INTEGRATED PEST MANAGEMENT OF POSTHARVEST INSECT PESTS OF WALNUTS

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The annual production of dried fruits and nuts in California exceeds 1 million tons, worth over $2 billion after processing. Insects cause postharvest losses conservatively estimated at $96 million each year. Currently, postharvest insect control for dried fruits and nuts is dependent on the use of methyl bromide and phosphine fumigants. Various toxicological, environmental, and regulatory concerns and the development of resistance in target pest populations make the future availability of fumigants uncertain. Although several non-chemical methods have been demonstrated to provide either immediate control or sustained protection, no single method provides an economical alternative to fumigation throughout the postharvest system. Our current project seeks to integrate short-term disinfestation methods with long-term protective techniques to overcome the limitations of individual non-chemical methods for walnuts. The test design used a controlled atmosphere of 0.4% O_2 for 6 days as an initial disinfestation treatment, followed by various long-term protective treatments. This report compares the results of the long-term protective treatments. For more detailed information on the initial disinfestation treatment, see *A two-stage low-oxygen treatment to control navel orangeworm and Indianmeal moth in walnuts*, D. G. Brandl and E. L. Soderstrom.

Materials and Methods: Commercial raisin bins (4 x 4 x 2 ft), each filled with 500 lbs of 'Hartley' walnuts, were used in the test. After the initial low oxygen treatment (see Brandl and Soderstrom for details) four bins each were placed under one of the three selected long-term treatments: 1) Indianmeal moth granulosis virus (0.0534 g virus preparation/lb nuts), 2) low temperature (≤10°C), or 3) controlled atmosphere (5.0% O_2). An additional four bins were held as untreated controls. Five mated pairs of Indianmeal moth (*Plodia interpunctella*) were introduced into each of the four treatment rooms each week for 11 weeks. Wing traps baited with Indianmeal moth pheromone (Consep Biolure®) were placed into each treatment room. The traps were monitored each week in the untreated, granulosis virus-treated (GV), and low temperature treated (LT) nuts. The trap monitoring the controlled atmosphere treated (CA) nuts was examined at the end of the test. The entire test was replicated three times.

Just before each long-term treatment began, a 15 lb walnut sample was removed from the surface of each bin. The nuts were passed over a modified raisin shaker and the debris examined for insects. From each bin sample, 100 nuts were opened and evaluated for damage. Additional subsamples were sent to the Diamond Walnut quality control laboratory for an industry standard quality evaluation. Similar samples were taken and evaluated 4, 8 and 12 weeks later from the untreated, GV, and LT nuts; the CA nuts were sampled when the test ended at 13 weeks. At this time, five 100 nut samples were taken from each bin in each treatment room and held for 6 weeks under ambient conditions. The nuts were then examined for the presence of Indianmeal moth adults.

Results: The results of the long term protective treatments are summarized in Table 1. No damage due to Indianmeal moth was found in any of the samples taken at the beginning of the test (0 weeks). During the course of the test, only two live Indianmeal moth larvae were recovered from any of the treated samples; both were found in the GV treated nuts. The highest level of Indianmeal moth-damaged nuts in the treated nuts was found in the GV treatment, but was limited to 0.5%. In contrast, an average of 243 Indianmeal moth were recovered from the untreated control by the 12 week sample; and almost 48% of the nuts were damaged by Indianmeal moth feeding. Also, high numbers of moths were caught in pheromone traps (Fig. 1) in the untreated room six weeks after the beginning of the long-term test. Average moth density in the untreated room rose to more than 800 moths/week by the end of the test. Low numbers of moths (a maximum average of 21/week) were caught from the GV treated nuts. No Indianmeal moths were caught from either the LT or the CA treated nuts. Untreated nut samples taken at the end of each test and held six weeks produced an average of 1271 adult Indianmeal moths/2000 nuts. Similar samples taken from GV treated and LT treated nuts produced averages of 3.7 and 1.0 moths/2000 nuts, respectively. No moths were recovered from samples taken from the CA treated nuts.

Results from the Diamond Walnut quality evaluations are presented in Table 2. Percentages of nuts with severe insect damage were similar to levels found in ARS evaluations, and show that all treatments prevented measurable damage. Treatments had little effect on other standard quality measures, although nuts held at low temperatures showed no change in peroxide levels, all other nut samples showed considerable increases. Casual observations showed that treatments had no effect on taste.

