EVALUATION OF SWEET CHERRY FRUIT AND STEM DAMAGE WHEN APPLYING PEROXYACETIC ACID OR SODIUM HYPOCHLORITE AFTER HARVEST

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INTRODUCTION:

The annual volume of sweet cherries shipped from the Pacific Northwest has risen dramatically to over 80,000 tons over the last five years. There has also been a major expansion in varieties. While Bing, the traditional variety, remains dominant, new varieties have been planted to lengthen the harvest season. The top varieties in terms of volume shipped are: Bing, Lapins, Sweetheart and Rainier. Rainier is the only light skinned cherry in this list; the others are dark skinned.

Although there is a small movement towards the shipment of stemless cherries, the vast majority of cherries are shipped with stems. Stem color and plumpness are used by some buyers to reflect cherry quality. Growers and packers do their best to conserve stem quality by rapidly reducing the temperature after harvest and keeping the humidity high in storage.

The current standard of postharvest treatment of cherries in the Pacific Northwest is to hydrocool the fruit at reception and again at the end of the packing process immediately prior to packaging. Chlorine (from sodium hypochlorite) or chlorine dioxide are the common hydrocooler sanitation chemicals for fruit sold domestically, and for some export shipments as well. These same chemicals may be applied on the packingline as a spray.

Peroxyacetic acid is currently used by apple packers as a dump tank or fruit spray biocide. Peroxyacetic acid (Sanipak™) could be adapted as a cherry hydrocooler sanitizer provided there are no adverse phytotoxic effects on either the cherry fruit or stem. The goal of these experiments is to determine if hydrocooling cherries with Sanipak™ causes injury to fruit or stems, compared to hydrocooling with water only or water sanitized with sodium hypochlorite. **This was <u>not</u> a trial of the effectiveness of either Sanipak™ or sodium hypochlorite to control fungal or bacterial organisms.**

METHODOLOGY:

Four varieties of cherries were sprayed with or dipped in five treatment regimes to determine the effect on cherry stem color and fruit appearance. The methodology employed in these experiments is outlined below.

a) **Varieties:** Bing, Rainier, Lapins and Sweetheart
b) **Growers:** fruit from 4 or 5 orchards per variety
c) **Replication:** three replicates per orchard per variety per treatment

d) **Units of replication:** 50 fruit per replicate, randomly sampled from a 2-lb clamshell

e) **Treatments:**

1. Five spray treatments (15 seconds): 80 ppm Sanipak™, 120 ppm Sanipak™, 80 ppm sodium hypochlorite, 120 ppm sodium hypochlorite and water as a control.
2. Five dip treatments (15 minutes): 40 ppm Sanipak™, 80 ppm Sanipak™, 40 ppm sodium hypochlorite, 80 ppm sodium hypochlorite and water as a control.
3. Application temperature of fruit and treatment solutions was 34 ºF

f) **Storage duration:** after treatment fruit were held for 14 days at 34 ºF and an additional 24 hours at 70 ºF prior to evaluation.

g) **Evaluation:** all varieties were evaluated for fruit luster and stem browning. In addition, Lapins were evaluated for fruit pitting and Sweethearts were evaluated for fruit pitting and cracking. Each fruit was given a rating using the following scales (as appropriate):

- Luster = shiny or dull
- Stem browning
  1. unaffected (stem = 0 to 25% brown)
  2. slight (25 to 50% brown)
  3. moderate (50 to 75% brown)
  4. severe (75 to 100% brown)
- Cracking = yes or no
- Surface pitting (see Figure 1)
  1. no pitting
  2. superficial (very shallow depression with diffuse edges)
  3. moderate (deep, wide pit with distinct edges)
  4. severe (very deep edges sunken into the pulp tissue)

