RESEARCH PROGRESS REPORT
LENTICEL BREAKDOWN IN GALA APPLES, 2008 CROP

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Executive Summary
Nine sets of experiments were conducted on Gala apples harvested in 2008 to determine the effect of orchard variability, SmartFresh application, presizing and other factors on orchards with historically high and low risk of developing lenticel breakdown (LB).

It should be noted that the amount of LB that developed in tested fruit in 2008 was far lower than in previous years.

- ***Experiment 1: SmartFresh****—SmartFresh applied within one day after harvest did not increase LB over control treatment (no SmartFresh) on fruit stored in long term CA. However, when SmartFresh application was delayed 14 days the incidence of LB increased. Further research on the effect of SF application interval and LB risk is scheduled for 2009.*
- ***Experiment 2: Time in Storage****—The longer fruit was in CA storage the higher the LB.*
- ***Experiment 3: Pre-harvest ReTain****—Fruit treated with ReTain prior to harvest had lower levels of LB after storage than untreated fruit.*
- ***Experiment 4: Orchard Factors****—The ranking of LB risk by orchard generally remained the same in 2008 as it was in 2007. Some orchards with fruit of low risk of LB were farmed as transitional organic and were from cooler growing regions. When stored until June, fruit harvested less mature with lower starch levels developed less LB than fruit harvested more mature.*
- ***Experiment 5: Mineral Content—****Peel of LB fruit had ratios of high nitrogen, potassium and magnesium coupled with low calcium levels. Individual nutrients were not adequately related to LB risk.*
- ***Experiment 6: Interval between Harvest and Cold Storage—****Temperature management immediately after harvest influenced both dye uptake and LB. Delayed cooling might be allowing fruit cuticle to heal and seal off cracks. Additional research is planned for 2009.*

- ***Experiment 7: Presizing—****Presizing prior to CA storage dramatically reduced LB after storage and packing.*
    - *Presizing to packing interval following CA storage affected LB. Immediate packing or delaying packing for 21 days reduced LB versus packing after 7 or 14 days.*
    - *"Conditioning" fruit after long-term CA significantly reduced LB after packing. Parameters of conditioning remain undefined.*
- ***Experiment 8: Individual Presize Factors—****Efforts were made to determine which presize factors affected LB. Calcium and sodium hypochlorite application, water immersion timing, drying speed, multiple water immersions and bin filling were unsuccessful in correlating with LB incidence. Additional research is needed.*
- ***Experiment 9: Predictive Tests—****The aniline dye and soap dip tests were not statistically predictive of and orchard developing LB; however when orchards were ranked against each other, there was a good relationship between orchards that developed more LB and had high prediction test scores versus those with less LB an low prediction score.*

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ABSTRACT

Lenticel breakdown (LB), a physiological disorder, is a serious economic problem that reveals itself most strongly after the fruit has been packed. Previous research has shown that maturity, storage regime, packing regime and chemical application on the packingline affect the incidence and severity of LB (Kupferman, http://postharvest.tfrec.wsu.edu).

During the 2007 harvest, fruit from a large number of orchards were evaluated to determine the effect of orchard variability and SmartFresh (1-MCP, AgroFresh, Spring House PA) treatment on the incidence and severity of LB. Fruit was treated with SmartFresh at harvest, removed from controlled atmosphere (CA) storage throughout the year, packed, and evaluated for LB. There was no significant difference in LB between SmartFresh-treated and untreated orchards. Orchard variability was highly significant with fruit from the same orchards developing LB regardless of the length of storage. Research is continuing to determine which orchard factors are associated with LB susceptibility.

During the 2008 harvest, fruit from 12 Gala orchards sampled in 2007 were selected for more intense study. Fruit were treated with SmartFresh within one day or 14 days after harvest or stored without treatment (control) and evaluated for LB after CA storage and packingline treatment (soap, wax) in January, April and June.

INTRODUCTION

LB has been a serious economic problem following packing, especially of Gala apples. This physiological disorder appears most dominantly after the fruit has been packed and manifests as darkened lenticels that often sink into the flesh (Figure 1). There is no apparent flesh injury typical of lenticel blotch pit or other nutrient related disorders (e.g., bitterpit). In highly competitive markets, such as in the USA, LB fruit is not saleable and must be used for other purposes.

Figure 1. Severe LB on Gala.

Previous studies in this lab and that of Dr. Eric Curry (USDA-ARS, Wenatchee) have shown that the use of certain fruit cleaners on the packingline can elevate the incidence of LB. Micrographs of LB-affected tissue show a lack of natural cuticular wax development in fruit prone to LB (Curry, personal communication). Additional exacerbating factors include the use of long-term CA storage, presize packing technology and the use of hot water to pack cold fruit.

This study was developed to determine the effect of fruit characteristics and the role of SmartFresh on the incidence and severity of LB. Time of packing, effect of sanitizing agents and the interval between presizing and packing after storage were also investigated.

RESEARCH SUMMARY

Research Methods

Fruit from 12 Gala orchards were obtained at time of harvest from packinghouses across Washington State. Three of the orchards had multiple picks, for a total of 15 orchards. The fruit were treated and stored loose in returnable plastic containers (RPCs). One-third of the fruit were not treated with SmartFresh (control), one-third were treated with SmartFresh one day after harvest and the final third were held for 14 days at 32 ºF in air before being treated with SmartFresh. Following the final treatment with SmartFresh all fruit were placed in CA storage (1.5% O_2, 0.5% CO_2 at 33 ºF). At harvest and at each removal from storage, fruit from each orchard were tested for the risk of LB using a dye infusion test and a soap solution test. The soap test under development induces LB in susceptible fruit using a known cell irritant, linear alkylbenzene sulfonate (LAS).

On removal from storage in January, April and June, fruit were held in regular air (RA) storage for 7 days prior to being passed over a research packingline. The fruit were cleaned by poly brushes using a standard soap treatment (RealClean at label rate, CH_2O, Olympia, WA) or a severe soap treatment (New Foam 7.0 at twice label rate[1], CH_2O, Olympia, WA), rinsed with fresh warm water then waxed with horsehair brushes (Brilliance III, CH_2O, Yakima, WA) and dried in an air tunnel. Fruit temperatures were 35 to 45 ºF at time of packing; Rinse water was 95 ºF and the dryer temperature was 115 ºF.

Fruit were then placed back into air storage (34 ºF) on trays in cartons for 5 days, then removed to room temperature (72 ºF) for 2 days and evaluated for LB using a scale of 0 (none) to 5 (severe). Fruit scored 3 and above were considered commercially unacceptable and are referred to in tables and figures as the percentage of fruit with LB.

Data was analyzed using a Generalized Linear Model (GLM) and Analysis of Variance (ANOVA) to determine statistical differences in the percentage of fruit with LB among orchards and SmartFresh treated and non SmartFresh treated fruit. Differences were considered significant at a Pr > F level of 0.05 or 95% confidence. The orchards were ranked by mean percentage of LB fruit and grouped into subsets, identified as a, b, c, etc. Some data was log transformed accorded to ANOVA protocol before determining significant differences and grouping orchards.

For the 2008 crop, there was very little LB seen in the fruit compared to previous years. The SmartFresh treatment applied after 14 days resulted in the most LB, while the control and SmartFresh applied after one day had significantly less LB. There was more LB seen in the June pullout than in the first two pullouts (January and April). In addition, the fruit packed in June had significant amounts of internal bitter pit symptoms. These results are discussed in a separate paper.

[1] For fruit and vegetable washing, the label rate of New Foam 7.0 is 0.2% to 0.4% (0.25 to 0.5 ounces per gallon), for the severe pack treatment, a rate of 0.8% (1 ounce per gallon) was used.

To jump to the results of a specific experiment, click on the experiment number below to see the discussion and results for that experiment in a new window.

Experiment 1: Effect of SmartFresh Application on LB

Fruit was placed into storage untreated, or after treatment with SmartFresh (1 ppm) for 24 hours within one day of harvest, or after 14 days. During the 14 to 30 days prior to CA storage all fruit was held at 34 ºF in RA storage.

Table 1. Effect of SmartFresh application on the percentage of fruit with LB treatment. January, April and June examinations combined.

Treatment	Standard Soap* LB (%)	Severe Soap* LB (%)
Control	1.7 b	8.2 b
SmartFresh +1	1.7 b	8.8 b
SmartFresh +14	2.7 a	12.4 a

* Standard soap treatment = RealClean at label rate
Severe soap treatment = New Foam 7.0 at twice label rate

Analyzed by columns. Differences were considered significant at a Pr > F level of 0.05 or 95% confidence. The orchards were ranked by mean percentage of LB fruit and grouped into subsets, identified as a, b, c, etc.

