HEAT TREATMENT: CAPABILITIES AND LIMITATIONS

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Heat treatments are an established, if obscure, method of disinfesting certain empty structures and equipment. Since the anticipated phase-out of methyl bromide fumigants, interest in this non-chemical pest management technique has been growing. Many of the advantages, disadvantages, considerations, observations, costs and results of using heat to disinfest empty food processing and storage structures are situational in reality. Like fumigation with methyl bromide, successful heat treatments depend upon trained personnel, careful preparation, employee cooperation, good weather, etc.

Some possible advantages of a heat treatment include the following:

- Perceived to be less dangerous than fumigation
- Fewer regulations than associated with fumigation
- Can monitor and adjust treatment easier than fumigation
- More effective than fumigation of a "leaky" structure
- More effective against pathogenic microorganisms

Some possible disadvantages of a heat treatment include the following:

- Generally ineffective at penetrating commodities and debris
- Significantly more expensive than a methyl bromide fumigation
- Exposure period may be longer than for a methyl bromide fumigation
- Strong potential for damage to equipment and structure
- Less known about actual heat treatments than fumigations

In spite of all the recent effort put into heat treatments, methyl bromide is still the most cost effective and efficient means of equipment and building disinfestation. However, heat treatments may be a good pest management tool for some situations where fumigation is not recommended (e.g. "leaky" structures or treatment of a small area). Heat treatments may also complement periodic methyl bromide fumigations (e.g. heat rises, methyl bromide sinks). Combination treatments involving heat and methyl bromide synergistically together or heating the structure and fumigating removed commodity and cleanings may allow for reduced use of methyl bromide.

Heat treatments require more sophisticated planning and much more air moving equipment than fumigation. Uneven heating increases the risk of damage and also exacerbating pest problems (short term and long term). Engineers who supervise heat treatments and who do not know pest biology and the hidden locations of pests risk failure. The goal of a heat treatment is not just to raise the temperature inside a structure to a certain level for a certain number of hours. The goal of the heat treatment is to kill all the pest species in whatever life stage they occur and wherever they may be found.

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During one commercial fumigation of a flour facility in 1999, small test vials were placed in 12 high locations, 12 low (floor) locations, and 12 mid-level locations in a large processing/packaging area. Each vial contained a tiny amount of flour with five adult confused flour beetles (Tribolium confusum) or five late instar larvae or approximately five eggs. All test specimens died during the 24 hour heat treatment where the maximum temperatures in the 36 locations ranged from 117^{o} to 152^{o} F. However, some resident insects in low spots (e.g. drains), in building corners, under objects on the concrete slab ground floor and inside small piles of flour inside milling or filling equipment or on the floor survived the treatment. It is interesting to note how adept the pests were at finding and exploiting insulated microenvironments within the treatment area.

To better determine heat sensitivity of stored product insect eggs, an abundance of two day old eggs with 8 grams of flour were placed in a 2 dram plastic vial. Ten mixed adults (parents of the eggs) were contained in a 2 dram plastic vial with approximately one gram of flour. Five common pest species were tested, including confused flour beetle, red flour beetle (T. castaneum), warehouse beetle (Trogoderma variable), saw-toothed grain beetle (Oryzaephillus surinamensis), and Indian meal moth (Plodia interpunctella). A set of ten vials were removed at two hour intervals starting at Hour 8 of the heat treatment. Saw-toothed grain beetle adults were more heat tolerant than the other four species with some surviving through Hour 12. Eggs of all species were more tolerant of heat than the adults however the immobile stage may have been better insulated by the extra flour. Warehouse beetle eggs were most tolerant of the treatment and survived past Hour 12.

One set of vials were placed in a space underneath the top layer of bags of flour on a loaded pallet along with a temperature monitor. The maximum temperature recorded at the vials was 88^{o} F. while the maximum temperature near the loaded pallet was 148^{o} F. All of the insects survived and the eggs seemed to have been stimulated by the heat treatment. More larvae and a more rapid rate of growth were noted 30 days after the heat treatment when compared to the untreated eggs held under the same conditions.

Certainly considerably more field data and experience is necessary before sweeping generalizations can be made on disinfesting an assortment of structures with heat. Questions are more common than answers. Why are there large differences in mortality of insects from the same genetic pool? How important is acclimation (e.g. killing insects in a 120^{o} F. flour mill in the summer compared to a cooler season or cooler region)? What is the optimum pattern of temperature increase to maximize mortality of various pests in the least amount of time while minimizing damage? What is the best (easiest to observe, most difficult to kill) pest to use for monitoring the progress of a heat treatment?

Finally, heat treatments are touted as being nontoxic however exposure to heat can be unpleasant. The risk of heat related maladies are quite real and increases in direct proportion to the time spent in the heated environment. A common problem is a moderately uncomfortable skin irritation or rash for extended periods after the heat treatment. Also, depending on the amount of talking and manner of breathing, irritation of the upper respiratory tract can result from involvement in a heat treatment. It is helpful to be familiar with heat-related illnesses and steps should be taken to minimize heat exposure to humans, particularly to some extremely heat sensitive individuals.