FINAL REPORT
WTFRC Project #PH03-354 **WSU Project #14C-4164-2912**

Project title: Lenticel Breakdown: The Packingline Component

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Objectives:
Characterize the role of packingline stressors on the development of Lenticel Breakdown (LB) to increase the industry's ability to pack susceptible fruit. Specific attention was paid to the following:

- Dump tank acidifiers and concentration
- Fruit cleaner formulation and concentration
- Wax type
- Presize
- Apple and rinse temperature at time of packing
- Brush speed
- HyperClean

Significant findings:

- In the laboratory tests using fruit dipped in dump tank acidifiers, fruit developed more LB damage when dipped in Mineral-XX than when dipped in Tri-Circ at both label rate and higher concentrations.
- Fruit dipped into solutions of Real Clean or 180 Cleaner developed less LB than fruit dipped into D-Scale, Acidex or Field Clean. Fruit dipped into solutions of Acidex developed the most LB damage in this trial.
- When applied at label rate using a drip bar, fruit treated with the cleaner Kleen-Pac AL+ developed more LB damage than fruit treated with New Foam 7.0, Phase II or D-Scale. D-Scale treated fruit had less LB damage than fruit treated with other cleaners.
- Many packinglines utilize cleaners at higher concentrations than label rate. Cleaners applied at higher concentrations caused more LB damage than when applied at label rate.
- When used with a cleaner, wax applied to warm fruit caused more LB damage than unwaxed cold fruit. The effect of wax formulation was inconclusive.
- Presized fruit was more susceptible to develop LB after packing than fruit packed without presizing.
- Cold apples that were rinsed with cold water had less LB damage than apples that were warmed in water (dump tank), rinsed with warm water, and waxed.
- Moderate differences in brush speed (Golden vs. Red speeds) did not affect the amount of LB damage.
- HyperClean did not affect LB incidence on fruit that had not been presized nor did it affect incidence on non-presized fruit when a cleaner was not applied. When used with a cleaner, presized fruit treated with the HyperClean system developed more LB damage than presized fruit not treated with HyperClean.

Methods:
At harvest, Gala apples were purchased from three orchards that had been recommended by Dr. Eric Curry as having had significant LB damage in several of the past three years. Apples were stored in their original wooden bins in the WTFRC/Stemilt rooms in CA. None of the fruit was treated with SmartFresh™. This fruit was used for all the experiments described below.

For Experiments I and II, fruit from the three orchards was used straight from the field bins. On January 22, 2004, half of the fruit from each orchard was presized using the Stemilt commercial presizer. The fruit was placed back into CA storage, and bins were removed as needed for subsequent trials. For Experiments III and IV, both presized and non-presized fruit from the same orchards were compared.

During visits to a number of packinghouses, it was learned that cleaners were being applied at higher than label rates. In some cases the packers would increase the concentration in the belief that it was important for the cleaner to develop suds. (This is not true with most modern cleaners.) In other cases the desire for an exceptional shine motivated the packer to increase cleaner concentration. In many cases the packingline technicians did not know the concentration stated on the label. To determine the effect of higher concentrations on the amount of LB damage, we used concentrations of 10 times and 4 times label rate. The 10x concentrations were used for cleaners whose label rates were 1% to 2%. The 4x concentrations were used for cleaners whose label rate was 5%. In this way, no more than a 20% solution of cleaner was applied to the fruit.

Methods Experiment I—Laboratory Study*:* Laboratory trials were performed in November and December 2003 by dipping apples in commercially used cleaners and dump tank acidifiers. A list of dump tank additives and cleaners used on commercial apple packinglines was obtained from Wilbur-Ellis Co.; these chemicals were obtained from the manufacturers (Table 1). In this experiment we used only fruit that had not been presized.

Table 1. Products utilized in the Laboratory Study (Experiment I).

