

Ethanol Accumulation Does Not Predict Soft Scald in ‘Honeycrisp’ apples

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This research was partially supported by the New York Apple Research and Development Program

‘Honeycrisp’ apples are susceptible to a range of physiological disorders, the main ones being bitter pit, soft scald and soggy breakdown. In a recent article (Al Shoffe et al. 2016), we described the difficulties of postharvest handling decisions; conditioning increases bitter pit incidence while preventing soft scald and soggy breakdown, but not conditioning decreases bitter pit incidence

“A predictor of susceptibility of ‘Honeycrisp’ to the physiological disorder is needed to aid the industry in making decisions about conditioning, storage temperature and storage length. In this project we tested the hypothesis that ethanol accumulation could be used as a marker of susceptibility without success.”

while increasing the risk of development of soft scald and soggy breakdown. Overall, losses due to bitter pit and other disorders has been estimated to be as high as \$7,000 per acre. Based on New York plantings of 2000 acres (assuming full bearing acres), losses represent \$14 million, which could be reduced greatly by control of these disorders.

A predictor of susceptibility of fruit to bitter pit and soft scald would allow better decision making. For example, knowing fruit had low risk for soft scald development would permit storage at low temperatures without conditioning and thereby reduce losses due to bitter pit. We are developing mineral analyses based on data described in a previous New York Fruit Quarterly by Al Shoffe et al. (2016). Here, we have focused on developing an indicator of soft scald susceptibility. In research from several years ago, we found a good relationship between ethanol accumulation in the fruit and soft scald development in ‘Honeycrisp’ apples. In this NYFVI-funded project we tested the hypothesis that this accumulation could be used as a marker of susceptibility of fruit to soft scald (Figure 1).

Methods

Fruit were obtained from different ‘Honeycrisp’ orchard blocks in Pennsylvania, the Hudson Valley, Western NY and the Champlain Valley regions. Three replicate sets of fruit were subjected to each of the following treatments:

1. 33°F
2. 38°F
3. 33°F after conditioning of fruit at 50°F for 7 days
4. 38°F after conditioning of fruit at 50°F for 7 days

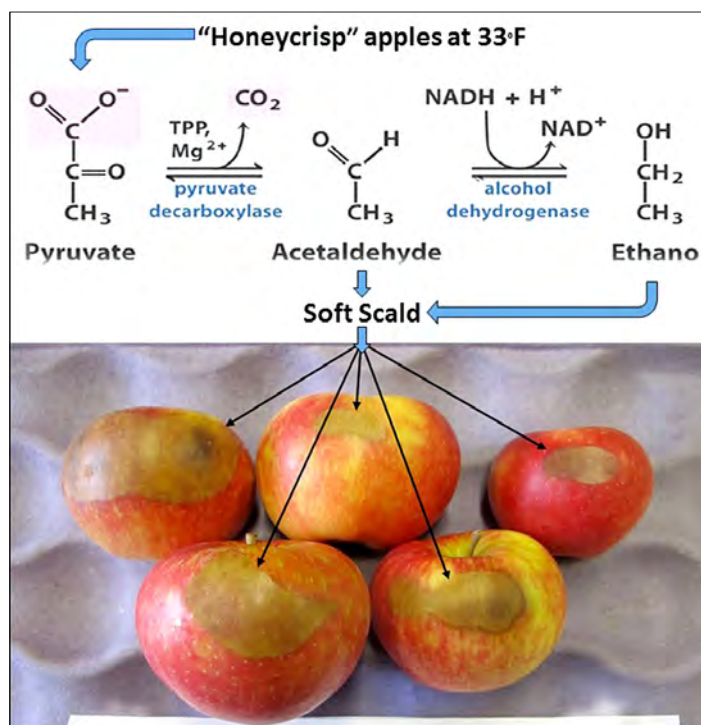


Figure 1. A hypothesis for the mechanism of soft scald development in ‘Honeycrisp’ apples.

Fruit were stored for 20 weeks, and storage disorders assessed after 7 days at 68°F. Peel samples were taken at harvest and at 1, 3, 5 and 10 weeks during storage. Five fruits per replicate were sampled, with the skin peeled stem to calyx from 4 sides of each fruit. The tissue was peeled directly into liquid nitrogen and then the frozen tissue was ground to a powder. Each 5 g sample was weighed into a 20 mL headspace vial and 2.5 g distilled water and 2.5 g saturated NaCl solution was added. These samples were frozen until analyzed for acetaldehyde and ethanol concentrations by gas chromatography.

