LOW PRESSURE TREATMENTS FOR CODLING MOTH ON FRESH FRUITS

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Codling moth, *Cydia pomonella*, is an important quarantine pest of fresh fruits such as apples, pears and cherries. The primary phytosanitary treatment used for exports to markets requiring quarantine protocols is fumigation with methyl bromide. Whereas Quarantine and Pre-Shipment (QPS) treatments are currently allowable under the Montreal Protocol, there is growing concern that the QPS exemption will eventually be lost. Consequently, alternative treatment protocols are being considered. Low pressure treatments, coupled with low temperatures and carefully regulated humidity, has been shown to prevent product deterioration caused by bacterial and fungal decay, and prevent wilting and fruit ripening during storage. This project looks at using these treatments to disinfest stone fruits of the various life stages of the codling moth.

Methods

Lab-scale VivafreshTM (Model RDC-0005, Atlas Technologies) LP systems using aluminum chambers (0.152 m^3) were used (Fig. 1). A two-stage rotary vane vacuum pump coupled with a sub-atmospheric regulator maintained precise pressures. Chamber pressure was monitored with a digital pressure gauge. A rotameter adjusted the air exchange rate, and ingoing air was humidified in order to keep the humidity near saturation (100%). The air exchange system was important in maintaining humidity and removing metabolic plant products such as ethylene. Relative humidity was measured with wet-bulb and dry-bulb temperatures using thermisters; similar thermisters were used to record temperatures inside the chamber and the chamber wall. Data from temperature and pressure sensors were sent to a computer control and recording system. The chambers were held in cold rooms set at the desired treatment temperatures; chambers were covered with foam insulation to reduce variation in temperature. Temperatures, humidities and pressures under various operating conditions were recorded. Preliminary tests at 10 mm Hg at 4 and 10°C to determine the codling moth life stage most tolerant to the treatment used lab-reared eggs, 7 d old larvae, 14 d old larvae and pupae.

Results

Temperature, pressure and humidity measurements show that the low pressure system is operating well within the desired limits. By adding 1.3 cm of foam insulation to the outside chamber walls, variation in chamber air temperature was reduced to ±0.04°C, which prevented condensation on the inner surface of chamber walls. Average relative humidity varied from 98.4-99.35%. In particular, the pressure regulators operated well with the air exchange system (Fig. 2), providing a means to maintain high humidity levels and prevent ethylene build up while keeping pressure variations to a minimum.

As expected, increasing treatment temperature from 4°C to 10°C reduced the treatment time needed for control (Table 1). There also did not appear to be any difference between mortality levels in continuous low pressure treatments and those in treatments where the pressure was released periodically to remove test insects. This will allow a single chamber to be used for multiple exposures, reducing the time needed to conduct dose response studies.

The egg stage appears to be the most susceptible to the low pressure, low temperature treatment, contrary to the results from earlier studies at 25 and 30°C in walnuts. In the first test, 100% mortality of the eggs was obtained after 20 days at 4°C alone, whereas mortality for the larval and pupal stages ranged from 20-47%, suggesting that the low temperatures may be partly responsible for the relatively high egg mortality. In the second test, 10 days at 10°C had little effect on egg hatch, but the low pressure treatments, even the shortest exposure, resulted in high mortality. The relatively high tolerance of the larvae and pupae may be due to the high humidity of the treatment. In earlier studies treatments were done at about 60% relative humidity, and larvae were found to be more susceptible to low pressures at lower humidity levels.

Conclusions

The laboratory low pressure system was shown to hold treatment parameters to the necessary limits. Preliminary studies with test insects indicate that large larvae and pupae may be the most tolerant stage, but more replicates are needed. Tests at 4°C show that treatments in excess of 20 days would be needed, and that to reduce the treatment time, increasing the temperature to 10°C may be necessary.

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Figure 1. Diagram of low pressure system, including vacuum, air exchange, pressure release and measurement systems (lines with arrows indicate gas flow; without arrows indicate signal transmission)

