Postharvest Decays of California Pomegranates - Developing Export Markets for California Producers -

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Presentation Overview

- Review of Diseases
- Disease Management – (For domestic and international markets)
  1) Preharvest Practices – clean culture
  2) Sanitation treatments
  3) Sorting and grading
  4) Sampling (2% level after packing)
    - Mainly internal rots – Alternaria/Aspergillus decay
  5) Postharvest fungicides
    - Treatments and rates
    - MRLs or tolerances
### Postharvest decays reported on pomegranates*

- Decays are caused by fungi.
- Internal decays may be initiated from insect damage (research needed).

<table>
<thead>
<tr>
<th>Decay*</th>
<th>Organism</th>
<th>Location</th>
<th>Potential CA crop loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gray Mold</td>
<td><em>Botrytis cinerea</em></td>
<td>CA, FL</td>
<td>ca. 50%</td>
</tr>
<tr>
<td>Aspergillus decay</td>
<td><em>Aspergillus niger</em></td>
<td>CA, AZ, TX</td>
<td>ca. 1-2% (&lt;6%)</td>
</tr>
<tr>
<td>Alternaria Decay</td>
<td><em>Alternaria sp.</em></td>
<td>CA</td>
<td>ca. 1-2% (&lt;6%)</td>
</tr>
<tr>
<td>Blue-Green Mold</td>
<td><em>Penicillium expansum</em></td>
<td>CA, FL</td>
<td>ca 1-5%</td>
</tr>
<tr>
<td>Dry Fruit Rot</td>
<td><em>Nematospora coryli</em></td>
<td>CA</td>
<td>Insect Dependent</td>
</tr>
<tr>
<td>Coniella Fruit Rot</td>
<td><em>Coniella granati</em></td>
<td>NC</td>
<td>---</td>
</tr>
</tbody>
</table>
Pomegranate blossom tissues colonized by *B. cinerea*

Harvested fruit

Mature flower

Colonized flower parts and decayed fruit
Gray mold caused by *Botrytis cinerea*

- Most important decay of pomegranate
- Flower parts are infected at bloom time
- Infections remain quiescent until fruit ripening
- Extended blossom period: bloom treatments not economical.
- The fruit crown that is covering the blossom parts prevents highly effective use of preharvest treatments and postharvest sprays.

Internal decay originating at blossom crown
Infection begins in the orchard especially following rain during flowering and early fruit development. The fungus may grow within the fruit without external symptoms. Infected fruit generally is of lighter weight and off-color. Insect damage sometimes associated with Aspergillus decay.
Infection begins in the orchard especially following rain during flowering and early fruit development. The fungus can grow within the fruit without external symptoms. Infected fruit generally is of lighter weight and off-color. Insect damage associated with Alternaria rot.

Estimated losses usually less than 1% but can be up to 6%.
Korean Pomegranate Export Protocol

Quarantined Pests

a. Diseases/Pathogens (2 species)
   - Alternaria Decay (*Alternaria* sp.)
   - Dry Rot (*Nematospora coryli* – Ascomycetous yeast)*

b. Insects (12 species)
   - Pepper fly (*Atherigona orientalis*)
   - Striped mealybug (*Ferrisia virgata*)
   - Filbert worm (*Cydia latiferraena*)
   - Codling moth (*Cydia pomonella*)
   - California red scale (*Aonideiella aurantii*)
   - Grape mealybug (*Pseudococcus maritimus*)
   - Pink hibiscus mealybug (*Maconellicoccus hisutus*)
   - Citrus peel minor (*Mamara gulosa*)
   - Black scale (*Saissetia oleae*)
   - Citrus thrips (*Scirtothrips citri*)
   - Omnivorous leaf roller (*Platynota stultana*)
   - Locust bean moth (*Apomyelois ceratoniae*)

* - Stigmatomycosis – a plant disease caused by fungi that are inoculated by insects.
### Regulatory status of postharvest decays of pomegranates in CA