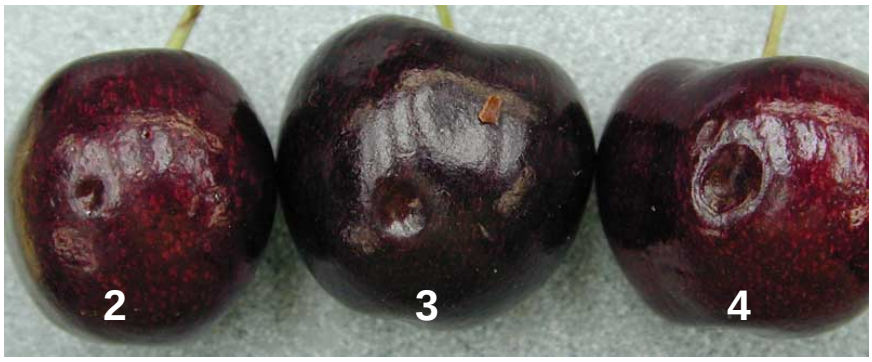

Figure 1. Surface pitting severity scores, shown on Sweetheart cherries, rated August 9, 2006.

h) Statistical analysis was performed on the data using a General Linear Models (GLM) Procedure. For those results that were statistically significant (<0.05 level) a Waller-Duncan K-ratio T test was performed to determine how the treatment variables were related to each other.

Fruit were purchased from a cooperating packinghouse in the Wenatchee area. The fruit were sampled from bins prior to hydrocooling by the packinghouse, placed in 2-lb clamshells and held in the cold prior to being transported to the WSU postharvest laboratory, where they were stored overnight at 34 ºF.

The following day the fruit were treated with spray and dip solutions. Solution concentrations and pH were measured prior to and directly after application. Dip solutions were made up in 30-quart ice chests immediately prior to each trial (Figure 2). Fresh dip solution was used for each treatment and replicate. The spray solutions were made up in a reserve tank immediately prior to each trial and sprayed onto fruit in clamshells within a cherry lug (Figure 3). Because spray duration was only 15 seconds, the same solution was used for all three replicates within each treatment. Solutions were held as close to 34 ºF as possible, using ice in closed bags to prevent dilution.

Figure 2. Cherry dip solution in ice chest, Lapins cherries treated July 19, 2006.

Figure 3. Cherry spray apparatus, Lapins cherries treated July 19, 2006

The sodium hypochlorite solutions were diluted from household bleach (6.15% sodium hypochlorite) and buffered to a pH of 6.5 through the addition of hydrochloric acid to maintain the free chlorine at levels as required. The solution concentrations and pH were checked prior to and after each treatment. The Sanipak™ solutions were diluted according to the product label; pH adjustment of the solutions prior to application was not necessary.

Following treatment, fruit were allowed to drip dry (unrinsed) until there was no free solution in the clamshell. Each clamshell was dried on the outside with a clean towel and then placed inside poly-lined boxes to prevent shrivel. An absorbent pad was placed inside each bag to absorb any free moisture that might remain. The fruit was held in cold storage (34 ºF) for two weeks and moved to room temperature (70 ºF) 24 hours prior to evaluation.

RESULTS:

Bing:

Fruit from five Bing orchards was treated on June 27, 2006 and evaluated on July 12. There were no statistical differences between orchards. There was no effect on fruit luster, pitting or cracking from any of the treatments. No discoloration of the fruit was observed for any treatment. There were some significant differences in the amount of stem browning between treatments (described below). Overall, the incidence of stem browning was low, with less than 5% of stems adversely affected.

Stem Browning—Spray Treatments: Bing cherries sprayed with 120 ppm sodium hypochlorite spray showed significantly more stem browning (4.6% of the stems were more than 25% brown) than the water spray treatment (Table 1). The stem browning from the 120 ppm Sanipak™ spray treatment was only slightly higher than, but not statistically different from, the 80 ppm Sanipak™ treatment and both sodium hypochlorite treatments.

Stem Browning—Dip Treatments: There was no significant difference in stem browning for either the sodium hypochlorite or Sanipak™ dip treatment (40 and 80 ppm) as compared to the water dip treatment. The stems of fruit treated with 80 ppm sodium hypochlorite dip showed significantly more browning (5.8% of the stems were more than 25% brown) than the 40 ppm sodium hypochlorite dip or either of the Sanipak™ dips.

