

Alternatives to Hot Water Treatment for Fruit Fly Control

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Hot Water Protocol

- Blamed for many arrival problems
- Systems for heating well designed and managed
 - 107 facilities in Central and South America
- Fruit handling before and after should be improved

Potential Options – near term

- Hot water treatment
- Forced hot-air
- Irradiation
- Controlled atmosphere temperature treatment (CATTs)

Forced-Hot Air

- Commercial systems in use
 - Mexico
 - The Philippines
 - Hawaii
 - Cook's Island
- Research shows less fruit damage than hot water
- More difficult to map thermal variation at start of each season than for hot water
- Potential for failed treatments is higher at present in some facilities
- Engineering improvements to current systems



Forced-Hot Air

- Approved treatment for Mexico to ship to U.S.
 - Forced hot air to center temperature of 48°C, hold 2 min.
- Approved treatment for Hawaii to U.S. Mainland
 - Forced hot air to center temperature of 47.2C in greater than 4 hours
- Similar treatments for other parts of the world

Forced-Hot Air



Irradiation

- Gamma radiation source (cobalt-60), x-ray, electron beam
- Limited facilities on-line
 - Interest in further installations in many countries.
 - Two commercial installations exist in Mexico.

Irradiation

- Mango tolerance in general is better than many fruits
 - Upper limit of tolerance must be determined for each cultivar
 - Determines throughput and cost
- Tolerance varies by variety
- Affect of maturity at treatment must be clarified
 - Some cultivars are less tolerant when mature green
- 150 Grays minimum dose for Mexican fruit fly
- The higher the upper dose tolerance, the easier for operations and it may reduce cost

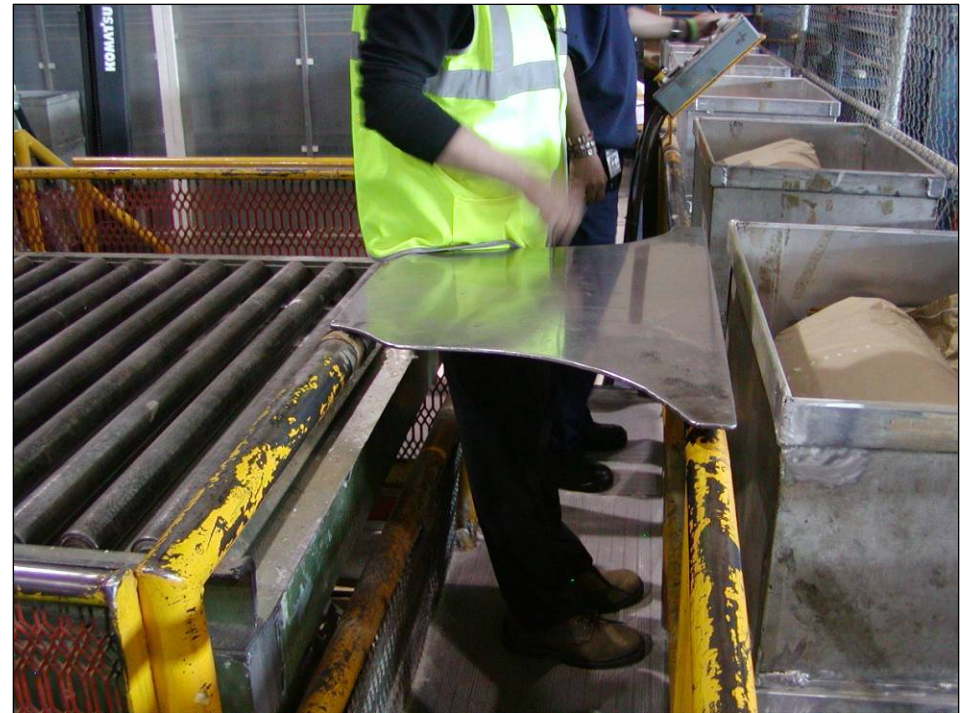
Irradiation – Fruit Tolerance

Variety	Maturity	Dose	Response
Keitt		0.6-0.9 kGy	No damage, sensory good
Tommy Atkins		>1 kGy	Flesh pitting and cell death, softening
Kent	Color break	1.5 to 3 kGy	softening

Irradiation – Fruit Tolerance

Variety	Maturity	Dose	Response
Haden	Mature Green	≥ 250 Gy	Skin scalding
	$\frac{1}{4}$ - $\frac{3}{4}$ Ripe	≤ 750 Gy	No Damage
	$\frac{1}{4}$ Ripe	≥ 750 Gy	Skin scald if treated after 6d at 12C
	$\frac{1}{2}$ Ripe	1 kGy	Skin scald if treated after 6d at 12C

