The use of Agrinse 7, a silicone-based surfactant, to control surface pests on harvested California 'Bing' sweet cherries

A report to the California Cherry Advisory Board

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SUMMARY

California 'Bing' sweet cherries were treated with a silicone-based surfactant, Agrinse 7, at several concentrations. For some treatments, liquid chlorine was added at 25, 50, or 100ppm. Fruit were exposed to Agrinse 7 and/or chlorine via a dip with slight agitation. After treatment, fruit were evaluated following storage in vented plastic bags to simulate either air or sea shipment to overseas markets, both followed by 15 hours of simulated shelf-life. Quality parameters that were evaluated include berry browning, stem color, pitting, cracking, and decay. In separate experiments, California 'Bing' sweet cherries were artificially infested with two-spotted spider mites or western flower thrips and exposed to Agrinse 7 and/or chlorine using a purpose-built shower system, after which removal of the arthropods or subsequent survivorship of those not removed was assessed.

Fruit quality data indicated only very minor differences between untreated and treated fruit. Overall, the quality of untreated and treated fruit was high and mean damage ratings were "none" or "none to slight". Agrinse 7 increased removal and mortality of two-spotted spider mite lifestages other than eggs over water alone. There was some variability in the data, but treatment with 0.9% Agrinse 7 resulted in no surviving mites except for eggs. There was little consistent effect of chlorine on removal or survival of non-egg mites. Survival differences were only significant in one case due to variability in both removal (affecting the number available for mortality testing) and kill. Water was very effective at removal and kill of Western flower thrips, but Agrinse 7 was better. The

addition of chlorine to Agrinse seemed to reduce its ability to remove thrips from the cherries, and appeared to have no effect on kill. The numbers of thrips remaining on the cherries after the shower treatments was less than 11, on average. Water appeared to be as effective as Agrinse 7 for removal of mite eggs. Agrinse 7 increased mortality of remaining mite eggs, and addition of chlorine appeared to increase mortality further.

INTRODUCTION

The export of cherries from California continues to expand from increased access to foreign markets. Australia, New Zealand, and Japan are examples of markets that California exporters hope to expand. The Australian market alone accounted for $2.2M, $2.0M, $0.9M, and $1.0M in 2003, 2004, 2005, and 2006, respectively (fluctuations in weather and crop load are responsible for the fluctuations in the total exports).

A variety of insects and mites are found on the surface of harvested fruit crops which may become an issue for exported products. In some cases, the presence of hitchhiking pests has already become a barrier to trade, while in other cases they have the potential to disrupt important trade relationships. Sweet cherries are currently fumigated with methyl bromide prior to shipment to Australia because of the presence of various mite and thrips species. Nearly 25% of the shipments in 2001 were re-fumigated with methyl bromide upon arrival in Australia due to finds of live mites. This has an even greater negative effect on fruit quality.

Sweet cherries shipped to Japan have long been fumigated for control of codling moth. If recent efforts to prove the non-host status of sweet cherry for codling moth are successful, and methyl bromide fumigation is no longer required, the presence of mites may then become an issue.

Alternative disinfestion treatments are being investigated due to fruit quality issues from methyl bromide treatment and potential restrictions to methyl bromide use. The goal of this research is to develop sufficient control measures that satisfy the phytosanitary requirements of important overseas markets while maintaining acceptable quality of export fruit. In collaboration with Jim Hansen of USDA ARS in Wapato, WA, we are investigating the use of surfactants for their ability to remove and/or kill arthropod pests on the surface of California ‘Bing’ sweet cherries. Previous year’s results with Silwet L-7, and a variety of proprietary formulations showed promise for both removal and mortality of target pests (Tipping et al., 2003). Results from the 2005 season indicated that Agrinse 7 (Ivanhoe Industries, Inc., Mundelein, IL) showed promise as a removal agent, and mortality results for two-spotted spider mites were favorable. There appeared to be no significant impact on cherry quality using this surfactant even when relatively high concentrations were used. This year, Agrinse 7 was tested both with and without various concentrations of liquid chlorine. Chlorine was tested for possible synergistic effects for removal and kill of the surface pests, and, as it is commonly used in commercial wash bins, to rule out possible fruit quality issues from the combined treatment. This year’s research focused on the removal and mortality of the surface pests, western flower thrips and two-spotted spider mites using a purpose-built shower to simulate commercial conditions. We also evaluated the potential effects on cherry quality.

