) to determine if this measurement could be used as a rapid method to test insecticidal atmospheres. Energy charge will be related to insect mortality after treatment with elevated CO_2. So rather than assessing mortality over time, after the insect is treated, measurements of energy charge could be made instead. It is our hope that by better understanding the physiology of

insect mortality due to elevated CO_2, effective insecticidal treatments can be more rapidly developed.

Back to Objectives

Propylene oxide/carbon dioxide mixture for control of postharvest insect pests of dried fruits and nuts - *J. Larry Zettler, San Joaquin Valley Agricultural Sciences Center, Parlier, CA*

A mixture of propylene oxide (PPO) and carbon dioxide (CO_2) at the rate of 8%:92% is being tested at atmospheric conditions for control of Indianmeal moth, navel orangeworm, and dried fruit beetle. The moths were exposed to the fumigant mixture in infested walnut meats while the dried fruit beetle was exposed in infested dried figs. Mortalities following 24 hr exposures suggest that this mixture is toxic at high doses (75 to 100 mg/L PPO) but sorption at these doses by walnuts and figs was 88 to 89%. Further tests are being conducted to include all life stages of these pests.

Back to Objectives

Susceptibility of pink hibiscus mealybug to methyl bromide - *J. Larry Zettler, San Joaquin Valley Agricultural Sciences Center, Parlier, CA*

Eggs, crawlers, early nymphs, late nymphs, and adults of the pink hibiscus mealybug were tested for methyl bromide susceptibility according to the APHIS quarantine treatment schedule for mealybugs (2 hr fumigation with 48 mg/L at 21 to 26C). Dose response tests indicated that the egg was most susceptible. Adults, early nymphs, late nymphs, and crawlers were equally susceptible but about 2X more tolerant than the eggs. Confirmatory tests showed that the APHIS schedule for mealybugs will provide quarantine security against the pink hibiscus mealybug.

Back to Objectives

Toxicity of sulfuryl fluoride (Profume) to fruit flies - *J. Larry Zettler, San Joaquin Valley Agricultural Sciences Center, Parlier, CA*

Laboratory tests were conducted against Medfly, melon fly, and oriental fruit fly to determine if sulfuryl fluoride is sufficiently toxic to be used as a quarantine treatment. Results of 4 hr fumigations at 23.6C showed that first and third instars of each species were

relatively susceptible to sulfuryl fluoride but the eggs, by contrast, were relatively tolerant. The large doses required to control the eggs in 4 hr fumigations preclude the efficient use of this fumigant as a quarantine treatment for these fruit flies.

Back to Objectives

Effect of modified atmospheres on microflora and respiration of California prunes - *J. Larry Zettler, San Joaquin Valley Agricultural Sciences Center, Parlier, CA*

We investigated the possibility that prunes stored in MAs will tolerate higher water activity levels than those stored at normal atmospheres and that the naturally occurring microfloral infection level on the prunes may generate the modified atmospheres that inhibit mold activity in airtight conditions. Artificially moisturized dried prunes were stored at various temperatures in either sealed containers (hermetic) or unsealed containers (aerobic). These studies showed that (1) the higher the moisture content and temperature, the more intense the O_2 consumption by the microflora showing, in most cases,

a linear relationship between O_2 consumption and time; (2) the

naturally occurring microfloral growth that flourishes and causes deterioration under aerobic conditions is inhibited under hermetic storage at moisture contents as high as 38%; and (3) the naturally occurring microfloral infection levels on prunes can generate the modified atmospheres that inhibit mold activity in hermetic conditions (i.e., 2 days at 25C and 38% moisture content)

Back to Objectives

Response of postharvest insects to vacuum - *J. Larry Zettler, San Joaquin Valley Agricultural Sciences Center, Parlier, CA*

Laboratory bioassays to determine the effect of vacuum on navel orangeworm, codling moth, and diapausing Indianmeal moth larvae have begun. Earlier work with vacuum has suggested that mortality is caused by low oxygen levels. Preliminary results with codling moth indicate that shorter exposure times are possible with vacuum than with low oxygen, suggesting that other mechanisms may be involved.