There was no difference in LB on untreated fruit or SmartFresh treated fruit when SmartFresh was applied one day after harvest (Figures 2 and 3). However, when SmartFresh was applied 14 days after harvest LB increased (Figure 4).

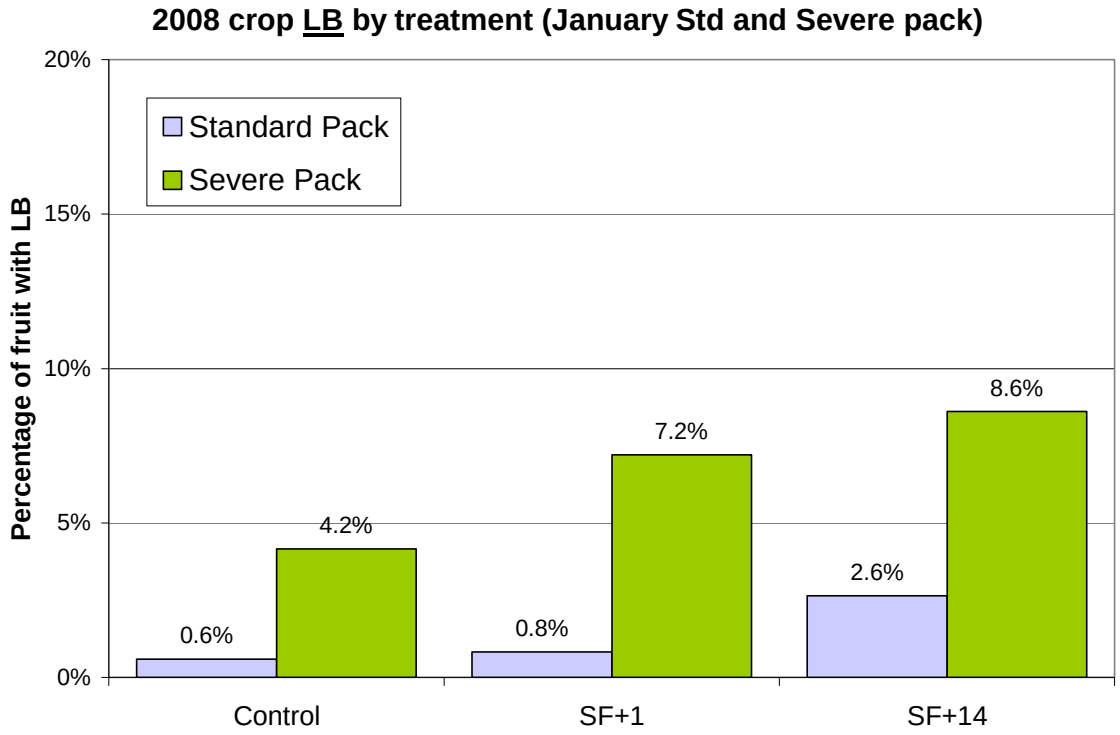

Figure 2. 2008 Gala crop**,** LB by treatment, average of 15 orchards, January pullout (Std. pack = RealClean at label rate, Severe pack = New Foam 7.0 at twice label rate.)

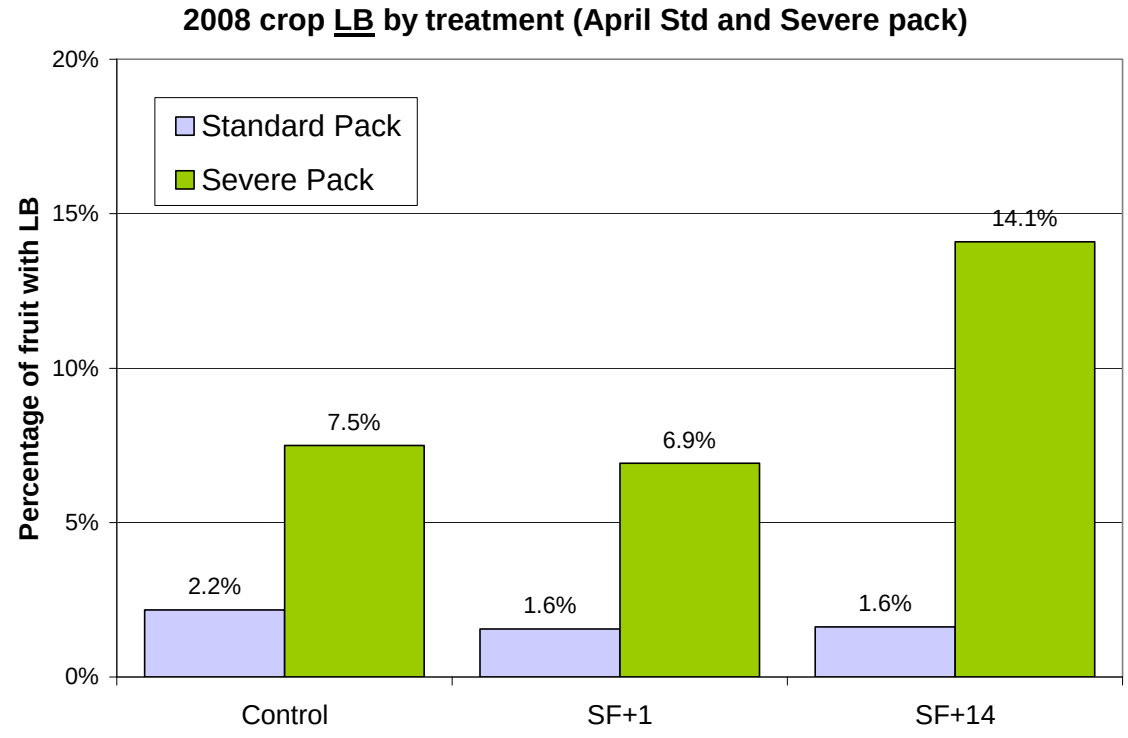

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Figure 3. 2008 Gala crop**,** LB by treatment, average of 15 orchards, April pullout. (Std. pack = RealClean at label rate, Severe pack = New Foam 7.0 at twice label rate.)

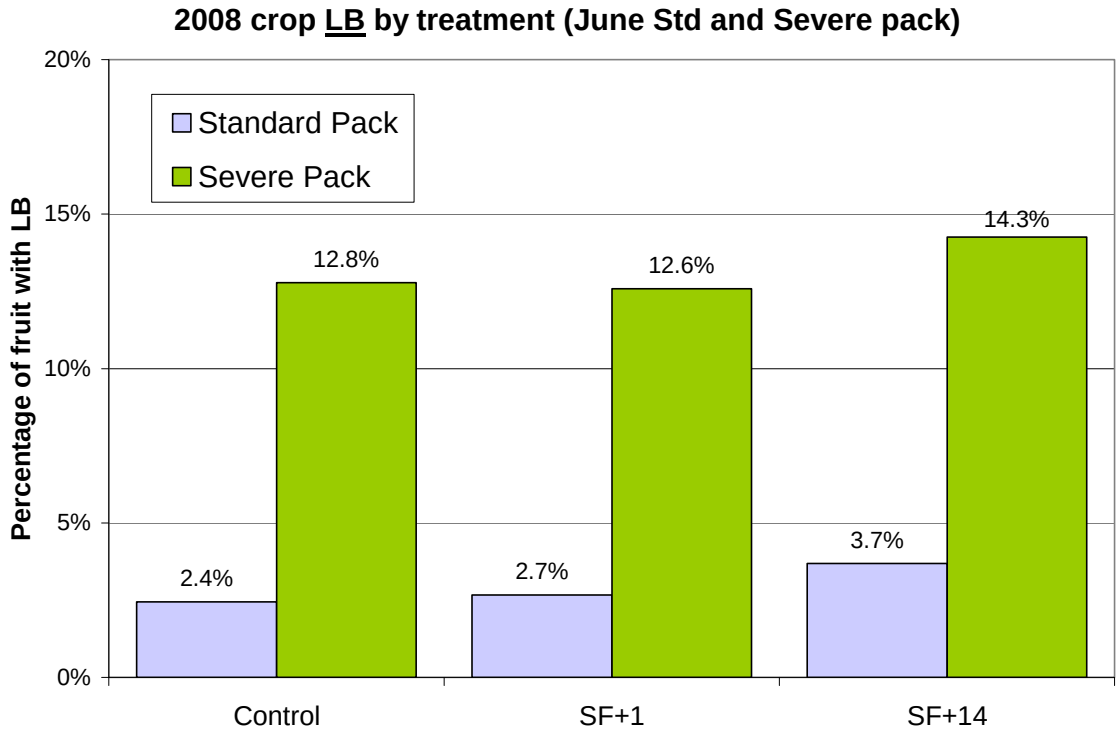

Figure 4. 2008 Gala crop**,** LB by treatment, average of 15 orchards, June pullout. (Std. pack = RealClean at label rate, Severe pack = New Foam 7.0 at twice label rate.)

