Factors Affecting Sweet Cherry Fruit Pitting Resistance/Susceptibility

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Sweet cherry pitting

- #1 postharvest disorder

- Pitting not only detract from the appearance but also hasten fruit deterioration
Rational of the study

• However, limited research on pitting of the new late-season cultivars.
  – ‘Sweetheart’, ‘Lapins’, ‘Skeena’
  – Pitting data in literature were generated on Lambert, Van, and Bing, with extremely contradictory results.

• Both growers and packers need the information on
  1. What cause pitting,
  2. Factors influence pitting susceptibility, on the current major cultivars.
Scenario of pitting formation

Healthy fruit

Epidermis
Hypodermis
Mesocarp
Vascular tissue

Pitting

Impact/compact damage on skin

10 layers of parenchyma cells in mesocarp collapsed and water loss

Necrotic lesion formed after 1-2 weeks in storage/shipping

Skin depression occurred underlied the necrotic lesion

Wade and Bain, 1980. cv. Ron’s Seedling
What cause pitting of sweet cherries

• Heat/moisture stresses cause pitting on trees (>90°F for 3d)
  – ‘Skeena’
  – ‘Regina’

➤ Mechanical stresses
Mechanical stress & Pitting

• Picking
  – Pitting generated by
    ➢ Squeezing by hands
    ➢ Fruit-to-bucket
    ➢ Fruit-to-fruit
    ➢ Fruit-to-stem
Mechanical stress & Pitting

• Picking

• Packing line
  – Cluster-cutting
  – Box-filling
    • Fruit-to-fruit
    • Fruit-to-stem

• Transportation:
  – compact damage
Pitting resistance/susceptibility

• However, it is often not possible to avoid all these mechanical stresses during picking, packing, and transportation. Therefore, **increasing fruit pitting resistance** is important.

• **Pre-harvest factors**
  – Pre-harvest GA$_3$ and Ca$^{2+}$ sprays
  – Harvest maturity
  – Crop load

• **Postharvest factors**
  – Postharvest Ca$^{2+}$ treatment
  – Edible coating
  – Fruit pulp temperature
1. Pre-harvest $\text{GA}_3, \text{Ca}^{2+}$ applications to increase pitting resistance of sweet cherries

Yan Wang and Todd Einhorn
1.1. GA<sub>3</sub> increased fruit firmness

- ‘Sweetheart’, ‘Lapins’
  - Two pitting susceptible cultivars
- Application rate,
- Application frequency,
- Production year,
- Application timing.

<table>
<thead>
<tr>
<th>GA Rates</th>
<th>2010 Sweetheart</th>
<th>2012 Sweetheart</th>
<th>2012 Lapins</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>380 a</td>
<td>298 b</td>
<td>261 b</td>
</tr>
<tr>
<td>0+ surfact.</td>
<td>417 a</td>
<td>331 a</td>
<td>297 a</td>
</tr>
<tr>
<td>20</td>
<td>416 a</td>
<td>418 a</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>417 a</td>
<td>331 a</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>416 a</td>
<td>419 a</td>
<td></td>
</tr>
<tr>
<td>30 (20+10)</td>
<td>416 a</td>
<td>418 a</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>414 a</td>
<td>345 a</td>
<td></td>
</tr>
<tr>
<td>40 (20+20)</td>
<td>417 a</td>
<td>352 a</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>417 a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>417 a</td>
<td>281 a</td>
<td></td>
</tr>
<tr>
<td>60 (20+40)</td>
<td>417 a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td>262 b</td>
<td></td>
</tr>
</tbody>
</table>

- GA<sub>3</sub> increased FF on both cultivars in different years
- Response saturated at a single, low rate (20-25 ppm)
- There is a wide application window: ±10d from straw color stage
As a result of the increased FF, \( \text{GA}_3 \) reduced pitting

- Response saturated at a single, low rate (20-25 ppm)
- Application window: ±10d from straw color stage
1.2. Pre-harvest calcium (Ca) sprays

• Ca plays an extremely important role in the fruit for
  – Cell wall structure and strength
  – Cell plasma membrane structure and integrity

• However, fruit are often deficient in Ca due to its low mobility in plants:
  – Acid soil
    • Ca in soil at low pH (i.e., <6) is not available for root uptake.
  – High growing temperature
    • Inhibit Ca uptake and transportation.
  – Water stress, high humidity
    • Plant uptakes and transports Ca by water flow in xylem.
  – Low crop load
    • Ca tends to move into actively growing leaves and shoots in stead of fruit in the condition of low crop load.
  – High N and K levels......
    • Competition
Tissue Ca content & pitting susceptibility

- Different cultivars
  - Pitting susceptible cultivars, like ‘Van’, have low Ca content,
  - Pitting resistant cultivars, like ‘Regina’, have higher Ca content.