Product	Manu-facturer	Labeled Use	pH	Purpose	Label Conc.	High Conc.
Mineral-XX	Pace	Dump tank	Acidic	Loosen spray/irrigation deposits on fruit	1%	10%
Tri-Circ	CH2O	Dump tank	Acidic	Loosen spray/irrigation deposits on fruit	1%	10%
Acidex	Pace	Line Spray	Acidic	Cleaner	5%	20%
D-Scale	CH2O	Line Spray	Acidic	Cleaner	1%	10%
180 Cleaner	Pace	Line Spray	Acidic	Cleaner	2%	20%
FieldClean	Pace	Line Spray	Alkaline	Cleaner	5%	20%
RealClean	CH2O	Line Spray	Alkaline	Cleaner	1%	10%

Cold apples (34ºF) were dipped into a warm water (90-110ºF) solution of each cleaner and held for 10 minutes. Apples were placed on fiber trays without being rinsed and held at 70ºF for two days prior to being evaluated for LB damage. Apple LB damage was rated on the following 1 to 5 damage scale:

1. No LB damage
2. Few lenticels affected, diffuse, damage only in lenticel
3. Affected lenticels are widespread on apple, damage only in lenticel
4. Widespread lenticel damage and some surrounding tissue damage
5. Widespread lenticel damage and profuse tissue damage

Fruit rated 3, 4 and 5 was considered commercially unacceptable. This commercial level of LB damage is reported in the Results section.

Results Experiment I—Laboratory Study: The effect of packingline cleaners on LB damage is shown in Figure 1. For the dump tank acidifier solutions, fruit developed more LB damage when dipped in Mineral-XX than when dipped in Tri-Circ at both label rate and higher concentrations.

For the cleaner solutions, fruit dipped into Real Clean or 180 Cleaner developed less LB than fruit dipped into D-Scale, Acidex or Field Clean. Fruit dipped into solutions of Acidex developed the most LB damage in this trial.

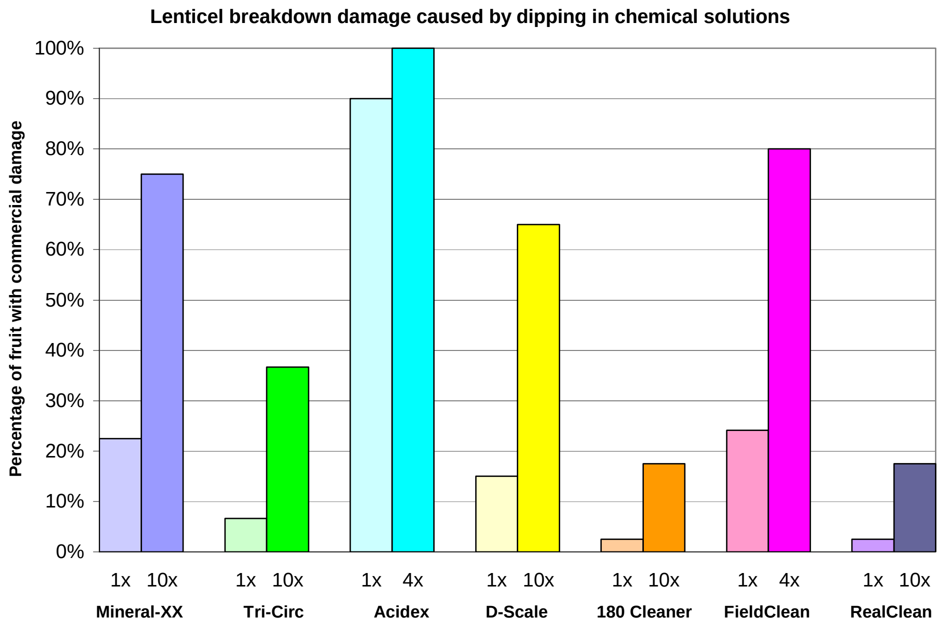

Figure 1. Effect of packingline chemicals and concentration on commercially unacceptable LB damage—fruit dipped in solution and not rinsed (Experiment I—Laboratory Study).

Methods Experiment II—Packingline Study I*:* The purpose of the Packingline Study I was to test the effect of various cleaners on LB damage using a packingline. Tests were conducted on non-presized fruit from February to March 2004 using the USDA packingline. Each cleaner was used at the label rate and again at either 4 or 10 times the label rate (Table 2). The brush bed on the packing line was coated with the test solution from a drip bar. The apples were placed on the brush bed and brushed for one minute. The fruit was then removed without rinsing and placed on trays to dry. After being held at room temperature for two to seven days, the apples were rated for LB damage on the same 1 to 5 scale used in Experiment I.

