OPTIMIZING AND GAUGING HEAT TREATMENT EFFECTIVENESS IN FOOD-PROCESSING FACILITIES

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The concept of heat treatment involves raising the ambient temperature of food-processing facilities to 50-60$^{o}$C and holding these elevated temperatures for 24-36 h. Heat treatment can be optimized by using the right amount of heat energy to raise the building temperature to a target temperature between 50 and 60$^{o}$C during different times of the year, complete heat treatment in 24 h or less, and obtain effective insect kill. Effectiveness of heat treatment against insects can be verified in "real time" by using live insects (confined in dishes) distributed throughout the facility, monitoring insect populations before and after heat treatment intervention by using food and/or pheromone baited traps, and using models that predict insect survival as a function of temperature and time.

Heat optimization techniques mentioned above were explored at three food-processing facilities—a pasta manufacturing facility (A) , a pet food manufacturing facility (B), and a breakfast cereal manufacturing facility (C) during 2006 and 2007.

In facility A, the 43,865 m3 volume of the pasta press area and the 3,396 m3 flour mill area were subjected to heat treatment during July 1-2, 2006. A gas-fired boiler provided the necessary heat and the heat was supplied to each of these rooms through vents in the top of the ceiling. Fans, 5 in the flour room and 24 in the press room were used to redistribute the heat within the rooms. Heat treatment in the flour room lasted 16 h and in the press room for 17 h. Temperatures in the press room were measured using 37 HOBO data-logging units and in the flour room using 12 HOBO units. The average temperature profiles in the two rooms were used to determine the target temperature and duration of heat treatment (rise and hold phases); these values along with measurements of the exposed surfaces, amount of steel, filtration (air exchanges) provided information for the heat energy required. The heat energy required was estimated using the Heat Treatment Calculator software developed at Kansas State University. The actual amount of heat energy used during the heat treatment was determined from gas consumption logs provided by the company, given 70% efficiency of the boiler and the price of natural gas as of July 1, 2007. Our Heat Treatment Calculator estimated heat energy was in agreement with the actual amount of heat energy used, and the costs estimated by our Calculators for heat treating the two rooms was $ 2,498 whereas the actual costs incurred by the company were $ 2,411.   Therefore, the Heat Treatment Calculator is a useful tool to determine approximately the right amount of heat energy required so that the costs of heat treatment can be minimized.

Trap captures of the red flour beetle adults and warehouse beetle adults in the press room (35 traps), flour room (10 traps), and outside (5 traps), showed that insect populations were present in all three locations.  Heat treatment significantly reduced the insect populations and the populations failed to rebound, because of good sanitation and exclusion practices instituted at this facility.

During January 25-26, 2007, facility B (2612 $m^3$ volume) was heat treated for 23 h using steam heaters. Heat was provided with four Hot Breath Heaters (Model CAQ-202–HS-T12, Armstrong Int'l.). The outside ambient temperature was -12 ºC (10 ºF).  The facility walls were insulated with Styrofoam and doors and windows were closed during heat treatment. Most of the floor locations monitored with HOBO data loggers showed temperatures to be below 50ºC and in a few locations closer to the heaters temperatures exceeded 50$^o$C.   The insects in cages placed on the floor were alive after the heat treatment, but insects in bug check cards placed 1 m above the floor were all dead. Overall, the four heaters were not adequate to conduct an effective heat treatment during the winter months.

In facility C, heat treatments are conducted on monthly using old steam heaters, and hence temperature regulation is an issue.  Temperatures exceeded 60$^o$C in many locations and the heaters had to be manually shut down and turned on, resulting in temperature fluctuations at the high end.  The heat treatment was effective on each of the three occasions (June, July, and September) because all live insects in test cages were dead at the end of the heat treatments.  The duration of heat treatment in this facility usually lasted 36 h, and based on our bioassay data it appears that the heat treatment can be completed in 24 h or less.

Data from the three facilities illustrates the importance of optimizing heat treatments by using the right amount of heat energy, using bioassays and insect population monitoring to verify degree and duration of insect suppression obtained due to heat treatment intervention, and conducting heat treatments in 24 h or less.  Heat treatment is an environmentally benign technology, and as the data from the three facilities shows is a viable methyl bromide alternative.  Facility A and C have been using heat treatments successfully for more than 13 years.  It is important to realize that the effectiveness of heat treatment, or for that matter fumigation, can be extended by practicing good sanitation, crack and crevice treatment with residuals, and pest exclusion practices.