Back to Objectives

Potential postharvest fumigants on fruit phytotoxicity and insect

mortality - *Louis Aung, James Leesch, Joel Jenner, USDA-ARS, Parlier, CA and Elizabeth G. Grafton-Cardwell, U.C. Riverside*

Methyl iodide (MI), carbonyl sulfide (COS), and sulfuryl fluoride (SF) were tested at selected dosages on lemons against California red scale (Aonidiella aurantii) and MI and COS were tested on nectarines against codling moth (Cydia pomonella). MI gave 100% red scale mortality at 40 mg liter^{-1}, but caused significant fruit injury. Conditioning lemons at 15 C for 3 days before MI fumigation lessened lemon phytotoxicity. Forced aeration at 3.5 standard liters per minute of lemons for 24 h following MI fumigation at 20 mg liter^{-1} significantly reduced phytotoxicity compared to 2 h postfumigation aeration after MI treatment. SF at 40 mg liter^{-1} gave 100% red scale mortality, but resulted in fruit phytotoxicity. Lemons treated with the highest selected dose of 80 mg liter^{-1} COS gave only 87% kill of red scale, but failed to reach the desired probit 9 level (99.9968%). Both MI and COS intensified nectarine peel color, delayed fruit softening, but did not alter overall fruit quality. MI gave 100% codling moth mortality at 25 mg liter^{-1}.

Back to Objectives

Use of ozone to control postharvest insects - *J. G. Leesch, Research Entomologist, USDA ARS, Horticultural Crops Research Laboratory, Commodity Protection and Quarantine Insect Research Unit, Parlier, California*

For the past 2 years, we have been looking at the possibility of using ozone as an alternative fumigant to methyl bromide. We began with 2 common stored product insects, Indianmeal moth (IMM) and confused flour beetle (CFB). We found that ozone alone is not very effective alone but when mixed with low levels of carbon dioxide, could prove to be an alternative. If vacuum were used as well as carbon dioxide, the efficacy increased over that of carbon dioxide alone. We also found that when ozone is administered to an immature stage if the insects, mortality continues until adult emergence occurs.

Back to Objectives

Testing of 2 additional prune plum varieties for export to Japan. - *J. G. Leesch, Research Entomologist, USDA ARS, Horticultural Crops Research Laboratory, Commodity Protection and Quarantine Insect Research Unit, Parlier, California*

Two years ago, we did the testing required to get the 'd'Agen' variety of prune plum accepted by Japan. Since then, the Japanese have been required by the WTO to revise their requirements for additional varieties of a commodity to be accepted after one variety has undergone the rigorous testing and been accepted. This year, we tested 2 additional prune plums, 'Moyer' and 'Tulare Giant' for acceptance by Japan according to the revised protocols developed by Japan in response to the WTO mandate. We were able to show that the varieties behaved similar to 'd'Agen' plums in their response to methyl bromide treatment. No damage or adverse effects were noted with the new varieties and methyl bromide actually slowed ripening of the fruit following fumigation.

Back to Objectives

The sorption of phosphine by whole walnuts. - *J. G. Leesch, Research Entomologist, USDA ARS, Horticultural Crops Research Laboratory, Commodity Protection and Quarantine Insect Research Unit, Parlier, California*

Several years ago, we were able to show that phosphine is highly sorbed by whole pecans. So much sorption took place that concentrations could not be maintained at high enough to kill some insects. This year, a report was received that indicated the same phenomenon might happen with walnuts. We have been able to show that indeed, high sorption by whole walnuts does occur when they are exposed to phosphine. We are continuing to investigate this high sorption in hopes of discovering the cause and any solutions for the high sorption.

Back to Objectives

The use of aeration to alleviate phytotoxicity of methyl iodide on lemons. *- J. G. Leesch, Research Entomologist, USDA ARS, Horticultural Crops Research Laboratory, Commodity Protection and Quarantine Insect Research Unit, Parlier, California*

In cooperation with Dr. Louis Aung, we are investigating the use of forced aeration to eliminate injury to lemons exposed to methyl iodide as an alternative treatment to methyl bromide. Studies to date indicate that increased forced aeration may eliminate injury seen with only the 2 or 4 hour aeration normally performed. This year we will be looking at the effect of lemon type and location on the use of forced aeration to eliminate injury.

Back to Objectives

Objective 4: Methods to improve postharvest handling or sanitation procedures to reduce susceptibility to decay or insects.

