DIATOMACEOUS EARTH COMBINED WITH HEAT TO CONTROL INSECTS IN STRUCTURES

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Methyl bromide is used extensively to control insects in food processing facilities. It is slated to be phased-out by the year 2001 in Canada and the United States because it causes significant damage to the Earth's ozone layer. There is a pressing need to find viable alternatives to methyl bromide. Heat treatments to control insect pests of food processing facilities have been used instead of, or in combination with, methyl bromide for more than 15 years by several companies. However, food processors have concerns about heat treatments for various reasons. To address some of these concerns, we began Investigating ways to render heat treatment more effective and less costly.

This report covers the use of an enhanced diatomaceous earth (EDE) formulation in conjunction with heat treatment. Diatomaceous earth PE) damages insect cuticle and causes death by dehydration. We chose Protect-It™, produced by Hedley Technologies, because It is as good as or better than other commercial DE insecticides. A Canadian patent application has been made on behalf of Hedley Technologies Inc. and Agriculture and Agri-Food Canada for using heat treatment in combination with DE.

In both laboratory scale and in commercial scale tests, a synergistic effect of EDE and heat was shown. The insects died faster and at lower temperatures. Laboratory experiments using the red flour beetle (Tribolium *castaneurn) showed* insects treated with the EDE at 3 g/m^2 and 50°C for 30 minutes were all dead one week after the treatment. By comparison, at least 25% of insects exposed only to heat treatment survived.

A field trial was conducted at the Quaker Oats plant in Peterborough, Ontario, Canada during their regular heat treatment on March 14-16, 1997. There were four treatments: Heat with EDE, Heat Alone, EDE Alone (room temperature), and No Heat or EDE (room temperature). Fifty adult confused flour beetles (Tribolium *confusum)* were confined in rings placed on the concrete floor. There were three replicates/treatment. We choose the basement of one of the heat-treated sections, as this is one of the most difficult areas to heat and the heating is more uniform. Floor temperatures were recorded every ten minutes. Survival was assessed once an hour. Protect- (an EDE) was applied using a commercial power duster at a rate of 1-2 g/m^2 , or by measuring EDE into rings at 1, 3, or 7 g/m^2.

Concrete floor temperatures rose at about 0.7°C/hour (1.25°F/hour) for the first 20 hours, and at about 0.25°C/hour (0.5°F/hour) the second 20 hours. The maximum floor temperatures obtained at different locations in the basement were 45 to 49°C (113 to 120°F). In a previous heat treatment, the maximum floor temperatures obtained were 51°C (124°F) in the basement and 56°C (133°F) in the upper floors. Relative humidity started at 19% rh and declined to 5% by the end of the test.

At the end of the test, there was no survival of insects in EDE and Heat treatment, some survival in the Heat Alone treatment, 100% survival in the No Heat or EDE treatment and 0 to 100% survival in the EDE Alone treatment (Table 1). We used two different areas for the EDE Alone treatments. The one used for the power dusting was cooler (17l*C or 630F) than the one used for the measured amounts (22°C or 72°F), and this may account for the differences in survival. Insects were completely controlled in the EDE and Heat treatment after 13-22 hours (Table 2) or when temperatures reached 41°C or IWF (Table 3). Insects that were exposed only to the heat died after 32-38 hours (Table 2) or when temperatures reached 46 to 47°C or 115 to 117°F (Table 3).

These results imply that the cost of heat treatment can be reduced and effectiveness improved through the combined use of heat and EDE. The use of heat and Protect-It™ offers good prospects for success as an alternative to methyl bromide. However, we would like to underline that this test had three elements that are not representative of a full plant application. One, insects were not allowed to escape to untreated areas, which will likely be the case in a full plant treatment. Two, the relative humidity was extremely low (5-19% RH) and in other facilities or at other times of the year, relative humidity could be higher and the effect of the DE may be lessened. Three, in a full plant application, some DE residues will remain, and could continue reducing insect populations after the heat treatment. Therefore, we recommend further work to demonstrate the usefulness of this combination technique on a larger scale.

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The full report is available on the World Wide Web at http://res.agr.ca/winn/home.html or through the authors.

Table 1. The survival (%) of insects after heat treatment was complete.