Table 1. Effect of sodium hypochlorite and Sanipak™ on **stem color** of **Bing** cherries.

Variety	Method	Treatment	Conc. (ppm)	Stem Browning (%)*				Average Score**
				1	2	3	4	
Bing	**Spray**	Water		98.5 a	1.5 c	0.0	0.0	1.01 b
		Sodium hypochlorite	80	98.1 ab	1.6 bc	0.3	0.0	1.02 b
		Sodium hypochlorite	120	95.3 c	4.0 a	0.5	0.1	1.05 a
		Sanipak™	80	96.4 abc	2.9 abc	0.7	0.0	1.04 ab
		Sanipak™	120	96.0 bc	3.5 ab	0.4	0.1	1.05 ab
Bing	**Dip**	Water		96.9 ab	2.8 ab	0.3	0.0	1.03 ab
		Sodium hypochlorite	40	98.3 a	1.7 b	0.0	0.0	1.02 b
		Sodium hypochlorite	80	94.1 b	5.3 a	0.5	0.0	1.06 a
		Sanipak™	40	99.1 a	0.9 b	0.0	0.0	1.01 b
		Sanipak™	80	98.1 a	1.9 b	0.0	0.0	1.02 b

* Percentage of stems in each category, 1 = <25% brown, 2 = 25-50% brown, 3 = 50-75% brown and 4 = >75% brown
** Average Score = weighted average of stem browning scores

Within each column each application method was analyzed separately. Mean values in a column not followed by a common letter are significantly different by Tukey's honestly significant difference ($P \leq 0.05$).

Stem Browning After Packing: In addition to the dip and spray treatments described above, a small sample of Bing cherries were evaluated to determine if Sanipak™ or sodium hypochlorite would inhibit stem browning after packing. On July 7, 2006, nine samples of Bing cherries were obtained from the end of the packingline. They were immediately brought back to the laboratory, divided into 3 replicates and treated in dip solutions of water, 80 ppm sodium hypochlorite and 80 ppm Sanipak™ for 15 minutes. The cherries were then drip dried, and packed in boxes for cold storage for 14 days as described above.

The Bing stems were evaluated on July 20, 2006 (Table 2). Both the sodium hypochlorite and Sanipak™ treatments had more stem browning than the water treatment, although there was no statistical difference between treatments.

Table 2. Effect of sodium hypochlorite and Sanipak™ on **stem color** of **Bing** cherries after packing on a commercial packingline.

Variety	Method	Treatment	Conc. (ppm)	Stem Browning (%)*				Average Score**
				1	2	3	4	
Bing	**Spray**	Water		83	16	0	1	1.2
		Sodium hypochlorite	80	74	23	3	0	1.3
		Sanipak™	80	69	25	4	2	1.4

* Percentage of stems in each category, 1 = <25% brown, 2 = 25-50% brown, 3 = 50-75% brown and 4 = >75% brown
** Average Score = weighted average of stem browning scores

Rainier:

Fruit from four Rainier orchards was treated on July 7, 2006 and evaluated on July 20. One orchard had significantly more stem browning (28 to 57% of stems with browning) than fruit from the other three orchards (0 to 29% of stems with browning). In the orchard with the high incidence of stem browning, the overall quality of the fruit was very poor (e.g., small size and skin blemishes).

There were no statistically significant differences in stem browning as a result of any of the treatments as compared to the water treatment. There was no effect on fruit luster from any of the treatments and no discoloration of the fruit was observed.

Stem Browning—Spray Treatments: Stem browning of Rainier cherries was equally affected by spraying water, sodium hypochlorite or Sanipak™ (Table 3).

Stem Browning—Dip Treatments: Stem browning of Rainier cherries was equally affected by dipping in water, sodium hypochlorite or Sanipak™. The percentage of brown stems for each dip treatment was approximately the same as the spray treatments (data not shown).

