Case History

Control of Pests of Dried Fruits and Tree Nuts by Temperature Treatments

Method of Control: High and Low Temperature Treatments

This method uses temperature extremes to control or kill pests. High temperatures may be obtained with forced hot air, vapor heat, hot water dips, microwaves or other radiofrequencies. Low temperatures may be obtained using freezers, refrigeration or night-air recirculation.

Crop/Commodity: Postharvest raisins, prunes, dates, figs, walnuts, almonds, pistachios, pecans, and other dried fruit and tree nuts. Approximately 2.3 million metric tons of almonds, walnuts, hazelnuts, raisins and prunes are produced world-wide. The United States produces the largest share, about 41 % of these products, with Turkey, Australia, South Africa, Greece, Chile, Mexico, Italy, Morocco, Spain, China, France and India producing significant amounts. (USDA, 1994).

Target Pest(s):

Target insects for these treatments may be divided into two groups, those that infest product in the field and those that infest product in storage. Typically, postharvest pests that infest product in the field do not readily reinfest product once it is in storage. These insects may be of quarantine concern. Postharvest product is continually vulnerable to infestation from pests that attack during storage.

Field pests that are of postharvest concern include:

- codling moth (*Cydia pomonella*)
- raisin moth (*Cadra figuliella*)
- driedfruit beetle (*Carpophilus hemipterus*)
- pecan weevil (*Cuculio caryae*)
- navel orangeworm (*Amyelois transitella*)

Insects of concern during storage include:

- Indianmeal moth (*Plodia interpunctella*)
- Almond moth (*Cadra cautella*)
- sawtoothed grain beetle (*Oryzaephilus surinamensis*)

Summary of Viability:

Because of the wide range of temperatures and application techniques, the viability of this method is not easily summarized. Both the use of low temperatures to manage insect populations and high temperatures for quarantine treatments have been used effectively in other commodities. Quality of dried fruits and nuts is often less effected by temperature extremes than fresh products. Because some drying techniques for dried fruits and nuts include high temperatures, product disinfestation may be achieved by relatively minor changes in current practices. Temperature treatments may best be used in combination with other methods.

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Pest Efficacy and Consistency:

General mode of action and efficacy: A relatively recent review on use of temperature extremes to control stored product insects (Fields, 1992) uses three zones to describe the response of an organism to temperatures: optimum, suboptimal, and lethal. Temperature treatments deal primarily with lethal temperatures, although populations may be managed with suboptimal temperatures. The range of lethal temperatures of either extreme is quite broad, with length of exposure being a critical factor. Different species and developmental stages have different susceptibilities to temperatures. For high temperatures, most stored product insects will not survive more than 24 hours at 40°C, 12 hours at 45°C, 5 minutes at 50°C, 1 minute at 55°C, and 30 seconds at 60°C (Fields, 1992). Fields (1992) also includes a table which summarizes the response of stored product insects to low temperatures.

Viability Evaluation Factors:

a. Tested under full laboratory and field conditions including field tests in Article 5 countries

1. Additional research and field development needed (time and resources) for full evaluation of the control method.

Much basic work on lethal temperatures for postharvest pests of dried fruits and nuts has been done, but for developing countries considering this method, pilot scale studies would be necessary to determine the cost and efficacy for their specific situation.

2. Tested in developing countries (identify countries)

The efficacy of heat treatments for insect disinfestation of stored dates has been studied in Iraq (Al-Azawi et al, 1983a, 1984). High temperatures have been combined with vacuum (Al-Azawi et al, 1983b) and with radiation (Ahmed, et al, 1986) for postharvest dates in Iraq. Low temperature storage of dried apricots, dates, figs and raisins was combined with radiation treatment in Pakistan (Wahid, 1987). The literature contains reports of laboratory studies only.

b. Efficacy with respect to crops and targeted pests

1. Pest efficacy and variability

High temperature treatments: The literature contains numerous reports on lethal limits for various postharvest insects of dried fruits and nuts. As summarized by Field (1992), most will not survive more than 24 hours at 40°C, 12 hours at 45°C, 5 minutes at 50°C, 1 minute at 55°C, and 30 seconds at 60°C. Different developmental stages respond differently, normally eggs and pupae are the most heat tolerant.