Table 2. Products utilized in Packingline Study I (Experiment II).

Product	Manu-facturer	Labeled Use	pH	Purpose	Label Conc.	High Conc.
Acidex	Pace	Line Spray	Acidic	Cleaner	5%	20%
D-Scale	CH2O	Line Spray	Acidic	Cleaner	1%	10%
Kleen-PAC AC	Solutec	Line Spray	Acidic	Cleaner	5%	20%
FieldClean	Pace	Line Spray	Alkaline	Cleaner	5%	20%
RealClean	CH2O	Line Spray	Alkaline	Cleaner	1%	10%
Kleen-PAC AL+	Solutec	Line Spray	Alkaline	Cleaner	5%	20%

Results Experiment II—Packingline Study I: Commercially unacceptable LB damage by cleaner is shown in Figure 2. Cleaners caused more damage at higher concentrations, except for D-Scale. In this study, D-Scale caused no damage at the higher concentration.

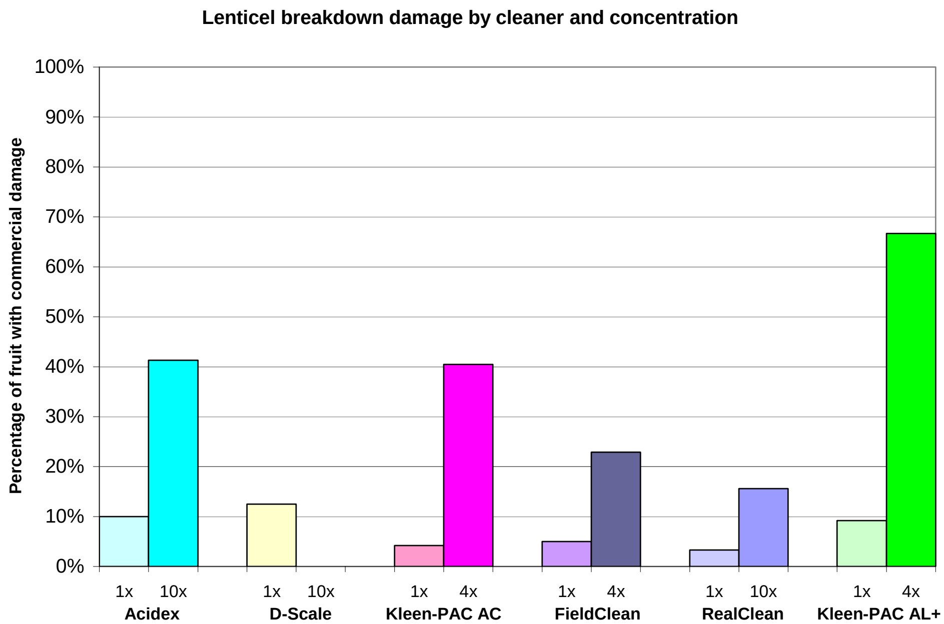

Figure 2. Effect of packingline chemicals and concentration on commercially unacceptable LB damage—fruit not rinsed (Experiment II—Packingline Study I).

Methods Experiment III—Packingline Study II: The purpose of Packingline Study II was to test the effect of presize, fruit and rinse temperature, cleaner type and concentration, and wax formulation on LB damage using a packingline. Tests conducted in March and April 2004 using the USDA packingline allowed us to simulate commercial conditions. In this experiment, widely used cleaners and waxes were applied, and both the rinse water and fruit temperatures were varied. An alkaline cleaner (Kleen-PAC AL+), a neutral cleaner (New Foam 7.0), two acid cleaners (D-Scale and Phase II Acid), a carnauba wax (APL-Brite 400C), and a shellac wax (AP40) were used. Six lots of fruit (non-presized and presized apples from each grower) were treated with each cleaner at two concentrations (label rate and 4x or 10x label rate).

