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Thermal Treatments: An Eco-Friendly Technique for Enhancing Quality of Fruit Crops

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SUMMARY

Postharvest decay is the major limiting factor for the extension of storage life of many perishable commodities. All fresh fruits for domestic and export markets should be free from dirt, dust, pathogens and chemicals before they are packaged. The susceptibility of freshly harvested fruits to postharvest decay increases during prolonged storage as a result of physiological changes that enable pathogens to develop in the fruits (Fallik, 2004). The use of chemical treatments to control insects, diseases and physiological process to extend storage life are potentially harmful to humans, so it has led interest in the use of alternative, non chemical treatments. Therefore, the interest in "non-conventional" methods for postharvest decay control of fruits has become increasingly important. Thermal treatment is one among the possibilities being explored. It has gain importance as a means to controldecay and added benefit of reducing the sensitivity of the commodity to chilling injury, thusextending the storage life by preventing both pathogens and pests attack.

INTRODUCTION

Heat has had a variety of uses since primitive times, such as in cooking and foodpreservation. But its use was limited for pest and decay control. But now it can be used for controlling decay and pest in the form of thermal treatments. Thermal treatments is a process in which a commodity is heated (water or air) until it reaches a minimumtemperature for a minimum period of time according to an official technical specification. Thermal treatment substitute as a non-damaging, physical treatment for chemical prevention.

Mode of Action of Thermal Treatments

Inhibition of pathogen growth

- The mode of action of hot water in reducing decay was investigated by studying the effects of this treatment on the pathogen and on the resistance mechanisms of lemon fruit.
- The hot water dip had a transient inhibitory effect on the pathogen, arresting its growth for 24-48 hours (Couey, 1998).
- During this lag period when the pathogen was arrested, the combined effects of the pathogen and the hot water dip induced to build up the resistance in the peel

Closing cuticle fractures and washing off pathogens from the wax surface

- Additionally, thermal treatment brought the disappearance of wax platelets normally present in untreated fruit and made the fruit surface relatively homogeneous.
- Thus, cuticular fractures, micro wounds and most stomata are partially or completely filled, and early-germinated spores are encapsulated and inactivated by molten wax.
- The occlusion of possible gaps for wound pathogens as well as the encapsulation and inactivation of early-germinated spores have been considered as additional factors in fruitprotection against decay.
- Production of lignin-like compounds in the inoculated sites began within 24hour after inoculation or wounding.
- When inoculation was followed by the hot water dip, lignin-like compounds accumulation continued for a week.

Types of Thermal Treatments

Hot water treatment

Here in this method crops are immersed in hot water before storage or marketing to control diseases. Treatment is generally utilized for fungal pathogen control, since fungal spores are either on surface or in first few cell layers under the peel of fruit. Recommended condition is 51-55 ^{0}C for 30 minutes for effective control of diseases (Porat *et al.*, 2000)

Vapor heat treatment

This treatment was developed to control insect infections after harvest. It consists of stacking the boxes of fruits in a room which is heated and humidified by injection of steam. Vapor method is a method of heating fruit with warm air saturated with vapour between 40 ^{0}C- 50 ^{0}C for 8 hours depending on the crop and variety. The temperature and exposure time are adjusted to kill all stages of insects Birla *et al.* (2004).

Forced hot air treatment

Hot air can be applied by placing fruit or vegetables in a heated chamber with a ventilating fan or by applying forced hot air during which the speed of air circulation is precisely controlled. Treatments using air ranges from 43-54^{0}C for 12-96 hours. It can be used for both fungaland insect control (Armstrong *et al.*, 1989).

Physiological Responses of Fruit Due to Thermal Treatment

- Ripening of heated fruit is delayed- Inactivation ethylene receptors takes place so thatsignal pertaining for further actions will be withheld.
- Decreased rate of softening of fruits due to inhibition of cell wall hydrolytic enzymes likeβ-galactonase
- Reduction in titratable acidity and increase in sugar content of the fruit.
- Respiration rate increases with exposure to higher temperature for intial period, then therate decreases than that of non-heated fruits.
- Thermo-tolerence- During a high temperature treatment the mRNA of fruit ripening genes disappears and those of heat shock proteins accumulate thus providing thetolerance to fruit to withstand the heat.
- Less sensitive to chilling injury-Solely because of HSP (Heat shock proteins), as heat shock protein accumulates during heat treatment, it also protects fruit from chillinginjury.

