HEAT PLUS DIATOMACEOUS EARTH TREATMENT FOR STORED-PRODUCT INSECT MANAGEMENT IN FLOUR MILLS

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One nontoxic alternative for stored-product insect control in food processing facilities is heat treatment. Temperatures necessary to kill many species of stored-product insects have been reported (Fields 1992), and are attainable in most processing facilities. Heat treatments are not new having first been conducted in North America in the early 1900s. This method was not practical in some facilities constructed primarily of wood. Today's construction using steel and concrete, however, can tolerate the high temperatures necessary for effective insect management. While modern building construction can tolerate temperatures in excess of 50°C, some of the equipment in processing facilities cannot. If the temperature requirements necessary for effective control could be reduced, then the heat could be successfully employed in these areas as well. One possible solution is to combine the heat treatment with an application of diatomaceous earth (DE). DE damages the insect's ability to regulate water retention by absorbing the cuticular lipids and causing death by dehydration (Ebeling 1971). The combination of heat plus diatomaceous earth was first evaluated in Canada by Fields et. al (1997) who concluded that, during a heat treatment, beetles exposed to DE died at lower temperatures than beetles exposed to heat alone. The objectives of this study were to further examine the combined impact of high temperature and DE on the mortality of confused flour beetle in a flour mill and to evaluate the affects of DE application rate on insect mortality in the mill environment during heat treatment.

Methods. This study was conducted on the second and third floors of the pilot flour mill at Kansas State University during a heat treatment on March 20-23, 1998. Two areas on each floor were selected to set up the bioassay. One area was located in the north end of each room near the duct where hot air entered the rooms and the other was located in the south end of the room away from the hot air duct. We anticipated differences in the heating rate among the areas, thus allowing us to test the combined heat plus DE treatment in different conditions. Prior to the DE application, plastic sheets were taped to the floor to mask out the insecticidal dust in areas to serve as undusted controls. The DE formulation selected for this study was Protect-It (Hedley Technologies Inc., Mississagua, Ontario). A licensed pest control operator using a Flowmaster Power Duster (Model 1907, Root Lowell Company, Lowell, Michigan) made the DE application. Less than 2 g/m^2 was applied on each floor. Plastic rings were glued to the floor using a removable sealant. The rings were placed on the floor to create 3 DE treatment levels; untreated, DE-treated, and half treated with the midline of the ring transected by the junction of the DE-treated and untreated surfaces. There were 3 rings for each treatment level within each of the 4 replications in the heated rooms. Adult confused flour beetles, 50 beetles per ring, were monitored at 60 min intervals during the heat treatment and the dead insects were removed after each inspection. Effectiveness of the heat and DE treatments was determined by the duration of survival during the treatment, the temperature at time of death, and the percentage of surviving beetles at the end of the heat treatment. Floor temperatures were measured next to each ring using HOBO Temp temperature loggers (Onset Computer Corporation, Pocasset, MA) and the humidity within each replicate was measured using HPBO RH/Temp humidity and temperature loggers.

Results. Temperature, relative humidity and insect mortality data are summarized in Figure 1. The north end of each room heated more quickly and to higher temperatures than did the south end. The relative humidity was about 30% at the beginning of the heat treatment. As the air temperature increased, the humidity initially increased and eventually dropped to 20 to 25 %. The initial increase in humidity, however, was much greater in the south end of each room than in the north end. Because the heated air that entered the room in the northwest corner was probably dryer than the air already present, the more humid air was displaced to the southern end of the room where the moisture dissipated at a slower rate than in the north end.

The temperature gradient substantially impacted the hours of heating necessary to cause 100% mortality. The beetles died more rapidly in the north end of each room where the temperature increased more quickly than in the south end where more time was necessary to attain lethal temperatures. The length of time necessary to kill 100% of the beetles was 25±1 h on the north end of the third floor while this level of control did not occurring on the south end of the second floor during the 64 h that the heat treatment was conducted.

The value of the DE application was evident only on the south end of the second floor where temperatures were lower than in the other heated areas. By the end of the heat treatment in this area, the beetles exposed to the surfaces that were fully or partially treated with DE had mortality levels of about 75% and 50%, respectively, compared to 15% for beetles exposed to heat only. One week after the heat treatment, however, all beetles exposed to heat plus DE were dead while < 1% of the beetles survived that were exposed to heat only. Generally, the beetles exposed to DE began to die sooner than those not exposed. In the areas that experienced higher temperatures, 100% mortality was reached at about the same time and temperature regardless of exposure to the dust.

In areas that are difficult to heat to temperatures lethal to insects, an application of DE appears to be of value. Even if the insects are not killed during a combined heat plus DE treatment, the DE offers residual value for insect control if left in place after treatment. Because of the residual value and nontoxic nature of DE, it may be suitable for use in combination with heat in areas containing heat-sensitive equipment. As the temperature increases, so does insect activity, which causes them to come in contact with DE as they move across a treated surface. Mortality is not immediate, as we frequently expect with traditional chemical insecticides, but will occur after a period of time.

References Cited

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Fig. 1. Floor temperature (°C), percent relative humidity and the cumulative percent mortality of *T. confusum* exposed to heat only or heat plus diatomaceous earth during a heat treatment in the pilot flour mill at Kansas State University. (a) South end of the third floor. (b) North end of the third floor. (c) South end of the second floor. (d) North end of the second floor.

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