In the cold fruit study, apples were taken straight from the cold room and placed on the packingline. A cleaner solution was dripped onto the brushes and apples. The fruit was on the brush bed for 2 minutes before being rinsed for 30 seconds with tap water (approximately 55ºF). The apples moved down the line for 2 minutes of brushing, then went through a 100ºF dryer for 2 minutes before being placed on trays and into boxes.

In the warm fruit study, the apples were placed in a 90ºF water bath for 2 minutes. This warmed the fruit to approximately 65ºF at 1 mm below the skin. Cleaner solution was dripped onto the brushes and apples. The apples were on the brush bed for 2 minutes before being rinsed for 30 seconds with warm water (approximately 90ºF). The fruit moved down the line for 2 minutes of brushing before wax was applied by a wigwag nozzle. The apples then went through a 110ºF dryer for 2 minutes before being placed on trays and into boxes.

The apples were stored at 34ºF for four days, then at room temperature (approximately 70ºF) for two days, and then evaluated for LB damage. Based on the amount of severe damage seen in earlier trials, the severity scale for LB was simplified as follows to reflect commercial damage:

0 = no damage
1 = slight damage, commercially acceptable quality
2 = moderate damage, commercially marginal quality
3 = widespread or severe damage, commercially unacceptable quality

Results Experiment III—Packingline Study II*:* LB damage was more severe on the presized fruit. Presize vs. non-presize LB damage for fruit of all growers is shown by cleaner (cleaners used at label rate) in Figure 3. All cleaners caused significantly more LB damage at higher concentrations (data not shown).

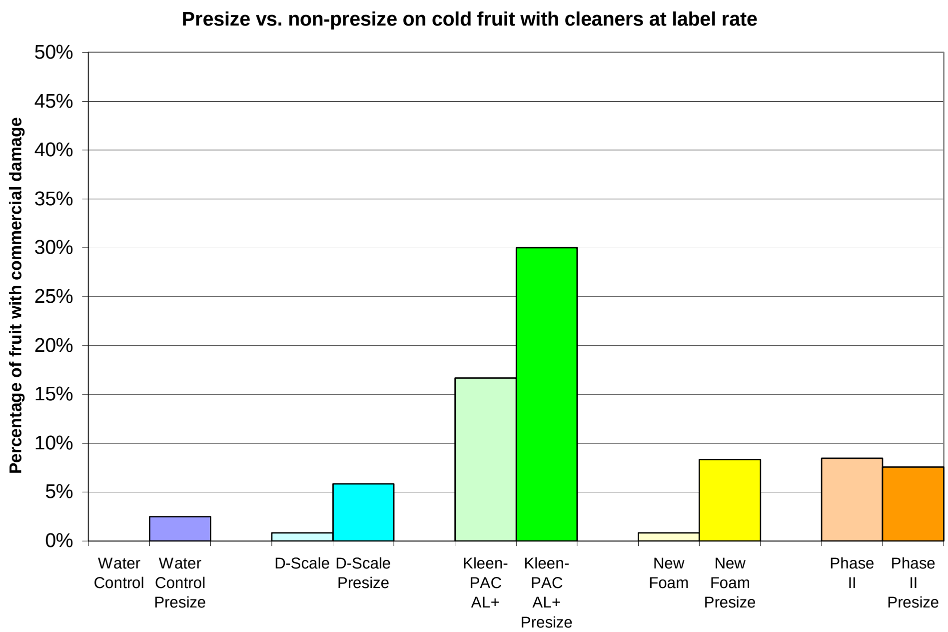

Figure 3. Effect of cleaner and presize on commercially unacceptable LB damage—fruit not waxed (Experiment III—Packingline Study II).

Fruit that was warmed at 90ºF for two minutes (simulating warm water dump tank conditions) prior to being run over the packingline showed more LB on the presized fruit (Figure 4). Data shown in Figure 4 are for cleaners used at label rates with carnauba or shellac wax. All cleaners caused significantly more LB damage at higher concentrations (data not shown). The effect of wax formulation (carnauba vs. shellac) on LB damage was inconclusive.

