A PRELIMINARY EVALUATION OF SOME NATURALLY OCCURRING VOLATILES ON CODLING MOTH EGGS

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Codling moth is a quarantine pest restricting fruit exports to Japan (Wearing 1987). In New Zealand codling moth has one or two generations per year depending on the locality, and the egg laying period extends throughout the summer period (Wearing 1984). Disinfestation of produce for codling moth eggs is necessary because eggs may be present in produce. The use of methyl bromide as a fumigant against codling moth eggs on cherries has been tested (Maindonald *et al.* 1992) but as methyl bromide is an ozone depleting gas, its availability may be limited in the near future. In this study some naturally occurring volatile organic compounds were evaluated as alternatives to methyl bromide.

Codling moths were reared on artificial diet and eggs laid on crinkled waxed paper. The waxed paper with eggs (< 3 days old) was cut into 50 mm x 100 mm rectangles and placed in polythene bags (225 mm x 400 mm, 40 µm thick), with one rectangle per bag. A total of 3920 codling moth eggs were used in the trial and the number of eggs per rectangle ranged from 32-170.

The volatile chemicals were applied with a fumigation apparatus (Fig. 1) which delivered a required concentration of volatile compound in CO₂. The quantity of the volatile to be used in fumigation was calculated by the relationship;

$$V = QCF/M S$$

where V = flow of volatile liquid, ml/min.; Q = flow of CO₂, litres/min.; C = volumetric concentration of volatile vapour in CO₂, litres/litre; F = formula weight of volatile, to g; S = specific gravity of volatile at 20°C, to g/ml; M = approximate molar volume of volatile (taken as 22.4 litres). The calculated quantity of the volatile was delivered by a calibrated peristaltic pump.

Figure 1: Schematic diagram of the fumigation apparatus used in the trial.

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Five aliphatic esters, two aliphatic alcohols, two aliphatic aldehydes and a C6-hydrocarbon (Table 1) were evaluated in this study. These compounds occur naturally in low concentrations in ripening fruit (Nursten 1970) and are responsible for much of the aroma of fruit. Two fumigation temperatures, 10 and 20 °C were used with two replicates at each temperature.

The selected fumigants, all of which are flammable liquids volatilised at 80°C, mixed with the CO₂ stream (100 litres/min), then cooled to room temperature (20°C) before being used to fill the polythene bag for fumigation. This preliminary screening was done with the full understanding that some gas may diffuse out through the polythene over the 3 hour period of the experiment. All chemicals were administered at a concentration of 1% (v/v) in CO₂. The effect of the chemicals in CO₂ was compared with no volatiles in CO₂. The bags containing codling moth eggs on waxed paper and the fumigant chemical were tied by winding a rubber band tightly 10 times round the mouth of the plastic bag to give an air-tight seal in the mouth of the bag under normal conditions. The bags were placed at 10 or 20°C and held for 3 hours. At the end of this period, the waxed paper with eggs was removed from the bag and placed inside a plastic pottle (750 ml). A piece of taffeta cloth (3.2 strands/mm) was placed between the pottle and the lid which had a 90 mm diameter hole for ventilation. The pottles with eggs were stored at 20°C for development. The number of eggs with a developing black-head capsule and hatching of the eggs at 11, 15 and 20 days after the treatment were recorded.

Results were analysed using generalised linear models with logit link and errors proportional to those for a binomial error model. Dunnett's (1955) test was used to test differences from control on the logit scale.

The fumigation temperature had no significant effect on the black-head formation or subsequent egg hatch and the pooled data were used in the analysis. All volatiles except n-hexane showed a significant effect on development of the black-head stage on days 11 and 15 (Table 1). Forty five percent of the eggs had started developing into the black-head stage by 11 days in the CO₂ control treatments. Cumulative egg hatch on day 20 was significantly reduced by acetaldehyde and ethyl formate (Table 1). Propionaldehyde appeared to have some activity ($P < 0.1$).

TABLE 1: Proportion of codling moth eggs at the black-head stage observed on days 11 and 15 and the cumulative egg hatch in 20 days after treatment with the volatile compounds.

Volatile Compound in CO ₂	Day 11		Day 15		Cumulative egg hatch	
	Mean	Std. err.	Mean	Std. err.	Mean	Std. err.
Acetaldehyde	0.00**	0.00	0.00**	0.00	0.00**	0.00
Butyl acetate	0.13*	0.05	0.09*	0.05	0.23	0.05
Butyl formate	0.18*	0.05	0.17*	0.05	0.34	0.09
Ethanol	0.08**	0.04	0.07**	0.04	0.13	0.07
Ethyl formate	0.03**	0.02	0.07**	0.03	0.03*	0.03
n-Hexane	0.37	0.04	0.34	0.05	0.23	0.05
Methanol	0.18*	0.06	0.19*	0.06	0.34	0.09
Methyl butyrate	0.11*	0.05	0.12*	0.05	0.19	0.08
Propionaldehyde	0.02**	0.02	0.02**	0.02	0.03	0.03
Propyl acetate	0.05*	0.05	0.08*	0.06	0.11	0.09
CO ₂	0.45	0.05	0.48	0.05	0.18	0.05

*, ** significantly different from CO₂ treatment at $P = 0.05$ and 0.01 respectively.

The mode of action of the volatiles in affecting egg development is not clear. However, the volatiles probably interfere with the respiration in eggs by diffusing

through the cuticle or into the intricate aeropyles (Hinton 1981) inside the chorion of the egg, affecting oxygen transfer within the egg.

These results with acetaldehyde and ethyl formate agree with other work done overseas (Leesch 1984; Stewart and Mon 1984; Aharoni *et al.* 1987) with natural volatiles in postharvest disinfestation of lettuce and grapefruit. The same authors reported that the volatiles were not phytotoxic at low concentration. The results of the current trial indicate that potential exists for some natural volatiles to be used as fumigants against codling moth, particularly acetaldehyde, ethyl formate and propionaldehyde. In the event of methyl bromide withdrawal natural volatiles may be a practical means of eradicating codling moth eggs from produce, and this aspect of research warrants further studies.

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