



Quarantine Treatments

Postharvest Control of
Insects & Other Pests

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Quarantine Pests

“A quarantine pest is a plant pest of potential economic importance to an area that is not yet present there or that is present but not widely distributed and officially controlled.”



Follett & Neven, 2006



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Overview



- World trade in agricultural commodities continues to increase
- Phytosanitary restrictions protect the agriculture in a region – Keeps bad bugs out
 - Should be based on a risk assessment, and not a zero risk
 - Should be based on scientific data, and not politics
- At times, phytosanitary regulations, without sound scientific support, are used as trade barriers



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Overview



- If accepted disinfestation measures are not available, quarantine pests will prohibit marketing of fresh agricultural products
 - Between countries
 - Between geographical areas within countries (e.g., between Florida and other states)



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Overview



- Quarantine or phytosanitary treatments eliminate, sterilize, or kill regulatory pests in exported commodities to prevent their introduction and establishment to new areas



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Treatments


- Treatment protocols are under the authority of the USDA Animal and Plant Health Inspection Service (APHIS)
- This includes overseeing treatment application



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■ ■ ■ Treatments

- Phytosanitary restrictions
 - Often a very high degree of insect control is required before commodities are allowed in
 - “Probit 9 mortality” = the treatment kills or sterilizes 99.9968% of the insect pests
 - ~ 3 survivor in 100,000 insects, or no survivors in 93,613 insects
- See http://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/treatment.pdf for a list of approved treatments




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■ ■ ■ Treatments Protocol Strategy

1. Kill the most resistant life stage of the pest (insect, etc.)
2. Cause NO physiological injury to the host commodity


- That’s a TALL order! And it doesn’t always work...



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■ ■ ■ Treatments


- Postharvest quarantine treatment factors are related to horticultural commodity differences
 - Maturity
 - Variety
 - Source
 - Handling procedures
 - Cost



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■ ■ ■ Treatments


- **Chemical**
 - Fumigation
 - Detergent washes
 - Insecticides
- **Physical**
 - Temperature
 - Cold treatments
 - Heat treatments
 - Irradiation
 - Controlled Atmospheres



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■ ■ ■ Fumigation


- **Most common** type of postharvest insect control
 - both for disinfection & storage
- Often **easy to use and relatively inexpensive**
- Future availability of some fumigants is questionable
 - **Human health issues**
 - **Environmental impacts**



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■ ■ ■ Methyl Bromide (MeBr)

- Most commonly used (general biocide)
- Under the Montreal Protocol (UN treaty):
 - 2005 phase out for developed countries
 - 2015 phase out for developing countries
 - Quarantine treatments & “critical uses” are exempt
- In general, there is a time temperature relationship
 - Higher temperatures require shorter exposure to the fumigant



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Commodities approved for methyl bromide fumigation:

grape	sweetpotato	yam
avocado	cut flowers	root crops
citrus	ornamentals	beans/lentils
pome fruit	leafy vegetables	berries
stone fruit	okra	celery
tomato	asparagus	cucumber
garlic/onion	kiwifruit	melons
pineapple	squash	sweetcorn
nuts	banana/plantain	potato



Schedule varies with target pest

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Phosphine



- Used limited to dried fruit and nuts
 - Fresh commodities often injured
- Slower to act than MeBr and does not penetrate as well
- On dried products, its use is often alternated with MeBr
- Phosphine is a potential carcinogen & its future is in doubt

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Hydrogen Cyanide (HCN)

- Many commodities are injured by HCN exposure
- HCN is also very hazardous to people
- Thus, HCN is not used very often
 - Has been used for citrus






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Physical Treatments

Temperature



- **Advantages:**
 - No residue left on the commodity
 - Relatively safe for workers
- **Disadvantages:**
 - Possible product injury
 - Higher energy costs
 - Treatment times potentially longer

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Cold Treatments

- Approved for a variety of insects on many commodities
- Most effective on insects from subtropical and tropical environments
 - However, crops from these areas are chilling sensitive
 - Potential used of other conditioning treatments to help protect the crops from CI






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Commodities approved for cold treatment:

Plum	Apple	Pomegranate
Nectarine	Pear	Persimmon
Peach	Grape	Passionfruit
Apricot	Citrus	Kiwifruit

Schedule varies with target pest






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Example Cold Treatment Protocol (Mediterranean Fruit Fly)

Days	Temperature*
10	0°C (32°F)
11	0.55°C (33°F)
12	1.11°C (34°F)
14	1.66°C (35°F)
16	2.22°C (36°F)



*Maximum allowable temperature

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Cold treatments can be applied during marine transport



However, if the temperature exceeds the maximum allowable, even by a fraction a degree at one reading, the treatment must be started over

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Conditioning Treatments (for chilling sensitive commodities)



Commodity	Duration	Temperature (C)
Grapefruit	3-7 days	10-30
Mango	1-4 days	36-40
Tomato	<60 minutes	40-55
Avocado	10 hours	38

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Heat Treatments



- Hot water dips, vapor heat, and high-temperature forced air treatments
 - e.g., mango, lychee, papaya, citrus
- Vapor heat was one of the first postharvest insect control methods (1920's)

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Heat Treatments



- Often shorter treatments than cold treatments
 - Size of commodity will affect the rate of heating
 - Therefore, different protocols may exist for different varieties of the same commodity or the same variety produced in different countries.