Experiment 2: Effect of Length of Time in Storage and Orchard on LB

There was no difference in the percentage fruit with LB in for the first two pullouts in 2009. The percentage of fruit with LB was higher in June than in the previous two pullouts. The incidence of LB overall on this fruit was significantly lower than in the same orchards from the 2007 crop (Table 2).

Table 2. Percentage of fruit with LB by time in storage, standard and severe packs (average of all treatments for 15 Gala orchards).

Pack*	January	Mar-Apr	May-Jun
2008 crop			
Standard	1 b	2 b	3 a
Severe	7 b	9 b	13 a
2007 crop			
Standard	16 b	28 a	31 a
Severe	61 a	66 a	64 a

* Std. pack = RealClean at label rate
Severe pack = New Foam 7.0 at twice label rate

Analyzed by rows. Differences were considered significant at a Pr > F level of 0.05 or 95% confidence. The orchards were ranked by mean percentage of LB fruit and grouped into subsets, identified as a, b, c, etc.

Experiment 3: Effect of Pre-Harvest ReTain on Appearance of LB after Storage

Because ReTain interferes with the natural synthesis of ethylene in the apple it might have an effect on the application of ethylene or SmartFresh. We applied ReTain to an orchard block at WSU – TFREC and sampled both ReTain treated fruit and those not treated with ReTain. Fruit treated with ReTain had lower levels of LB than fruit that had not been treated (Table 3).

Table 3. Percentage of fruit with LB (control and SmartFresh +1 treatments combined, there was no 14-day SmartFresh for the ReTain treated fruit), standard and severe packs combined.

Evaluation Date	Orchard Id.	Not Treated	ReTain Treated
January	Gala 20	25% a	8% b
April	Gala 20	20% a	5% b
June	Gala 20	26% a	7% b

Analyzed by rows. Differences were considered significant at a Pr > F level of 0.05 or 95% confidence. The orchards were ranked by mean percentage of LB fruit and grouped into subsets, identified as a, b, c, etc.

Experiment 4: Orchard Factors

There was a significant effect of orchard on LB (Table 4). The pattern of severity remained the same as in previous years. Those orchards that were of high risk in previous years were high risk in 2008. We observed that those orchards from the warmer districts had more LB than those from the cooler districts, yet temperature data collected from the orchards did not show an easily discernable difference. Also, we observed that those orchards designed as transitional organic had lower risk of LB than those managed under a conventional program.

Table 4. Orchard ranking (highest to lowest LB) based on the percentage of fruit with LB at each pullout, average of all treatments (standard pack).

January		April		June		Overall LB	
Gala 20	a	Gala 20	a	Gala 20	a	**Gala 20**	**a**
Gala 21	b	Gala 3	b	Gala 3	b	**Gala 3**	**b**
Gala 6	b	Gala 21	bc	Gala 7	bc	**Gala 7**	**c**
Gala 3	b	Gala 7	bcd	Gala 22	cd	**Gala 21**	**c**
Gala 23	b	Gala 6	bcde	Gala 6	cd	**Gala 6**	**c**
Gala 19	b	Gala 23	cde	Gala 23	cd	**Gala 23**	**cd**
Gala 1	b	Gala 1	cde	Gala 4	cd	**Gala 22**	**cd**
Gala 14	b	Gala 4	cde	Gala 10	cd	**Gala 4**	**cd**
Gala 4	b	Gala 9	cde	Gala 19	cd	**Gala 19**	**cd**
Gala 22	b	Gala 10	cde	Gala 21	d	**Gala 10**	**cd**
Gala 11	b	Gala 19	cde	Gala 1	d	**Gala 1**	**cd**
Gala 10	b	Gala 22	de	Gala 11	d	**Gala 9**	**d**
Gala 15	b	Gala 15	e	Gala 15	d	**Gala 11**	**d**
Gala 7	b	Gala 14	e	Gala 14	d	**Gala 14**	**d**
Gala 9	b	Gala 11	e	Gala 9	d	**Gala 15**	**d**

Analyzed by columns. Differences were considered significant at a Pr > F level of 0.05 or 95% confidence. The orchards were ranked by mean percentage of LB fruit and grouped into subsets, identified as a, b, c, etc. Significance: Pr > F 0.0001.

When maturity was compared with the overall LB rating those orchards with fruit that have more starch cleared from the flesh (higher starch number; delayed harvest) were more prone to LB after long-term storage (Figure 5). Fruit from orchards 3, 7 and 20 (data points in blue triangles) developed higher levels of LB than orchards 1, 9, 11, 14, 15 and 21 (data point in green squares) and also had higher starch levels at harvest. However, this was not true in all cases and other maturity indices such as firmness, ethylene, and background color were not well correlated with LB.

Experiment 5: Role of Mineral Content

Apple peels were sent to a laboratory for mineral analysis from fruit from orchards that developed significant LB from each pullout. Both affected and unaffected fruit were sampled.

Fruit that developed LB had higher (potassium, magnesium, nitrogen to lower calcium) ratios than those that did not develop LB (Tables 5, 6 and 7). It is difficult to determine which of these minerals most affect the risk of LB, but it appears that fruit with high nitrogen and low calcium levels have the highest risk of LB. This reinforces the information gathered on the 2007 crop that mineral balance is important to resisting LB stressors.

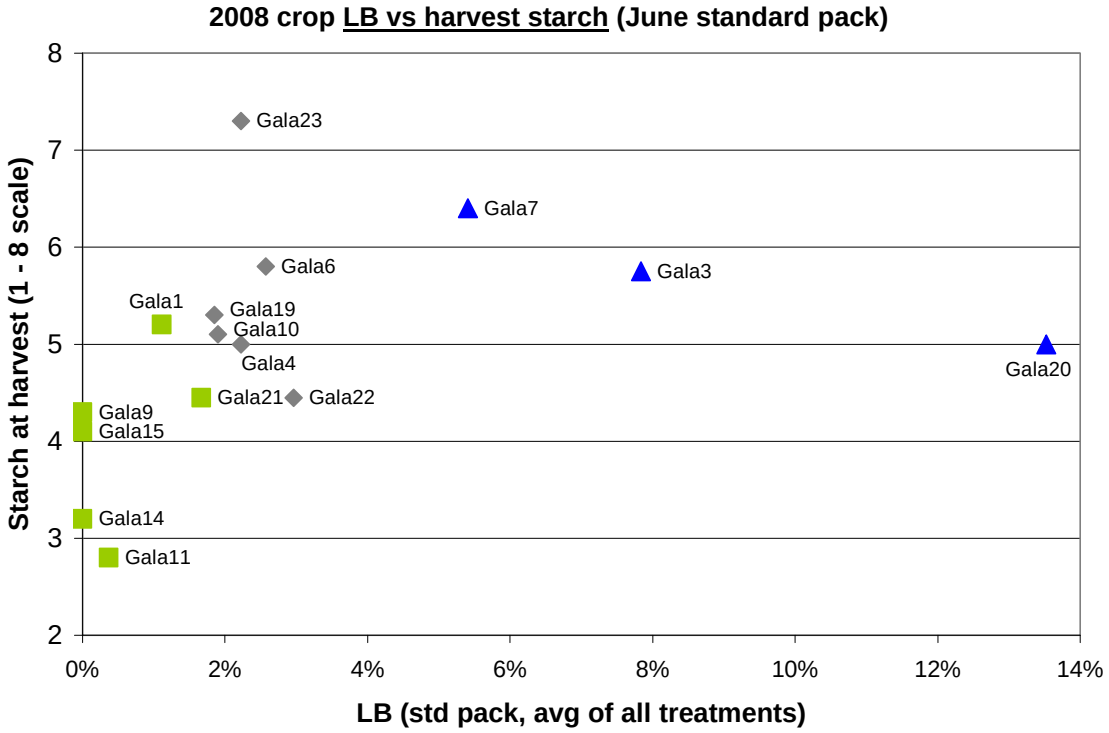

Figure 5. Plot of starch at harvest (1 to 8 scale, Cornell System) against LB after storage and packing. Orchards with low LB damage are shown as green squares, medium LB damage as grey diamonds, and high LB damage as blue triangles

Table 5. Mineral content ratios for fruit with and without LB in January (the average mineral ratio of Gala 3, 6 and 20 is shown on the right).

Orchard	Treatment	Soap*	LB	K+Mg/Ca + N/Ca	LB	Avg. Ratio
Gala 3	SF+14	Std	no LB	**12.6**	no LB	**11.0**
		Std	LB	**18.8**	LB	**19.5**
		Severe	no LB	**17.0**	no LB	**14.9**
		Severe	LB	**19.3**	LB	**24.9**
Gala 6	SF+14	Std	no LB	**9.3**		
		Std	LB	**18.0**		
		Severe	no LB	**11.4**		
		Severe	LB	**18.7**		
Gala 20	SF+14	Std	no LB	**11.3**		
		Std	LB	**21.7**		
		Severe	no LB	**16.2**		
		Severe	LB	**36.8**		

* Std. soap = RealClean at label rate, Severe soap = New Foam 7.0 at twice label rate.