Irradiation Facility



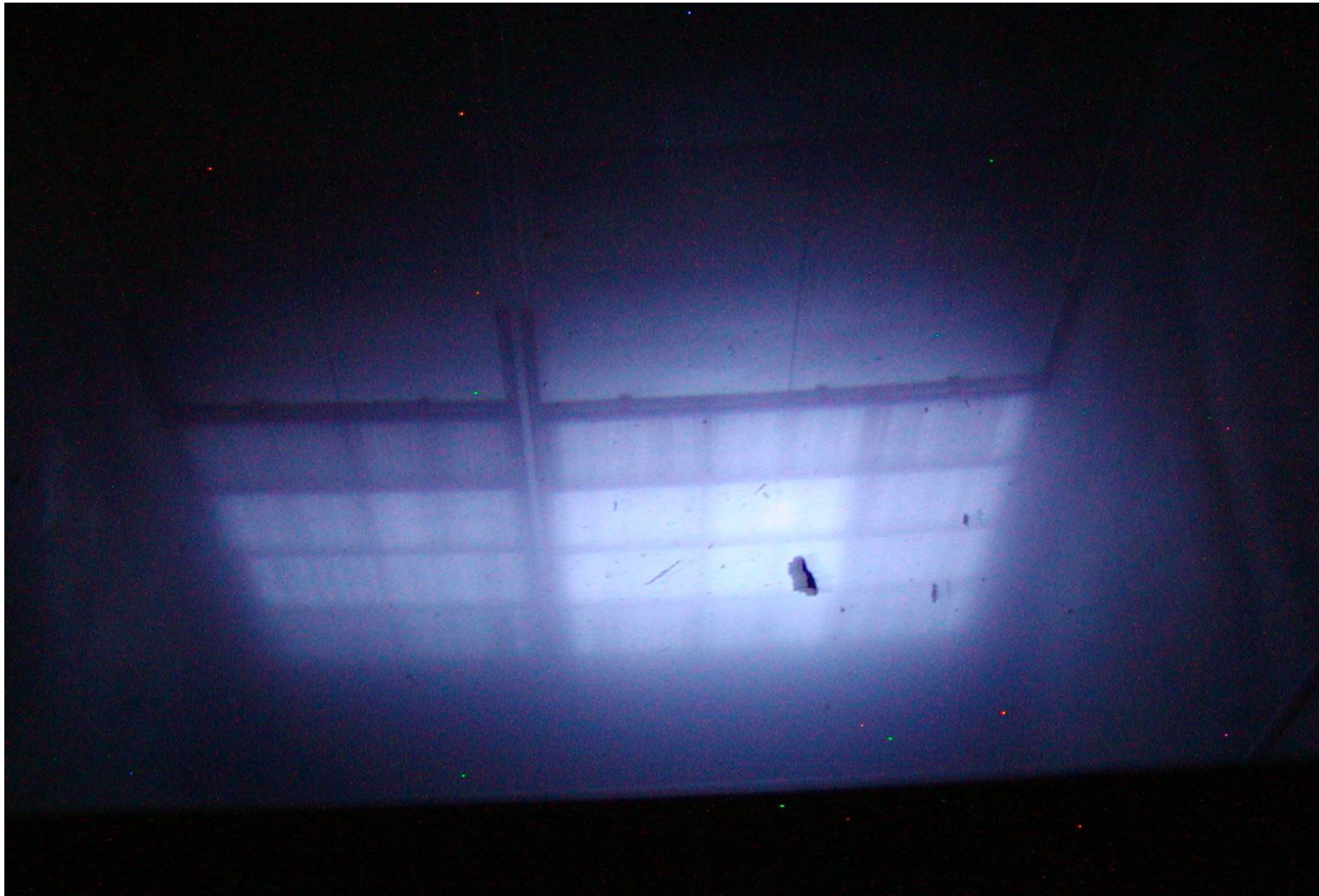
Irradiation Facility



Irradiation Facility



Irradiation Facility



CATTS

Controlled Atmosphere Temperature Treatment

- Controlled atmosphere with forced hot air
 - Nitrogen used to displace oxygen
 - Carbon dioxide added
 - Dual stress on fruit flies
 - Shorter treatment than hot air alone
 - Some commercial units available