Payne and Wells (1974) showed that either a 3 minute exposure to steam, a 3 minute dip in 77°C water or a 5 minute dip in 60°C were effective in controlling pecan weevil. Nelson and Payne (1982) used 40-Mhz dielectric heating treatments of less than one minute to kill pecan weevil larvae in both inshell pecans and pecan pieces, but noted some potential problems with pecan quaity. Wilkin (1987) found that rapid microwave heating of shelled walnuts to 75°C followed by cooling to ambient was effective in controlling various storage insects, and noted that exposure to 60°C for 15 minutes killed all stages of *Tribolium castaneum, Oryzaephilus surinamensis*, *Cadra cautella* and *Plodia interpunctella.* Lindgren and Vincent (1953) obtained 90% mortality of adult nitidulids after exposure to 120°F for from 4 to 20 minutes, depending upon the relative humidity. Al-Azawi, et al (1984) found *Carpophilus hemipterus* adults to be the most heat tolerant, with exposures of from 25 to 60 minutes to 50°C needed to obtain complete mortality. Al-Azawi et al (1983a) obtained complete mortality of *Cadra cautella* after exposure to 60°C for 0.17 to 0.55 hours, depending upon the developmental stage and relative humidity.

Food processors and grain millers have been using heat to sterilize facilities for some time (Sheppard, 1984). High temperatures have been combined with radiation (Ahmed, et al, 1986), vacuum (Al-Azawi et al, 1983b), and controlled atmosphere (Soderstom ???). Some tree nut dehydration methods employ temperatures that are lethal to insects.

Johnson et al (1996) showed that navel orangeworm did not survive pistachio dehydration.

Low temperature treatments: Fields (1992) summarizes the literature concerning the effects of low temperatures on stored product insects. Generally, storing grain at 20°C or less will stop the development of most stored product insects, although lower temperatures are recommended to prevent damage. Johnson et al (1995, 1996) has shown that storage of walnuts or raisins at 10°C will protect product against Indianmeal moth infestation.

Storage of product at temperatures between 0 and 10°C may prevent development of insect populations but will only disinfest product after lengthly (> 2weeks) exposure periods. Disinfestation with more practical exposure periods is possible with sub-freezing temperatures. To obtain 99% mortality of *Carpophilus* pupae, Donahaye et al (1991) required 90 hours at -5°C, 10.35 hours at -10°C, and 2.25 hours at -18°C. Most postharvest insects of dried fruits and nuts can not survive extended exposure to commercial freezer temperatures (-18°C).

Because storage of product at temperatures of between 0-10°C protects but does not give quick disinfestation, low temperature storage may be combined with other disinfestation methods. Johnson et al (1996) sucessfully combined low temperature storage with disinfestation by modified atmosphere to manage insect populations in walnuts and raisins. Johnson et al (1996) used high temperature disinfestation followed by night air recirculation to control insects in postharvest prunes. Low temperature storage of dried apricots, dates, figs and raisins was combined with radiation disinfestation (Wahid, 1987).

2. **Crop impact (yield/quality/storage life) and consistency**

High temperatures Dried fruits and nuts are less affected by heat treatments than fresh commodities. Tree nuts often use high temperatures during dehydration. Payne and Wells (1974) noted that hot water dips and steam used for control of pecan weevil were compatible with normal pecan production. Nelson and Payne (1982) noted a decrease in pecan germination after 43 Mhz dielectric heating treatments, but was unsure of the effect on product quality. Walnuts, because of their high oil content, are susceptible to rancidity when dehydrated at temperatures above 43.3°C (Batchelor and Christie 1924), although Lowe et al (1961) found that short exposures to higher temperatures may be possible. Wilkin (1987) noted that microwave heating to 60°C for 15 minutes did not seem to adversely effect walnut quality.

Maier et al (1964) found that heat processing of dates could be used to improve their color, texture and general quality, provided moisture content was carefully controlled, but noted that temperatures in excess of 60°C could result in off-flavors, off-colors and astringency. Bolin (1976) showed that heat treated raisins remained softer during storage, and were less vulnerable to sugaring.

