# MODELING A GENERIC LETHAL HEAT DOSE FOR MEXICAN FRUIT FLY (*Anastrepha ludens*)

Donald B. Thomas & Krista C. Shellie*. *USDA-ARS Crop Quality and Fruit Insects Research Unit, 2301 S. International Blvd. Weslaco, TX 78596.*

Heat treatments are a viable alternative to methyl bromide fumigation for the disinfestation of fresh fruit and vegetables. The regulation of international and interstate movement of commodities requires treatment efficacies on the order of probit-9 quarantine security levels. Treatments must be efficacious, yet not so severe as to damage the commodity or so consumptive of time and resources as to be economically infeasible.

Fruit fly larvae of the family Tephritidae are the most important fruit infesting insects from the standpoint of quarantine security. The third instar larvae are the most resistant to quarantine treatments. It is known that mortality rates from heat treatments vary as a function of ambient conditions, such as humidity, gaseous exchange, and conductivity of the substrate. These variables likewise affect commodity tolerance. Because the specifications of disinfestation protocols eventually become legislated into mandatory quarantine regulations, it is desirable to identify a uniform set of parameters which will define treatment efficacy in practical terms.

A direct measurement of temperature treatments that result in probit-9 mortality levels would require treatment of millions of third instar larvae. Moreover, the larvae would have to be inside hundreds of thousands of individually infested fruit in order for the measurements to be realistic. Such tests would be logistically impossible. However, we are able to model thermal death rates to give statistically accurate probit-9 estimates with a reasonable number of replicated measurements of mortality at different temperature increments. To generate biologically meaningful data, we simulated rapid and slow heating rates that were relative to the actual fruit center temperature heating profiles of mangoes, grapefruit, tangerines, valencia and navel oranges when exposed to hot water or hot forced air treatments that provide Probit-9 level quarantine security (Figure 1). For example, the Hot Forced Air treatment against *Anastrepha* species listed in the USDA-APHIS PPQ treatment manual requires 300 minutes of exposure to forced air at 46°C. The center temperature of grapefruit exposed to this treatment reached 44°C in approximately 170 minutes. We simulated the rapid and slow heating profiles in computer driven hot water baths. Artificially infested fruit cores were placed into water tight, highly heat conductive metal cylinders. The cylinders were then immersed in the water baths. Thermistor probes were placed in the fruit cores to assure that fruit core temperatures closely tracked the computer controlled water bath temperatures.

We set our computer driven water baths to simulate slow and rapid heating profiles that encompassed a range of actual fruit heating rates (Fig. 1). The slow heating simulation was similar to the heating profile for Valencia orange when exposed to forced air at 46°C. The water bath temperature was heated from room temperature (23°C) to 44°C within 120 minutes (120 minute ramp) and maintained at 44°C for various periods of time. The rapid heating profile reached the same target temperature of 44°C in 20 minutes (20 minute ramp).

Ripe papaya provided the core fruit substrate. Eight day old Mexican fruit fly larvae were introduced to the papaya cores the day before treatment so they were 9 d old at treatment. Holding times tested were from 20 to 60 min with 5 replicates of each treatment. Control cylinders were immersed in water baths at 23°C and had an average of 94.2% survival (survival defined as adult eclosion).

Figure 2 shows the dose/survival relationship with non-transformed data. The survival data for the slow heating rate was applied to the Thermal Kinetic Model which uses log transformed data after Abbott's correction for control survival. This model employs an exponential function k which is the reciprocal of the slope of the regression of dose against survival as a means of linearizing the mortality data for the estimation of the probit-9 treatment dosage. (Thomas & Mangan, 1997. J. Econ. Entomol. 90: 527-534). The probit-9 estimate of our model resulted in a total treatment time of 228 minutes (a 120 minute ramp with a holding temperature of 44°C for 107.7 minutes). The holding time of 107.7 minutes at 44°C falls within the 95% confidence limits of the estimate of 101.7 minutes (Thomas & Mangan 1997) obtained using constant temperatures water baths with naked larvae.

The center temperature profiles for Probit-9 level treatments depicted in Fig. 1 were all at or slightly hotter than 44°C for longer than the 107 minutes predicted by our model, with the exception of the hot water immersion treatment for mango. In this treatment, the center temperature of the mango reached 44°C in only 50 minutes and was maintained at or above 44°C for only 15 minutes. This strikingly less severe heat dose requirement for hot water immersion suggests that heating rate influences mortality of third instar larvae, and that the gas diffusion barrier provided by water during immersion may interact with heat to enhance insect mortality. Valencia oranges exposed to forced air at 46°C took the same amount of time for their center temperature to heat to 44°C as did our slow heating rate model, and their fruit center temperature remained at or slightly above 44°C for approximately 110 minutes, only 3 minutes longer than our predicted Probit-9 holding time requirement.