Efficacy of alternative antimicrobials for decay and human pathogen disinfection - *Trevor Suslow, Marcella Zuniga, Vegetable Crops, UCDavis*

Recently we have been conducting a preliminary evaluation of a product called SunSmile® as an alternative (to chlorine) water disinfectant and fruit and vegetable wash-aide. It has been marketed without direct pesticidal claims but the distributor has been promoting pathogen control to customers. We have informed interested users that EPA registration is required for these uses. Baseline efficacy data was requested by users to determine whether there was a realistic expectation for pathogen disinfection before addressing the legal aspects of product registration. The formulation is reported to be an unspecified mixture of plant extracts that have FDA GRAS (Generally Recognized As Safe) status. The primary active ingredient listed for anti-fungal activity, benzoin, has very limited published research on its general antimicrobial properties. However, the extracts from its natural plant sources are widely reported as having anti-fungal action, which is of interest to us.

Thus far, we have tested the product, at labeled rates (5ml per gallon), on the elimination of the bacterial decay pathogen *Erwinia* and bacteria of food safety concern, *Salmonella* and *E. coli*, from inoculated water samples. Inoculated populations became undetectable within 10 minutes at room temperature and essentially eliminated within 20 min in chilled water at 34°F. Product prepared one hour prior to artificial contamination was equally effective in killing bacteria. Spores of the decay fungi *Botrytis* and *Geotrichum* were also tested in water with the labeled rate. In these tests, *Botrytis* was eliminated within 5 minutes and *Geotrichum* with 10 minutes exposure. Dose:response efficacy, range of pathogens, and stability testing under various water quality and temperature conditions, as well as efficacy on fruit and vegetable surfaces is in progress.

Evaluation of antimicrobial gloves for reducing pathogen transfer during handling Production activities, harvest, packing, re-pack, and retail display operations for many fruits and vegetables remain heavily dependent on hand-labor, often with a high frequency of direct hand contact to the edible surface. Currently, there are no

prohibitions against bare hand contact if adequate training and facilities for personal hygiene are available. However, many workers chose or are instructed to use various types of gloves for a variety of reasons. Gloves, if used properly, can help reduce the possible transfer of pathogenic microbes from hands to fruit as well as reduce the chance of injury due to fingernail puncture at harvest or packing. Although cotton or other fabric blend gloves have been used in the past, disposable latex or other polymer-type gloves are frequently used today to comply with buyer requirements specified in food safety programs. For resistance to tearing and for worker comfort, especially during hot weather, cotton gloves have many advantages over latex gloves. In addition to the potential for inducing allergic reactions (especially latex gloves) among some individuals, retained body heat and free moisture in disposable gloves has been shown to promote bacterial growth on the skin surface. Traditional cotton gloves, however, become easily soiled during use and may harbor and transfer spores or cells of spoilage microorganisms or pathogens associated with human illness.

Recent technologies have been developed that allow the treatment of cotton and other fiber-based materials with a binder that can be reversibly associated with halogen-based compounds, such as chlorine molecules. After treatment, the fibers attain a durable and regenerable anti-microbial quality. There is the potential to inactivate a wide range of decay pathogens and foodborne and waterborne pathogens of human health concern. This antimicrobial fabric finishing technology, developed by Dr. Gang Sun of the University of California, Davis, was initially designed for use in medical apparel such as surgical gowns and nurses clothing. The treated materials have been evaluated on human test subjects and found to be safe and non-irritating, under normal conditions of use. Activated fibers will kill microbes by readily transferring the disinfectant molecules, which can then be replaced by a simple washing in sodium hypochlorite (bleach) to recharge the material.

The novel application of this technology to gloves for agricultural workers, as well as other applications, to minimize or prevent the carry-over and transfer of bacteria and fungi is the focus of current research in our lab at UCD in collaboration with Dr. Sun. In preliminary studies, both decay bacteria and fungi and microbes of food safety concern have been shown to be killed following contact with Binder:Chlorine cotton gloves. Thus far, challenge studies have been conducted in the laboratory with non-treated and treated swatches of standard agricultural cotton-based gloves (both heavy and lightweight). The survival of the bacteria *Erwinia carotovora, Salmonella* spp., and *E. coli*, and the decay fungi *Monilinia fructicola,*

Geotrichum candidum (Sour Rot)*Botrytis cinerea* (Grey Mold), and *Rhizopus stolonifer* has been shown to be greatly reduced following placement on treated gloves.

