Acidity of Honeycrisp – Key to Eating Quality and Competitiveness of Northeastern Apple Growers

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Students sampling fruit from different acid levels as part of a sensory analysis at the Dondo lab at Cornell have consistently preferred the higher acid samples to the lower acid samples. This should mirror overall consumer preference.

During the past decade, Honeycrisp (HC) has continued to be the number one sought-after variety by consumers in the US. Until the 2023 crop year, demand and premiums have remained well above all other varieties, from grower returns to retail sales. Although all of the major apple-producing states have continued to plant, the low yield and low pack out of this variety continues to be a challenge for all of its growing regions in the US and Canada. Rootstock selection, microclimate, a high biennial bearing index, bitter pit, and multiple storage disorders are not even the full list of problems. With the overproduction of most commercial fresh market apple varieties, prices from the fall crops of 2023-2025 have been lower than average, across the region and in nearly all varieties. While HC returns have typically been as much as 3½ times higher than other varieties, it has fallen to levels dangerously close to the cost of production. If the "day of reckoning" has arrived, then research based strategies need to be to ensure the loss and waste of this premium variety is minimized.

In addition, increased production has also led to consumer dissatisfaction with fruit flavor. HC in the market can have crisp texture but disappointing flavor. The bland flavor has been associated with low acid levels in the fruit – despite HC being a sweet fruit, acidity is the underlying positive flavor component. The challenge for the industry is to improve the flavor profile of this much wanted variety, especially with new club varieties entering the marketplace. Early research by Dr. Jim Mattheis (USDA Wenatchee) found that higher acid content at harvest was associated with higher acidity and better flavor after long-term storage.

Determining harvest maturity at the correct timing for HC has proven difficult and inconsistent. For most varieties, internal ethylene concentrations (IECs), as measured in ppm by a gas chromatograph, can be correlated with maturity. The start of measurable (0.2-0.5 ppm) IEP signals the start of the ripening phase, in which the fruit are very near optimum maturity for long-term, controlled atmosphere (CA) storage. In addition, there can be a steady or exponential rise in IEC in which fruit can become overmature and unsuited for CA and must be packed and marketed quickly. However, with Honeycrisp, IEC does not correlate with maturity. There is also no correlation with when to harvest for any storage regime, length, or marketing window using IEC in HC. Currently, a number of other quality indicators are used to try and determine ideal harvest timing for storage/market destination. One of the primary harvest indicators used in HC is red color. In concert with acceptable flavor, red color that "jumps out" when the yellow background color makes the red appear almost fluorescent/iridescent is ideal. The major flaw with using color is that weather patterns in the days/weeks prior to maturity can affect color. For instance, cooler and cloudier weather patterns can wash out existing color or cause poor color development altogether. Another quality indicator that can help time harvest is firmness. Again, weather patterns during a large part of the growing season or close to harvest can affect firmness. Above average precipitation can cause fruit to be softer than target levels for CA storage. Drought or below average precipitation can cause fruit to be firmer than normal, and trick growers into harvesting too late if they are waiting for firmness to get into target range for a "normal" season. SSC (%), measured by a refractometer, indicates the overall sweetness of the fruit. As with the above quality indices, weather patterns can affect the SSC and perceived sweetness and flavor. Above average precipitation can cause fruit to have lower SSC and not taste as good. Conversely, drought or below average precipitation can cause fruit to have higher SSC than normal, and make for sweeter tasting fruit.

Another quality indicator to help identify the optimum harvest date is the starch pattern index (SPI). A sample of apples are cut in half and sprayed with an iodine solution. The conversion of starches to sugars causes the purple-colored iodine solution to cause lower staining. Varying stages of ripeness (variety specific) show patterns in the fruit. At Cornell, we use a score of 1-8, with 1 being completely unripe (purple) and 8 being completely overripe (white). Each variety has a set standard between 1 and 8 for suggested harvest. A lower value is used for midterm to long-controlled atmosphere (CA) storage while a higher value (later harvest) can be used for fruit to be packed relatively quickly and stored short term in regular air). While SPI can be a guideline to when to harvest for a planned storage/marketing plan, weather patterns can also swing it out of alignment with other maturity/quality indicators. For instance, a droughty season can cause a small amount of carbohydrates to be deposited into the fruit. When these fruit enter the maturation phase, the conversion of starch to sugars happens relatively quickly, and is not a great indicator of when to harvest and does not reflect true maturity. Another relatively new way to help gauge maturity is the delta absorbance (DA) meter. This instrument measures loss of chlorophyll in the peel and can be used as an effective indicator of fruit ripening. This instrument is a vis–NIR portable spectrometer which measures delta absorbance (Ziosi et al. 2008). Absorbance of radiation of wavelengths 670and 720 nm is converted to absorbance based on the Beer–Lambert Law and the index of absorbance difference (I_{AD}) and represents the absorbance peak of chlorophyll-a and the background spectrum, respectively. The lower the number, the more mature the apple is (less chlorophyll remaining). Past research has shown that DA readings in our region for HC are often not in alignment with other maturity/quality indicators.

