Non-Mineral Prediction of Bitter Pit in ‘Honeycrisp’ Apples

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As every grower and storage operator knows well, ‘Honeycrisp’ apples are highly susceptible to bitter pit (Figure 1). The disorder is found both in the orchard as tree pit, and after storage. The first type reduces harvest yield, but the latter type is especially devastating, as losses of high quality fruit can occur during storage, resulting in major reductions of pack out rates. The conditioning treatment of 7 days at 50°F, and the warmer storage temperature of 38°F that is recommended to reduce risk of soft scald, also contributes to the bitter pit problem (Al Shoffe et al. 2016). Our overall goal is to develop prediction methods for soft scald and bitter pit susceptibility of fruit from different orchard blocks so that management decisions can be made about storage protocols. Examples include: 1. Storage of fruit with high bitter pit susceptibility without conditioning and at 33°F prior to early marketing; and 2. Storage of fruit with low bitter pit susceptibility with conditioning and at 38°F with confidence of minimal losses due to bitter pit during storage.

The majority of research on prediction methods for bitter pit susceptibility has been focused on mineral analyses. Typically, fruit with low calcium and high magnesium, potassium and nitrogen concentrations have higher risk of bitter pit development during storage. Correlations between calcium, either alone or as ratios with other minerals, can be used as predictors of risk, but the industry is not well set up for routine rapid mineral sampling of fruit just before harvest. These methods are also costly and require access to laboratories.

Several non-chemical methods to predict bitter pit have been investigated around the world. These include dipping or infiltrating fruit with magnesium solutions, use of an ethylene releasing agent such as ethephon, and a passive method where fruit are kept at warm temperatures (e.g., 68°F) to allow bitter pit to develop. In this NY Apple Research and Development trial, we tested these three methods in the 2016/2017 season. The results were promising enough to warrant further expansion beyond just two orchards. We chose the ethylene and passive methods for further work; magnesium treatments were not used further, as it was often too difficult to distinguish between bitter pit and magnesium toxicity.

Materials and Methods

In 2017, fruit were harvested from 6 commercial blocks in the Hudson valley (HV) region and from 6 commercial blocks in western New York (WNY). Three sets of 10 trees were labeled in each block and harvested on two occasions:
1. Three weeks before anticipated harvest.
2. At commercial harvest.

At each harvest, fruit were washed and peel tissues from the calyx end of 20 fruit per replicate were taken for mineral analysis at the Cornell Nutrient Analysis laboratory.

Fruit from three weeks before anticipated harvest were used to induce bitter pit: 40 fruit per replicate were either kept at 68°F for up to three weeks (passive method) or treated with 2000 ppm ethephon (Motivate, 21.7% ethephon) and kept at 68°F for up to three weeks (ethylene method). Bitter pit was assessed at weekly intervals for both methods. At commercial harvest, fruit were stored at 38°F with and without conditioning at 50°F for 7 days.
Bitter pit was assessed in these fruit after 4 months of storage plus 7 d at 68°F.

**Results**

Bitter pit incidence in the fruit harvested three weeks before commercial harvest and treated with either the ethylene or passive methods are shown in Figure 2. Both methods induced similar bitter pit levels, even though there was a wide range of disorder development across orchards in both regions. Overall, there was no statistical difference between treatments: an average of 8% for both treatments in the HV fruit, and 25% and 29% in passive and ethylene treatments for WNY fruit. Actual bitter pit in fruit harvested commercially and stored for 4 months, either with or without conditioning, is shown in Figure 3. Although conditioned fruit had higher bitter pit than unconditioned fruit, as has been often found before, the strong relationship between the predicted bitter pit and actual bitter is easy to see. This relationship is clear when the data for all orchards are plotted (Figures 4 and 5).

We also compared the strength of the relationships by the prediction methods with those based on mineral analyses before and at harvest (Table 1). Both passive and ethylene methods had as good, if not higher, R\(^2\) values as those based on minerals at each sampling time. [The closer the R\(^2\) value is to 1.0, the more precise the correlation between factors.] It is interesting to note that the R\(^2\) values were also higher between minerals and bitter pit development when the minerals were sampled 3 weeks before commercial harvest.

**Summary**

This study shows that bitter pit can be induced in fruit harvested three weeks before commercial harvest and that there is a good correlation between susceptibility predictions and actual bitter pit obtained in fruit after cold storage for four months. The relationships are as good as or superior to those obtained by mineral analysis of fruit before or at harvest. Such a method is a powerful tool for storage operators in making management decisions. This method will be tested in a larger number of orchard blocks in 2018.

There was little difference between the passive and ethylene methods. We have chosen the passive method for future work because it is more straightforward than the ethylene method, which requires the more laborious process of dipping fruit, and may have label use restrictions.

**References**


**Acknowledgments**

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Figure 4. Relationship between bitter pit after 4 months of storage at 38°F + 7 days at 68°F, and bitter pit incidence predicted by the Passive and Ethylene methods.

Figure 5. Relationship between bitter pit after 4 months of storage at 38°F + 7 days at 68°F (conditioned before storage) and bitter pit incidence predicted by the Passive and Ethylene methods.

Table 1. Relationship between bitter pit after 4 months storage at 38°F with and without one week conditioning at 50°F + 7 d at 68°F and bitter pit incidence predicted by sampling fruit and keeping them at 68°F without (passive) and with (ethylene) for up to 3 weeks, and minerals from 3 weeks before the anticipated harvest and/or from commercial harvest taken from the calyx-end of the fruit.

<table>
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<th>Sampling time</th>
<th>Factors</th>
<th>38 °F</th>
<th>C + 38 °F</th>
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<tr>
<td></td>
<td></td>
<td>R²</td>
<td></td>
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<tr>
<td>3WBH</td>
<td>Passive</td>
<td>0.48</td>
<td>0.66</td>
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<tr>
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<td>Ethylene</td>
<td>0.61</td>
<td>0.71</td>
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<tr>
<td></td>
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<tr>
<td></td>
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<tr>
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<td>(K+Mg)/Ca</td>
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<td>0.57</td>
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<tr>
<td>At commercial harvest</td>
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