Back to Objectives

Sampling apple culls to support the systems approach for quarantine - *James D. Hansen, USDA ARS-YARL, Wapato, WA*

Sorting efficacy was followed in 17 grower lots at six packing houses from the beginning of the packing line to the final pack. The number of fruits examined included 28,000 before sorting, 14,376 from the cull bin, and 12,539 in the final pack. 'Fuji' was the most dominant cultivar, followed by 'Golden Delicious,' 'Delicious,' then 'Gala.' Only two (one alive) codling moths were found in the dump tank station, 24 (12 alive) were in the culls, and none were in the final pack. Codling moth damage was found in about 0.1% of the pre-sort, 1.9% in the culls, and only one fruit in the final pack. Culling efficacy was not directly influenced by packing line speed.

Back to Objectives

Objective 5: Influence of energy wave inputs such as irradiation, uv, raido frequency or microwave on postharvest decay and insect infestations.

Heat as a quarantine treatment against codling moth in cherry - *James D. Hansen, USDA ARS, Wapato, WA; Juming Tang, Washington State University; and Steve Drake, ARS, Wenatchee, WA*

A series of tests were conducted to determine efficacy of warm water treatments. Two methods were developed based on cherries produced in California and the Pacific Northwest (PNW). For California cherries, the efficacious treatment was a 5 min prebath at 43°C (109 °F), followed by warm water exposure, either for 8 min at 48°C (118° F), 6 min at 49°C (120°F) or 4 min at 50°C (122°F), then hydrocooled until fruit core temperature drops to about 4°C (39°F). The warm water exposure can be either a bath or a shower. For PNW cherries, the efficacious treatment was a direct warm water immersion for 6 min at 50° (122°F) or 4 min at 54°C (129°F), followed by hydrocooling until fruit core temperature drops to about 4°C (39°F). Initial tests indicated no significant adverse effect on fruit

quality for both of these methods. Hydrocooling is for maintaining fruit quality and does not contribute to treatment efficacy.

Back to Objectives

Use of radio frequency energy to control navel orangeworm - *Judy Johnson, USDA-ARS-HCRL, Parlier, CA and Juming Tang, Washington State University*

A small radio frequency oven (27 MHz) combined with heated forced air was used to heat walnuts infested with fifth instar navel orangeworm larvae to 55°C and maintain that temperature for 5 or 10 minutes. Walnuts reached the target temperature of 55°C in about 5 minutes, with total treatment times of 10 and 15 minutes. All treatments resulted in 100% mortality of navel orangeworm.

Back to Objectives

Use of radiofrequency energy and hot water as an alternative to methyl bromide fumigation for California 'Bing' sweet cherries - *Xuqiao Feng, Bill Biasi, and Elizabeth Mitcham, Pomology, UCDavis*
Cooperating Personnel: Jim Hansen, USDA, ARS, Wapato, WA; Juming Tang and Shaojin Wang, Washington State University; Steve Drake, USDA, Wenatchee, WA

California cherry fruit exported to Japan must first be fumigated with methyl bromide due to the possibility of codling moth infestation. This fumigant is currently being phased out of use in the US for soil and structural fumigation; however, an exemption exists for quarantine treatments. Despite this exemption, there are concerns about potential future regulatory action, and the availability and cost of methyl bromide. Therefore, there exists a need to develop alternative quarantine treatments. A number of hot air and hot water treatments have previously been tested using 'Bing' sweet cherries. Although some results from tests using Washington fruit appeared promising, California fruit were unacceptably damaged by all treatments. California 'Bing' sweet cherries heat to 122°F (50°C) in approximately 5 minutes by water heating. However, increases in fruit pitting and decay were noted after 1 or 2 weeks of storage following hot water treatment.

Experiments in Washington were more promising. Shorter heat treatments at higher temperatures had less effect on the quality of California "Bing' cherries. Use of osmoticum ($CaCl_2$) in the water was not able to reduce fruit damage at the higher temperatures required

for insect mortality. Radiofrequency (RF) heating allows cherry fruit to be heated to insecticidal temperatures in as little as 2 min as compared with 5 min or longer by hot water heating (Ikediala et al. 2001). In addition, RF treatment could be accomplished on-line because of the treatment speed. Based on the preliminary results, the following aspects will be focused on this year: 1) determine the heat tolerance characterics of California 'Bing' cherries and compare with Washington Bing cherries; 2) determine the tolerance of California 'Bing' cherries to radio frequency heating and conduct tests of heating uniformity in saline solutions; and 3) determine the response of codling moth larvae to radio frequency heating.