- ‘Bing’ from different orchards
  - Higher Ca content, less pitting,
  - Lower Ca content, more pitting.
Different orchards: ‘Skeena’

Tissue Ca: 400ppm dw

Tissue Ca: 601ppm dw
**Pre-harvest Ca\textsuperscript{2+} sprays on ‘Lapins’**

- A preliminary trial: CaCl\textsubscript{2} at 0.2% multiple sprays (6) on ‘Lapins’
  - Increased tissue Ca content
Pre-harvest Ca\(^{2+}\) sprays on ‘Lapins’

- A preliminary trial: CaCl\(_2\) at 0.2% multiple sprays (6) on ‘Lapins’
  - Increased tissue Ca content
  - Increased FF
  - Reduced pitting susceptibility
Pre-harvest Ca$^{2+}$ sprays on ‘Lapins’

- A preliminary trial: CaCl$_2$ at 0.2% multiple sprays (6) on ‘Lapins’
  - Increased tissue Ca content
  - Increased FF and pitting resistance
  - Limited pedicel browning after 3 weeks of storage/shipping
Pre-harvest Ca$^{2+}$ sprays on ‘Lapins’

- A preliminary trial: CaCl$_2$ at 0.2% multiple sprays (6) on ‘Lapins’
  - Increased tissue Ca content
  - Increased FF and pitting resistance
  - Limited pedicel browning
  - Reduced decay after 4 weeks of storage + 2d at room temperature.
Pre-harvest Ca\textsuperscript{2+} sprays improve heat resistance

- A preliminary trial: CaCl\textsubscript{2} sprays on ‘Skeena’ before heat stress.
  - Reduced pitting caused by heat stress.

![Control vs. CaCl\textsubscript{2} at 0.2%](image_url)
Need more research on pre-harvest Ca$^{2+}$ sprays

• To optimize:

1. **Ca sources:** $\text{CaCl}_2$, $\text{Ca(NO}_3)_2$, Ca citrate, Ca acetate, Chelated Ca

2. Application rate

3. Application timing

4. Application frequency
2. Harvest maturity affects pitting susceptibility of sweet cherries

Yan Wang and Todd Einhorn
Harvest maturity affects fruit quality

- As harvest timing delayed: ‘Sweetheart’ ctifl 3-6; ‘Lapins’ ctifl 4-7
  - Fruit size increased,
  - **SSC accumulated.**

<table>
<thead>
<tr>
<th></th>
<th>SSC 2012 Lapins</th>
<th>SSC 2012 Sweetheart</th>
<th>SSC 2013 Lapins</th>
<th>SSC 2013 Sweetheart</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>18.1b</td>
<td>20.2b</td>
<td>14.8c</td>
<td>19.4b</td>
</tr>
<tr>
<td>H2</td>
<td>19.5ab</td>
<td>19.3b</td>
<td>16.6b</td>
<td>19.7b</td>
</tr>
<tr>
<td>H3</td>
<td>20.3a</td>
<td>21.6a</td>
<td>20.6a</td>
<td>21.8a</td>
</tr>
</tbody>
</table>

- However, fruit softened.
  - ‘Sweetheart’ 5.0-6.0
  - ‘Lapins’ 6.0-7.0

<table>
<thead>
<tr>
<th></th>
<th>FF 2012 Lapins</th>
<th>FF 2012 Sweetheart</th>
<th>FF 2013 Lapins</th>
<th>FF 2013 Sweetheart</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>325a</td>
<td>391a</td>
<td>316a</td>
<td>492a</td>
</tr>
<tr>
<td>H2</td>
<td>325a</td>
<td>359b</td>
<td>289a</td>
<td>510a</td>
</tr>
<tr>
<td>H3</td>
<td>289b</td>
<td>350b</td>
<td>257b</td>
<td>456b</td>
</tr>
</tbody>
</table>
Harvest maturity affects pitting susceptibility

- As harvest timing delayed, ‘Sweetheart’ ctifl 3-6; ‘Lapins’ ctifl 4-7
  - However, fruit softened.
  - Pitting susceptibility increased.
    - ‘Sweetheart’ at 5.0-6.0; ‘Lapins’ at 6.0-7.0
More mature, more susceptible to pitting

- Collected on line
Late harvest

- Pedicel browning: senescence
- Luster color loss

After 4 weeks in storage at 32°F
Conclusion (harvest maturity)

➢ To balance eating quality and shipping quality:
  – ‘Sweetheart’ at ctifl 4.5
  – ‘Lapins’ at ctifl 5.5

- Enough size and sugar,
- Less pitting, better luster, limited pedicel browning after storage/shipping.
3. Crop load (Yan Wang and Todd Einhorn)

- Three Crop loads:
  - Low = 2-3 fruit/spur; Moderate = 5-7 fruit/spur; Heavy = >10 fruit/spur.