Table 6. Mineral content ratios for fruit with and without LB in April following packing with standard soap treatment (the average ratio of each orchard is shown on the right).

Orchard	Treatment	Soap*	LB	K+Mg/Ca + N/Ca	Orchard	LB	Avg. Ratio
Gala 3	Control	Std	no LB	**21.1**	Gala 3	No LB	**18.6**
	Control		LB	**26.3**		LB	**25.9**
	SF+1		no LB	**19.9**			
	SF+1		LB	**31.2**	Gala 7	No LB	**18.8**
	SF+14		no LB	**15.0**		LB	**24.7**
	SF+14		LB	**20.2**			
Gala 7	Control	Std	no LB	**20.6**	Gala 20	No LB	**22.0**
	Control		LB	**27.7**		LB	**52.7**
	SF+1		no LB	**16.9**			
	SF+1		LB	**21.6**	Gala 9, 11, 14, 15	No LB	**11.7**
	SF+14		no LB	**NA**			
	SF+14		LB	**NA**			
Gala 20	Control	Std	no LB	**28.5**			
	Control		LB	**43.1**			
	SF+1		no LB	**17.9**			
	SF+1		LB	**26.7**			
	SF+14		no LB	**19.4**			
	SF+14		LB	**88.2**			
Gala 9	SF+14	Std	no LB	**10.5**			
Gala 11	SF+14	Std	no LB	**10.0**			
Gala 14	SF+14	Std	no LB	**9.5**			
Gala 15	SF+14	Std	no LB	**16.7**			

* Std. soap = RealClean at label rate

Table 7. Mineral content ratios for fruit with and without LB in June. Standard soap treatment for all analyses (the average ratio of each orchard is shown on the right).

Orchard	Treatment	Soap*	LB	K+Mg/Ca + N/Ca
Gala 3	Control	Std	no LB	**6.73**
	Control		LB	**9.62**
	SF+1		no LB	**9.40**
	SF+1		LB	**11.80**
	SF+14		no LB	**10.10**
	SF+14		LB	**17.06**
Gala 7	Control	Std	no LB	**10.43**
	Control		LB	**15.55**
	SF+1		no LB	**11.01**
	SF+1		LB	**15.51**
	SF+14		no LB	**7.87**
	SF+14		LB	**10.61**
Gala 20	Control	Std	no LB	**12.07**
	Control		LB	**14.48**
	SF+1		no LB	**6.78**
	SF+1		LB	**10.77**
	SF+14		no LB	**10.05**
	SF+14		LB	**12.57**

Orchard	LB	Avg. Ratio
Gala 3	No LB	**8.74**
	LB	**12.83**
Gala 7	No LB	**9.77**
	LB	**13.89**
Gala 20	No LB	**9.63**
	LB	**12.61**

* Std. soap = RealClean at label rate

Experiment 6: Effect of Interval between Harvest and Cold Storage

Testing the premise that the length of time between harvest and cold storage and the temperature of the fruit during that time might play a role in LB development in susceptible fruit, apples were held at ambient temperature (72 ºF) after harvest and dyed at various intervals (Figures 6 and 7). Additional fruit were sampled and placed in RA storage at these same intervals.

This very preliminary experiment showed that during this delayed cooling period, more dye was taken up immediately after harvest than several days later, implying that lenticels were open or cracked at harvest. After holding the fruit at ambient temperature (72 ºF) less dye was taken up and it is theorized that the open cracks in the skin of the fruit might have healed over time in the warm environment.

Additional fruit was run over the packingline in February 2009, after being stored in RA. LB in this fruit after packing showed the same pattern as the dye uptake during the delayed cooling period (i.e., more LB in the fruit that was placed directly into RA and less LB in fruit that was held in warm air prior to RA). Consequently it might be advantageous to delay RA in susceptible lots of Galas to allow the cuticle time to heal, and thus reduce the risk of LB.

Additional experiments to test this observation will take place during harvest in 2009.

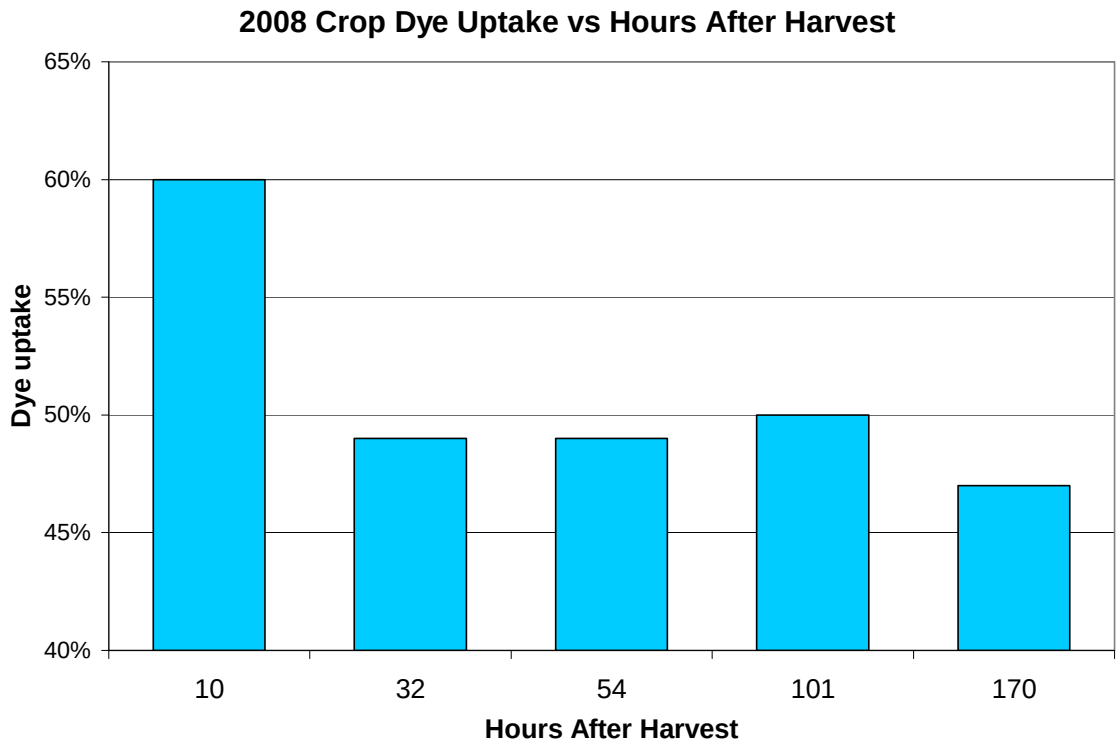

Figure 6. Hours after harvest versus dye uptake (percentage of fruit with dye rating > 2 [Scale is 1 = no dye uptake to 5 = skin of fruit is heavily dyed, not clearly associated with lenticels]).

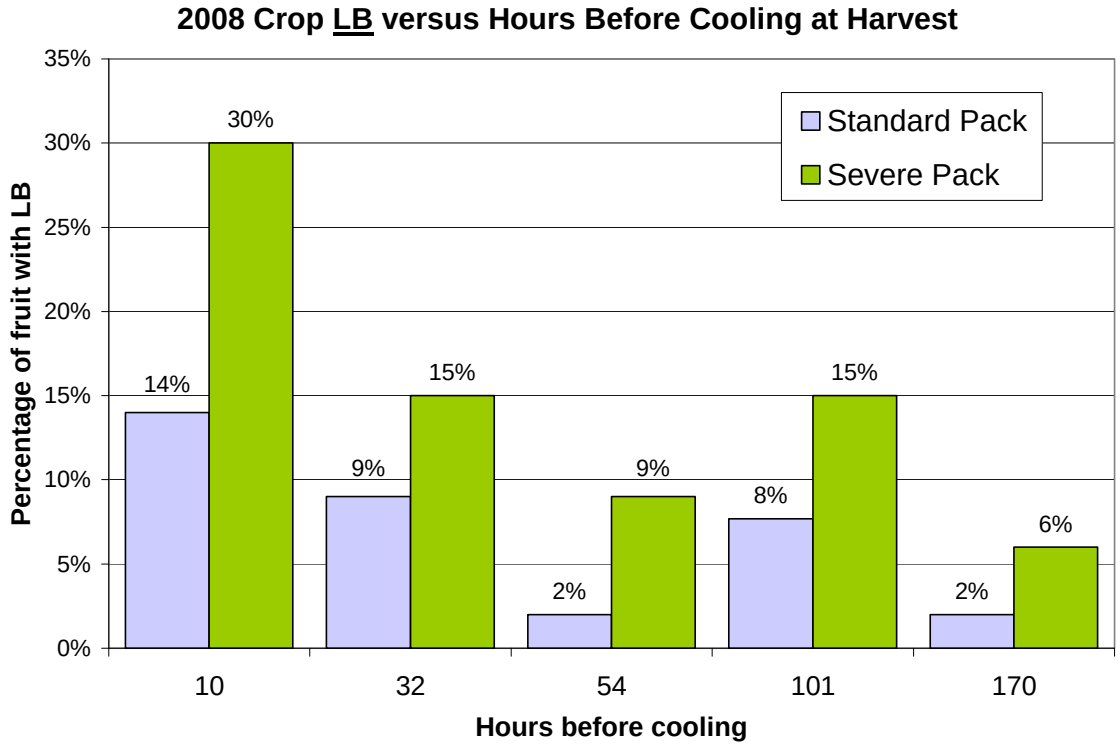

Figure 7. Interval between harvest and cooling vs. LB after packing in February 2009. (Std. pack = RealClean at label rate, Severe pack = New Foam 7.0 at twice label rate.)

