QUARANTINE TREATMENTS FOR HAWAIIAN FRUIT FLIES: RECENT STUDIES WITH IRRADIATION, HEAT AND COLD

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Hawaii has the potential for increased production of specialty tropical fruits, but export of these commodities to the U.S. mainland and other destinations is prevented by quarantine regulations directed against fruit flies (Diptera: Tephritidae). Four species of pest fruit flies with quarantine status occur in Hawaii: the Mediterranean fruit fly, *Ceratitis capitata,* the oriental fruit fly, *Bactrocera dorsalis,* the melon fly, *Bactrocera cucurbitae,* and the so-called Malaysian fruit fly, *Bactrocera latifrons.* Commodity specific postharvest quarantine treatments directed at the first three species and allowed under USDA regulations are: a hot air/vapor heat treatment for papaya, *Carica papaya;* cold storage treatments for carambola, *Averrhoa carambola,* and "Sharwil" avocado, *Persea americana;* a hot water immersion treatment for litchi, *Litchi chinensis;* and irradiation treatments for papaya, carambola and litchi. To date no treatments have been developed or approved for B. *latifrons,* which is a fly species that infests fruits in the family Solanaceae. Here we report on recent developments of an irradiation treatment for *B. latifrons,* a hot air treatment for fruit flies infesting rambutan, *Nephelium lappaceum,* and progress toward a cold treatment directed at medfly infesting litchi.

Irradiation for B. *latifrons.* Dose-response studies with eggs, first instar larvae, and mature third instar larvae of *B. latifrons* using gamma irradiation for a Co^{60} source determined that the most tolerant life stage was the third instar larva. Additional dose response data from 11,000 larvae treated in diet were subjected to probit analysis. The dose estimated to prevent adult emergence of 99.9968% (probit-9) of treated individuals was 150 Gy. Confirmatory tests of the 150 Gy dose were performed using green bell peppers, *Capsicum annuum,* each artificially infested with 400-800 mature third instar larvae. Emergence of adults from untreated control larvae in peppers was used to estimate the number of adults that could have emerged from treated peppers. After four separate trials of treating infested peppers we calculated that the treatment population represented 157,111 insects that could have developed to the adult stage. No adult *B. latifrons* were recovered from any of these treated insects. Thus 150 Gy can serve as an irradiation treatment against *B. latifrons* to prevent adult emergence with a probit-9 level of security.

Heat Treatment for Rambutan. Fruit flies rarely infest rambutan, however interceptions have been recorded for oriental fruit fly and medfly in this host. Controlled laboratory studies indicated that oriental fruit fly could infest damaged rambutans, and field collections from the Big Island of Hawaii recovered rambutan fruits infested with this species. We developed a hot air treatment for rambutan directed at medfly and oriental fruit fly that was modeled on the currently used hot air treatment for papaya. The

papaya treatment utilizes an end-point fruit center temperature of 47.2°C following an increase in temperature over several hours (USDA APHIS treatment T103b). Studies in an experimental temperature-programmable high temperature forced air chamber found that rambutans would reach 47.2°C in about 1 hour or less when heated at the slowest rate. Some fruit fly immatures survived treatments of infested rambutans that ended when seed surface temperature reach 47.2°C, and also in studies when the seed surface temperature of 47.2° was held for 15 min. Ultimately we adopted the following treatment and applied it to several cultivars of rambutan artificially infested with eggs and larvae of medfly and oriental fruit fly: raise seed surface temperature from ambient to 47.2°C in 1-2 hrs, hold at 47.2° for 20 min (total heating time should not exceed 2 hrs), cool under running water to 25°C or less. Treated population sizes were estimated from the number of pupae resulting from eggs or larvae infesting a sub-sample of untreated fruit. Since rambutan is a relatively poor host for larval development, eggs and larvae were extracted from treated and control fruit following treatment and placed on laboratory diet to complete development. Mortality levels greater than 99.9968% were achieved with this treatment for medfly eggs (n=421,751), medfly first instar larvae (n=170,107), oriental fruit fly eggs (n=143,121) and oriental fruit fly larvae (n= 141,962). Quality losses in rambutan begin soon after harvest and are manifested as blackening of the skin and spinterns; heat treatment accelerates this process. We recommend treating fruit soon after harvest, and store in plastic bags under refrigeration at 10°C following treatment, prior to immediate marketing.

Cold Storage Treatment for Medfly. USDA APHIS currently allows a cold treatment (treatment T107a) to be used against medfly for 17 commodities, from 49 countries. A form of this treatment has been approved for carambola and "Sharwil" avocado from Hawaii. The schedule for the cold treatment includes holding fruit at 1. 1°C or less for 12 days. Initial studies aimed at adopting this treatment for tephritids infesting litchi in Hawaii found eggs of medfly, oriental fruit fly, and melon fly could by killed in litchi at the probit-9 level using 1.1°C for 12 days. However, first instar larvae of these species survived with mortality levels less than probit-9; medfly larvae were the most tolerant at a mortality level of 99.9051 %. Hold time-mortality experiments (dose-response) at 1.1°C with first instar medflies were conducted and regression analyses on these data suggested the probit-9 dose should be approximately 16 to 19 days. Probit 9 level confirmatory experiments (greater than 100,000 insects tested) at 1.1°C yielded mortality levels of 99.8564% at 12 days, 99.9780% at 14 days, and 99.9994% for both 16 and 18 days. Although our results show a treatment is possible at 16 days that can provide probit 9 quarantine security against medfly in litchi, the quality of fruit subjected to this treatment was low. If some level of security less than probit 9 were needed for tephritids in litchi, then a suitable cold treatment could be developed that would minimize loss of fruit quality. Our finding that mortality of medfly larvae in litchi is lower than that found previously for the same species in carambola suggests that host fruit may influence mortality of fruit flies exposed to cold treatments.