FINAL REPORT

WTFRC Project no: CH-01-09

Title: Large scale test of radio frequency radiation as a quarantine treatment against codling moth in cherry

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Objectives:
The objectives of this project were 1) to further improve the repeatability and efficiency of the radio frequency (RF) treatment method; 2) to conduct large scale testing to meet the Ministry of Agriculture, Forestry and Fisheries (MAFF)-Japan requirements, by demonstrating the efficacy of the RF treatment against the least susceptible infesting life stage by using a 30,000 treatment population of codling moth, a major step for official approval of the treatment by Japan; 3) to determine mortality on cherry fruit fly larvae by using the treatment intended for codling moth.

Significant findings:

- A series of tests were conducted to determine efficacy of warm water treatments. Two methods were developed based on cherries were produced: California and Pacific Northwest (PNW).

- For California cherries, the treatment was a 5 min prebath at 43°C (109 °F), followed by warm water exposure, either for 8 min at 48°C (118°F), 6 min at 49°C (120°F) or 4 min at 50°C (122°F), then hydrocool until fruit core temperature drops to about 4°C (39°F). The warm water exposure can be either a bath or a shower.

- For PNW cherries, the treatment was a direct warm water immersion for 6 min at 50° (122°F) or 4 min at 54°C (129°F), followed by hydrocooling until fruit core temperature drops to about 4°C (39°F).

- Initial tests indicated no significant adverse effect on fruit quality for both of these methods. Hydrocooling is for maintaining fruit quality and does not contribute to treatment efficacy.

- We observed no significant difference in the increase of fruit core temperatures between the bath and shower methods.

- The brief cold storage of California fruits had no impact on larval survival.

Methods:

1. Originally, this research was to be done with the RF unit to heat fruits in water. Because the unit did not arrive at the laboratory in for the cherry season, warm water treatments were used instead as surrogates for the RF treatments. These warm water treatments were appropriate because the rapid increase in core temperatures was comparable to that from a RF unit. The cherries were treated using two methods. The first method was conducted on California cherry using a shower

to deliver warm water. The second method was used on PNW cherries using direct immersion. All treatments were done using 50 ppm chlorine to reduce inoculation by pathogens in the water.

2. Immature 'Bing' cherries were obtained from California for early season fruits (average size: 12.3 Row, 5.8 g) and Washington for late season fruits (average size: 12.0 Row, 6.3 g). Codling moth larvae were obtained from the rearing colony at the Yakima Agricultural Research Laboratory (YARL). Each cherry was infested with third instar codling moth, 50 infested fruits per treatment replicate, then allowed overnight at room temperature to penetrate the fruits. California fruits were held in cold storage near freezing before treatment. Treatment evaluation was conducted the day following treatment. Control fruits were not treated in water, but held near room temperature 20°C (68°F) for the duration of the treatment. California fruits were subjected to cold storage.

3. To evaluate fruit quality after treatment, uninfested mature 'Bing' sweet cherries were treated the same as the infested cherries. The same criteria were used as for all previous quality evaluation studies. Quality studies were conducted at UC-Davis for California cherries and at the USDA-ARS Wenatchee Laboratory for PNW cherries. Quality parameters included firmness, Ssc, TA, etc. Particular attention was placed on stem color and shelf life (two weeks).

Results and discussion:

Although California cherries were treated cold, the prebath quickly warmed the fruits (Fig. 1.). The cold exposure by itself, as used in the controls, did not cause larval mortalities. There was no significant difference in fruit core warming rates using either the treatment bath or shower (Fig. 1). Complete efficacy (100% mortality) at the lowest temperature exposure was established with 8 min at 48°C (118°F) to 4 min at 50°C (122°F) of water temperature (Figs. 2 and 3).