Application Method	Area	Survival (%)±SEM		Significant Differences[1]
		DE-Treated	Untreated	*
Power Duster	Heated	0±0	9±4	
	Unheated	100±0	100±0	ns
Measured 3 g/m2	Heated	0±0	3±2	ns
Measured 3 g/m2 Doors	Heated	0±0	17±15	ns
Measured 1 g/m2 Floor	Heated	0±0	15±4	*
	Unheated	161±10	100±0	**
Measured 3 g/m2 Floor	Heated	0±0	15±4	*
	Unheated	0±0	100±0	**
Measured 7 g/M2 Floor	Heated	0±0	15±4	*
	Unheated	0±0	100±0	**

1. One-tailed t-test, ns= no significant difference, * = p< 0.05, ** = p < 0.01

Table 2. The duration of survival in heated and unheated areas, with and without Protect-It™.

AppIcation Method	Area	Time of Death	Duration (h)±SEM DE-Treated	Untreated	Significant Differences[1]
Power Duster	Heated	First	11±1	22±0	**
		Median	17±1	35+1	**
		Last	22±1	☹	--
	Unheated	First	☹	☹	--
		Median	☹	☹	--
		Last	☹	☹	--
Measured Amounts 3 g/M^2 Windows	Heated	First	9±0.3	21±2	**
		Median	13±1	35±0	**
		Last	19±2	☹	--
Measured Amounts 3 g/M^2 Doors	Heated	First	6±0	22±0	**
		Median	9±0.3	32±2	**
		Last	15±0	☹	--
Measured Amounts 1 g/m^2 Floor	Heated	First	9±0.3	20±3	*
		Median	14±0.2	36±2	**
		Last	21±1	☹	--
	Unheated	First	12±2	☹	--
		Median	29±3	☹	--
		Last	☹	☹	--
Measured Amounts 3 g/M^2 Floor	Heated	First	6±1	20±3	*
		Median	9±0.4	36±2	**
		Last	15±1	☹	--
	Unheated	First	11±1	☹	--
		Median	16±0.2	☹	--
		Last	27±2	☹	--
Measured Amounts 7 g/M^2 Floor	Heated	First	5±0.3	20±3	*
		Median	9±1	36±2	**
		Last	13±2	☹	--
	Unheated	First	8±2	☹	--
		Median	15±0.5	☹	--
		Last	23±5	☹	--

1. One-tailed kest, ns= no significant difference, * $p< 0.05$, **= $p<0.01$, ☹ not achieved during test

Table 3. The temperature at different levels of mortality in heated areas, with and without Protect-It™.

Application Method	Area	rime of Death	Temperature (*C)tSEM DE-Treated	Untreated	Significant Differences[1]
		First	38.7±1.0	432±0.7	**
Power Duster	Heated	Median	40.0±0.8	46.3±0.5	**
		Last	42.6±0.6	☹	--
Measured Amounts		First	36.6±0.8	40.9±1.2	*
3 g/M2	Heated	Median	37.5±0.5	44.2±1.6	**
Windows		Last	41.5±1.7	☹	--
Measured Amounts		First	35.8±2.0	42.7±0	*
3 g/M2	Heated	Median	37.8±1.1	47.4±0.1	**
Doom		Last	40.2±0.5	☹	--
Measured Amounts	Heated	First	45.5	51.9	*
3 g/M2	(in direct path	Median	48.5	51.9	**
Door	of heated air)	Last	49.9	☹	--
		First	37.5±0.4	41.4±0.9	--
Measured Amounts 1 g/M2	Heated	Median	39.6±0.3	46.4±0.4	--
Floor		Last	41.9±0.5	☹	--
		First	35.7±0.4	41.4±0.9	**
Measured Amounts 3 g/M2	Heated	Median	37.9±0.1	46.4±0.4	**
Floor		Last	40.4±0.1	☹	--
		First	35.2±0.1	41.4±0.9	**
Measured Amounts 7 g/M2	Heated	Median	37.2±0.3	46.4±0.4	**
Floor		Last	39.0±0.8	☹	--

1. One-tailed t-test, ns= no significant difference, * =p< 0.05, ** = p<0.01

☹ Not achieved during test