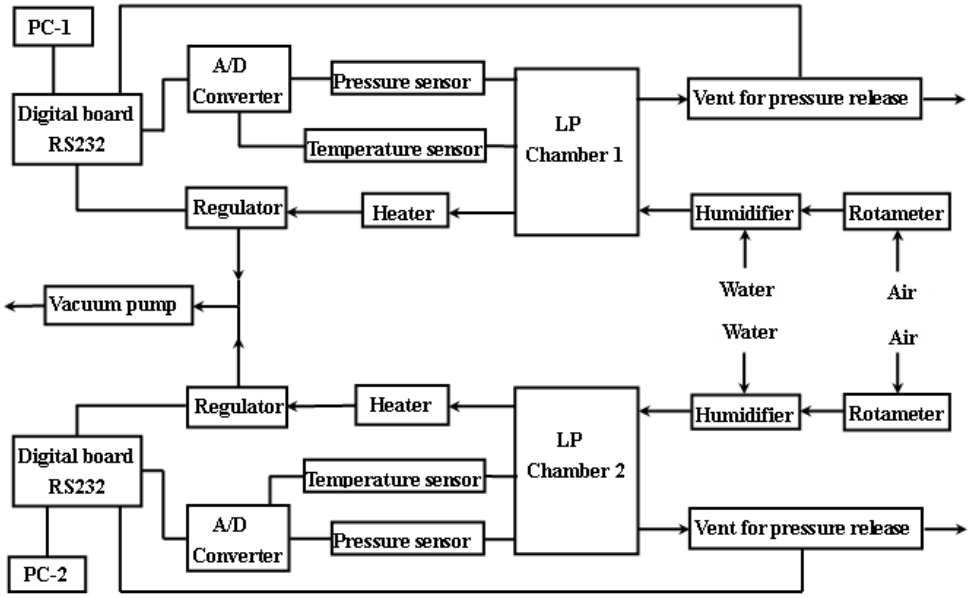

Figure 2. Hypobaric chamber pressure stability at 10, 25, and 50 mm Hg at 4°C with air exchange rates of 1, 0.2, and 0.1 vol/h, respectively

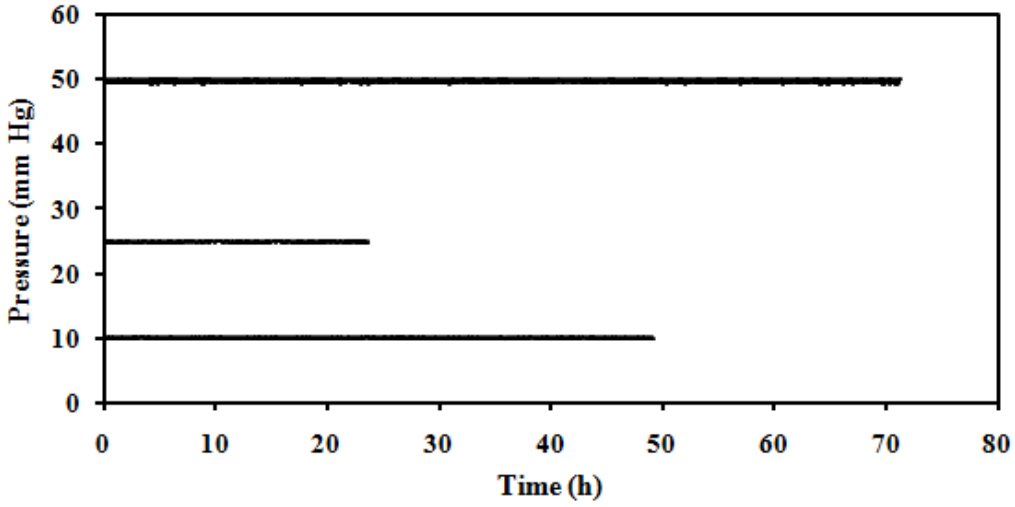

Table 1. Response of various life stages of codling moth to low pressure, low temperature treatments; values are % mortality

Treatment	Life Stage			
	Eggs[1]	7 day larvae[2]	14 day larvae[2]	Pupae[2]
Test 1 ï 10 mm Hg at 4°C				
Control	26.7	0.0	0.0	0.0
LP - 5 d *	89.7	30.0	16.7	14.3
LP - 10 d *	100.0	50.0	36.7	17.1
LP -15 d *	100.0	75.0	46.7	34.3
LP - 20 d *	100.0	95.0	56.7	37.1
LP continuous ï 20 d	100.0	97.5	60.0	57.1
4°C only ï 20 d	100.0	42.5	46.7	20.0
Test 2 ï 10 mm Hg at 10°C				
Control	39.7	0.0	0.0	0.0
LP - 6 d *	99.4	50.0	45.7	41.7
LP - 8 d *	100.0	86.1	48.6	61.1
LP - 10 d *	99.4	91.7	68.6	83.3
LP - 12d *	97.4	100.0	94.3	97.2
LP continuous ï 12 d	98.7	94.4	97.1	100.0
10°C only ï 12d	34.1	5.6	20.0	22.2

* Chamber was opened periodically to remove treatments

[1] % mortality determined by direct counts of hatched and unhatched eggs

[2] % mortality calculated by comparing adult emergence of treatments to controls