Back to Objectives

Application of Radio Frequency Treatments to Control Insects in Walnuts
- Xuqiao Feng, Bill Biasi and Elizabeth Mitcham, Pomology, UCDavis
Cooperating Personnel: Juming Tang and Shaojin Wang, WSU; Judy Johnson, USDA-ARS, Fresno; Jim Hansen, USDA-ARS, WA

The goal of this project is to develop practical and environmentally friendly technologies for the walnut industries to meet phytosanitary requirements for domestic and international commerce using RF energy. Postharvest walnut losses are caused by direct feeding damage and by contamination with infesting insects in the field and/ or during storage. The three most economically significant of these pests are codling moth (*Cydia pomonella*), Navel orangeworm (*Amyelois transitella*), and Indianmeal moth (*Plodia interpunctella*). Methyl bromide (MeBr) fumigation of walnuts is routinely used to meet commercial phytosanitary requirements to control these insect pests. A potential alternative disinfestation treatment involves the use of radio frequency (RF) energy. Our preliminary results show that RF heating to 131°F (55°C) with hot air holding for at least 5 minutes resulted in 100% mortality of the fifth instar Navel orangeworms with no negative effects on walnut quality. We have also demonstrated that the insects heated faster than the walnuts. It would appear that RF heating has excellent potential as a disinfestation method for in-shell walnuts. This year we will study scaling-up small-scale treatment protocols to commercial processes and the possibility of using RF to control insect pests and at the same time reducing non-uniform moisture content in washed in-shell walnuts. We will also refine treatment protocols with infested walnuts to reduce treatment times and increase throughputs, determine effects on walnut quality following long term storage, and conduct sensory analysis of walnuts treated with the refined protocol. A laboratory demonstration will be carried out at UCDavis for industry.

Back to Objectives

Use of Radio Frequency Energy to Control Insects and Microorganisms in Harvested Almonds - *Xuqiao Feng, Bill Biasi and Elizabeth Mitcham, Pomology, UC-Davis*
Cooperating Personnel: Juming Tang and Shaojin Wang, Biological Systems Eng., WSU; Linda Harris, Food Science and Technology, UCDavis; Judy Johnson, USDA ARS, Parlier, CA

The California almond crop is currently treated before and during storage with chemical fumigants, primarily phosphine, for postharvest control of navel orangeworm, peach twig borer and various stored product beetles. Recent issues with Salmonella contamination have highlighted the need for an acceptable treatment to reduce bacterial populations on raw almonds. Currently, propylene oxide is mainly used to reduce bacterial populations. There is an increased interest in reducing the use of chemicals on foods, particularly after harvest, and a non-chemical treatment for almond disinfestation and microbial control is desirable. Radio frequency (RF) heating has the potential to control insect pests and reduce microbial populations on almonds after harvest. Our preliminary work with navel orangeworm indicates that disinfestation of the fifth instar -- the most heat resistant lifestage -- requires heating to 131°F and holding at that temperature for 5 minutes. In walnuts, this temperature is achieved in 5 minutes with RF energy and it is possible for this time to be shorter with higher energy input. As to the reduction of microbial populations on almonds after harvest, a combination of radio frequency heating with high humidity may be required for lower time/temperature combinations that result in a "closer to raw" product. We will first determine if beetles and peach twig borer are more resistant to heating than navel orangeworm and then conduct small and large-scale tests with almonds infested with navel orangeworm larvae or other more resistant species determined to confirm the temperature required for complete control. After investigation on the use of radio frequency heating and combinations of this with high humidity to control *Salmonella* Enteritidis and *Aspergillus flavus* on harvested almonds, effects of radio frequency heating for control of insects and for control of microorganisms on almond quality will also be determined. Finally, large-scale tests of heating uniformity within a bed of almonds will be conducted.