Because the PNW cherries were treated at room temperature, they were not subjected to a prebath. This reflects the differences in commercial operations between California and the PNW. Complete efficacy was obtained with 6 min at 50°C (122°F) to 4 min at 54°C (129°F) (Fig.4). Any exposure below this resulted in survivors. Although the infested fruits used in both treatment methods were about the same size, cherries from the PNW are typically larger (Row 9 to 12) than those from California (Row 10 to 13). Thus, a longer treatment exposure will be required for PNW cherries.

Post-treatment hydrocooling is intended for maintaining fruit quality; comparison tests of efficacy between treatments with hydrocooling and those without indicate that hydrocooling does not contribute to efficacy treatment. Evaluations on fruit quality for either the PNW cherries (Fig.4) or those from California (Fig. 5) indicate that the efficacy is below the region where fruit injury occurs. Thus, there is flexibility so that a severe treatment required to obtain the probit 9 level (99.996832% pest mortality) may be obtained within the range of fruit tolerances. Furthermore, packing house operations do not have to be that precise in the timing of these treatments.

This research indicates that efficacious treatments against codling moth larvae can be obtained without causing long term damage to fruit quality for both California and PNW cherries. This is a major accomplishment in the development of quarantine treatments. Previously, it was thought that cherries could not tolerate temperatures required to control codling moth larvae. Yet, not only are the thermal exposures lower than the region of fruit damage, but these exposures can also be used for the basis of quarantine treatments against codling moth in other fruits. Further research is needed to define the limits of fruit quality and to factors affecting fruit injury from thermal treatments.

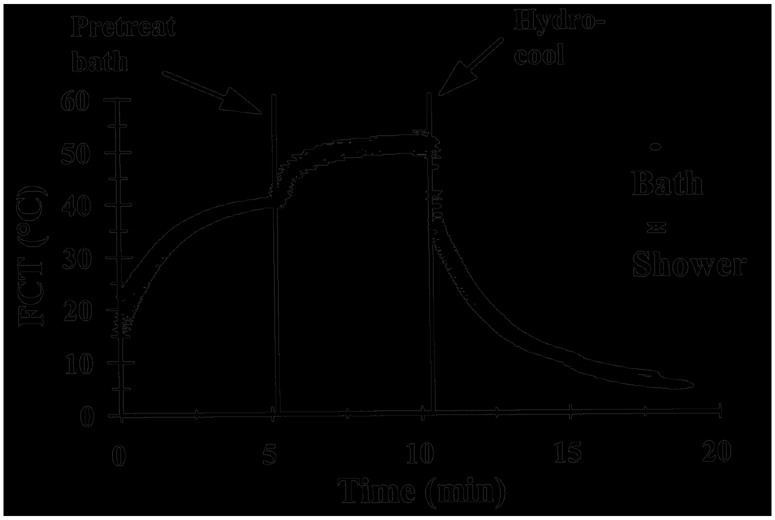

Figure 1. Typical temperature profile of the fruit core (FCT) of California cherry exposed to a 5 min prebath at 40^{0}C and either a 5 min bath or shower at 51.5^{0}C (125^{0}F), followed by 4^{0}C (39^{0}F) hydrocooling.