<table>
<thead>
<tr>
<th>Decay</th>
<th>Organism</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gray Mold</td>
<td><em>Botrytis cinerea</em></td>
<td>Non-Quarantined</td>
</tr>
<tr>
<td>Black Heart Rot</td>
<td><em>Aspergillus niger</em></td>
<td>Non-Quarantined</td>
</tr>
<tr>
<td>Alternaria Decay</td>
<td><em>Alternaria sp.</em></td>
<td>Quarantined</td>
</tr>
<tr>
<td>Blue-Green Mold</td>
<td><em>Penicillium expansum</em></td>
<td>Non-Quarantined</td>
</tr>
<tr>
<td>Dry Fruit Rot</td>
<td><em>Nematospora coryli</em></td>
<td>Quarantined</td>
</tr>
</tbody>
</table>

Two fungal decays are listed for quarantine action:
- Alternaria decay (because the species was unknown)
- Dry fruit rot because it is reported as a stigmatomycosis disease in CA (Fawcett 1929).
Korean Pomegranate Export Protocol

Protocol 2008-2012

a. California pomegranates for shipment by air or sea
b. Orchards and packinghouses registered with APHIS
c. Traceability of lots through entire harvest and export process

Field Requirements (Orchards must be registered)

a. Old fruit and dead branches removed
b. Pickers, graders, and officials trained in the ID of Alternaria decay
c. Korean export fruit segregated from other fruit lots
d. Fruit must be disinfected with 200 ppm Cl solutions for 45 sec
e. All package labeling coded for: orchard, PH, and “for Korea”

Export Inspection and Treatment

a. 2% of each consignment before shipment
b. Sealed containers
c. MB fumigation in US or in Korea (under APHIS or NPQS oversight)
d. NPQS inspection of paperwork, sealing and ID, then fruit inspection
Decay management in the field

- No pre-harvest fungicide treatments are available or effective for preventing all diseases

- *Korean Protocol* -
  - Clean Culture: Removal of dead branches and mummified fruit from orchard
  - Training of pickers and graders to exclude internal decays of fruit during harvest and packing (e.g., shaking of branches by hand prior to harvest to remove potentially diseased fruit)
Decay management in the packinghouse

- **Korean Protocol** -
  - Optimum storage to prevent decay
  - Sanitation – Chlorine washes
    - Concentration: 200 ppm
    - Exposure Time: 45 sec
    - Rinse with Water
  - Fruit sorting and grading -
    - Remove all off-colored fruit
    - Remove fruit with injuries and cracks
- **Industry Guidelines** -
  - Fungicide applications to prevent gray mold
Fruit sanitation

After bin dumping fruit are being washed with chlorine solution.

No phytotoxicity on fruit at rates up to 200 ppm chlorine for 1 min exposure.
Fruit sorting

Remove fruit with
- Discolorations
- Light weight
- Cracks
- Splits
- Bruises
- Sunburn

Fruit with internal *Alternaria* or *Aspergillus* decay – are often discolored (off-colored) and are of lighter weight.
Optimal storage conditions for pomegranates

- 7°C (45°F) for longer than 2 months
- 5°C (41°F) is acceptable for up to 2 months
- 90-95% relative humidity.
- CA of 5% Oxygen + 15% Carbon dioxide, especially if storage for longer than 3 months is desired.
Current and future postharvest fungicides for gray mold decay management of pomegranate in the US

- Phenylpyrroles
  - Fludioxonil (Scholar)
  - Fenhexamid (Judge)

- Hydroxyanilides (SBI-III)
  - Pyrimethanil (Penbotec)

- Anilinopyrimidines
  - Fludioxonil

- Premixtures
  - Fludioxonil + Cyprodinil (Switch)

- Polyoxins
  - Ph-D

*Reduced risk fungicides* is an EPA classification of a pesticide with:
1) Low environmental impact
2) Greater human and animal safety
3) Compatible with IPM programs
4) Used at lower rates

- MRLs established within Codex; Only Scholar has FAT registrations in Japan.
### Pomegranates

- Use Scholar as a postharvest dip or drench for the control of Botrytis fruit rot in pomegranates.
- **Do not make more than one postharvest application to the fruit.**
- Scholar is stable in chlorine solutions and at 60°C.

