

Environmental and Chemical Methods to Reduce Postharvest Decay of Citrus Fruit

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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

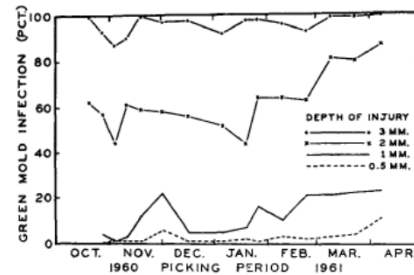


Fig. 161. Effects of puncture injury and fruit maturity on the susceptibility of Marsh grapefruit to green-mold infection. (From Smoot and Melvin, 1961.)

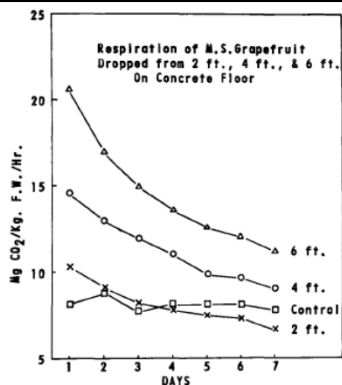
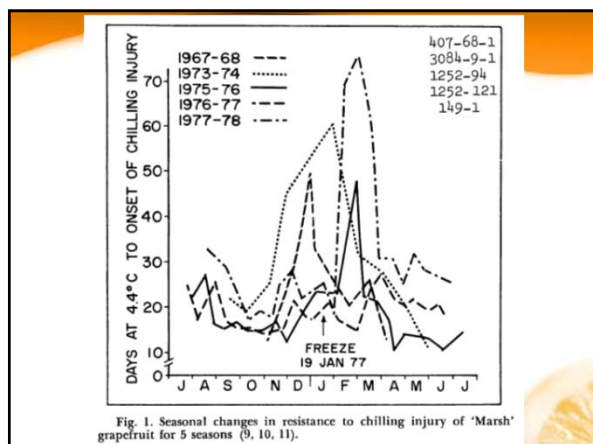


Fig. 83. Respiration rates of Marsh Seedless grapefruit when dropped from various heights onto a hard surface. (From Vines *et al.*, 1968.)

Recommended Temperatures

Citrus type	Optimum holding temperatures (°F)
Grapefruit	50–60
Lemons, limes	50
Mandarin-type fruits	40
Oranges	32–34



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. (Citrus)	Canada (Citrus)	CODEX (Citrus)	EU (Citrus)	Japan (G & O)	Taiwan (G & O)	Korea (G & O)
Azoxystrobin	15	10	15	15	10	10	7 (G); 5 (O)
Fludioxonil	10	10	10	10	10	5	10 (G); 5 (O)
Imazalil	10	5	5	5	5	2	5
Pyrimethanil	10; 11 (L)	10	7	8	10	7	7
SOPP (2 Phenylphenol, O-phenylphenol)	10	10	10	5	10	10	10
Thiabendazole (TBZ)	10	10	7	5	10	10	10

University of Florida

UF/IFAS Postharvest Programs & Information

Home Indian River REC Horticultural Sciences Search

General Postharvest Information

Citrus Packinghouse Newsletter 2010-2015, Index, Archives

Topical Index Postharvest, Maturity & Quality, Diseases & Decay Control, Cold Storage, Sanitation & Food Safety, Marketing

Our goal is to generate and disseminate information so that perishable horticultural commodities are delivered to consumers fresh, safe, nutritious and in the form as e.g. ripe or fresh-cut consumers desire.

Packinghouse Day 2015 Postharvest, Maturity & Quality, Diseases & Decay Control, Cold Storage, Sanitation & Food Safety, Marketing. Details & presentations can be found in the Postharvest Science section. [More...](#)

Pesticide Residues & Limits Look up the latest citrus MRLs for selected export markets and other resources for all commodities. [More...](#)

Food Safety

Mission To support Florida's diverse Postharvest Horticulture industries through research, extension and teaching.