Low temperatures Both tree nuts and dried fruits maintain their quality better under refrigerated storage at temperatures of 0-5°C (Hardenburg et al, 1986, Norman, et al 1976). Nury et al (1960) noted that extended storage of golden raisins at 10 and 2°C caused sugaring. Freezing seems to have little detrimental effect on dried fruit quality;

soft dates remain in good condition when stored at -18°C for a year (Hardenburg et al, 1986). Most tree nuts withstand freezing (Hardenburg et al, 1986), although the high oil content of walnuts results in the development of rancidity if the product is not used soon after thawing.

3. Potential for methyl bromide emission reductions

Should temperature treatments be used as a substitute for all methyl bromide on postharvest dried fruits and nuts, emissions from these applications would be eliminated. Should temperature treatments be used only for certain specific applications, such as packaged product or quarantine treatments, then methyl bromide emissions would be reduced proportionately.

c. Ease of application

1. Type and ease of application (logistics)

California processors of dried fruits and nuts normally use methyl bromide or phosphine to fumigate incoming product and for as long as a year during bulk storage. Use of fumigants is easily integrated into current handling and storage practices. Substitution of heat treatments, freezing or low temperature storage, in commodities where these temperatures are not already used for other applications, will require major changes in handling methods. Use of refrigeration in bulk storage will require extensive retrofitting of existing facilities. Use of high temperatures for disinfesting dried fruit in storage bins will take longer than current fumigation methods. Tree nuts are often moved in thin layers along conveyor belts, and high temperatures may be applied to these products more quickly. Small scale processors may be able to use transportable freezer units to disinfest their product.

2. Safety (grower, worker, consumer)

Temperature treatments have no direct impact on consumer safety. Workers risk potential exposure to high and low temperatures, but much of the industry already has other applications that use similar temperatures. Reasonable industry standard precautions must be taken to ensure worker safety.

3. Special requirements and restrictions on use

There should be no special requirements or restrictions for use of these methods. Should the method be used for quarantine purposes, the necessary clearances with the importing countries would be required.

4. Potential non-target impacts

This method will only directly effect insects that occur within the commodity or storage environment. Because any insect within the product is undesirable, all may be considered as target species.

d. Relevance to climatic conditions, soil and cropping patterns

1. Geographical areas (acres and climatic conditions)

Climatic variation has little effect on efficacy or practicality. Lack of irradiation equipment in the geographic area where the product is continues to be a problem in many regions.

2. **Soil types**

   Not applicable.

3. **Cropping patterns, rotations, and/or land use**

   Not applicable.

e. Commercial availability

1. **Registration potential/requirements/status**

   Other than for use with quarantine applications, there should be no registration requirements. U. S. Animal Plant Health Inspection Service has registered both high and low temperature treatments for use as quarantine treatments for other commodities.

2. **Commercial availability (materials/engineering)**

   Much of the technology necessary for use of temperature treatments exists in other applications. Several companies are offering small scale temperature treatments for various stored products. To apply these methods to the volumes of dried fruits and nuts produced in California will be impractical, or will require the refinement of existing technoloy.

3. **Technology readily transferable**

   Much of the technology neccessary for these methods exists in other applications. Additional work is needed to transfer these methods to dried fruit and nut disinfestation.

4. **Public/consumer acceptance**

   Provided the methods maintain product quality without increasing product price, the public should readily accept these methods.

f. Economic viability

1. **Direct effects**

   There are no comprehensive studies on the cost of heat treatments for dried fruits and nuts. Costs of such treatment would be high, due to neccessary retrofitting of storage facilities, initial equipment costs, and energy use. Rhodes (1986) showed that to hold the bulk of California dried fruits and nuts under refrigeration would be considerably more expensive than fumigation. Where these methods are already in partial use for other applications, such as low temperature storage of walnuts for quality maintenance, the costs would be lower.

2. **Indirect effects**

   Because these methods may take longer to apply than fumigation, normal product flow may be changed, and may require additional storage facilities.