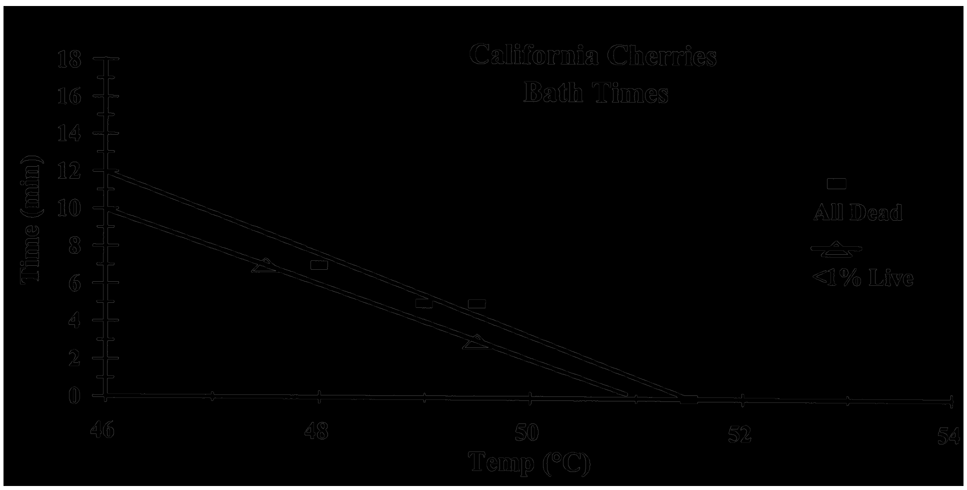

Figure 2. Treatment efficacy of California cherries when exposed to showers at specific temperatures for a range of durations.

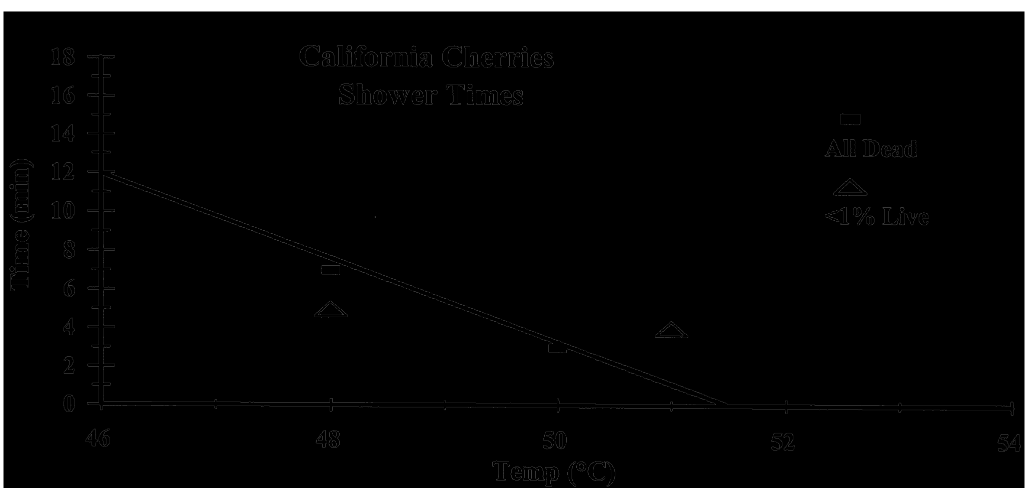

Figure 3. Treatment efficacy of California cherries when exposed to water baths at specific temperatures for a range of durations.