Experiment 7: Presize Experiments

A series of experiments were conducted to determine the effects of presizing on LB. Bins of fruit from a single grower lot were presized in a commercial warehouse shortly after harvest in August 2008. These fruit were stored with bins from the same grower lot that were not presized.

On April 6, 2009, the CA room holding these bins of fruit was opened. On April 7, 2009, bins of fruit were run through the presizer at the warehouse. Samples were removed both before (from the flume) and after the bin filler. Samples that were removed before the bin filler were put into returnable plastic containers (RPCs) and stacked on a pallet. Fruit that went through the bin filler was put in a bin. The fruit was loaded into pick-up trucks and transported from the warehouse in Yakima to the WSU Postharvest laboratory in Wenatchee.

Additional bins of fruit were conditioned in RA storage for 14 days prior to being run through the presizer. Again, samples were removed before and after the bin filler and transported from Yakima to Wenatchee.

Experiment 7a: Effect of Presizing Prior to Long-term Storage

Because previous experiments have shown that apples presized after long-term CA storage have a high risk of LB, we evaluated fruit that was presized in August, stored in bins in CA and packed in April. This was compared with fruit from the same orchard that was presized in April prior to packing (Figure 8). Galas presized at harvest and stored in long-term CA before packing had significantly less LB than fruit presized immediately prior to packing.

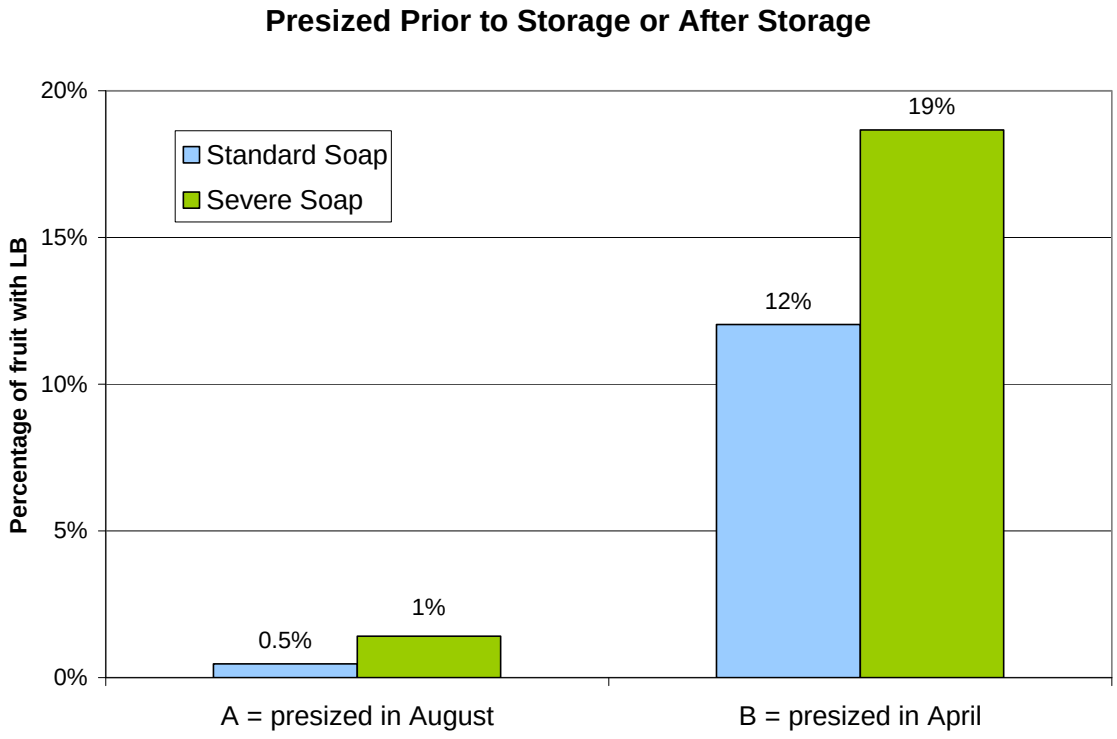

Figure 8. Comparison of LB developing after packing on fruit presized at harvest prior to CA storage with fruit presized after CA storage. Both standard and severe soap treatments are shown. (Std. soap = RealClean at label rate, Severe soap = New Foam 7.0 at twice label rate.)

Experiment 7b: Effect of Interval between Presize and Packing

There is interest in determining the effect of the interval between presizing and packing after long-term storage on LB. Fruit were held in RA storage and packed on the same day or, 7, 14 and 21 days after presizing in April. See Figure 8 for the standard soap and Figure 9 for the severe soap treatment.

Fruit presized in August and packed in April had little or no LB. For the fruit presized in April, fruit packed 7 or 14 days following presize developed significantly higher levels of LB than those packed 21 days after presizing. When a mild soap (standard soap) was utilized, fruit packed the same day as presizing had a low incidence of LB as compared with packing after 7 or 14 days (Figure 9); however when a severe soap was used, the LB on the fruit packed the same day as the presizing had almost as much LB as the fruit packed after 7, or 14 days (Figure 10).

Following CA storage it appears that the risk of LB is highest when the interval between presizing and packing is 7 or 14 days as compared with allowing the fruit to remain in RA storage for 21 following presizing. An alternative would be to pack the fruit immediately after presizing using a very mild soap.

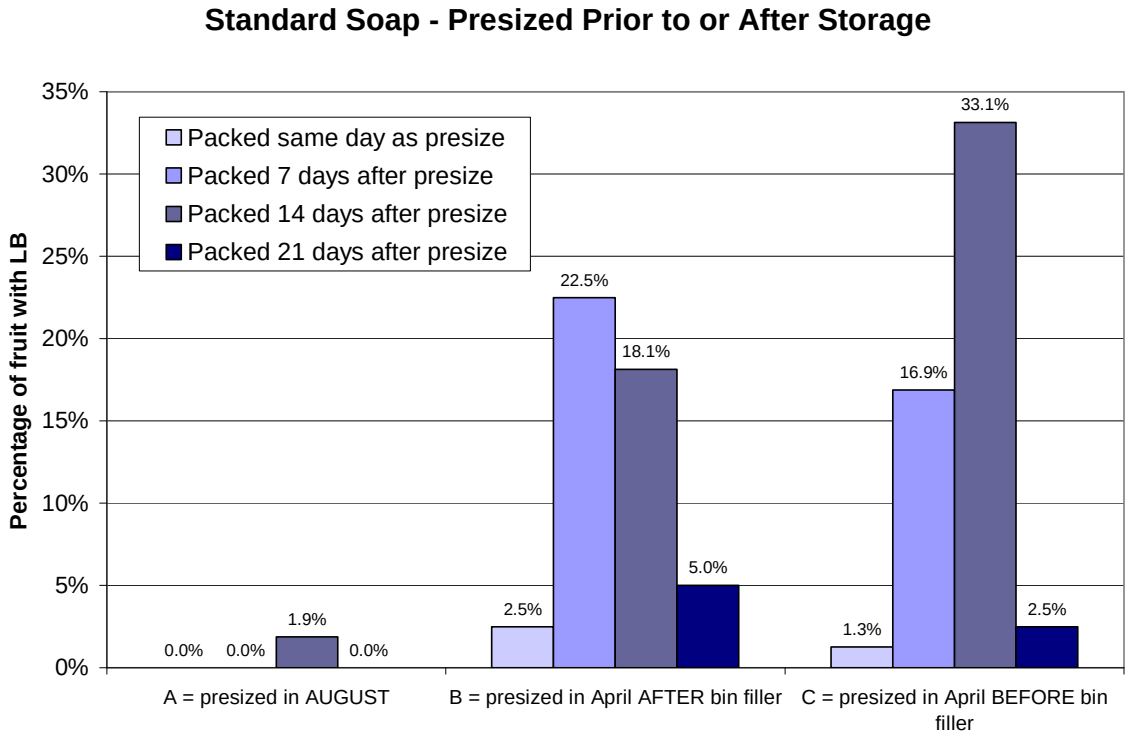

Figure 9. Comparison of LB developing after packing on fruit presized at harvest prior to CA storage with fruit presized after CA storage. Standard soap was utilized. (Std. soap = RealClean at label rate.)

