The Need

- Control of postharvest decay is always a concern.
- Many factors influence the potential for decay development:
  - Preharvest field conditions.
  - Harvesting & handling practices.
  - Postharvest temperatures, relative humidity, exposure to ethylene, etc.

Options?

- Preharvest - No reliable replacement yet for Benlate or Topsin.
  - Copper, Aliette, and Phosphorous acid products to reduce Brown rot.
- Postharvest control measures.
  - Careful handling
  - Optimum postharvest environmental conditions
  - Good sanitation practices
  - Use of fungicide
    - Must be effective against latent organisms such as Diplodia and Anthracnose

Careful Handling

- Fig. 161. Effects of puncture injury and fruit maturity on the susceptibility of Murcott grapefruit to green-mold infection. (From Nemes and Miriman, 1981.)

Recommended Temperatures

<table>
<thead>
<tr>
<th>Citrus type</th>
<th>Optimum holding temperatures (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grapefruit</td>
<td>50–60</td>
</tr>
<tr>
<td>Lemons, limes</td>
<td>50</td>
</tr>
<tr>
<td>Mandarin-type fruits</td>
<td>40</td>
</tr>
<tr>
<td>Oranges</td>
<td>32–34</td>
</tr>
</tbody>
</table>

Fig. 30. Respiration rates of Murcott sweet orange fruit. (From Yano et al., 1968.)
Relative Humidity

- To low (<85%) = fruit prone to stem-end rind breakdown.
- To high (>95%) = free water (condensation) is likely that will promote decay.
- When fruit is held in plastic containers, such as pallet boxes, the relative humidity should be 90%–98%.
  - However, when fruit is packed in fiberboard cartons, the humidity should be lower (85%–90%) to prevent carton deterioration.

Relative Humidity

- High relative humidity during handling, storage, and transit helps to maintain fruit turgidity and freshness and enhances healing of minor injuries, thereby reducing susceptibility to green mold.
- Excessive fruit brushing on the packingline also promotes water loss and causes abrasions for pathogen entry.
- The best means of reducing water loss is to rapidly handle the fruit under high RH and apply a protective wax coating to retard desiccation.

Sanitation

- Sanitation kills or removes spores of fruit pathogens from the environment.
  - Regularly clean & sanitize the packinghouse and fruit contact surfaces.
  - Remove fruit, leaves, & other trash.
- Remove decayed fruit ASAP (even outside the packing facility)!
- Keep dirty incoming fruit separate from clean fruit going out.
- Use sanitizers in recirculated water and monitor frequently (continuously if possible).
  - Be sure to follow label instructions.

Fuigicides (chemical control)

- Currently Registered Fungicides for Citrus Postharvest Treatments
  - Thiabendazole (TBZ)
  - Imazalil
  - Sodium o-phenylphenate (SOPP)
  - Fludioxonil (Graduate)
  - Fludioxonil + azoxystrobin (Graduate A+)
  - Pyrimethanil (Penbotec)

Postharvest Fungicide MRLs

Global MRL Database (https://www.globalmrl.com)

| Chemical Name                  | U.S. | Canada | CODEX | EU | Japan | Taiwan | Korea (
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Azoxystrobin</td>
<td>15</td>
<td>10</td>
<td>6</td>
<td>10</td>
<td>5</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Fludioxonil (Graduate)</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Fludioxonil + azoxystrobin (Graduate A+)</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Pyrimethanil</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Thiabendazole (TBZ)</td>
<td>10</td>
<td>10</td>
<td>7</td>
<td>5</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
Thiabendazole (TBZ)
- Controls stem-end rot and green mold.
  - Some effectiveness against anthracnose.
  - Does not control sour rot or black rot.
- Recommended concentrations:
  - 1000 ppm (0.1%) as a water suspension.
  - 2000 ppm (0.2%) in a water-based wax.
- Not very soluble in water.
  - Constant agitation required.
- Include a sanitizer (e.g., chlorine) with recirculated solutions.

Imazalil
- Especially effective against green mold.
  - Diplodia and Phomopsis - generally less effective than TBZ.
  - Some activity against black rot.
  - Ineffective against sour rot and brown rot.
- Recommended concentrations
  - 1000 ppm (0.1%) as a water suspension
  - 2000 ppm (0.2%) in a water-based wax
- Not compatible with chlorine.
- Imazalil is on CA’s Prop 65
  - list of substances known to the State to Cause Cancer
  - No Significant Risk Level (NSRL) = 11 µg/day

SOPP
- Sodium o-phenylphenenate, also called
  - 2 Phenylphenol
  - O-phenylphenol (OPP)
- Effective against green mold & sour rot.
  - Little to no control of Diplodia or Phomopsis stem-end rot, or black rot.
- Recommended concentration:
  - 2% aqueous solution, pH at 11.5–12.0 is the most effective treatment.
  - Some include 0.2% sodium hydroxide for pH control, and 1% hexamine to minimize phytotoxicity.

Fludioxonil
- Effective against green mold and Diplodia stem-end rot.
- Much less green mold sporulation control compared to imazalil.
- Compatible with chlorine.

Fludioxonil + Azoxystrobin
- Graduate A+
- Good sporulation control.
Fallglo Tangerines

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Diplodia (%)</th>
<th>Total decay (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>14.36a</td>
<td>23.19a</td>
</tr>
<tr>
<td>TBZ (1000 ppm)</td>
<td>4.31b</td>
<td>11.74b</td>
</tr>
<tr>
<td>Imazalil (500 ppm)</td>
<td>5.65b</td>
<td>11.34b</td>
</tr>
<tr>
<td>Graduate A* (600 ppm)</td>
<td>5.00b</td>
<td>11.25b</td>
</tr>
<tr>
<td>TBZ (1000 ppm) + Graduate A* (300 ppm)</td>
<td>1.35b</td>
<td>4.58b</td>
</tr>
<tr>
<td>TBZ (1000 ppm) + Graduate A* (600 ppm)</td>
<td>1.32b</td>
<td>5.04b</td>
</tr>
</tbody>
</table>

Significance: ***

Dipped 10 sec. in respective solution (all included 100 ppm chloride except Imazalil). Degreened for 5 d (85°F, 95% RH. 5 ppm ethylene). Washed & waxed (carnauba) and stored at ambient temperatures for 35 d.

Pyrimethanil

- Effective against green mold
- Much less effective against Diplodia stem-end rot.
- Not evaluated against other common FL diseases.

Efficacy of selected compounds against brown rot of navel oranges caused by *P. citrophthora* in laboratory studies

Phosphite for Brown Rot

- Phytophthora species
- Often appears from mid-August until rainy periods cease
- Preharvest control methods:
  - Usually, a single application of Aliette, Phostrol, or ProPhyt before the first signs of brown rot appear in late July is sufficient to protect fruit through most of the normal infection period. Provides 60-90 days control.
  - Copper fungicides "may be applied in August before or after brown rot appearance and provide protection for 45-60 days."

Phosphite for Postharvest Brown Rot Treatment

- KPHOS (1.2%) + TBZ (250 ppm)
- Control

Phosphite for Postharvest Brown Rot Treatment

- KPHOS (1.2%) + TBZ (250 ppm)
- Control

Graham et al., 2012

Adaskaveg, 2009

Zhang, 2009
Thank You!

• For more information, visit the UF Postharvest Website

http://irrec.ifas.ufl.edu/postharvest/