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Mango Hot Water Treatment

- Min. pulp temp. at start of tmnt. 21°C (70°F)
- Fruit must be submerged >4 inches
- Water must circulate constantly and be min. of 46.1°C (115°F)
- Duration 65 to 90 min. depending on fruit origin, size and shape (variety)
- Fruit may be hydrocooled after hot water tmnt. in water that is max. of 21°C (70°F)
- If hydrocooled: a) wait 30 minutes, or b) hot water treatment must be extended 10 minutes

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Mango Hot Water Treatment

1. Arrival
2. Inspection
3. Pre-sizing
4. Screened treatment area
5. Hot water treatment
6. Hydrocooling

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Examples

- Hot water treatment of mangos (various fruit fly species)

Internal cavitation Scald

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Irradiation Treatments

- Gamma rays**
 - Isotopic sources: cobalt-60 or cesium-137
- X-rays**
 - Electrically driven machine source
- Electrons** from E-beam

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Irradiation as a Quarantine Treatment

- Irradiation is approved for fruits and vegetables up to 1,000 Grays (Gy) (FDA 1986)
- APHIS requires generic minimum doses of 70-400 Gy for various Tephritid fruit flies and other arthropod plant pests
 - 'Generic' in that the required dose is not dependent on the commodity that is being treated, just the pest species

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Irradiation Treatments

- Insect sterilization often requires doses < 300 Gy
- Decay control (esp. fungi) often requires doses > 1,000 Gy
- For required levels of irradiation to the center of pallets, outside product must receive 2-3X the minimum C60 or Cs137 dose
- E-beam requires treatment of individual cartons

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Sterilizing Dose versus Lethal Dose

- Sterilization Dose**
 - 150 Gy for fruit flies
 - 300 Gy for other insects
- Lethal Dose** - varies with species
 - 750 - 1000 Gy

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Irradiation Treatments

- When irradiation is used to sterilize insects, the receiving country must trust the exporters that the live insects they see are really harmless
- Social considerations:
 - US consumers are accepting more. Acceptance by other countries (not Japan, limitations for EU)?
 - Acceptance of irradiation facilities?



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Irradiation Effects on Ripening and Senescence

- Inhibits ripening of subtropicals and tropicals at 250-350 Gy
- Accelerates lemon degreening at >500 Gy
- May see uneven ripening and accelerated deterioration after treatment



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Relative tolerance of selected commodities to doses <1000 Gy

Minimal damage	Inconsistent results	Significant damage
Apple	Apricot	Avocado
Cherry	Banana	Cucumber
Guava	Citrus	Grape
Longan/rambutan	Fig	Green bean
Mango	Litchi	Olive
Muskmelon	Pear	Pepper
Papaya	Pineapple	Sapodilla
Peach/nectarine	Plum	Squash
Strawberry	Loquat	Soursop
tomato		



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Examples of injury (<1000 Gy) which may occur with storage

Commodity	Type of Injury
Avocado	Internal browning; skin discoloration
Lemon / Limes	Formation of cavities along segment walls
Oranges / Grapefruit	Peel damage, including pitting
Table Grapes	Stem darkening
Peppers	Calyx discoloration; accelerated discoloration



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Considerations pertaining to adoption of irradiation

- Some hosts are injured at <1000 Gy
- Sterilization dose vs. lethal dose
- Dosimetry
- Not a substitute for good handling
- Cost and Logistics
- Social Issues




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Controlled Atmospheres

- CA quarantine treatments involve raising the level of CO₂ and/or lowering the level of O₂ in combination with heat or cold to reduce the duration of the lethal treatment and help maintain commodity quality




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Controlled Atmospheres

- Insects vary in susceptibility to CA
- Commodities tend to tolerate low O₂ better than high CO₂
 - >60% CO₂ and/or <0.5% O₂ appear to be the best treatments
- Treatment duration is temperature dependent (higher temps = shorter duration)
- May be used in combination with heat or cold to reduce the duration of the lethal treatment and help maintain commodity quality
- Could be applied during marine transport




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Waxes and Other Coatings

- Presence of coatings can have dramatic effects on responses to quarantine treatments
- Probably due to internal tissue modified atmosphere effects




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Alternative Methods

- **Systems Approach**
 - Integration of numerous biological & physical factors with operational procedures to provide overall quarantine security
 - Can be time-consuming & costly to develop
 - Developed so that if one of the mitigating measures fail, built in safeguards keep the overall risk to negligible levels
- **Eradication**
 - Removal of all target pests from a geographical area, with little chance of normal re-infestation




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Alternative Methods

- Declaration as a **Nonhost** for all or part of its growth cycle
 - E.g., Unblemished, mature green 'Cavendish' bananas from Hawaii can be harvested and shipped to the mainland as a nonhost commodity even though ripe bananas are a preferred host for fruit flies
 - **Fruit flies will not lay eggs on mature green bananas**
 - This can be difficult because the physiological basis for host non-preference or non-suitability by a pest is often not understood




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Alternative Methods

- Establishment of **Pest Free Areas (PFAs)**
 - Officially identified or established areas in which a target pest does not occur and is maintained as such
 - The identity of the commodity must be maintained throughout to prevent mixing with non-certified product
 - Enhanced by geographic (e.g., mountains or large bodies of water) or temporal (i.e., developmental period of susceptibility) barriers




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Experimental Treatments

- New fumigants
 - E.g. methyle iodide, carbonyl sulfide, sulfuryl fluoride, & ozone
- New temperature treatments
 - E.g. used of radio frequency (RF) & conditioning treatments
- Hyperbaric pressure & Vacuum



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