Calendar

- Upcoming Events
- Previous Events
- Extension Calendar

IFAS Resources

- EDIS Postharvest and Handling
- IFAS Extension
- IFAS Research
- College of Agriculture and Life Sciences (CALS)

Careers

- Job Opportunities, Agriscience Society for Hort. Sci.
- Academic Careers

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

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

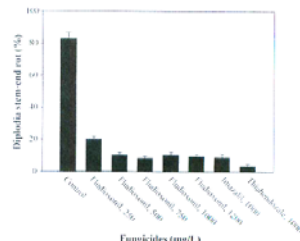
- Especially effective against green mold.
 - Diplodia and Phomopsis - generally less effective than TBZ.
 - Some activity against black rot.
 - Ineffective against sour rot and brown rot.
- Recommended concentrations
 - 1000 ppm (0.1%) as a water suspension
 - 2000 ppm (0.2%) in a water-based wax
- 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-phenylphenate, 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

Treatment	Diplodia (%)	Total decay (%)
Control	14.36a	23.19a
TBZ (1000 ppm)	4.31b	11.74b
Imazalil (500 ppm)	5.65b	11.94b
Graduate A+ (600 ppm)	5.00b	11.25b
Graduate A+ (1,200 ppm)	1.35b	4.58b
TBZ (1,000 ppm) + Graduate A+ (300 ppm)	5.93b	7.96b
TBZ (1,000 ppm) + Graduate A+ (600 ppm)	1.32b	5.04b
Significance	***	*

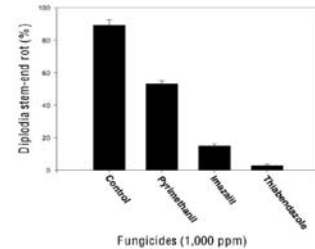
Harvested Sept. 24, 2009,
Dipped 10 sec. in respective solution (all included 100 ppm chlorine except Imazalil),

Degreened for 5 d (85F, 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.



Zhang, 2009

Phosphite for Brown Rot

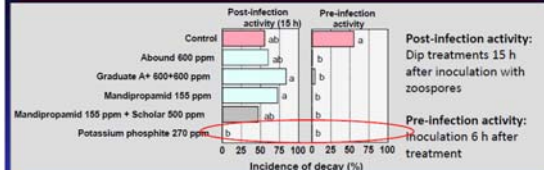


Brown rot

- *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.”

Graham et al., 2012

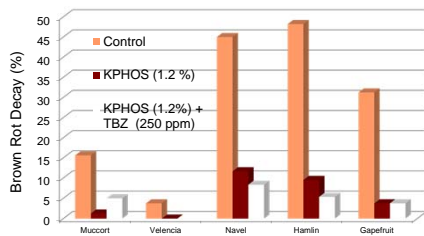
Efficacy of selected compounds against brown rot of navel oranges caused by *P. citrophthora* in laboratory studies



- All treatments evaluated including Abound, Graduate A+, mandipropamid (Revus), mandipropamid-Scholar mixtures, and potassium phosphite (phosphorous acid; Nutriphite, ProPhyt) were highly effective as pre-infection treatments
- Potassium phosphite was the only compound that was effective as a post-infection treatment in this trial.
- Potassium phosphite was also highly effective against brown rot caused by *P. hibernalis* in other studies.

Adaskaveg, 2009

Postharvest Phosphite Treatment to Control Brown Rot



Disease	Months of prevalence	Varietal susceptibility	Treatments*
Brown rot	Aug-Dec	'Hamlin' and 'Navel' orange, grapefruit	Preharvest (Aliette®, 5 lbs/a; Phostrol®, 4.5 pints/a; ProPhyt®, 4 pints/a; copper, label rate)
Diplodia SER ^d	Sept-Dec	All	Bin drench (TBZ ^e or imazalil, 1000 ppm) Packaging (TBZ, 1000 ppm aqueous, 2000 ppm water wax)
Anthraxnose	Sept-Nov	'Robinson' and 'Fallglo' tangerines, 'Navel' orange, grapefruit	Bin drench (TBZ, 1000 ppm)
Green mold	Dec-June	All	Bin drench (TBZ or imazalil, 1000 ppm) Packaging (SOOPP, 2%; TBZ and/or imazalil ^f , 1000 ppm aqueous, 2000 ppm water wax)
Sour rot	Nov-Feb	Specialty fruits	Packaging (SOOPP, 2%)
Phomopsis SER	Jan-June	All	Packaging (TBZ and/or imazalil, 1000 ppm aqueous, 2000 ppm water wax)
Alternaria SER	July-Sept	Oranges and grapefruit (summer storage)	Packaging (Imazalil, 1000 ppm aqueous, 2000 ppm water wax)

* Postharvest materials are specified as ppm or % of active ingredient. Preharvest fungicides except copper are indicated as rates of formulation. Apply Aug-Dec, 30-day preharvest interval. Apply Aug-Dec, 0-day preharvest interval. ^d Stem-end rot. ^e TBZ - thiazobenzole. ^f Use when TBZ residues are a problem for fruit going to juice. ^g SOOPP - sodium o-phenylphenate. ^h Effective for sporulation control on fruit within packed cartons.

Thank You!

- For more information,
visit the UF Postharvest Website

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