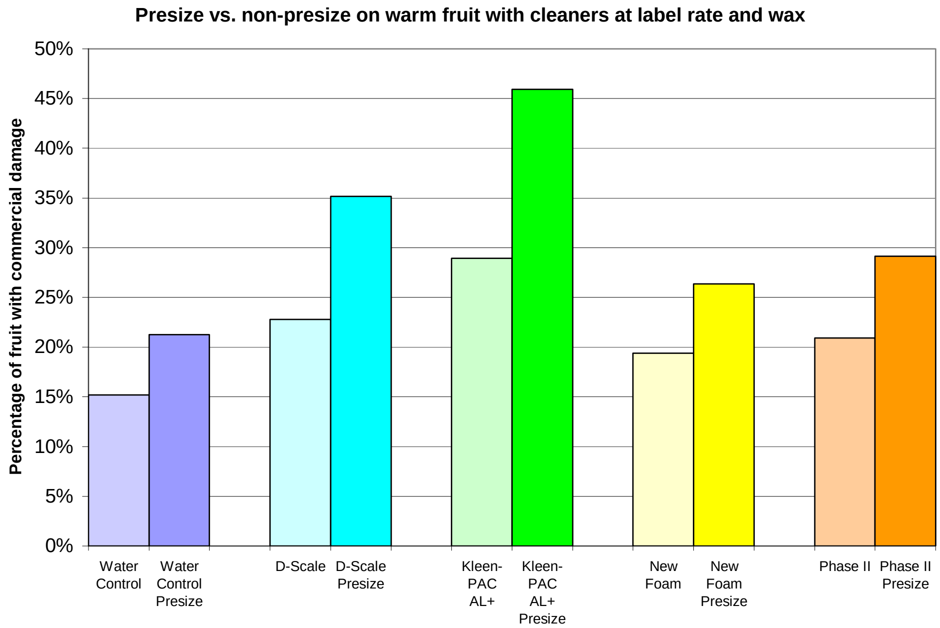

Figure 4. Effect of cleaner and presize on commercially unacceptable LB damage—warm fruit with a warm rinse and waxed with carnauba or shellac (Experiment III—Packingline Study II).

Methods Experiment IV—Commercial Packingline Study: A study was performed at the Northern Fruit commit-to-pack packingline in April 2004 to test whether applying cleaner and wax, changing brush speed, or adding the HyperClean treatment would affect the amount of LB damage. HyperClean uses high volume high velocity water sprayed over the fruit on the brushes to remove decay and clean the fruit.

A bin from each of the six treatments (three presize and three non-presize) was selected for use. For control fruit, a sample was taken prior to the bin of fruit being placed on the line, another sample was taken from the dump tank, and a third sample was passed over the packingline using water only (no cleaner or wax). A portion of each bin of fruit was then passed over the packingline with a cleaner (D-Scale at label rate) and wax (carnauba) at two brush speeds. The “slow” speed is the brush speed normally used for Golden Delicious, and the “fast” speed is normally used for Red Delicious. The HyperClean unit was used on half of the fruit at each brush speed. Fruit evaluations were conducted after the apples had been placed in storage at 34ºF for 3 or 4 days followed by 70ºF for 24 hours. Sixty apples from each treatment were examined for LB and scored on the same 0 to 3 scale used in Experiment III.

Results Experiment IV—Commercial Packingline Study: Fruit that was run over the commercial packingline using cleaner and wax had significantly more LB damage than fruit from either the dump tank control (fruit not passed over packingline) or water control (fruit passed over the packingline with water only—no cleaner or wax). See Figure 5.

Brush speed did not have any effect on the amount of fruit with LB damage (data not shown).

When used with a cleaner, presized fruit treated with the HyperClean system developed more LB damage than presized fruit not treated with HyperClean (Figure 6). The HyperClean treatment did not have a significant effect on non-presized fruit.