### SC (Soluble Concentrate) Fungicide

For Control of Certain Post-Harvest Diseases of Kiwi, Pome Fruit, Stone Fruit, Pomegranate, and Yam

**GROUP 12 FUNGICIDE**

Active Ingredient:
Fludioxonil (CAS No. 131341-86-1) . . . . . . . . . . . . . . . . . . 20.4%
Other Ingredients: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 79.6%
Total: 100.0%

Scholar SC contains 1.92 lbs a.i./gal.

<table>
<thead>
<tr>
<th>Application Method</th>
<th>Disease</th>
<th>Rate (fl. oz)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scholar SC</td>
<td>Botrytis fruit rot</td>
<td>32 fl oz/100 gals</td>
<td>Mix 32 fl oz in 100 gals of water, wax/emulsion, or aqueous wax/emulsion; Dip for 30 sec.; Change after 200,00 lbs of fruit are treated.</td>
</tr>
<tr>
<td>In-line Dip/Drench</td>
<td>Botrytis fruit rot</td>
<td>16 oz/100 gal</td>
<td></td>
</tr>
<tr>
<td>Scholar WP</td>
<td>Botrytis fruit rot</td>
<td>16 oz/100 gal</td>
<td></td>
</tr>
<tr>
<td>In-line Dip</td>
<td>Botrytis fruit rot</td>
<td>16 oz/100 gal</td>
<td></td>
</tr>
</tbody>
</table>
Implications concerning the two labels:

• Potential label issue with regulatory agencies
• Potential for pathogen resistance to develop if the crop is treated once with each formulation (repeated exposure to the same chemical that has the same mode of action may result in selection of less sensitive isolates)
  • **High Risk:** Cull fruit that are treated multiple times and then returned to orchard or dumping
  • **Low Risk:** All treated fruit are shipped out of the packinghouse and not stored
• Potential for MRLs to be exceeded when multiple applications are done.

Research goal: Register alternative modes of action with international MRLs established. Currently registering Switch (fludioxonil/cyprodinil), pyrimethanil, and polyoxin-D and others.
Commercial treatment of pomegranates

Fruit are moved into a dip tank with fungicide solution, excess fungicide is being drained from fruit, fruit coatings are applied, and fruit are dried in a dryer.

Scholar 50WP /Scholar SC
Rate: 16 oz to 32 fl oz/200,000 lb

Judge 50WG
Rate: 24 oz/200,000 lb
Efficacy of fungicide dip treatments for management of gray mold of pomegranate

* - Fruit were dipped for 1 min. All treatments were in 20% Decco 251.
Evaluation of commercial Scholar dips against gray mold

RESULTS

3 months storage:
Control 12.2% decay
Treated 1.6% decay

5 months storage:
Control 27.2% decay
Treated 5.5% decay

Postharvest fungicides:
Scholar (fludioxonil) and Judge (fenhexamid)
New postharvest treatments for management of gray mold of pomegranates
Efficacy in the presence of sodium hypochlorite

Dip treatments were done for 15 sec. Fungicide solutions with chlorine were prepared 24 h before use. Fruit were incubated for 8 weeks at 55F.

<table>
<thead>
<tr>
<th>Inoculated fruit</th>
<th>No chlorine</th>
<th>With chlorine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>Ph-D 16 oz</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Penbotech 500 ppm</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td>Scholar SC 16 fl oz</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td>Switch 16 oz</td>
<td>b</td>
<td>b</td>
</tr>
</tbody>
</table>

Recommendations for packinghouses:
Chlorine mixed into the Scholar dip treatment has little to no affect the efficacy of the fungicide.
Effectiveness of fungicide application methods for management of postharvest decays of pomegranate

Aqueous applications of fungicides followed by CDA carnauba wax treatments.