- Heavy crop load reduced fruit size, SSC, and fruit firmness (FF).

<table>
<thead>
<tr>
<th></th>
<th>At harvest</th>
<th>2 weeks at 32 °F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FD (mm)</td>
<td>RR (mL kg⁻¹ h⁻¹)</td>
</tr>
<tr>
<td>Lapins 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>30.9a</td>
<td>21.4b</td>
</tr>
<tr>
<td>M</td>
<td>29.1b</td>
<td>24.7ab</td>
</tr>
<tr>
<td>H</td>
<td>27.3c</td>
<td>25.9a</td>
</tr>
</tbody>
</table>

|                |            |                  |             |         |        |             |         |        |          |        |
| Lapins 2013    |            |                  |             |         |        |             |         |        |          |        |
| L              | 31.4a      | 22.6b            | 258a        | 20.1    | 0.63   | 295         | 20.1    | 0.55   | 2.82b    |        |
| M              | 29.3b      | 23.1b            | 263a        | 16.8    | 0.54   | 254         | 16.6    | 0.47   | 2.80b    |        |
| H              | 27.2c      | 28.6a            | 218b        | 14.4    | 0.56   | 257         | 16.1    | 0.46   | 3.01a    |        |

|                |            |                  |             |         |        |             |         |        |          |        |
| Sweetheart 2012|            |                  |             |         |        |             |         |        |          |        |
| L              | 28.9a      | 16.7b            | 366a        | 20.6a   | 0.87a  | 388a        | 21.2a   | 0.77a  | 2.56b    | 5.5b   |
| M              | 27.0b      | 16.8b            | 338b        | 19.5a   | 0.89a  | 365b        | 19.3b   | 0.76a  | 2.61ab   | 11.1a  |
| H              | 26.2c      | 23.5a            | 329b        | 17.3b   | 0.84a  | 356b        | 16.9c   | 0.70b  | 2.79a    | 12.3a  |

|                |            |                  |             |         |        |             |         |        |          |        |
| Sweetheart 2013|            |                  |             |         |        |             |         |        |          |        |
| L              | 28.4a      | 17.6a            | 409a        | 22.5a   | 0.91a  | 511a        | 22.1a   | 0.85a  | 2.22a    |        |
| M              | 28.2a      | 18.8a            | 415a        | 22.7a   | 0.85b  | 520a        | 21.3a   | 0.8b   | 2.28a    |        |
| H              | 27.5a      | 19.3a            | 394a        | 20.5b   | 0.73c  | 488b        | 19.7b   | 0.71c  | 2.29a    |        |
Crop load affects pitting susceptibility

- Heavy crop load, more susceptible to pitting.
**FF is a pitting resistance predictor**

- A wide range of fruit quality and pitting susceptibility was generated by GA$_3$, harvest maturity, and crop load treatments:
  - FF had a significant negative correlation with pitting susceptibility.
  - SSC, size, RR, and TA were poorly related to Pitting.

![Graphs showing the relationship between FF and induced pitting severity, natural pitting, and fruit firmness for Sweetheart and Lapins varieties.](image)
4. Postharvest Ca treatment

- Calcium salts are widely used in food industry.

- **Calcium carbonate**
- **Calcium citrate**
  - Enhance nutritional value

- **Calcium lactate**
- **Calcium chloride**
- **Calcium phosphate**
- **Calcium propionate**
- **Calcium gluconate**
  - Preservation
  - Enhancement of product firmness
Postharvest Ca treatment

• Calcium treatments represent a safe and effective method for increasing the quality and storage life of a wide range of fruit.
  – apple, peach, tomato, cantaloupe, grapefruit, pomegranate, strawberry, papaya...
  – OptiCAL®

• However, no reports on sweet cherry.

• Two year study:
  – The effect of adding OptiCAL® in hydro-cooling water on pitting of sweet cherry
Postharvest Ca treatment and tissue Ca content

- **Opti-CAL®** in hydro-cooling water at 0.2-2.0% for 5 or 30 min.
  - Increase tissue [Ca]
  - Cherry fruit uptake Ca\(^{2+}\) pretty fast at low temperature, compared to other fruit.
Postharvest Ca treatment and pitting

- **Opti-CAL®** in hydro-cooling water at 0.2-2.0% for 5 min.
  - Increase FF, reduce pitting susceptibility

![Graph showing fruit firmness and pitting severity for Sweetheart and Lapins varieties with different CaCl₂ concentrations.](image)
Postharvest Ca treatment and pedicel quality

- Opti-CAL® in hydro-cooling water for 5 min maintained ‘Lapins’ pedicel quality at 0.2-0.5% but damaged pedicel at 1.0-2.0%.
Postharvest Ca treatment and pedicel quality

- Opti-CAL® in cold water for 15-30 min maintained ‘Skeena’ pedicel quality at 0.2-0.5% but damaged pedicel at 1.0-2.0%.
5. Edible coatings

Research reported that the following coatings improve shipping quality of sweet cherries.