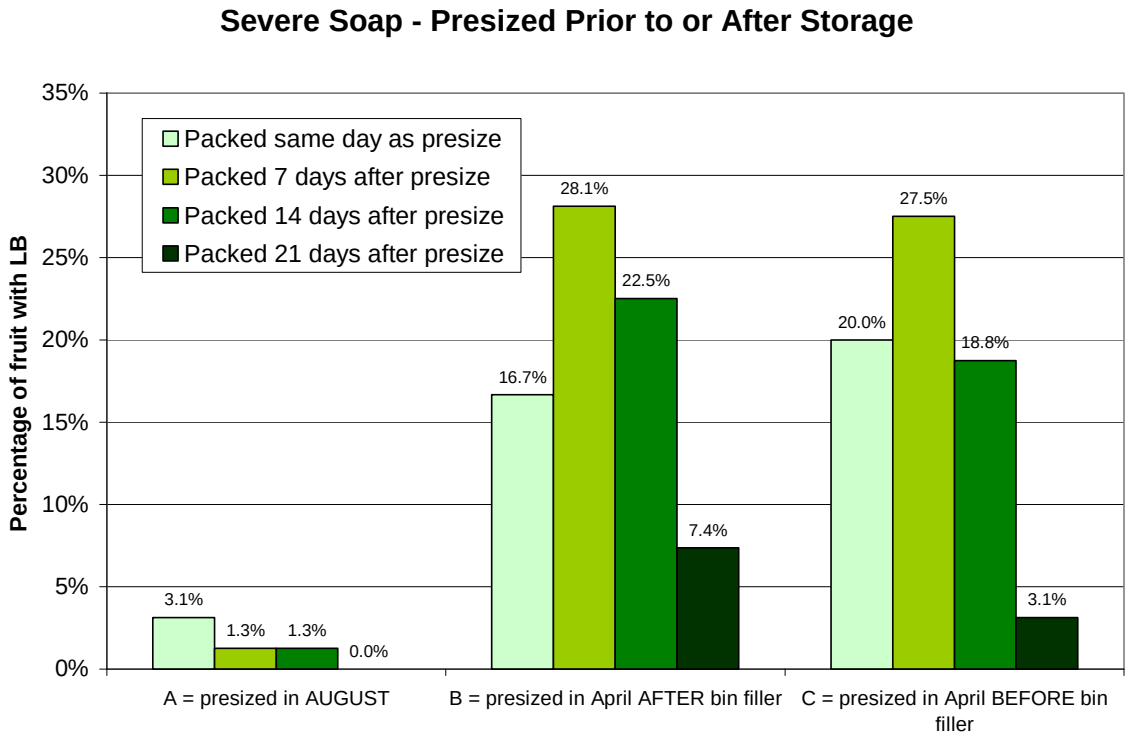

Figure 10. Comparison of LB developing after packing on fruit presized at harvest prior to CA storage with fruit presized after CA storage. Severe soap was utilized. (Severe soap = New Foam 7.0 at twice label rate.)

Experiment 7c: Effect of Bin Filler on incidence of LB

To determine whether the hydrostatic pressure on fruit as it is lifted into the bin at the end of the presize might have an effect on the incidence of LB fruit were either removed from the flume prior to or after the bin filler. There was no effect of the bin filler on LB following packing. It is possible that transport of the fruit from the packinghouse in Yakima (CHEPs vs bins) could have influenced this result.

Experiment 7d: Effect of "Conditioning" CA-Stored Fruit Prior to Presizing

To minimize LB, some packers "condition" the fruit following long-term CA storage prior to presizing. In this experiment fruit was conditioned in a commercial facility for 14 days prior to being transported to the lab and packed on the same day, or 3, 7, 14 or 21 days later.

A 3-day pack interval was added because the fruit warmed to an internal temperature of between 70 to 80 ºF during transport from Yakima to Wenatchee, and it was not known what affect this warm temperature would have on the incidence of lenticel breakdown (Figures 11 and 12). This test showed the positive value of conditioning Gala apples stored in long term CA prior to packing.

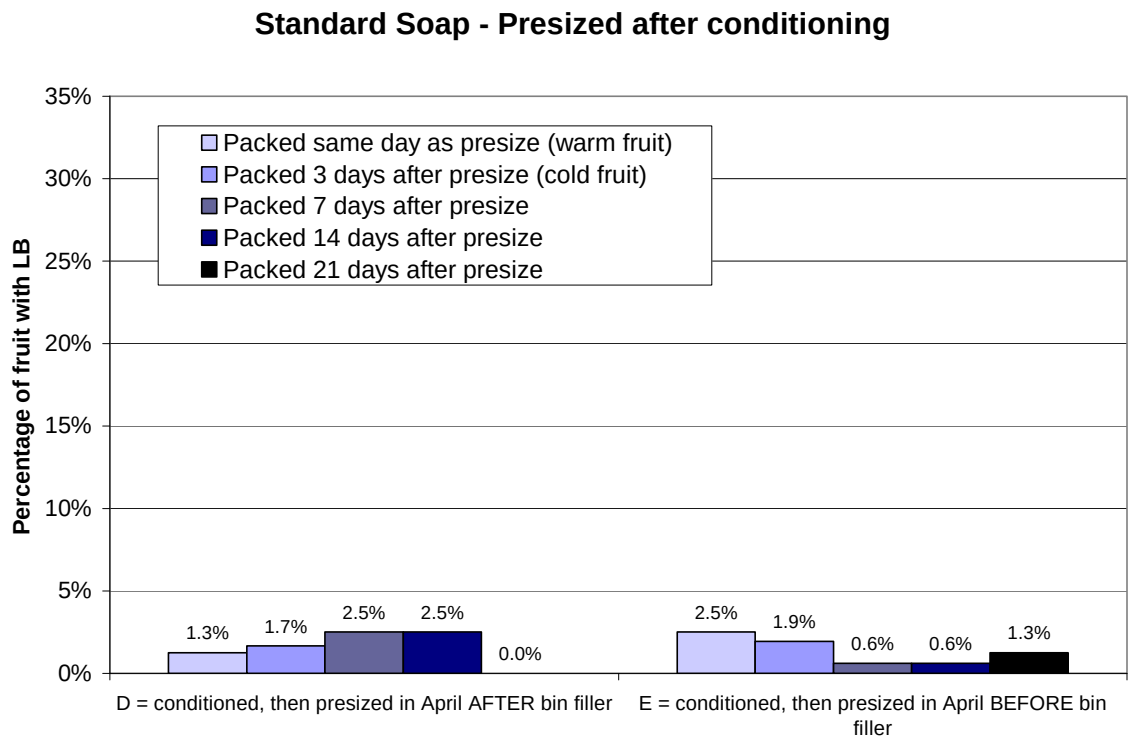

Figure 11. Comparison of LB developing after packing on fruit conditioned for 14 days after CA storage, then presized. Standard soap was utilized. (Std. soap = RealClean at label rate.)