Another fruit characteristic that changes with fruit maturation is fruit acidity. The purpose of this project was: 1) to determine if fruit acidity could be a tool in the toolbox to determine optimum maturity and 2) if acidity could also predict good eating quality.

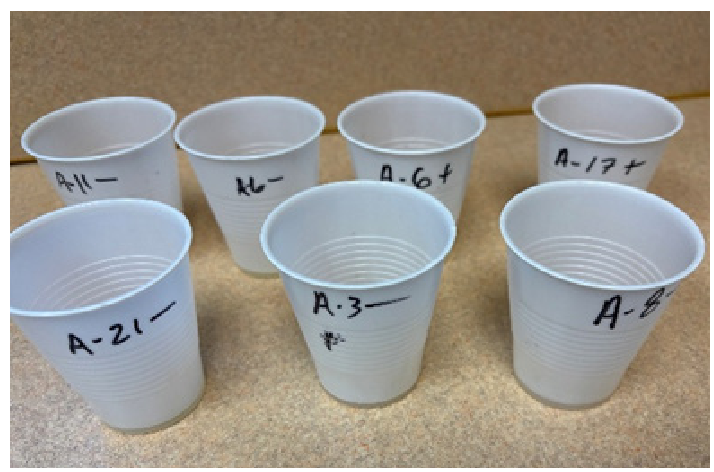
Materials and Methods

At the correct maturity timing for Honeycrisp harvest (September 6-12, 2024, for year 1) we collected 14 samples from orchard blocks located on 9 separate farms in Western NY state. In year 2, at the correct maturity (September 10-19, 2025) we collected 22 samples from orchard blocks from 12 separate farms. The samples were divided into 2 sub-samples with half treated with 1-MCP, and half untreated. Each sub-sample consisted of 120 apples at harvest. 100 apples from each sample were taken to Lake Ontario Fruit, Inc. and treated or not treated with 1-MCP, and conditioned at 50°F for seven days before being put into a 38°F room in regular air storage for 4 months. The remaining 20 fruit per sample were taken to the harvest maturity lab at Orleans County Cooperative Extension. Standard maturity measurements were taken, which included DA meter, firmness, total soluble solids (brix), acidity and starch pattern index (SPI). For the brix and acidity readings, the juice from the hole punches taken for firmness was used. After calibration with distilled water, approximately 5 ml of the sample juice were placed on the ATAGO brix/ acid meter PAL-BX/ACID5 (Apple) Master Kit (ATAGO USA, Bellevue, WA). The first time the button was pushed, it gave the brix readings. After the meter was cleaned and dry with distilled water and dried with Kimwipes™, approximately 1gram of juice was placed in the beaker on the scale provided with the ATAGO test kit. Distilled water was added to bring the total volume weight to 50 grams. After a quick stir, approximately 5 ml of the solution was placed on the meter with the button pushed a second time giving the acidity measurement, defined as total acidity to malic acid conversion, noted as percent acid. After the third button push, the brix:acid ratio was computed.

At approximately 30 and 60 days postharvest, a 20-apple sample was taken from each of the sample bags. These were brought back to the harvest maturity lab and tested for firmness, brix, acidity, and brix:acid ratios with the equipment and methods described earlier.