Ancillary studies: Studies to determine the effect of low temperatures on Indianmeal moth reproduction and the persistence of the granulosis virus were also conducted. Indianmeal moth adults were found to survive for several months at 10°C, but females were nearly sterile after 25 days. Eggs were killed after two weeks at 10°C. Results from the GV persistence study are still being analyzed.

Conclusions: The results of our initial tests were encouraging; all three long term protective treatments kept Indianmeal moth populations at acceptable levels. Each of the protective treatments have both advantages and disadvantages. The GV treatment was the least costly and would require little plant modification, but was specific for the Indianmeal moth and, although detectable damage was prevented, did not completely prevent Indianmeal moth development. The CA treatment was very effective, and was more energy efficient than the low temperature treatment, but treatment rooms could not be entered without first purging the atmosphere. The low temperature treatment was energy expensive, but treatment rooms could be entered at will. All three treatments maintained product quality throughout the test.

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Table 1. Damage and infestation levels in walnut samples*

Sample (weeks)	Treatment	% Indianmeal moth damaged nuts (Mean)	Live Indianmeal moth (Mean)
0	Untreated	0	0
	GV	0	0
	LT	0	0
	CA	0	0
4	Untreated	1.0	2.0
	GV	0.1	0.3
	LT	0	0
8	Untreated	10.1	36.0
	GV	0	0
	LT	0	0
12	Untreated	47.7	243.0
	GV	0.5	0.3
	LT	0.1	0
	CA	0	0

* Samples could not be taken from the controlled atmosphere treatment at 4 and 8 weeks.

Table 2. Diamond Walnut Quality Evaluations

Sample (weeks)	Treatment	% H_2O	Peroxide Values	% free fatty acids	% Damage		
					Insect	Rancid	Total
0	Untreated	3.09	0.43	0.20	3.4	0.0	9.1
	GV	3.09	0.39	0.24	2.9	0.2	8.6
	LT	3.10	0.28	0.21	2.2	0.4	9.4
	CA	3.15	0.35	0.22	2.6	0.1	11.7
12	Untreated	3.25	0.60	0.30	58.7	0.0	62.9
	GV	3.14	0.65	0.30	5.3	0.1	11.6
	LT	3.23	0.29	0.28	3.7	0.2	10.9
	CA	3.09	0.61	0.25	5.0	0.1	11.3

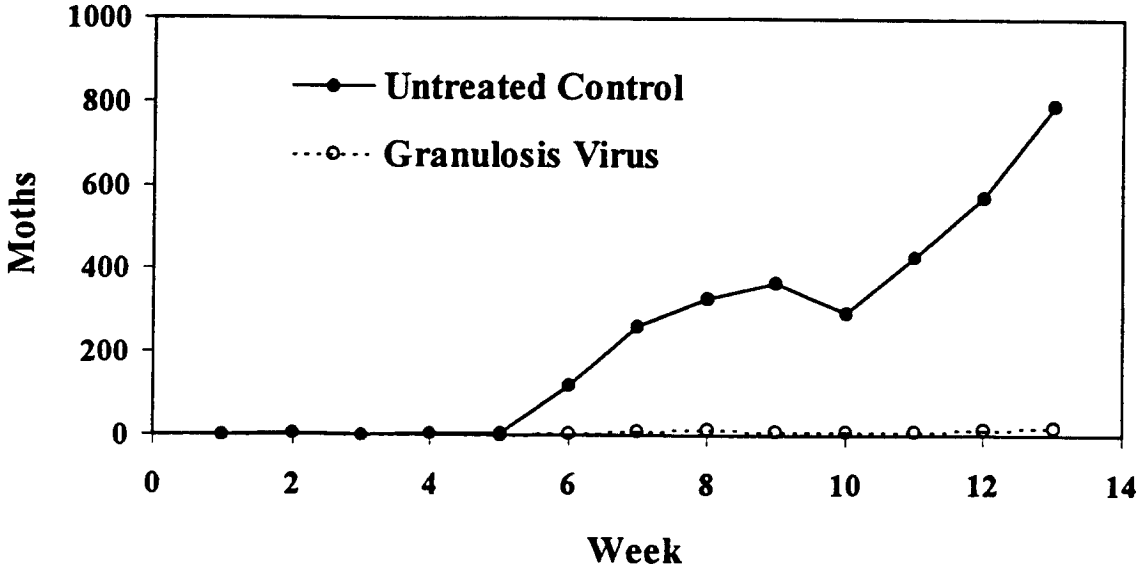

Figure 1. Average number of Indianmeal moths caught in pheromone traps in rooms containing untreated and granulosis virus treated nuts.