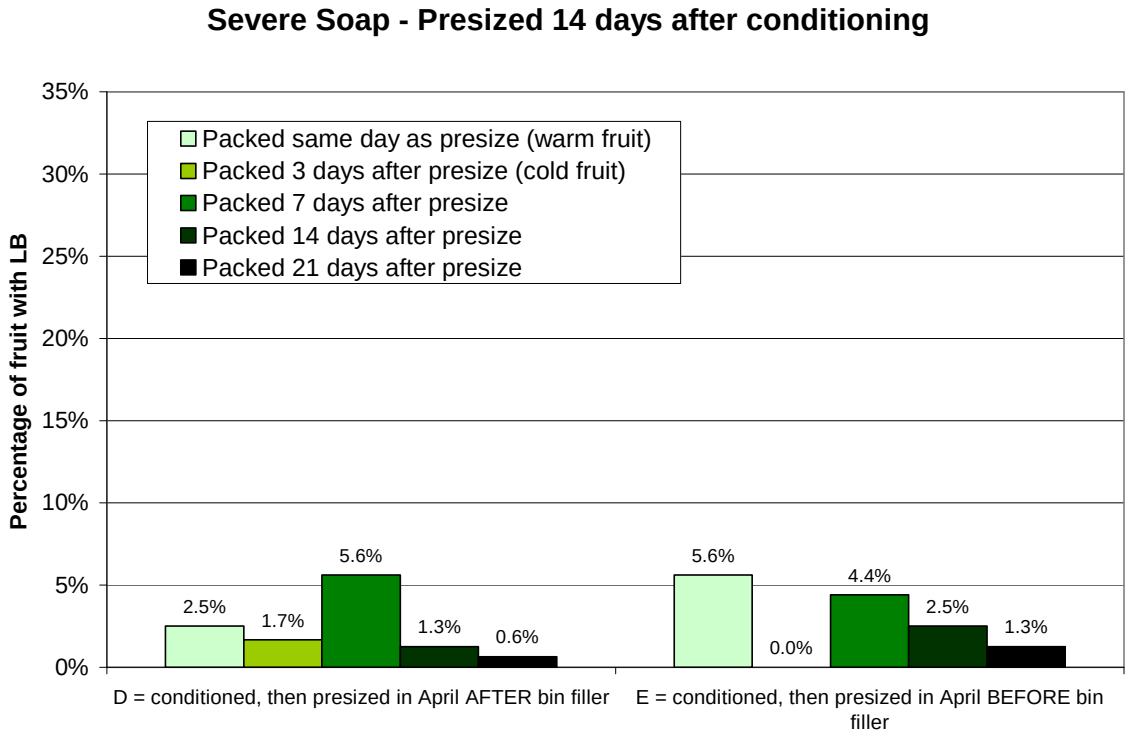

Figure 12. Comparison of LB developing after packing on fruit conditioned for 14 days after CA storage, then presized. Severe soap was utilized. (Severe soap = New Foam 7.0 at twice label rate.)

Experiment 7: Summary

LB incidence was compared on fruit packed from the same orchard held under different storage and presizing sequences. The treatments were:

A. Presized in August before storage and packed after CA storage
B. Presized and packed after CA storage, fruit removed AFTER the bin filler
C. Presized and packed after CA storage, fruit removed BEFORE the bin filler
D. Conditioned for 14 days after CA storage, presized, fruit removed AFTER the bin filler
E. Conditioned for 14 days after CA storage, presized, fruit removed BEFORE the bin filler

All packing was done in April after CA storage.

The largest number of fruit with LB came from Treatments B and C in which fruit were presized and packed after storage. There was no difference in LB between fruit presized in August (Treatment A) prior to CA or fruit conditioned after CA and prior to presizing (Treatment D). Treatments A, B and D are shown in Figure 13. Because the bin filler did not have a not significant affect on LB, the samples taken before the bin filler (Treatments C and E) are not shown.

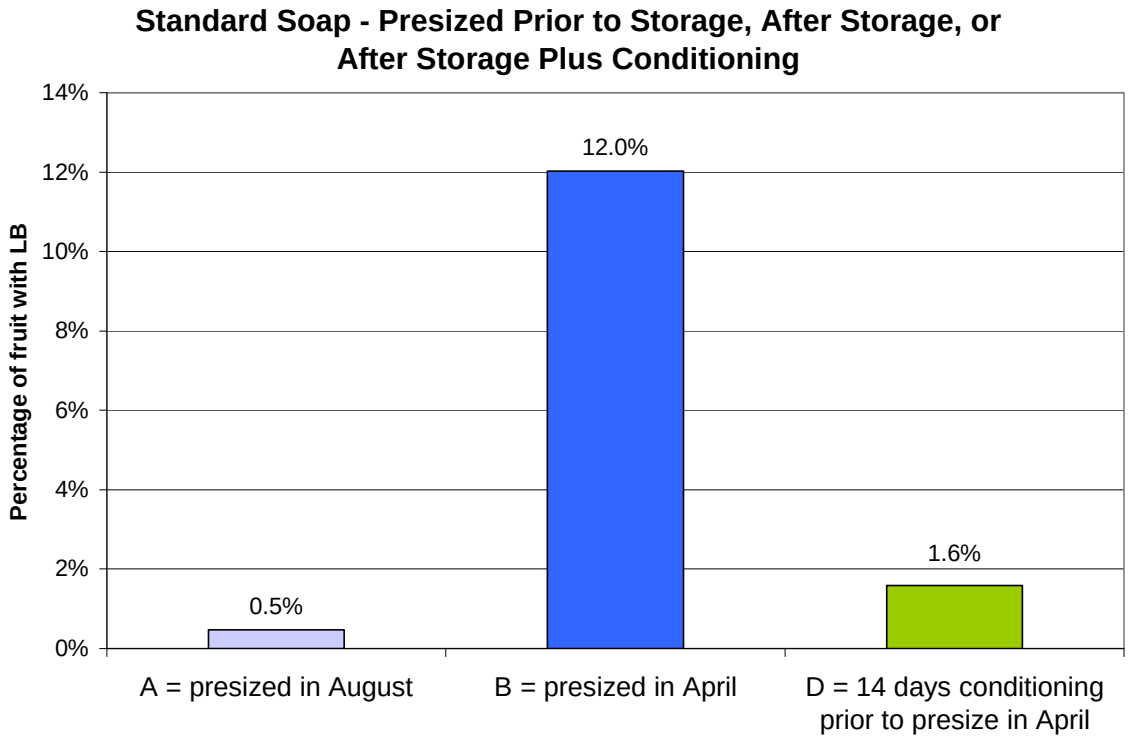

Figure 13. A comparison between presizing Galas prior to storage, presizing after removal from storage and conditioning for 14 days after storage prior to presizing. The average LB for all packing intervals (same day, 7, 14 and 21 days) is shown.

Experiment 8: Effect of Calcium and Sodium Hypochlorite, Drying Speed, and Water Immersion on Lenticel Breakdown

Note: The purpose of experiments 8a, b and c was to determine what part of the presize process actually damages the fruit. The fruit we used had been stored in RA for approximately 2 weeks after being removed from CA. This 2-week period essentially "conditioned" the fruit, so there was very little LB in a season in which there already was little LB in any fruit. These experiments should be repeated in 2009 with LB susceptible fruit that we can test the day they are removed from CA.

A series of experiments was conducted to determine the effects of stressors experienced by fruit on the packingline, i.e., calcium or sodium hypochlorite, drying speed following immersion, and multiple water immersions on LB. In April 2009, three bins of fruit were obtained from a commercial lot that had a history of LB problems. These fruit were removed from CA at a warehouse in Yakima and transported to the laboratory in Wenatchee and held in RA for approximately two weeks before the experiments were conducted.

Experiment 8a: Effect of Calcium and Sodium Hypochlorite

Sodium hypochlorite, which is typically present in packingline dump tanks at concentrations ranging from 30 to 100 ppm free chlorine, is one of the chemical stresses that may contribute to LB. To test whether higher concentrations of sodium hypochlorite would cause LB, or if calcium hypochlorite would cause more or less LB, fruit was treated with different solutions. Samples were removed from the bins of LB-susceptible fruit and treated under pressure (4 inHg) for 15 seconds in one of the following 5 solutions (the ppm listed is the amount of free chlorine in each solution):

1. Water
2. 100 ppm free chlorine from calcium hypochlorite
3. 100 ppm free chlorine from sodium hypochlorite
4. 300 ppm free chlorine from calcium hypochlorite
5. 300 ppm free chlorine from sodium hypochlorite

Following the treatments, the fruit was put in RA storage for 7, 14 or 25 days before being packed on the research packingline. There was very little LB seen on the fruit (data not shown).

Experiment 8b: Effect of Drying Speed

Following presizing in the spring, fruit may be held for various lengths of time in rooms with different levels of relative humidity (RH) prior to packing. To test the effects of fast (low RH) and slow (high RH) drying, samples were removed from the bins of LB-susceptible fruit and treated under pressure (4 inHg) for 15 seconds in a clean water solution, placed into containers for fast or slow drying, and then allowed to dry for various lengths of time (4 hours, or 1, 2, 3, 7, 14 or 21 days) prior to being packed on the research packingline.

- Fast drying = fruit on trays in CHEPs in low RH cold room (45% RH)
- Slow drying = fruit on trays in poly-lined boxes in high RH cold room (73% RH)

There was no difference in LB between the fast and slow drying treatments; and no statistical difference in LB based on the packing interval following the immersion treatment (data not shown).