Treatments were for 15 sec. Drench applications were done using an in-line, re-circulating system.
New postharvest treatments for management of gray mold of pomegranates

Dip treatments were done for 15 sec. Drench treatments were done on an experimental packingline on a roller bed. Fruit were incubated for 8 weeks at 55F.

Treatment of inoculated fruit

Graph showing the incidence of gray mold (%): Control, Penbotec 500 ppm, Scholar SC 16 fl oz, Switch 8 oz, Switch 16 oz.
Efficacy of postharvest fungicides for managing fruit decays of pomegranate

<table>
<thead>
<tr>
<th>Status</th>
<th>Fungicide</th>
<th>A.I.</th>
<th>Gray mold</th>
<th>Penicillium decays</th>
<th>Black heart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registered</td>
<td>Scholar</td>
<td>Fludioxonil</td>
<td>+</td>
<td>+</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>Judge</td>
<td>Fenhexamid</td>
<td>+</td>
<td>-</td>
<td>---</td>
</tr>
<tr>
<td>Pending</td>
<td>Switch</td>
<td>Fludi/Cypro.</td>
<td>+</td>
<td>+</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>Penbotec</td>
<td>Pyrimethanil</td>
<td>+</td>
<td>+</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>Ph-D</td>
<td>Polyoxin-D</td>
<td>+</td>
<td>-</td>
<td>---</td>
</tr>
</tbody>
</table>

Black heart (*Aspergillus niger* and *Alternaria* spp.) cannot be managed by postharvest treatments.
# Pesticide Residues in Food

## Maximum Residue Limits; Extraneous Maximum Residue Limits

<table>
<thead>
<tr>
<th>Commodity</th>
<th>MRL (undef)</th>
<th>Footnote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple pomace, Dry</td>
<td>20</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Basil</td>
<td>10</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Basil, dry</td>
<td>50</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Beans (dry)</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>Beans, Shelled</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Beans, except broad bean and soya bean</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Blackberries</td>
<td>5</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Blueberries</td>
<td>2</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Broccoli</td>
<td>0.7</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Cabbages, Head</td>
<td>2</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Carrot</td>
<td>0.7</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Cereal grains</td>
<td>0.05</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Chives</td>
<td>10</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Chives, dry</td>
<td>50</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Citrus fruits</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Cotton seed</td>
<td>0.05</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Cucumber</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Dewberries (including boysenberry and loganberry)</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Edible offal (mammalian)</td>
<td>0.05</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Egg plant</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Eggs</td>
<td>0.05</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Grapes</td>
<td>2</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Kiwifruit</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Lettuce, Head</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Meat (from mammals other than marine mammals)</td>
<td>0.01</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Melons, except watermelon</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Milks</td>
<td>0.01</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Mustard greens</td>
<td>10</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Onion, Bulb</td>
<td>0.5</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Onion, Spring</td>
<td>5</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Peas (dry)</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>Peas (pods and succulent=immature seeds)</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Peas, Shelled (succulent seeds)</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Peppers, Sweet</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pistachio nuts</td>
<td>0.2</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Pome fruits</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Potato</td>
<td>0.02</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Poultry meat</td>
<td>0.01</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Poultry, Edible offal of</td>
<td>0.05</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Rape seed</td>
<td>0.02</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Raspberries, Red, Black</td>
<td>5</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Squash, Summer</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Stone fruits</td>
<td>5</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Straw and fodder (dry) of cereal grains</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Strawberry</td>
<td>3</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Sweet corn (corn-on-the-cob)</td>
<td>0.01</td>
<td>Interim MRL (2005-2009)</td>
</tr>
<tr>
<td>Tomato</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Watercress</td>
<td>10</td>
<td>Interim MRL (2005-2009)</td>
</tr>
</tbody>
</table>