CATTS

Controlled Atmosphere Temperature Treatment

- Treatments recently approved by APHIS for exports only
 - Apples: codling moth and oriental fruit moth
 - 12°C/h, 3h, chamber at 46°C with 1% O₂, 15% CO₂
 - Stone fruit: codling moth and oriental fruit moth
 - 12°C/h, 3h, chamber at 46°C with 1% O₂, 15% CO₂

CATTS Facility



CATTS Facility



CATTS Facility



Longer Term Solutions

- Microwave or radio frequency
- Fly Free Zone
- Systems Approach

Microwave or Radio Frequency

- Rapid heating of fruit
- Much shorter than hot water or hot air treatments
- Requires engineering of system to treat fruit in water
- Tolerance has not been thoroughly tested
 - one preliminary study with single fruits
- Uncertain if potential benefits warrant the investment in this technology

Fly Free Zone

- Pest management programs designed to keep pest populations below pest risk levels
- Allow certification of the product in the field based on regulatory requirements
- Trapping array is certified
- Survey data from traps activate various options
 - Continue certification
 - Withdraw certification
 - Initiate suppression measures to return compliance
- Depends on efficiency of trap survey to reliably indicate pest situation in the field

Fly Free Zone

- Common factors in certifying host fruit as originating from fly free areas
 - Geographic separation of production area from infested areas
 - Trapping system to verify absence of fly infestation
 - Maintenance of identify of fruit harvested from certified areas to prevent mixing with non-certified fruit

Fly Free Zone

- Certification criteria may include
 - Sterile fly releases
 - Prophylactic bait sprays
 - Preferred or alternate host removal
 - Utilization of trap crops
 - Inspection for larvae through fruit cutting or incubation procedures

Examples of Fly Free Zone

- Mexican fruit fly in Texas for citrus (1981)
 - Initial rationale
 - Low numbers of flies detected July to April when citrus became susceptible
 - Populations were further reduced with sterile fly releases
 - Limit to Northern distribution of fruit fly area
 - Limited alternative hosts in summer
 - Initial regulatory measures
 - Trap density of 5 per square mile in citrus
 - Limited fruit movement from these areas to specific months of the year (prior to January 1)
 - Suspend certification if 5 or more flies are found

Fly Free Zone in Texas

- Modified program based on concern from other states in U.S.
 - Cutting grapefruit to validate trap data
 - 30,000 before program implemented and 30,000 during first 30 days of program
 - Remove certification if ...
 - 1 larva or 1 gravid female found
 - 1 additional male or nongravid female found in 1.5 mile radius of original find or
 - More than 3 flies found in traps

Fly Free Zone in Texas

- Two to three more years of research to refine and validate plan
 - Year-round dispersal of sterile flies
 - Use of bait spray as needed
 - Use of McPhail traps for surveys

Systems Approach

Integrate biological and operational factors to meet quarantine requirements

Quarantine Considerations

- None of the options are easy to achieve or apply
- The capital investment to move to a new treatment method is always significant, but it is important to invest in alternatives
- Fruit tolerance issues and the chances for fruit damage exist with all treatments
- One option that is strongly recommended is to improve the hot water protocol
 - Large investment in infrastructure
 - Heating portion is running well



Hot Water Treatment Facilities



Hydro-cooling Facilities



Hydro-cooling Procedures

- Most use intermittently or not at all
- Time after hot water
 - a few use 30 minute delay but most hydro-cool immediately if they do hydro-cool
- Length of hydro-cooling
 - 2 to 30 minutes
- Hydro-cooler Water Temperature
 - 21.1 to 31.7°C
- Center Pulp Temperature after Hydro-cooling
 - 36.7 to 42.2 °C
- Fruit often held 12 to 24 hours before packing

Close Stacking After Heat Treatment



Cool Fruit Before Shipment



Steps to Improve Hot Water Treatment

1. Do not treat immature fruit
2. Improve temperature control in hot water tank
3. Hydro-cool all fruit
 - a. To pulp temperature of 27°C (30 min⁺)
 - b. Maintain water at 21 to 22°C
 - c. Sanitize water appropriately
4. Pack ASAP after hydro-cooling
5. Provide overhead fans to keep fruit cooler during holding time with space between stacks
6. Pack fruit as soon as possible
7. Pre-cool fruit after packing with forced-air to 13-15°C
8. Pre-cool container before loading

Overall Recommendation

- Take steps to improve overall fruit handling and temperature management
- Implement consistent and improved hydro-cooling procedures
- Explore other treatment options including irradiation, forced-hot air and CATTs (high temperature CA)