Back to Objectives

Use of Radio Frequency Energy to Control Insects in Harvested Pistachios - *Xuqiao Feng, Bill Biasi, and Elizabeth Mitcham, Pomology, UC-Davis*
Cooperating Personnel: Juming Tang and Shaojin Wang, Biological Systems Eng.,

WSU; Judy Johnson, USDA ARS, Parlier, CA

Quality, safety and marketability of California pistachio nuts are reduced by damage from several insect pests, of which Navel orangeworm and Indian mealmoth are the primary concerns. Pistachios are currently treated during storage with chemical fumigants, primarily phosphine, for postharvest control of these insect pests. In addition, some raw pistachios must be fumigated with methyl bromide for export shipment, and there are some preshipment treatments with methyl bromide for the domestic market. A potential alternative disinfestation treatment involves the use of radio frequency (RF) energy. Our preliminary research with walnuts has shown that the temperature of the walnut kernel increases rapidly to the level (53-55°C) adequate for insect control. This short treatment does not cause quality deterioration in comparison with untreated kernels. We will conduct small and large-scale tests with pistachios infested with navel orangeworm larvae, the most resistant species, to confirm the temperature required for complete control, then determine effects of RF heating on control of insects on pistachio quality. In addition, large-scale tests of heating uniformity within a bed of pistachios will be conducted.

Back to Objectives

Objective 6: Use of natural enemies for biological control and increased understanding of basic biology of postharvest insect pests and decay organisms.

Controlled atmosphere, temperature management and granulosis virus for Indian mealmoth control - *Patrick V. Vail, Laboratory Director, USDA-ARS, 9611 S. Riverbend Avenue, Parlier, CA*

Large scale tests on integrated pest management of Indianmeal moth (IMM) larvae in dried fruits and nuts have been completed. These tests incorporate controlled atmosphere, temperature management, and the granulosis virus (GV) isolated from the IMM. The GV was applied to walnuts, almonds, and raisins as a long term protectant. Samples of the respective commodities were observed for damage and moth emergence monthly over a two year period. Complete protection was observed after a four month period and high levels of activity (reduction in moth emergence) were observed for over a year.

Back to Objectives

Recovery of *Habrobracon hebetor* in dried fruits and nuts by DFA inspectors - *Judy Johnson, USDA-ARS-HCRL, Parlier, CA*

An exemption exists that allows release of parasitoids into bulk-stored grains and packaged products in warehouses. However, release of parasitoids into bulk-stored dried fruits and nuts is not included in the exemption. Before IPM strategies using parasitoids can be implemented in dried fruits and nuts, data must be generated to support a similar exemption. Samples of dried fruits and nuts containing known numbers of *Habrobracon hebetor*, a common postharvest parasitoid, were submitted to the Dried Fruit Association for standard quality inspections and filth analyses. Inspectors recovered most of the parasitoids placed in prunes, walnuts, almonds and pistachios, but were less successful at recovering parasites from raisins and figs. Additional work is needed to determine the degree to which normal processing may remove parasitoids from finished product. Back to Objectives

Effect of Combinations of Hot Water Dips, Biological Control and Controlled Atmospheres for Control of Gray Mold on Harvested Strawberry - *Annette Wszelaki and Elizabeth Mitcham, Pomology, UCDavis*

The efficacy of hot water, biological control and controlled atmospheres (CA), alone and in combinations, in controlling gray mold on harvested strawberry fruit was tested. All fruit were wound inoculated with *Botrytis cinerea* Pers.:Fr.. Inoculated fruit were subsequently dipped in hot water at 63 °C for 12 sec, inoculated with a biological control yeast, *Pichia guilliermondii* Wickerham, and/or immediately stored at 5 °C under air or 15 kPa CO_2 for 5 and 14 d

followed by 2 d at 20 °C to simulate market conditions. Fruit treated with the combination of heat, biocontrol, and CA had significantly less decay than those in all of the other treatments after 5 d at 5 °C plus 2 d at 20 °C. After 14 d at 5 °C and 14 d at 5 °C plus 2 d at 20 °C, the heat + biocontrol + CA treatment continued to control decay though not significantly more than CA alone, biocontrol + CA, or heat + CA treatments. Some damage occurred following heat treatment; however, quality parameters did not differ between treatments. Overall, the combination treatments did not provide better control than the current commercially used treatment of 15 kPa CO_2.

Back to Objectives

UCDAVIS

Postharvest Technology Research Information Center
Department of Plant Sciences
Mail Stop 2, Room 3047 Wickson Hall
University of California
One Shields Ave., Davis, CA 95616-8683
Send comments to postharvest@ucdavis.edu

Ipm/objectives_2002.shtml updated February 10, 2003.