Experiment 8c: Effect of Multiple Water Immersions

Fruit that is presized undergoes multiple water immersions (dump tank, flume, bin filler) during presize, is stored for a period of time and then is run over the packingline where it undergoes more water immersion (dump tank and rinse spray). To determine whether it is the multiple water immersions from presizing that cause more LB in presized fruit, samples were removed from the bins of LB-susceptible fruit and treated to multiple water immersions (not under pressure), with a 2–minute drying time between each immersion:

1. 10 minutes at 36 ºF
2. 10 minutes at 45 ºF
3. 10 minutes at 45 ºF
   (the fruit was stored in RA after this step)
4. 10 minutes at 80 ºF
5. 2 minute spray of 80 ºF water

The first 3 steps were intended to mimic the multiple water immersions of a pre-size operation. The treated fruit was stored in RA for 1 or 7 days after this step. Steps 4 and 5 were intended to mimic the dump tank and a rinse bar (the dump tank on the research packingline is not used as part of the standard Gala LB packing protocol). The control fruit was treated with steps 4 and 5 only.

The fruit treated with multiple water immersions prior to packing had more LB than the control fruit, both after 1 day and 7 days in storage. Fruit that held in RA for 7 days prior to being packed had more LB than the fruit that was packed 1 day after treatment (Figure 14). However, these differences were not statistically significant.

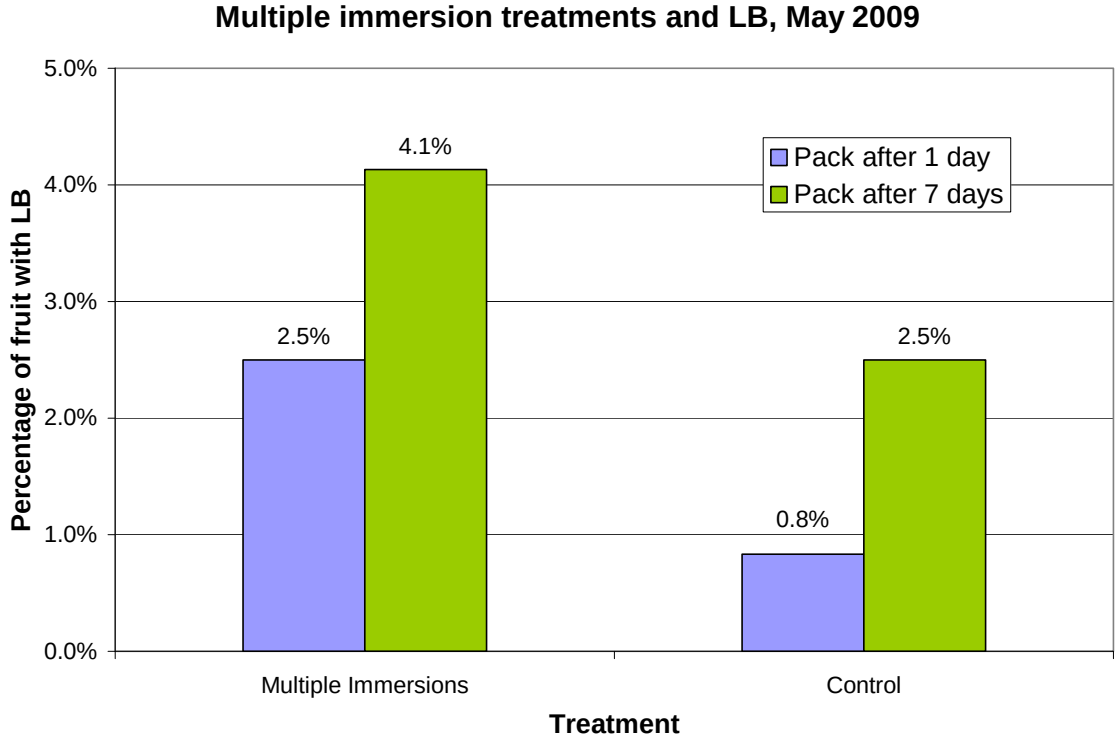

Figure 14. Effect of multiple vs. single immersion in water and packing after 1 or 7 days. (Std. pack = RealClean at label rate.)

Experiment 9: Tests to Determine Risk of LB

Fruit from each orchard were subjected to the dye uptake test and the soap stress test, both at harvest and after removal from CA storage in January, April and June. The methodology for each test is described below.

- The dye uptake method utilized 20 fruit (room temperature) that were rinsed with cool running water, and then submersed into a tank containing, 0.2% aniline blue dye. After the tank was sealed a vacuum was pulled to 10 inHg within 15 seconds and held for 30 seconds. The fruit were then removed from the dye bath, rinsed under clean running water and scored within 24 hours. Scale was 1 = no dye uptake to 5 = skin of fruit is heavily dyed, not clearly associated with lenticels.
- The soap stress test utilized 20 fruit (cold) which were submersed in a New Foam cleaner solution (2x label rate = 80 mL/10 L) at 70 ºF for 5 seconds. The fruit were placed upright in fiber trays to dry and were evaluated for LB damage after 24 hours (damage will continue to worsen over time). Scale was the same as for LB damage after packing (0 = none to 5 = severe).

The dye test and soap tests were not statistically predictive of LB that appeared after the packingline treatment in a linear relationship whether the prediction tests were performed at harvest or at time of removal from storage. However, when orchards were ranked against each other using the prediction tests there was a good relationship between orchards that developed a great deal of LB and high prediction test scores versus those the did not develop LB on the packingline and low prediction test scores. Both the dye and soap tests are essentially tests for the number and, perhaps, size of open lenticels in a sample of fruit. Because maturity is also a factor in LB, further analysis of the data, adjusting for starch content may allow refinement of the predictive quality of the dye and soap tests.

CONCLUSION

Lenticel breakdown did not appear to be as serious in the 2008 crop as in previous years. The fruit we sampled from 12 Gala orchards did not develop as severe symptoms of LB as it had previously. Personal communications with packers indicates that there was less LB this year; however, commercial experience may be based on increased knowledge of how to avoid this problem.

The timing of postharvest application of SmartFresh was a significant factor in the appearance of LB. SmartFresh application was made 1 or 14 days after harvest. Application of SmartFresh one day after harvest had no effect on LB. Delaying application to 14 days after harvest showed an increase in LB following long-term CA storage and packing. Research is scheduled for the 2009 crop to determine the effect of SmartFresh application on LB during this 14-day timeframe.

Multiple removals from storage (January, April and June) showed an increase in LB incidence with time in storage. This is slightly different from previous years in which the peak LB period was in April, with less LB seen in later pull outs.

Orchard factors appear again to have a strong effect on LB risk. Relative ranking of the orchards based LB susceptibility was the same as in previous years. Orchards in the cooler districts and those farmed organically appear to have lower risk of LB. This has not been proven experimentally.

Fruit mineral content may be a key to LB risk. Fruit with LB have different peel mineral content compared with fruit from the same orchard without LB. Individual nutrients are not necessarily related to LB risk. Apples with LB have higher ratios of nitrogen, potassium and magnesium, to calcium in the peel tissue. So the question may be posed: whether LB and bitterpit or LB and lenticel blotch pit are related. Gala apples do not have a reputation for being high risk of bitterpit, yet their parent, Golden Delicious is a high risk variety. Why don't Goldens get LB? We encountered a disorder which is new to us in the flesh of Gala apples in June. This is described in a separate report but looks very much like internal bitterpit.

An exciting discovery this year deserves more research. Gala apples held at warm (ambient) temperatures immediately after harvest picked up less dye and after storage were less susceptible to LB than fruit that were cooled immediately. It is possible that fruit needs more of an acclimation time after harvest prior to storage.

Presizing has been shown to affect LB risk, especially in fruit presized after January. A series of experiments with this crop proved that presizing prior to storage effectively lowered this risk when fruit were packed after long-term storage. "Conditioning" the fruit in RA after long-term CA storage prior to presizing also reduced risk of LB.

The interval between presize and packing following long-term CA storage affects LB. Fruit treated with a mild soap had less LB 1 or 21 days after presizing. Fruit packed 7 or 14 days after presizing developed more LB. The mechanism for this change in susceptibility remains unclear. Packers might want to consider this when scheduling fruit after presize.

Research on reasons for the detrimental effect of presizing long-term stored Gala apples was conducted. Calcium and sodium hypochlorite were tested as agents that might promote LB. Speed of drying after water immersion as well as time, temperature and repeated immersions in water were tested. Dr Eric Curry (USDA-ARS) reported that apples treated with sodium hypochlorite prior to storage developed skin damage while in storage. Our findings have not shown that fruit is highly susceptible to damage from reasonable levels of sodium hypochlorite when applied after storage. Risk of damage is reduced when an adequate rinse is utilized.

The information obtained for the hypochlorite, water immersion and drying tests is not as valuable as I would like in understanding LB due to a number of factors. For one, this year we learned that fruit which has been 'conditioned' in RA after CA storage develops less LB than fruit directly out of storage. The fruit we utilized in this work had been conditioned and developed very little LB. We would like to repeat this work with susceptible fruit immediately out of storage.

Washington packers have seen less economic damage from LB than in the past for a number of reasons; among them is the involvement of AgroFresh in sponsoring research. Thank you.