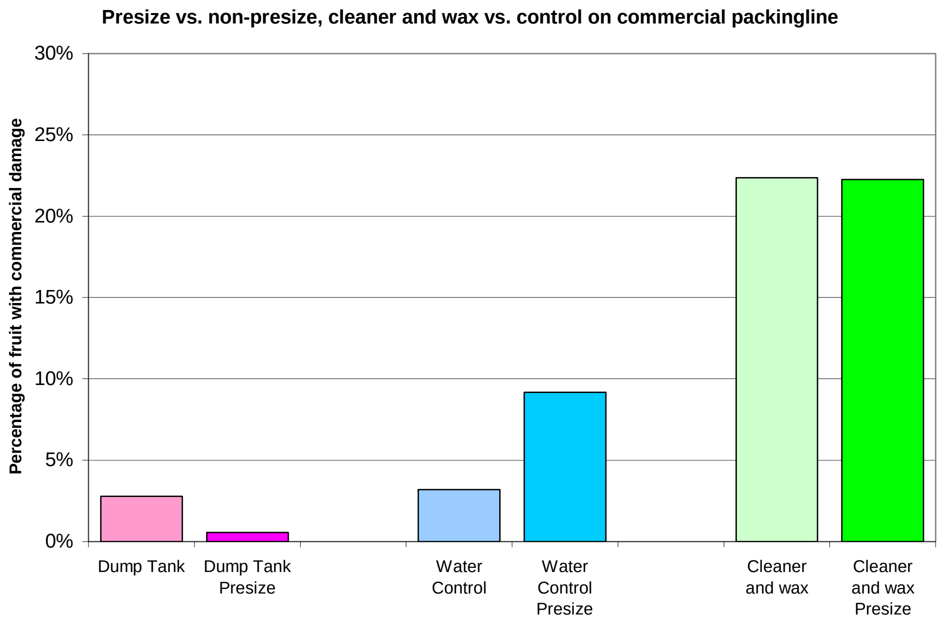

Figure 5. Effect of presize, cleaner and wax on commercially unacceptable LB damage—commercial packingline (Experiment IV—Commercial Packingline Study).

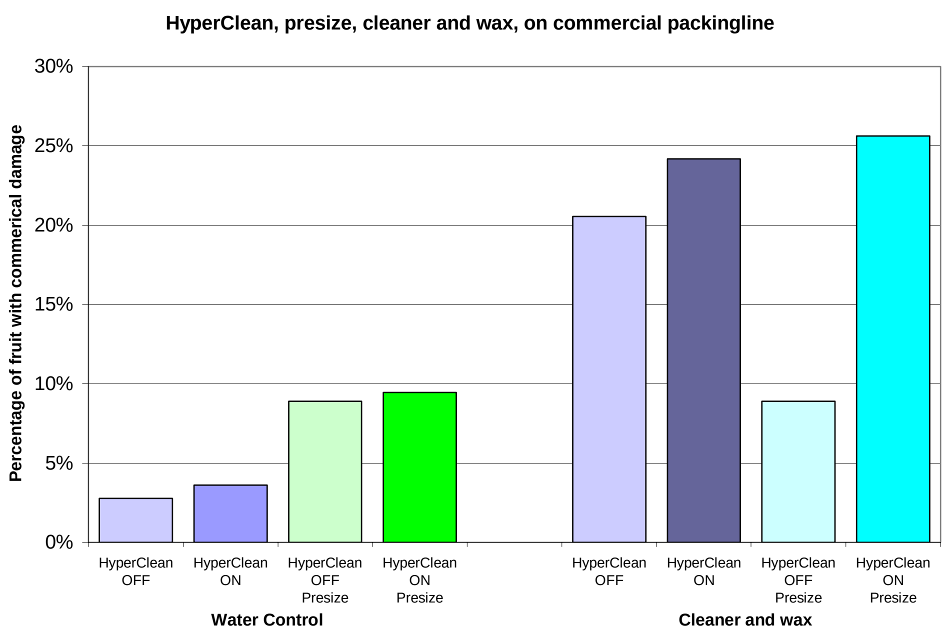

Figure 6. Effect of HyperClean, presize, cleaner and wax on commercially unacceptable LB damage—commercial packingline (Experiment IV—Commercial Packingline Study).