Results

Harvest indices of fruit from the regions were variable and few regional patterns were detectable (Table 1). Overall, lowest internal ethylene concentrations (IEC) were found in fruit from Western NY and Champlain, but even in the other regions, at least one block of fruit had low IEC.

Soft scald incidence was assessed in the fruit that had been untreated or conditioned, and then stored at 33°F or 38°F for 20

Table 1. Harvest indices of 'Honeycrisp' apples from Pennsylvania (PA), Hudson Valley, Western NY and Champlain regions. Means with different letters are significant at P = 0.05, with small letters representing differences in orchards within a region and capital letters showing differences between regions.

Region	Orchard	IEC (ppm)	SPI	Firmness (lb-f)	SSC (%)	TA (g 100 ml ⁻¹)
PA	1	22c	6.8b	15.1bc	12.9e	0.40a
	2	14d	7.1b	16.3ab	14.5b	0.52bc
	3	41b	7.7a	14.7cd	13.1de	0.41bc
	4	21c	7.7a	15.7ab	13.3cde	0.41bc
	Average	25B	7.3A	15.5A	13.5AB	0.44A
Hudson Valley	1	13de	5.7d	15.1b	12.9e	0.44b
	2	67a	7.6a	16.5a	13.6cd	0.31e
	3	36b	7.3ab	15.0b	12.7e	0.35de
	Average	39A	6.9B	15.5A	13.1B	0.37C
Western NY	1	12de	7.2b	14.3d	13.9bc	0.36d
	2	7ef	6.3c	15.9ab	15.5a	0.50a
	3	4f	7.3ab	12.4e	11.9f	0.35de
	Average	8C	6.9B	14.2C	13.8A	0.40B
Champlain	1	5f	5.5d	15.0c	13.0de	0.37cd
	2	19c	6.4bc	14.0d	13.2de	0.35de
	3	7ef	6.2c	15.6bc	15.2a	0.41bc
	Average	10C	6.0C	14.9B	13.8A	0.38BC

Table 2. Soft scald incidence (%) in 'Honeycrisp' apples from Pennsylvania (PA), Hudson Valley, Western NY and Champlain regions in fruit without or with conditioning at 50°F for a week and stored in 33°F or 38°F for 20 weeks. Means with different letters indicate statistical separation at P = 0.05.

Region	Orchard	33°F	33°F + conditioning	38°F	38°F + conditioning
PA	1	0.0d	0.0d	0d	0d
	2	0.5d	0.4d	0d	0d
	3	0.5d	0.0d	0d	0d
	4	0.0d	0.0d	0d	0d
Hudson Valley	1	6.0cd	0.6d	0d	0d
	2	0.0d	0.7d	0d	0d
	3	1.4d	0.5d	0d	0d
Western NY	1	18c	2d	0d	0d
	2	29b	0d	0d	0d
	3	64a	9cd	0d	0d
Champlain	1	1d	2d	0d	0d
	2	4d	7cd	0d	0d
	3	16c	1d	0d	0d

weeks (Table 2). As we find routinely, a storage temperature of 38°F resulted in no soft scald, even without conditioning. Soft scald incidence can be increased by storage at 33°F, however, with the often observed regional patterns where risk is low in PA and HV, and more variable in the Western NY and Champlain regions. Conditioning reduced but did not consistently eliminate risk of soft scald development in fruit stored at 33°F.

Our goal in this project was to investigate if ethanol and acetaldehyde concentrations in the peel were associated with soft scald development. Figures 2–5 show the concentrations of ethanol at each sampling time for fruit from the orchards in each region. (Note that acetaldehyde data are not shown, as patterns are similar to those shown for ethanol.)

Several features are apparent from these results:

1. Variation of ethanol accumulation within and among regions is high.
2. Ethanol accumulation is usually greater at 33°F than at 38°F, and higher in fruit stored at 33°F without conditioning than with conditioning. (Averages for both acetaldehyde and ethanol for weeks 3, 5 and 10 are provided in Table 3).
3. Maximum accumulations typically occur at weeks 5 and 10 in fruit stored at 33°F, but less consistently at 38°F.

At face value, therefore, the concept that soft scald is associated with ethanol accumulation seems supported by lower concentrations at higher storage temperatures and sometimes with conditioning. However, the relationships between regions and orchards for ethanol and soft scald are poor (Figures 2–5; Table 2).

