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Management of Postharvest Decay of Fresh Citrus Fruits without Using Conventional Chemical Fungicides

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COST
COOPERATION
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*Valencian Institute of Agrarian Research
Postharvest Technology Center (CTP)
Laboratory of Pathology*

Outline

- ❑ Major postharvest diseases
- ❑ Alternative control strategies: NPIDM
- ❑ Postharvest control treatments alternative to conventional fungicides
 - Physical treatments
 - Reduced-risk chemical control treatments
 - Biological control treatments
 - Combination of alternative treatments
 - Adoption of alternative treatments

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Major postharvest diseases



Green mold
Penicillium digitatum



Blue mold
Penicillium italicum



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NPIDM

Non-Polluting Integrated Disease Management

- ❑ Knowledge of pathogen epidemiology and all preharvest, harvest, and postharvest factors that can influence the incidence of postharvest diseases (disease triangle)
- ❑ Take action on every factor at the right moment through non-polluting means to minimize economical losses



Preharvest actions



Actions at harvest



Postharvest actions

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Physical control treatments

Antifungal treatments

- Heat treatments: curing, hot water
- Irradiations: UV-C light, other irradiations
- Gaseous shocks



Complementary treatments

- Cold storage
- Cold storage in controlled (CA) or modified (MA) atmospheres
 - Conventional: low O₂, CO₂
 - Ozonated: 0.1-1 ppm O₃



Heat treatments

Curing (hot air)

- Storage at high temperature (>30°C) y RH (>90%) for 1-3 days



Hot water

- Immersion: 1-5 min dips in water at > 40°C
- Hot water rinsing and brushing (HWRB):
10-30 s at 55-65°C over rotating brushes

Irradiation



❑ UV-C light

- Illumination with far UV light (100-280 nm) at low doses (0.5-8 kJ/m²)
- Different experimental prototypes
- Need to be effectively integrated in the packingline

❑ Other irradiation

- Ionizing radiation: γ rays (radioactive), β rays (electron beam), X rays
- Pulsed light
- Radiofrequency
- Microwaves



Ozonated atmospheres

- ❑ Cold storage in ozone-enriched rooms (0.1-1.0 ppm O₃)
- ❑ Very high oxidant power: workers safety and produce phytotoxicity issues
- ❑ Need to continuously monitor gas concentration



Recent Advances in Alternative Postharvest Technologies to Control Fungal Diseases in Fruits & Vegetables, 2006: 39-70 ISBN: 81-7895-244-0
Editors: Rosalba Troncoso-Rojas, Martín E. Tiznado-Hernández and Alberto González-León

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Ozone applications for sanitation and control of postharvest diseases of fresh fruits and vegetables

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Chemical control treatments

Reduced-risk chemical treatments

Natural or synthetic compounds with known and minimal toxicological effects on mammals and environment

- ❑ Natural compounds
- ❑ Food additives and GRAS compounds
- ❑ Disease resistance inducers
- ❑ Antifungal edible coatings



Natural compounds

□ Plant extracts, volatiles, essential oils

- Acetaldehyde, jasmonates, ethanol, hexanal, citral, flavanones, polymethoxyflavones, coumarins, etc....
- *Thymus* spp., *Mentha* spp., *Myrtus* spp., *Eucalyptus* spp., *Camelia* spp., *Cinnamomum* spp., *Rosmarinus* spp., *Origanum* spp., *Salvia* spp., *Acacia* spp., *Artemisia* spp., etc.
- Extracts from agri-food by-products and waste

□ Peptides and proteins



Food additives and GRAS compounds

- Inorganic salts: carbonates, bicarbonates,... Na, K,...
- Organic salts: sorbates, benzoates, parabens... Na, K,...
- 2-3 min dips in 2-3% solutions. Synergy with heat (40-50°C)
- Cheap, fungistatic activity, low persistence
- Some commercial implementation



Disease resistance inducers

- ❑ Preharvest application, but also postharvest (generally lower activity)
 - Potassium silicate, sodium silicate
 - Salicylic acid (SA)
 - Benzothiadizole (BTH)
 - β -aminobutyric acid (BABA), etc.



Antifungal edible coatings

- ❑ Double function (physiological, pathological): replace conventional waxes formulated with synthetic fungicides
- ❑ Natural: Chitosan, *Aloe* spp. gels,...
- ❑ Synthetic: composite films and coatings
 - Hydrocolloid (proteins/polysaccharides) and lipid matrixes formulated with antifungal ingredients
 - Food additives and GRAS compounds
 - Natural compounds (essential oils,...
 - Biocontrol agents



Outline

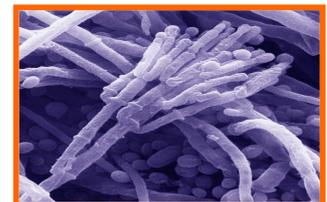
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Biological control treatments

Biological control treatments

❑ Antagonistic microorganisms

- Bacteria, yeasts, filamentous fungi
- Control based on interaction between living organisms. Important worldwide research
- Null effect on ecological balance, high persistence



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Combination of alternative treatments

- ❑ Stand-alone treatments
 - Alternative antifungal methods cannot reach the levels of efficacy, persistence, and broad-spectrum activity of conventional chemical fungicides
- ❑ Combination of two or more treatments
 - Additive or synergistic effects to increase efficacy and/or persistence
 - Complementary effects to obtain both curative and preventive activity
 - Commercial implementation of effective treatments that are too impractical, costly, or risky as single treatments

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Adoption of alternative treatments

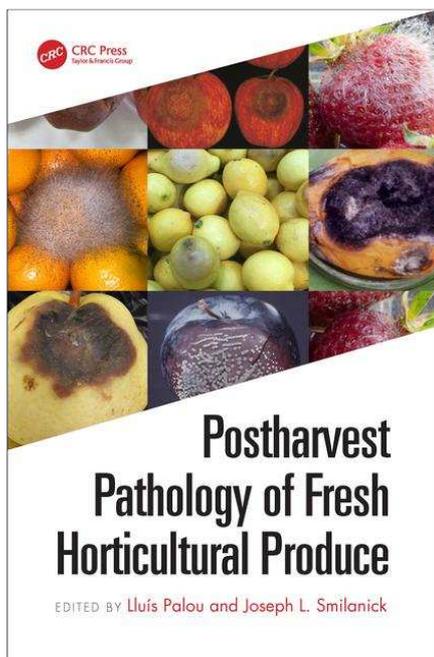
- ❑ Besides the antifungal activity, it is important to determine the effect on treated citrus fruit
 - Effect on analytical and sensory quality
 - Effect on bioactive compounds and nutritional quality
 - Effect on cold storage potential and shelf life



Adoption of alternative treatments

□ Regulatory limitations in the EU

- Only **active substances** (chemicals, antagonistic microorganisms) registered as **plant protection products** (PPP) for this specific use. Included in the EU Pesticides Database
- **Food additives** (EU) or **GRAS salts** (US FDA) need specific approval. Different legislations. Potassium sorbate (E 202) used for aqueous and coating applications.
- **Basic substances** are special active substances not predominantly used as PPPs. Only sodium bicarbonate (SBC, E 500ii) and chitosan are approved for citrus postharvest.



- CRC Press, 2020
- 3 sections:
 - ✓ Main diseases
 - ✓ General aspects of infection
 - ✓ Alternative control means
- 24 chapters, 842 pgs
- 75 authors from 19 countries



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Thanks for your attention!!



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