Section: Integrated Pest Management

Optimizing heat treatments for management of stored-product insects in food-processing facilities

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Abstract

Stored-product insects associated with food-processing facilities are managed with fumigants (methyl bromide and sulfuryl fluoride), aerosols, residual products and heat. Heat treatment is safe, effective and an environmentally friendly technology for managing insects in food-processing facilities. Heat is a viable alternative to methyl bromide, a structural fumigant that was phased out in the United States, except for certain critical uses, as of 2005. Heat treatment involves raising the temperature of the whole structure or a portion of it to temperatures between 50 and 60°C, and maintaining these high temperatures for at least 24 h. Optimizing heat treatments requires determining the right amount of heat energy to raise and hold the temperatures for effective disinfestation, predicting insect mortality in "real time" during a heat treatment so that corrective action can be taken to improve efficacy, and stopping the heat treatment when all insects have died.

At Kansas State University, Heat Treatment Calculator software was developed to estimate the heat energy required as well as costs of doing a heat treatment using various energy/fuel sources. The calculator also allows the user to explore "what if" scenarios (alter ambient and threshold temperatures, select a fuel type) of a heat treatment. The calculator was validated during heat treatment of a large pasta facility and the calculator heat energy estimates were compared with company heat energy values based on amount of natural gas consumed. The calculator estimates were within 4% of the actual energy values and cost.

A novel thermal death kinetic model was developed and validated using the heat tolerant stages of the confused flour beetle (old larvae) and red flour beetle (young larvae). The model was based on a logarithmic decrease in insect numbers as a function of time at specific temperatures, and a logarithmic decrease in insect numbers as a function of temperature. The model accurately predicting insect survival as a function of time, and the decrease in survival during a heat treatment was faster at higher heating rates (3-5°C/hour). The model predicts insect survival based only on time-dependent temperature data. This model has been used to show survival curves for data collected from numerous facilities subjected to heat treatments. However, the limitation is that these curves can be generated using a Microsoft® Excel program after data are collected. In most cases, plotting survival curves as a function of time-dependent temperature data revealed that heat treatments can be effectively conducted in 24 h or less.

In order to provide "real time" insect survival estimates based on temperature data during a heat treatment, another software called E.A.R.T.H. (Efficacy Assessment in Real Time during Heat Treatment) was developed. This program requires a base station connected to a computer that sits outside a heated facility. Wireless sensors are placed throughout the facility in designated areas, and during heat treatment these sensors communicate with the base station and transfer "real time" temperature data. The acquired data are used by the thermal death kinetic model to predict insect survival in "real time". The temperature data and the survival curves are displayed graphically for each wireless sensor and the user can view these curves during a heat treatment. This allows the user to determine if certain areas are not heating properly, enabling corrective action to be taken in these locations to improve heat treatment efficacy, such as moving a fan, placing an additional heater, or moving a heating duct. The software has been validated at Kansas State University pilot flour mill and at a commercial facility in 2009. The use

of this software should allow the users to stop a heat treatment when predictions show that all of the insects, in locations where temperatures are being measured, are dead.

A major ready-to-eat breakfast cereal company does heat treatments for 34 h in their large facility at approximately monthly intervals using old steam heaters. Our research at this facility using the tools described here showed that all insects, including the heat tolerant stages, were completely killed within 12 h. As a result the company currently does heat treatments for only 24 h with cost savings of $28,000 per year. The use of the Heat Treatment Calculator software, thermal death kinetic model, and the E.A.R.T.H. software are recent developments, and should be used to improve and gauge facility heat treatments. The use of these tools will improve heat treatment efficacy while at the same time reducing costs to the users.

Keywords**:** Heat treatment, Optimizing treatments, Software programs, Models, Real time data acquisition