In PA, almost no soft scald was detected, but ethanol accumulated to high levels in fruit from Orchard

Table 3. Acetaldehyde and ethanol concentration (mg/kg), as an average of weeks 3, 5 and 10 in storage, in the peel of 'Honeycrisp' apples from Pennsylvania (PA), Hudson Valley, Western NY and Champlain regions in fruit without or with conditioning at 50°F for a week and stored in 33°F or 38°F. Means with different letters indicate statistical separation at P = 0.05.

Region	33°F	33°F + conditioning	38°F	38°F + conditioning
Acetaldehyde				
PA	2.1b	1.4cde	1.2efg	1.0fg
Hudson Valley	1.3defg	1.8bc	0.9g	0.9g
Western NY	2.6a	1.6cde	0.9g	0.9g
Champlain	1.7bcd	1.4cdef	0.9g	0.9g
Ethanol				
PA	23a	13de	9ef	7f
Hudson Valley	13de	19bc	6f	7f
Western NY	27a	16cd	5f	6f
Champlain	13de	9ef	4f	5f

3. In the Hudson Valley, where soft scald was also negligible, ethanol accumulated in conditioned fruit at higher levels than unconditioned fruit at 33°F. In Western NY, ethanol accumulation in fruit from Orchard 2 was relatively low, while 29% soft scald was detected, and was very similar in fruit from Orchards 1 and 3,

which had 18% and 64% soft scald, respectively. In the Champlain region, however, ethanol accumulation was higher in Orchard 3 with the highest soft scald incidence.

Overall, however, regression analyses showed weak correlations between soft scald and ethanol concentrations for each