- **Semperfresh™**
  - Registered for sweet cherry postharvest use.

- **Alginate**
  - Brown Algae

- **Chitosan**
  - Shrimp shells and other sea crustaceans.

- **Aloe Vera**
Edible coatings

- Literature indicated that edible coatings improve shipping quality by
  1. Reduce respiration rate
  2. Reduce moisture loss
     - Pedicel quality
  3. Reduce decay and food safety microbial.

- We found that edible coating application rates affect pitting expression of PNW sweet cherry.
Semperfresh™ and pitting

- **Semperfresh™ at 0.5% reduced pitting**
  - ‘Chelan’
  - ‘Sweetheart’
  - Reduced moisture loss

- Higher rate at 1.0% increased pitting of ‘Sweetheart’.
  - Localized O₂ deficiency
## Semperfresh™ and pitting

### Dilution rate for this pack

<table>
<thead>
<tr>
<th>Crop</th>
<th>% Active (SEMPERFRESH)</th>
<th>Dilute to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bartlett pear</td>
<td>0.5%</td>
<td>26.5 gal</td>
</tr>
<tr>
<td>Comice pear</td>
<td></td>
<td>(100 litres)</td>
</tr>
<tr>
<td>Packhams pear</td>
<td>0.7%</td>
<td>19 gal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(72 litres)</td>
</tr>
<tr>
<td>Cantalope melon</td>
<td>0.8%</td>
<td>16.5 gal</td>
</tr>
<tr>
<td>Galia melon</td>
<td></td>
<td>(62 litres)</td>
</tr>
<tr>
<td>Papaya</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avocado</td>
<td>1.0%</td>
<td>13 gal</td>
</tr>
<tr>
<td>Granny Smith apple</td>
<td></td>
<td>(50 litres)</td>
</tr>
<tr>
<td>Golden Delicious</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cherry</td>
<td>1.0%</td>
<td>13 gal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(50 litres)</td>
</tr>
<tr>
<td>Plum</td>
<td>1.1%</td>
<td>12 gal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(45 litres)</td>
</tr>
<tr>
<td>Banana</td>
<td>1.2%</td>
<td>11 gal</td>
</tr>
<tr>
<td>Pineapple</td>
<td></td>
<td>(42 litres)</td>
</tr>
<tr>
<td>Lime</td>
<td>1.5%</td>
<td>9 gal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(35 litres)</td>
</tr>
</tbody>
</table>

The above rates are general recommendations; local varietal or environmental factors may influence response to treatment.
Semperfresh™

Control

Semperfresh™ 0.5%

Control

Semperfresh™ 1.0%
6. Fruit pulp temperature and pitting susceptibility

- The lower the pulp temperature, the more susceptible to pitting.
  - Lapins
  - Sweetheart
Box filling and pitting

- Fruit pulp temperature at **box filling** = 32-35°F, therefore, extremely sensitive to pitting.
  - Reducing the drop height or cushion the drop reduced pitting incidence.
Take home messages

- Heat/moisture stresses can cause ‘Skeena’ pitting on the trees.

- Pre-harvest GA$_3$ at a single low rate and Ca$^{2+}$ multiple applications at low rate enhance fruit firmness and reduce pitting susceptibility.

- More mature, softer fruit and more susceptible to pitting
  - The optimum harvest maturity: ‘Sweetheart’ at 4.5; ‘Lapins’ at 5.5

- Heavy crop load reduces fruit firmness and increases pitting.

- Tissue Ca content is related to pitting resistance.
  - Sweet cherry fruit uptake Ca$^{2+}$ at low temperature fast.
  - Adding OptiCAL™ at 0.2-0.5% in hydro-cooling water for 5min increases fruit Ca$^{2+}$ content and pitting resistance.
  - Higher rates at 1.0-2.0% damage pedicel quality.

- Semperfresh™ reduce pitting at 0.5%, but increase pitting at higher rate.

- The lower the fruit pulp temperature, the higher susceptibility to pitting.
  - Box filling during on-line packing generates significant pitting.
  - Reducing drop height or cushion the drop during box filling reduce pitting.
Thank you for your attention and research support!