Advantages Achieved by Thermal Treatments

- Reduces post harvest decay or rots.
- Avoids or reduces the chilling injury of fruits crops during storage.
- Reduces post harvest fungal diseases.
- Maintains the quality of fruits during storage.
- Controlling pests as a quarantine treatment.
- Making the possible use of postharvest fungicides at lower concentrations.

Table 1. Hot water treatments (HWT) for fruit crops, optimal temperature and aim of the treatment.

Crop	Treatment	Optimal temperature	Aim
Mango	HWT	45-50^{0}C(5 min)	Decay control
Banana	HWT	53^{0}C (9 min)	Decay control, Better quality
	HWT	42^{0}C (15 min)	Delay peel blackening
Mandarins	HWT	50^{0}C(5 min)	Better Quality
Papaya	HWT	54^{0}C(4 min)	Decay control
Sapote mamey	HWT	60^{0}C(60 min)	Decay control, Better flesh color
Pineapple	HWT	50^{0}C(3 min)	Decay control
Grape fruit	HWT	50^{0}C(20 sec)	Decay control and chilling injuries
Mandrin	HWT	50^{0}C (3 min)	Decay control

Table 2. Quarantine thermal treatments

Commodity	Target pests	Treatment schedule
Hot water immersion		
Lime	Mealy bugs and other surface pests	49°C or above for 20 min
Longon from hawaii	*Bactrocera dorsalis*	49°C or above for 20 min

Mango	*Ceratitis capitata, Anastrepha spp., Anastrepha ludens*	46°C for 65–110 min, depending o fruit
High-temperature forced air		
Citrus from Mexico, infested ar USA	*Anastrepha spp*	Raise centre of fruit to 44°C ove hold at 44°C for 100 min
Mango from Mexico	*Anastrepha spp*	Until seed surface reaches 48°C.
Papaya from Chile, Belize and Hawaii	*Ceratitis capitata, Bactrocera dorsalis, B. cucurbitae*	47.2°C (fruit centre) for at least treatment time
Vapour heat treatment		
Papaya, pineapple from Hawaii	*Ceratitis capitata, Bactrocera dorsalis, B. cucurbitae*	44.4°C (fruit centre) for 8.75 h (heating rate variable)
Clementine, orange grapefruit fromMexico	*Anastrepha spp.*	Raise centre of fruit to 43.3°C over8 43.3°C for 6 h

Table 3. Combination of thermal treatments with low doses of fungicides

Crop	Thermal treatmentregir	Optimal temperature(°C)/ti	Fungus/pathogen
Banana	Hot water treatment + Prochloraz A	50/5min	*Collechotrichum musae*
Papaya	Hot air treatment + TBZ a	48.5 or 50/4 h	*C. gloeosporioids*
Mango	Hot water treatment + Bavistina	52/10 min	*C.gloeosporioides, Diploidia natalensis*

Table 4. Integration of thermal treatment with other environmentallyfriendly technique

Crop	Thermal treatmentregime	Optimal tempera (°C)/time	Fungus/pathogen
Apple	Hot air treatment + bio-control+ controlled atmosphere	38/4 days	*C. acutatum/P. italicum*
Apple	Hot air treatment + controlled atmosphere + 1-MCP	38/4 days	*C. acutatum/P. italicum/Botrytis ciner*
Strawberry	Hot air treatment + Modified atmosphere packing	45/3 h	*B. cinerea/Rhizopusstolonifer*
Strawberry	Hot water treatment + controlled atmosphere + biocontrol	63/12s	*B. cinerea*

CONCLUSION

In view of consumer’s increasing awareness of the possible harmful effects of chemical fungicides on human health, it is the only reasonable to expect the simple, eco-friendly, safe and chemical free methods, such as thermal treatments. It has gain importance as a means to control decay and added benefit of reducing the sensitivity of the commodity to chilling injury, thus extending the storage life by preventing both pathogens and pests. The use of thermal treatments in combination with other safe treatments or even with very low doses of fungicides can increasetheir efficacy to a satisfactory level.

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