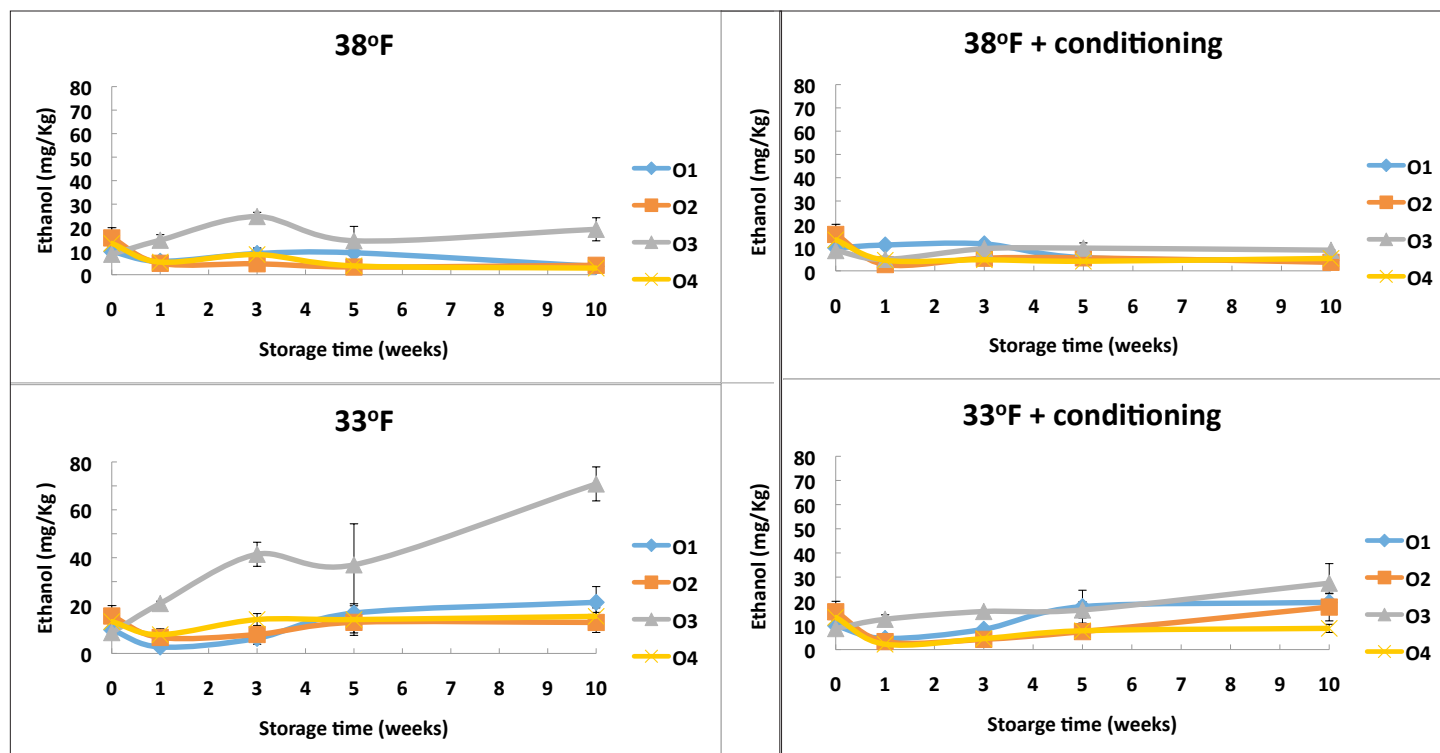


Figure 2. Ethanol concentrations in 'Honeycrisp' apples harvested from four Pennsylvania orchards and stored at 33°F or 38°F without or with conditioning at 50°F for 7 days.

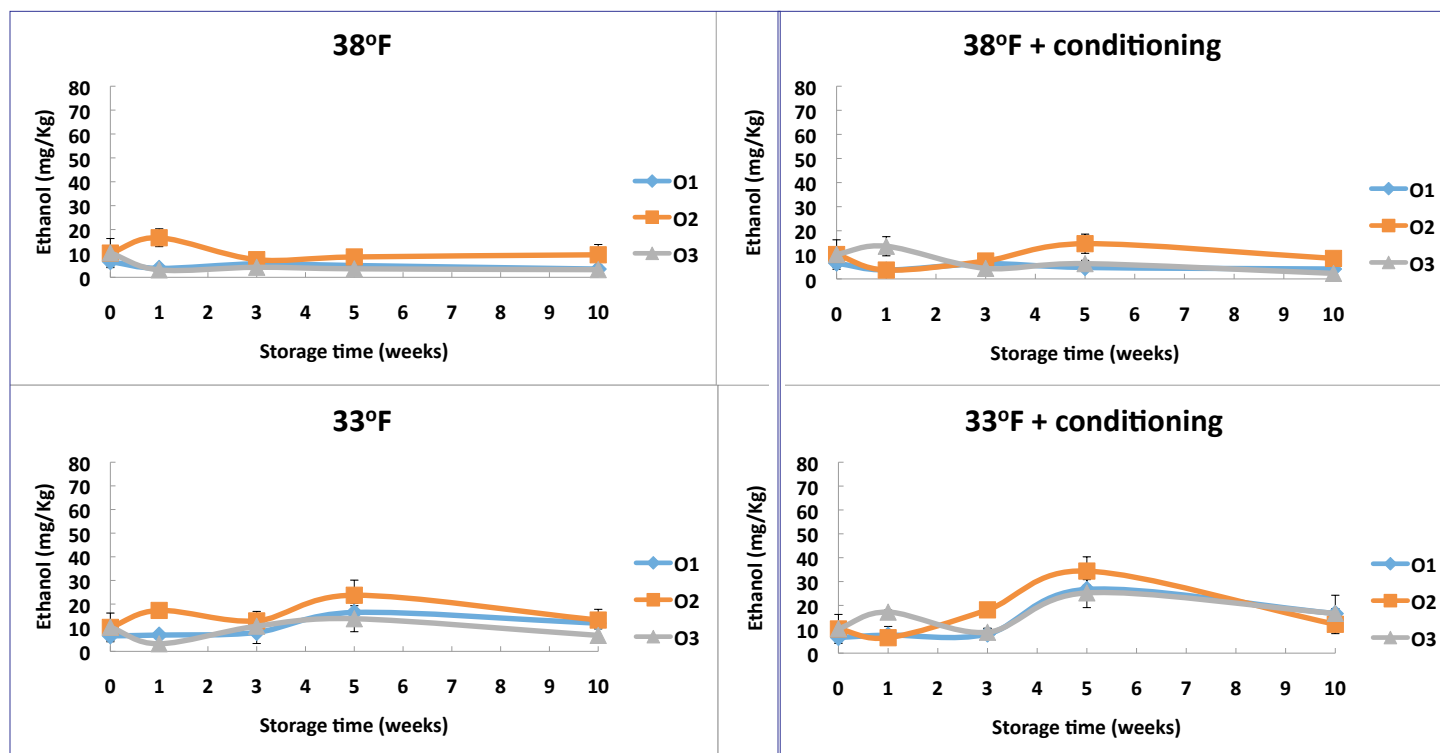


Figure 3. Ethanol concentrations in 'Honeycrisp' apples harvested from three Hudson Valley orchards and stored at 33°F or 38°F without or with conditioning at 50°F for 7 days.

sampling week. The strongest R^2 values (a measure of how good the relationships between the two factors are) never exceeded 29%.