OBJECTIVES

1. Determine the effect of various surfactant materials and concentrations on the presence and survivorship of various life stages of two-spotted spider mites and western flower thrips on sweet cherry fruit.

2. Confirm the tolerance of cherry fruit to promising surfactant treatments.

MATERIALS AND METHODS

Fruit materials

‘Bing’ sweet cherries were obtained from harvested field bins in orchards in the San Joaquin Valley of California during the commercial harvest season. Fruit were immediately transported to the Postharvest Laboratory at UC Davis, and sorted for major defects such as stem freshness, pitting, decay and cracking. After sorting, fruit were randomly divided into treatment units.

Fruit Quality

For quality assessment tests, fruit were held at 0°C overnight before treatment. Three replications of 20 cherries with fresh green stems and no surface damage were placed in each treatment solution (1,000mls of surfactant and/or chlorine diluted in tap water in a 1,800 ml beaker) at 0°C. Beakers containing fruit and treatment solution [water; Agrinse 7; chlorine (25, 50 or 100 ppm) or Agrinse 7 with chlorine] were placed on a platform shaker and set at a low speed to achieve slight agitation for 3 or 5 minutes. Fruit were then removed from solution and placed on dry paper toweling to wick away excess moisture. Fruit were stored in vented plastic consumer bags to simulate either air shipment [2 days at 5°C (41°F)] or sea shipment [14 days at 0°C (32°F)] to overseas markets, each followed by 15 hours of simulated shelf-life in bags at 20°C. All fruit in the experiments were subjected to a series of quality evaluations after simulated storage and shelf-life. The 20 cherries in each replicate were evaluated for stem color, berry browning, pitting, cracking, and decay. Standards for subjective quality evaluation of cherries were as follows: 1 (none), 2 (slight), 3 (moderate), and 4 (severe). Cherry quality data were analyzed with the GLM procedure in the Statistical Analysis System (SAS) software, version 6.2.

Arthropod Removal and Survival

Two-spotted spider mites (*Tetranychus urticae* Koch) were reared in the laboratory on cotton seedlings (*Gossypium hirsutum* L.) at a constant temperature of 24ºC (24L: 0D). Western flower thrips, *Frankliniella occidentalis* (Pergande), were reared in the laboratory on fresh green beans at a constant temperature of 24°C (12L:12D). For artificial infestation, 10-15 mite-infested cotton leaves or 300-500 mixed stage thrips were placed with 32-35 cherries overnight in a lidded deli cup (32 oz.) with a large hole in the lid sealed by a fine mesh. A purpose-built shower was used to simulate cherry rinsing in a commercial packing shed (see Fig 1). A submersible pump circulated water from a holding tank to a reservoir with a perforated base to simulate a commercial shower system. The total flow through the shower head was controlled by the pump (flow rate of 3.2-4.3 gallons/min). For treatment, cherries were carefully lifted out of the deli cup (cotton leaves were removed) and placed in the perforated circular tray located 12 inches below the shower head for 3 or 5 minutes, then removed.

After treatment, cherries that had been infested with two-spotted spider mites were placed in deli cups with Tangle trap™ (The Tanglefoot Company, Grand Rapids, MI) around the edge to prevent mite escape. Cherries that had been infested with western flower thrips were placed in lidded deli cups with fine mesh screen over the top. Infested cherries were held at 24ºC for 48 hours, thrips and mites were then evaluated for mortality/survival of pests not removed by the shower. Survival data are presented with standard errors (SE).

A second set of cherries infested with mites, as previously described, was used to assess mite egg removal. Infested cherries were placed under the shower head for 3 or 5 minutes, then removed. After treatment, cherries were immediately evaluated for the presence of mite eggs. Egg counts were recorded and data were transformed (square root) and analyzed using the Tukey-Kramer HSD test (JMP).

To assess mite egg mortality, a small pipette was used to transfer several drops of solution (or water) to a plastic Petri dish (6 cm). A fine bristle paintbrush was used to transfer mite eggs to the solutions by removing webbing with eggs from mite-infested cotton plants. Any mite life stages other than eggs were quickly removed and the eggs were allowed to sit in the solution for 3 or 5 minutes. The excess solution was then wicked away with a small piece of filter paper. Tangle trap™ was placed around the edge of the Petri dish to prevent mite escape. Egg mortality was assessed beginning on day 5 and was concluded after 14 days. At the present time we have completed the first replication of this set of experiments. We expect to complete this data set in November 2006. No statistical analysis was performed on this data: means and SE are shown in Table 6.