Methods Experiment V—Packinghouse Survey: Interviews were conducted with managers of 31 packinglines to ascertain their experiences with LB on Gala apples during the packing of the 2002 and 2003 crops. Face-to-face interviews were conducted in the spring of 2004 using a questionnaire to obtain consistent information.

Results Experiment V—Packinghouse Survey: The interviews provided a revealing look at the practices followed by many of the packers of Gala apples. There are a number of ways to determine the practices followed by a commercial company. Probably the least reliable is that used in this study in which managers were interviewed. A weakness of this process is that day-to-day practices may not precisely follow management guidelines. Another is that there are some technical details (amount of time of fruit on brushes, settings of pumps, precise chemicals used) may be overlooked by management, since technical people can be left in charge with inadequate supervision and controls. However, this study provides some insight into some of the reasons that LB has become a problem.

For the most part, general practices in most packinghouses are similar. Fruit storage conditions are similar, as is air temperature management. A strong difference is the use of presize vs. commit-to-pack lines. Chemical use on the packingline is also different, particularly in the way in which fruit-cleaning compounds are mixed and applied. SmartFresh™ use was not uniform across the industry.

Lenticel Breakdown was a problem in only about half (48%) of the packing facilities of the managers interviewed (Table 3). However, in those facilities it was a serious problem. Packers who reported problems with LB on Gala apples while packing the 2003 crop were more likely to have used SmartFresh™ on this fruit prior to storage. They also applied cleaners in concentrate form, rather than from a mixing barrel, and applied the cleaner using a drip bar, rather than nozzles. They followed the cleaner with a very hot rinse of water and then waxed the fruit using carnauba wax.

Table 3. Summary of the factors that differed between the practices of those packers who reported having LB damage on Gala apples in 2003 and those who did not have problems.

LB	Sheds Affected (%)	Fruit Affected (%)	SmartFresh™ Applied (% Yes)	PreSize (%)	Cleaner: Concentrate Application	Cleaner: Drip Bar	Rinse Water Temp	Wax: Carnauba (%)
No Problem	52%	0	62%	50%	40%	55%	79ºF	50%
Problem	48%	>20%	73%	50%	55%	70%	93ºF	71%

Scientific experiments with suitable replication and controls should be conducted to determine whether the implications of these interviews hold up under scrutiny.

It is important to note that not all Gala apples were affected with LB, so the understanding of why certain lots are susceptible must be a matter of priority.

Discussion:

There is no question that some lots of Galas are much more susceptible to LB damage. Although it is possible to use the aniline blue dye test developed by Dr. Curry to determine susceptibility, this has not been proven on a commercial scale. Therefore, a prudent strategy is to treat all fruit as if it might be susceptible to LB damage.

Presizing susceptible fruit increased the amount of LB damage. However, it is not understood what it is about presizing that sets up the fruit for LB. Half of the packers who were interviewed for the survey presized Gala apples and did not report having fruit with LB damage. Gala apples should be packed on a commit-to-pack line when packing fruit from susceptible orchards.

Cold fruit held cold throughout packing and treated with cleaners applied at label rate had less LB damage than fruit that was warmed and treated with cleaner and wax during the packing process.

Packers should pay close attention to the type and concentration of the chemicals used in the packing process. During the survey (Experiment V—Packinghouse Survey) many managers were unable to remember which cleaners were being applied. Packinghouse visits revealed that many packers were using cleaners at much higher concentrations than the label directed. In these trials, apples treated with cleaners at high concentrations almost invariably developed more LB than those treated at label rate. Fruit treated with some cleaners even at label rate developed more LB than when treated with other cleaners.

Budget:

Project title: Lenticel Breakdown: The Packingline Component
PI: Eugene Kupferman
Project duration: 2003 (1 year)
Budget: $ 31,679

Item	**Year 1 (2003)**
Salaries *	12,749
Benefits (12%)	4,180
Wages	6,034
Benefits (16%)	966
Equipment	0
Supplies **	7,000
Travel	250
Miscellaneous ***	500
Total	31,679

* Chris Sater (benefits 40%) for 2 months and Jake Gutzwiler (benefits 29%) for 3 months.
** Fruit, packing supplies and chemicals.
*** Line time at Northern Fruit.