Table 3. Effect of sodium hypochlorite and Sanipak™ on **stem color** of **Rainier** cherries.

Variety	Method	Treatment	Conc. (ppm)	Stem Browning (%)*				Average Score**
				1	2	3	4	
Rainier	**Spray**	Water		91.5	5.5 b	2.7	0.3	1.1
		Sodium hypochlorite	80	85.3	11.2 ab	2.8	0.7	1.2
		Sodium hypochlorite	120	81.5	14.3 a	3.0	1.2	1.2
		Sanipak™	80	88.5	5.5 b	3.8	2.2	1.2
		Sanipak™	120	85.2	10.0 ab	3.7	1.2	1.2

* Percentage of stems in each category, 1 = <25% brown, 2 = 25-50% brown, 3 = 50-75% brown and 4 = >75% brown
** Average Score = weighted average of stem browning scores

Within each column each application method was analyzed separately. Mean values in a column not followed by a common letter are significantly different by Tukey's honestly significant difference ($P \leq 0.05$).

Lapins:

Fruit from four Lapins orchards was treated on July 19, 2006 and evaluated on August 1. There were no significant differences between the dip and spray treatments and the water control for stem browning, fruit luster or cracking. No discoloration of the fruit was observed for any

treatment. There were no statistical differences between orchards. There was a significant increase in fruit pitting from the 80 ppm sodium hypochlorite dip treatment.

Stem Browning: There was no significant difference between water, sodium hypochlorite or Sanipak™ treatments applied as either spray or dip on stem browning of Lapins cherries. Over 90% of the Lapins stems retained their green color (data not shown).

Surface Pitting—Spray Treatments: There was no significant difference in the extent of surface pitting on Lapins cherries from the chemical treatments when applied as a spray. The percentage of fruit with surface pitting for the spray treatments was approximately the same as the dip treatments (data not shown).

Surface Pitting—Dip Treatments: Surface pitting on Lapins increased as the dip concentrations of sodium hypochlorite and Sanipak™ increased (Table 4); however, only the 80 ppm sodium hypochlorite dip caused significantly more surface pitting than water.

Table 4. Effect of sodium hypochlorite and Sanipak™ dips on **surface pitting** of **Lapins** cherries.

Variety	Method	Treatment	Conc. (ppm)	Surface Pitting (%)*				Average Score**
				1	2	3	4	
Lapins	Dip	Water		45.8 a	28.2 c	18.0	8.0	1.9 b
		Sodium hypochlorite	40	41.0 ab	33.4 bc	13.8	11.8	2.0 b
		Sodium hypochlorite	80	24.8 c	42.8 a	16.8	15.5	2.2 a
		Sanipak™	40	42.3 ab	35.0 abc	12.9	9.8	1.9 b
		Sanipak™	80	34.7 bc	37.2 ab	13.3	14.8	2.1 ab

* Percentage of fruit in each category, 1 = none, 2 = superficial, 3 = moderate and 4 = severe surface pitting
** Average Score = weighted average of surface pitting scores

Within each column each application method was analyzed separately. Mean values in a column not followed by a common letter are significantly different by Tukey's honestly significant difference ($P \leq 0.05$).

Sweetheart:

Fruit from four Sweetheart orchards was treated on July 26, 2006 and evaluated on August 9. There were no statistical differences between orchards and no effect on fruit luster from any of the treatments. No discoloration of the fruit was observed for any treatment. Stem browning and surface pitting were both significantly greater than the water treatment for the 120 ppm sodium hypochlorite spray treatment. All other treatments were similar to the water treatment. Surface pitting was a serious problem in Sweethearts, with over 80% of the fruit pitted. Fruit cracking ranged from 3.5 to 7% of total fruit, but was not related to any specific treatment (data not shown).

Stem Browning—Spray Treatments: Sodium hypochlorite applied as a spray at 120 ppm caused significantly more stem browning on Sweetheart cherries (40% of the stems were more than 25% brown) than any other treatment (Table 5).