Conclusion

Our preliminary research indicated that acetaldehyde and ethanol accumulation was associated with soft scald development in 'Honeycrisp' apples. However, application of this method to

different orchard blocks across four growing regions revealed that accumulation of these compounds cannot be used universally as a meaningful predictor of soft scald development. Although this outcome is very disappointing, the results will be used by an industry that is still developing postharvest management techniques necessary to provide high quality fruit for the market with minimal losses resulting from storage disorders.

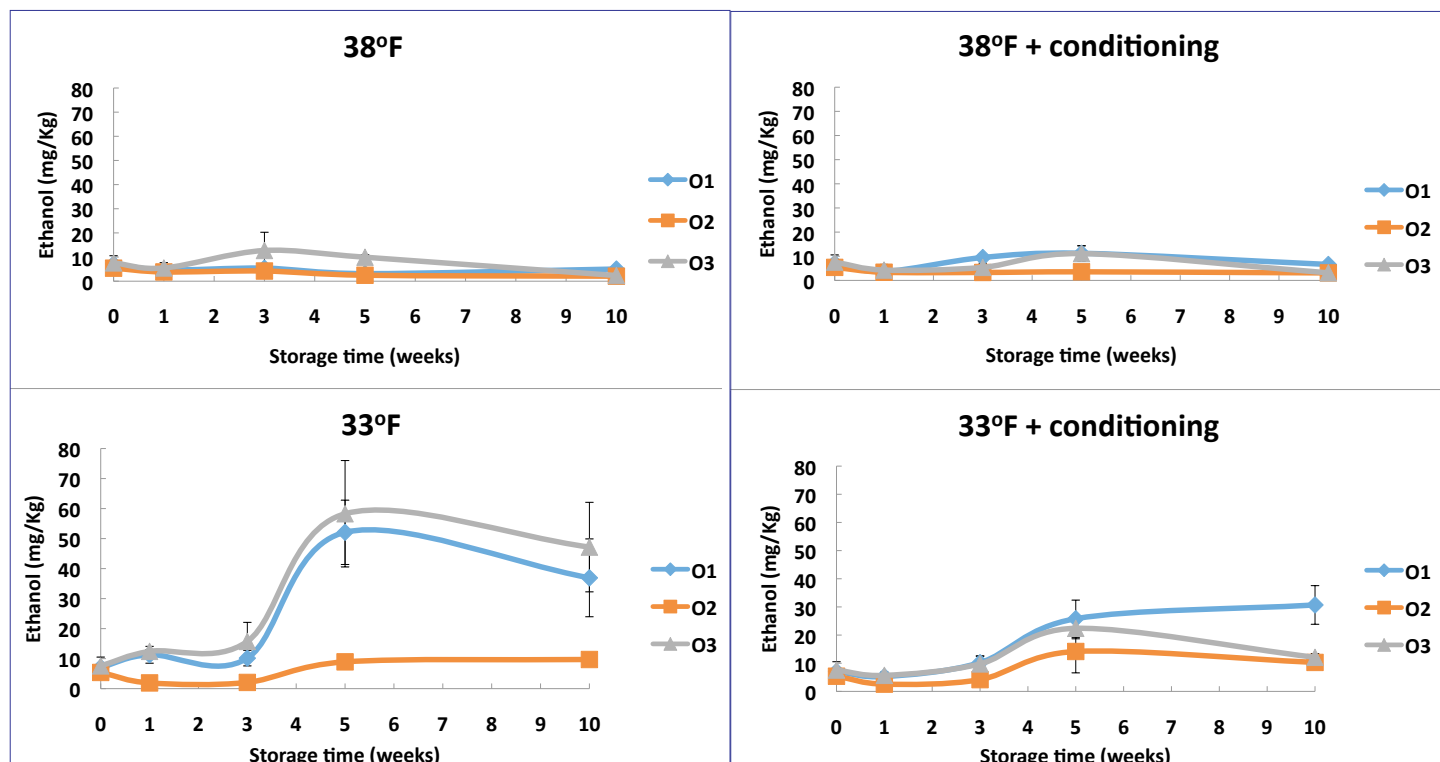


Figure 4. Ethanol concentrations in 'Honeycrisp' apples harvested from three Western NY orchards and stored at 33°F or 38°F without or with conditioning at 50°F for 7 days.