Results and Discussion

Fruit Quality

There was no significant difference in cherry browning or decay between treatments. Overall, stem condition, surface pitting, and cracking were similar between control and treated fruit. There was one instance in each of these quality parameters where a statistical difference between treatment means occurred, which usually resulted from an unexplained deterioration of a small number of fruit under evaluation. For these means, the differences were very minor in scale and would not be distinguishable from a practical perspective. Stem condition and surface pitting scores are presented in Tables 1 (air shipment) and 2 (sea shipment). There was a slight increase in stem and pitting scores in sea shipment verses air shipment, but quality remained very good.

Arthropod Removal and Survivorship

The ability of a water or Agrinse 7 shower to remove juvenile and adult stages of two-spotted spider mites and western flower thrips is shown in Table 3. Water was effective at removing both pests; however, Agrinse 7 was more effective at removing mites than water alone and the higher concentration was more effective with 0.9% Agrinse 7 giving the best removal results. Thrips were removed as well with water as with Agrinse 7.

Overall, the survivorship of both juvenile and adult two-spotted spider mites and western flower thrips was low in all Agrinse 7 treatments compared with untreated controls (Tables 3 and 4). However, the water only control was just as effective as the Agrinse 7 treatment, with the exception of two-spotted spider mites exposed to a 3-minute rinse where survivorship was significantly lower in all Agrinse 7 treatments (Table 3). Higher concentrations of Agrinse 7 tended to have lower survivorship of mites and thrips; however, the addition of chlorine did not appear to have any effect. The 5 minutes shower appeared to be slightly more effective than the 3 minutes shower. The total number of remaining and surviving thrips was very low in all treatments including the water control. Previous data from 2005 indicated that two-spotted spider mite exposure to 0.5 or 1.0% Agrinse 7 resulted in lower survivorship (less than 10%) than compared to a water only control (approx. 60%).

Our 2005 data indicated that two-spotted spider mite egg removal with 0.5 or 1.0% Agrinse 7 was approximately 48%. Results from this year's research are presented as the mean number of eggs remaining on the fruit, not the removal rate since the egg population prior to treatment was unknown. This is due to the nature of the shower rinse and the inability to retrieve specimens washed from the cherries during treatment. There was no significant difference between the water only control and treatments containing Agrinse 7 and/or chlorine. The total number of eggs remaining was low compared to the untreated controls (175.7 $\pm$ 86.6).

Mortality of two-spotted spider mite eggs exposed to 0.6% or 0.9% Agrinse 7 was higher than that for the untreated or water controls which were very low. There were no differences in egg mortality between 0.6 and 0.9% Agrinse 7. Mortality was higher for both concentrations when Agrinse 7 was combined with 100ppm chlorine. However, mortality did not exceed 55% in any treatment. The effects of the treatments on mite eggs will be clearer when our study is completed, and additional concentrations of chlorine will be tested.

Conclusions

Fruit quality data continues to indicate that there are no significant effects on cherry quality when Agrinse 7 is applied postharvest. Our cumulative results indicate no negative impacts on cherry quality across a range of concentrations, including those higher than would probably be used commercially. Both water and Agrinse 7 showers removed significant numbers of juvenile and adult two-spotted spider mites and thrips and mite eggs, but the data was somewhat variable. Agrinse 7 was more effective at killing all life stages of mites remaining on the cherries after the shower, especially at the 0.9% concentration. The lack of statistically significant differences between the treatments for arthropod mortality and removal could be an artifact of experimental design. Last year's data indicated a marked decrease in survivorship for mites exposed to

Agrinse 7 (and other surfactants). Our experimental design last year allowed us to closely monitor the number of arthropods used, and those removed from cherries during rinsing. While this data was very valuable to collect and allowed us a higher degree of accuracy where mortality or survivorship is concerned, in the end we must assess the performance of our treatments under commercial conditions. The overall low number of live mites and thrips following our shower treatments is very encouraging and the indication that the addition of chlorine could reduce survivorship in mite eggs (one of the more difficult stages to kill) is important. Future plans include a closer look at mite egg mortality (currently underway) and a modification of the current shower system to allow for recovery of removed arthropods so that removal and survivorship can be assessed in more detail.

Table 1. Cherry **stem browning and surface pitting** scores for California 'Bing' sweet cherries exposed to a range of concentrations of Agrinse 7 and/or 100ppm chlorine followed by a simulated **air shipment** of 2 days at 5°C (41°F) and an additional 15 hours of simulated shelf-life at 20°C (68ºF). Quality scores were as follows: 1 (none), 2 (slight), 3 (moderate), and 4 (severe).