Stem Browning—Dip Treatments: Stem browning of Sweetheart cherries was equally affected by dipping in water, sodium hypochlorite or Sanipak™. The percentage of brown stems for each dip treatment was approximately the same as the spray treatments (data not shown).

Table 5. Effect of sodium hypochlorite and Sanipak™ sprays on **stem color** of **Sweetheart** cherries.

Variety	Method	Treatment	Conc. (ppm)	Stem Browning (%)*				Average Score**
				1	2	3	4	
Sweetheart	**Spray**	Water		73.6 a	19.0	5.3 b	2.0 b	1.4 b
		Sodium hypochlorite	80	79.4 a	17.5	3.7 b	0.8 b	1.3 b
		Sodium hypochlorite	120	59.8 b	22.1	11.1 a	6.9 a	1.7 a
		Sanipak™	80	79.4 a	17.8	2.3 b	0.5 b	1.2 b
		Sanipak™	120	72.4 a	19.2	6.5 ab	1.8 b	1.4 b

* Percentage of stems in each category, 1 = <25% brown, 2 = 25-50% brown, 3 = 50-75% brown and 4 = >75% brown
** Avg. Score = weighted average of stem browning scores

Within each column each application method was analyzed separately. Mean values in a column not followed by a common letter are significantly different by Tukey's honestly significant difference ($P \leq 0.05$).

Surface Pitting—Spray Treatments: Sodium hypochlorite applied as a spray at 120 ppm caused more pitting on Sweetheart cherries (90% of the cherries were pitted) than the water treatment (Table 6).

Surface Pitting —Dip Treatments: Surface pitting of Sweetheart cherries was equally affected by dipping in water, sodium hypochlorite or Sanipak™. The percentage of surface pitting for each dip treatment was approximately the same as the spray treatments (data not shown).

Table 6. Effect of sodium hypochlorite and Sanipak™ sprays on **surface pitting** of **Sweetheart** cherries.

Variety	Method	Treatment	Conc. (ppm)	Surface Pitting (%)*				Average Score**
				1	2	3	4	
Sweetheart	**Spray**	Water		17.1	37.7	38.7 ab	6.2 c	2.3 b
		Sodium hypochlorite	80	17.3	37.3	40.5 a	4.8 c	2.3 b
		Sodium hypochlorite	120	10.4	35.6	43.0 a	11.0 b	2.5 a
		Sanipak™	80	14.6	36.6	33.3 bc	15.6 a	2.5 ab
		Sanipak™	120	17.6	39.1	30.0 c	13.6 ab	2.4 ab

* Percentage of fruit in each category, 1 = none, 2 = superficial, 3 = moderate and 4 = severe surface pitting
** Average Score = weighted average of surface pitting scores

Within each column each application method was analyzed separately. Mean values in a column not followed by a common letter are significantly different by Tukey's honestly significant difference ($P \leq 0.05$).

CONCLUSIONS:

It was encouraging to see that fruit quality (i.e., luster, cracking and pitting) was not negatively affected by either chemical (sodium hypochlorite or Sanipak™) or application method (spray or dip). When stem browning occurred, it was at the higher chemical concentrations. In most instances fruit treated with Sanipak™ had less stem browning than fruit treated with sodium hypochlorite when chemicals were applied at the highest levels (120 ppm spray and 80 ppm dip).

The concentrations chosen for this series of experiments ranged from what is thought to be appropriate at the lower levels, to excessive at the higher levels. The higher levels were included in order to determine the extent of damage that might occur should too high a concentration be applied in a commercial situation.

Fruit pitting is a serious problem in the Lapins and Sweetheart varieties. Surface pitting was specific to these varieties and not related to the chemical spray or dip treatments.

The results reported here point to the possibility of using Sanipak™ as alternative to sodium hypochlorite as a water sanitizer for cherry packinglines based on the findings of no phytotoxic effects on either the fruit surface or stems from Sanipak™-treated water under these experimental conditions.

This study did not test the efficacy of Sanipak™ to control fungal or biological organisms. This study is limited by the fact that only four varieties of cherries from four or five growers in one season were included.

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