At approximately 120 days postharvest, the remaining samples were taking out of storage. There was some loss to rots, and these were culled out prior to final use of the samples. Of the good apples from 10-20 were used for final acidity measurements at the harvest maturity lab. The remaining usable apples were tested for firmness, brix, acidity, and brix:acid ratios with the equipment and methods described earlier. After this testing was concluded, a subset of samples representing two samples each from the three acid categories (high, medium, and low) corresponding to the acid levels described earlier were taken to the sensory analysis (SA) lab in the care of Dr. Robin Dando on the Cornell University campus. The SA is a scientifically validated voluntary taste testing by students. In 2024, 86 students completed the SA. In 2025, 72 students completed the SA. The SA includes a computer that accompanied the samples. Each sample also had a picture of a "typical apple", from the actual samples,

Figure 1. High quality Honeycrisp apples from a farm in Orleans County in September of 2025.



Honeycrisp apple juice samples awaiting testing for their acidity levels in after 30 days in storage, in October of 2025.

whole. Each participant in the SA scored these samples, from the whole apple picture and its visual appearance, including taste, texture, aroma, and off flavors. Each sample had a random code assigned to it.

Results

The principle measurement for this entire study was the acidity, again defined as total acidity to malic acid conversion. From unpublished data from Dr. Jim Mattheis of USDA, there are three main acid categories for apples that are eaten for the

Table 1. Changes in acidity during storage of Honeycrisp from14 Honeycrisp orchards in Western NY in 2024.

		Total Acidity (malic acid conversion), %				
ID	**Trt**	**Harvest**	**30 Days PH**	**60 Days PH**	**90 Days PH**	**AVG**
A-1	NO 1-MCP	0.65	0.52	0.58	0.45	0.55
A-1	1-MCP	0.65	0.33	0.62	0.39	0.50
A-2	NO 1-MCP	0.87	0.68	0.78	0.75	0.77
A-2	1-MCP	0.87	0.56	0.58	0.82	0.71
A-3	NO 1-MCP	0.56	0.37	0.31	0.30	0.39
A-3	1-MCP	0.56	0.21	0.41	0.34	0.38
A-4	NO 1-MCP	0.68	0.37	0.66	0.45	0.54
A-4	1-MCP	0.68	0.37	0.53	0.44	0.51
A-5	NO 1-MCP	0.64	0.63	0.74	0.47	0.62
A-5	1-MCP	0.64	0.58	0.73	0.68	0.66
A-6	NO 1-MCP	0.43	0.53	0.70	0.73	0.60
A-6	1-MCP	0.43	0.47	0.55	0.46	0.48
A-7	NO 1-MCP	0.38	0.34	0.89	0.31	0.48
A-7	1-MCP	0.38	0.38	0.51	0.46	0.43
A-8	NO 1-MCP	0.56	0.54	0.59	0.62	0.58
A-8	1-MCP	0.56	0.49	0.52	0.49	0.52
A-9	NO 1-MCP	0.29	0.00	0.00	0.14	0.11
A-9	1-MCP	0.29	0.23	0.26	0.19	0.24
A-10	NO 1-MCP	0.64	0.43	0.59	0.59	0.56
A-10	1-MCP	0.64	0.50	0.48	0.44	0.52
A-11	NO 1-MCP	0.47	0.50	0.42	0.38	0.44
A-11	1-MCP	0.47	0.41	0.43	0.38	0.42
A-12	NO 1-MCP	0.47	0.46	0.35	0.35	0.41
A-12	1-MCP	0.47	0.35	0.29	0.31	0.36
A-13	NO 1-MCP	0.86	0.55	0.69	0.51	0.65
A-13	1-MCP	0.86	0.27	0.72	0.61	0.62
A-14	NO 1-MCP	0.30	0.44	0.30	0.32	0.34
A-14	1-MCP	0.30	0.35	0.27	0.24	0.29
AVG	**ALL**	0.56	0.42	0.52	0.45	0.47
MIN	**ALL**	0.29	0.00	0.00	0.14	0.11
MAX	**ALL**	0.87	0.68	0.89	0.82	0.77
AVG	**No 1-MCP**	NA	0.45	0.54	0.46	0.50
AVG	**1-MCP**	NA	0.39	0.49	0.45	0.44

Sensory Analysis Ithaca 12-4-24 (1-MCP)

High	#>.6	2,5
Medium	#>.4, <.6	1,6
Low	# < 0.4	9,11*

*11 actually averages medium

Table 2. Changes in acidity during storage of Honeycrisp from 22 Honecyrisp orchards in Western NY in 2025.