Treatment	3 minute		5 minute	
	Stem Browning	Pitting	Stem Browning	Pitting
Untreated control	1.1 a	1.2 bc	1.1 a	1.3 a
Water only control	1.0 a	1.2 c	1.1 a	1.3 a
0.1% Agrinse 7	1.1 a	1.3 ab	-	-
0.1% Agrinse 7 + chlorine	1.0 a	1.3 abc	-	-
0.6% Agrinse 7	1.0 a	1.2 bc	1.4 a	1.3 a
0.6% Agrinse 7 + chlorine	-	-	1.0 a	1.3 a
0.9% Agrinse 7	1.0 a	1.4 a	1.2 a	1.2 a
0.9% Agrinse 7 + chlorine	1.0 a	1.3 ab	1.2 a	1.2 a
100 ppm chlorine	1.0 a	1.2 bc	1.2 a	1.1 a

Means separation was performed by least significant difference (LSD), $P \leq 0.05$. Within a column, means followed by the same letter are not statistically different.

Table 2. Cherry **stem browning and surface pitting** scores for California 'Bing' sweet cherries exposed to a range of concentrations of Agrinse 7 and/or 100ppm chlorine followed by a simulated **sea shipment** of 14 days at 0°C (32°F) and an additional 15 hours of simulated shelf-life at 20°C (68ºF). Quality scores were as follows: 1 (none), 2 (slight), 3 (moderate), and 4 (severe).

Treatment	3 minute		5 minute	
	Stem Browning	Pitting	Stem Browning	Pitting
Untreated control	1.2 a	2.1 a	1.5 cd	1.5 a
Water only control	1.2 a	2.0 a	1.5 cd	1.6 a
0.1% Agrinse 7	1.2 a	1.9 a	-	-
0.1% Agrinse 7 + chlorine	1.1 a	1.9 a	-	-
0.6% Agrinse 7	1.2 a	1.7 a	1.9 a	1.5 a
0.6% Agrinse 7 + chlorine	-	-	1.3 d	1.6 a
0.9% Agrinse 7	1.1 a	1.7 a	1.6 bc	1.6 a
0.9% Agrinse 7 + chlorine	1.1 a	2.1 a	1.4 d	1.5 a
100 ppm chlorine	1.2 a	2.0 a	1.7 ab	1.5 a

Means separation was performed by least significant difference (LSD), $P \leq 0.05$. Within a column, means followed by the same letter are not statistically different.

Table 3. **Survivorship** of two-spotted spider mite (active mite stages) and western flower thrips exposed to various concentrations of Agrinse 7 with or without 100ppm chlorine in a purpose-built shower system for **3 minutes**. Results are shown as mean number of survivors (SE) (three replications per treatment) and mean number of arthropods remaining after the shower (SE).

Treatment	Two-spotted spider mite		Western flower thrips	
	Mean # survivors	Mean # remaining	Mean # survivors	Mean # remaining
*Untreated control	272 (53.5)	312.7 (56.9)	76 (26.0)	161.2 (28.3)
Water only control	188.7 a	277.7 (65.0)	2.3 a	8.0 (2.5)
0.1% Agrinse 7	33.7 b	146.3 (36.9)	1.7 a	3.0 (1.0)
0.1% Agrinse 7 + chlorine	22.0 b	167.7 (48.7)	1.7 a	5.7 (1.3)
0.9% Agrinse 7	10.3 b	117.0 (43.2)	0.3 a	0.7 (0.7)
0.9% Agrinse 7 + chlorine	17.0 b	113.0 (7.2)	2.0 a	7.3 (3.4)

Within a column, means followed by the same letter are not statistically different.
*Untreated controls were not used in the statistical analysis but are presented as a comparison to the treatments.

Table 4. **Survivorship** of two-spotted spider mite (active mite stages) and western flower thrips exposed to various concentrations of Agrinse 7 with or without 100ppm chlorine in a purpose-built shower system for **5 minutes**. Results are shown as mean number of survivors (SE) (three replications per treatment) and meant number of arthropods remaining after the shower (SE).