* - Pomegranate – US-5; Codex-2; Japan-5; Korea-2; Taiwan-2 ppm.
## Codex MRLs - Fenhexamid

<table>
<thead>
<tr>
<th>Commodity</th>
<th>MRL (undef)</th>
<th>MRL (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almond hulls</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Almonds</td>
<td>0.02(*)</td>
<td></td>
</tr>
<tr>
<td>Apricot</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Blackberries</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Blueberries</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Cherries</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Cucumber</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Currants, Black, Red, White</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Dewberries (including boysenberry and loganberry)</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Dried grapes (=currants, raisins and sultanas)</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Edible offal (mammalian)</td>
<td>0.05(*)</td>
<td></td>
</tr>
<tr>
<td>Egg plant</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Gherkin</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Gooseberry 5
Grapes 15
Kiwifruit 15
Lettuce, Head 30
Lettuce, Leaf 30
Meat (from mammals other than marine mammals) 0.05(*) (fat)
Milks 0.01(*) F
Nectarine 10
Peach 10
Peppers 2
Plums (including prunes) 1
Raspberries, Red, Black 15
Squash, Summer 1
Strawberry 10
Tomato 2

* - Pomegranate – US-2; Codex---; Japan-3; Korea-1; Taiwan--- ppm.

[www.mrldatabase.com](http://www.mrldatabase.com)
Postharvest fungicides for pomegranate

Rates and US / Codex MRLs (tolerances)

• Judge 1.5 lb/200K lb – Fenhexamid: 2 ppm US and ? Codex
• Scholar 1 lb/200K lb – Fludioxonil: 5 ppm US/ 2 ppm Codex

MRLs (Korean tolerances KFDA & KMA)

• Judge 50WDG – Fenhexamid – 1 ppm
• Scholar 50WP – Fludioxonil – 2 ppm

www.mrldatabase.com
Summary of postharvest treatments and handling procedures for pomegranates

1. **Chlorine** - 100 (200 for Korea) ppm in drench and wash bed
2. **Rinse** - Fresh water rinse after chlorine brush bed
3. **Sorting** - Off-colored, low density, injured/decayed fruit removed
4. **Scholar Dip or In-line Drench** – 8-16 oz/100 gal for 15-30 sec
5. **Recycling Dip or Flood Tank Sanitation** - Tank disinfection:
   a. **Chlorine**: 100 (200) ppm sodium hypochlorite
6. **Forced Air Dry on Active Rollers, Fruit Coating, & Drying**: Re-capture fungicide for efficient use, treat with pack or carnauba (w/ fungicide) fruit coating and dry (heated, forced air).
7. **Cold Temperature Storage**:
   Longer than 2 months - 7°C (45°F); shorter - 5°C (41°F);
   high humidity (90-95%), and modified atmospheres (if possible).
Requirements for the Korean Market for California Pomegranates

**Fungal Decay Management**
- Clean cultural production practices
- Chlorine washes at a concentration of 200 ppm (USDA-APHIS inspection)
- Sorting to remove visible off-grades that may contain internal decays (i.e., Alternaria decay)
- Treatment with a postharvest fungicide (e.g., Scholar)
- Fruit inspections

**Insect Management**
- Prevention of insect infestation in orchards
- MB fumigation of fruit lots
- Fruit inspections
Future Regulatory Goals for California Pomegranates and the Korean Market

**Fungal Decay Management**

- Change chlorine washes from current 200 ppm to a standard concentration of 100 ppm
  - Prevent equipment damage
  - Demonstrable efficacy of multiple in-line treatments
    - Wash bed
    - Fungicide tank

**Quarantine lists**

- Remove Alternaria decay from the quarantine:
  - Proper identification of the species
  - Demonstration of ubiquitous distribution
QUESTIONS?