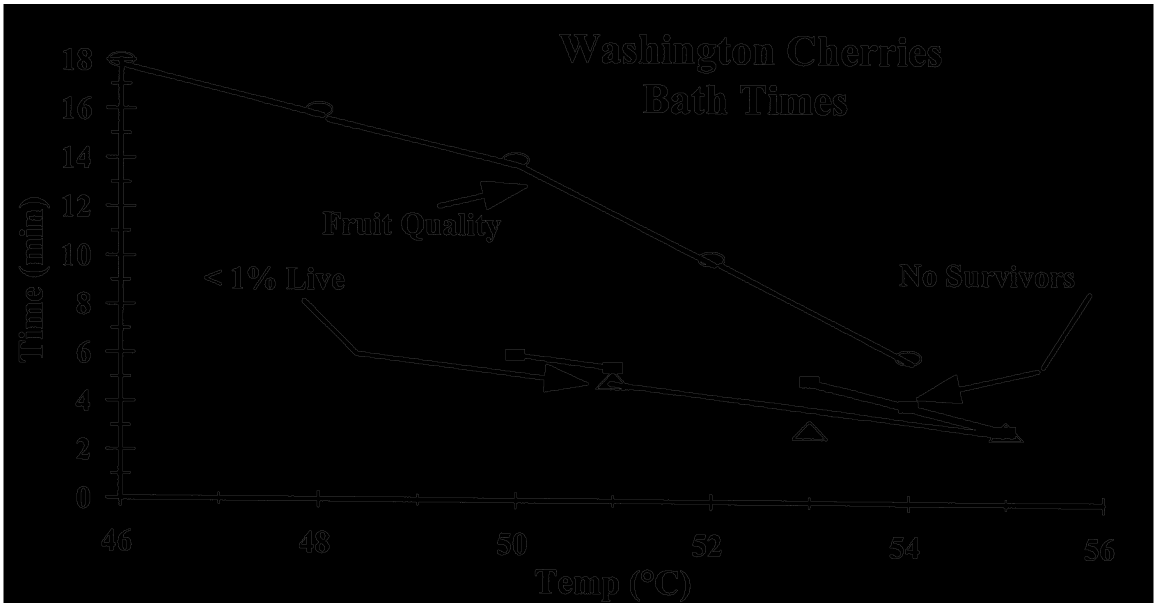

Figure 4. Treatment efficacy and fruit quality of cherries from the PNW when exposed to water baths at specific temperatures for a range of durations.

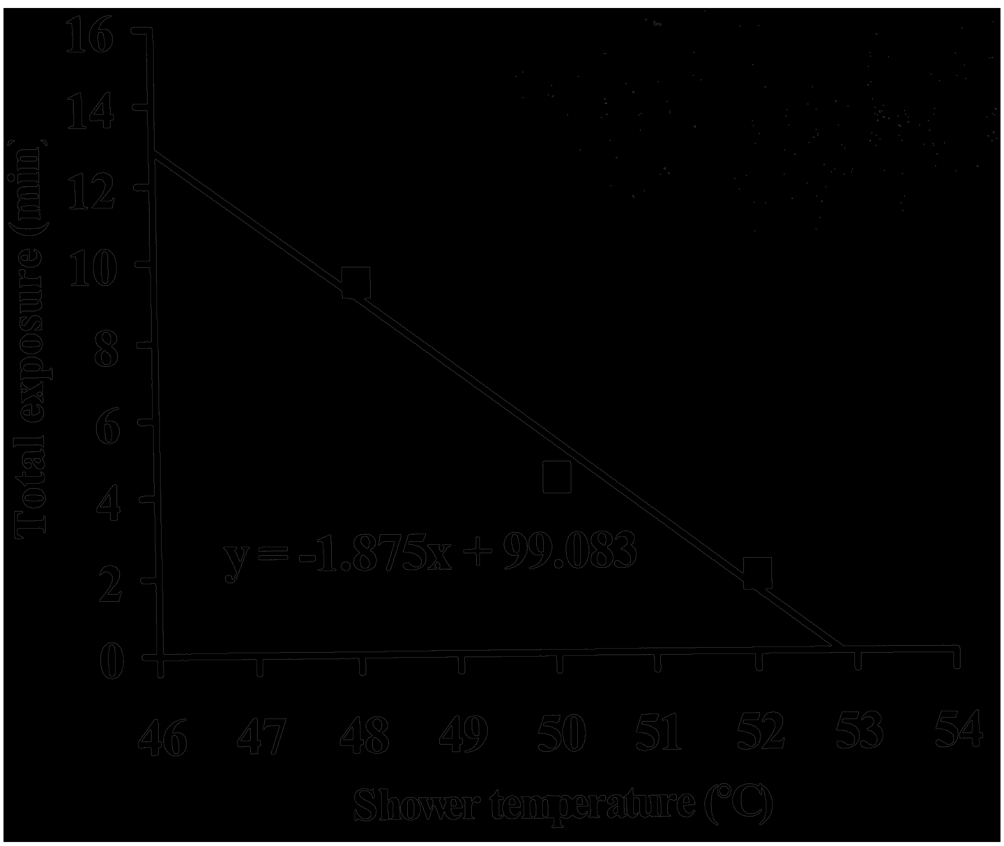

Figure 5. Based on California cherries, maximum treatment times at different temperatures form a linear regression line, beyond which fruit quality will be unacceptable after two weeks.