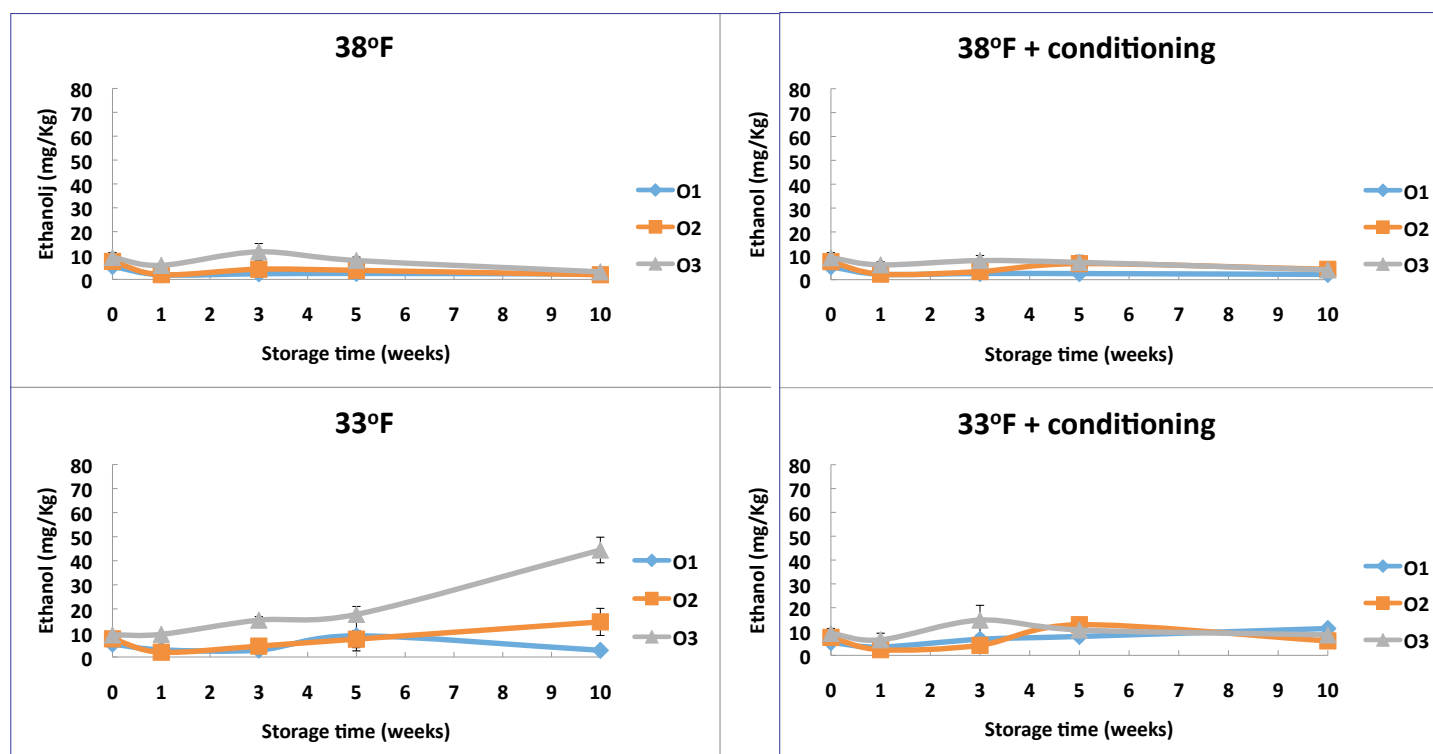


Figure 5. Ethanol concentrations in 'Honeycrisp' apples harvested from three Champlain Valley orchards and stored at 33°F or 38°F without or with conditioning at 50°F for 7 days.

Acknowledgement

We thank the many growers and storage operators in New York and Pennsylvania who generously provided fruit for these experiments, and to Tara Baugher, Lee Showalter and Leighton Rice, Rice Fruit Company for organizing delivery of PA-grown fruit to Ithaca.

This work was supported by the New York Farm Viability Institute, New York Apple Research and Development Program and the USDA National Institute of Food and Agriculture, Hatch project 2013-14-483, Improving Quality and Reducing Losses in Specialty Fruit Crops through Storage Technologies (NE-1336). Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the National Institute of Food and Agriculture (NIFA) or the United States Department of Agriculture (USDA).

Reference

Al Shoffe, Y., Nock, J. F., Baugher, T. A., and Watkins, C. B. 2016. Honeycrisp – to condition or not condition? *New York Fruit Quarterly* 24(2):19–23.

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