Treatment	Two-spotted spider mite		Western flower thrips	
	Mean # survivors	Mean # remaining	Mean # survivors	Mean # remaining
*Untreated control	272 (53.5)	312.7 (56.9)	76 (26.0)	161.2 (28.3)
Water only control	12.0 a	21.3 (13.2)	2.3 a	3.3 (1.2)
0.6% Agrinse 7	19.3 a	231.7 (84.0)	2.3 a	5.7 (1.3)
0.6% Agrinse 7 + chlorine	0.0 a	1.3 (0.9)	1.0 a	11.0 (3.0)
0.9% Agrinse 7	0.0 a	6.0 (1.2)	0.3 a	0.7 (0.3)
0.9% Agrinse 7 + chlorine	0.0 a	7.0 (4.1)	3.0 a	3.7 (2.7)

Within a column, means followed by the same letter are not statistically different.
*Untreated controls were not used in the statistical analysis but are presented as a comparison to the treatments.

Table 5. **Removal** of two-spotted spider mite eggs exposed to 0.1%, 0.6% or 0.9% Agrinse 7 with or without 100ppm chlorine for 3 or 5 minutes (three replications).

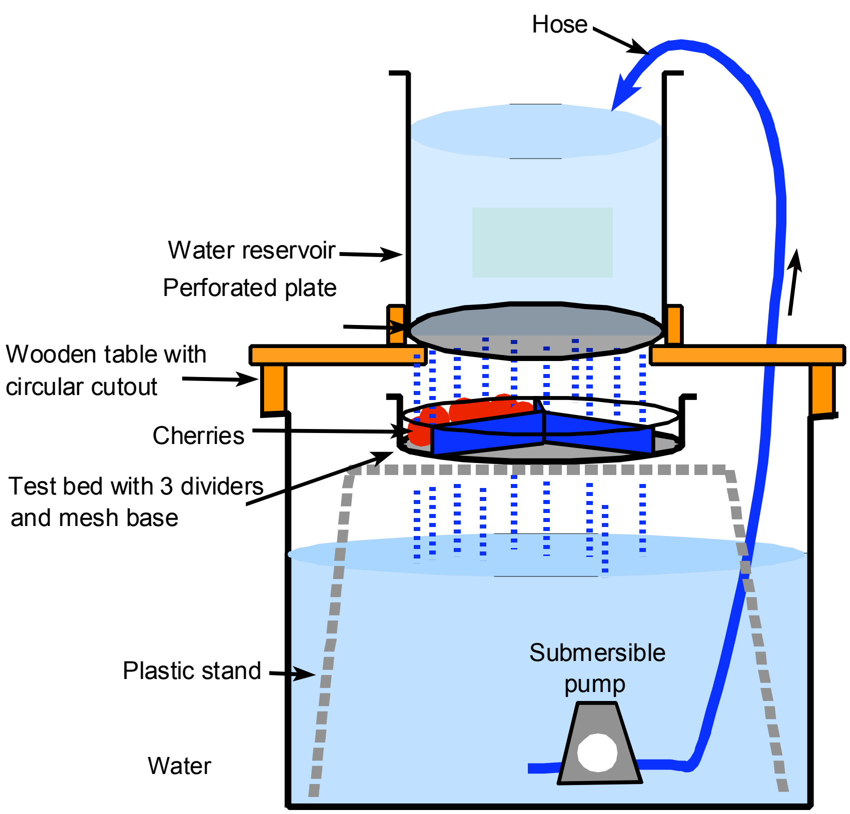
Treatment	Mean # Eggs Remaining	
	3 minute	5 minute
*Untreated control	175.7 ± 86.6	175.7 ± 86.6
Water only control	23.3 a	15.3 a
0.1% Agrinse 7	22.0 a	-
0.1% Agrinse 7 + chlorine	10.0 a	-
0.6% Agrinse 7	-	31.3 a
0.6% Agrinse 7 + chlorine	-	7.7 a
0.9% Agrinse 7	4.3 a	16.7 a
0.9% Agrinse 7 + chlorine	16.7 a	14.7 a

There was no significant difference between the water only control and treatments at the $P \leq 0.5\%$.
*Untreated controls were not used in the statistical analysis but are presented as a comparison to the treatments

Table 6. **Mortality** of two-spotted spider mite eggs exposed to 0.6% or 0.9% Agrinse 7 with or without 100ppm chlorine for 5 minutes (SE).

Treatment	Mean % Mortality (SE)
Untreated control	10.3 (3.8)
Water only control	8.5 (4.1)
0.6% Agrinse 7	30.2 (11.4)
0.6% Agrinse 7 + chlorine	54.3 (41.9)
0.9% Agrinse 7	26.9 (10.1)
0.9% Agrinse 7 + chlorine	55.4 (30.1)

Fig. 1 Purpose-built shower equipment used to simulate commercial conditions for rinsing California cherries.



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