Orchard	MCP treatment	Total Acidity (malic acid conversion), %				
		Harvest	**30D**	**60D**	**90D**	**Average**
A-1	MCP		0.33	0.32	0.29	0.31
A-1	no MCP	0.58	0.44	0.48	0.43	0.45
A-2	MCP		0.61	0.48	0.37	0.49
A-2	no MCP	0.75	0.63	0.47	0.34	0.48
A-3	MCP		0.58	0.52	0.62	0.57
A-3	no MCP	0.67	0.65	0.54	0.59	0.59
A-4	MCP		0.52	0.51	0.54	0.52
A-4	no MCP	0.81	0.59	0.47	0.37	0.48
A-5	MCP		0.72	0.63	0.58	0.64
A-5	no MCP	0.72	0.60	0.68	0.66	0.65
A-6	MCP		0.43	0.42	0.40	0.42
A-6	no MCP	0.63	0.46	0.36	0.32	0.38
A-7	MCP		0.52	0.66	0.46	0.55
A-7	no MCP	0.84	0.64	0.59	0.51	0.58
A-8	MCP		0.35	0.29	0.31	0.32
A-8	no MCP	0.46	0.28	0.26	0.27	0.27
A-9	MCP		0.55	0.42	0.36	0.44
A-9	no MCP	0.62	0.34	0.35	0.32	0.34
A-10	MCP		0.51	0.51	0.49	0.50
A-10	no MCP	0.48	0.54	0.37	0.47	0.46
A-11	MCP		0.59	0.74	0.40	0.58
A-11	no MCP	0.82	0.62	0.70	0.59	0.64
A-12	MCP		0.77	0.64	0.64	0.68
A-12	no MCP	0.88	0.61	0.45	0.70	0.59
A-13	MCP		0.49	0.40	0.41	0.43
A-13	no MCP	0.66	0.50	0.48	0.45	0.48
A-14	MCP		0.57	0.51	0.43	0.50
A-14	no MCP	0.71	0.53	0.45	0.47	0.48
A-15	MCP		0.24	0.21	0.18	0.21
A-15	no MCP	0.39	0.14	0.14	0.17	0.15
A-16	MCP		0.88	0.70	0.69	0.76
A-16	no MCP	0.95	0.56	0.51	0.62	0.56
A-17	MCP		0.43	0.50	0.45	0.46
A-17	no MCP	0.49	0.38	0.35	0.40	0.38
A-18	MCP		0.40	0.36	0.24	0.33
A-18	no MCP	0.32	0.29	0.36	0.36	0.34
A-19	MCP		0.59	0.43	0.53	0.52
A-19	no MCP	0.52	0.41	0.33	0.36	0.37
A-20	MCP		0.29	0.35	0.27	0.30
A-20	no MCP	0.49	0.30	0.31	0.22	0.28
A-21	MCP		0.28	0.32	0.43	0.34
A-21	no MCP	0.57	0.35	0.31	0.26	0.31
A-22	MCP		0.32	0.37	0.27	0.32
A-22	no MCP	0.61	0.30	0.56	0.29	0.38
AVG	**ALL**	0.64	0.48	0.45	0.42	0.45
MIN	**ALL**	0.32	0.14	0.14	0.17	0.15
MAX	**ALL**	0.95	0.88	0.74	0.70	0.76
AVG	**No 1-MCP**	NA	0.46	0.43	0.42	0.44
AVG	**1-MCP**	NA	0.50	0.47	0.43	0.46

Sensory Analysis Ithaca 12-8-25 (each set of samples -1-MCP & +1-MCP)

	Acid Level (%)	Sample #
High	#>.6	5
Medium	#>.4, <.6	10
Low	# < 0.4	15

fresh market. High = >0.6% total acidity. Medium= 0.4% to 0.6%, and low=under 0.4%. In 2024 at harvest, the 14 orchard blocks had approximately 43% of the samples at the high acid level, 36% of the samples at the medium acid level, and approximately 21% of the samples at the low acid level. Since half the samples were treated just after harvest with the ethylene blocker 1-MCP, and half were left untreated, there were 28 total samples for the subsequent analyses. In 2025 at harvest, the 22 orchard blocks had approximately 9% of the samples at the high acid level, 52% of the samples at the medium acid level, and approximately 39% of the sample at the low acid level. Since half the samples were treated with the ethylene blocker 1-MCP, and half were left untreated, there were 44 total samples for the subsequent analyses. Past research and observations have shown that 1-MCP helps retain acidity, even in samples stored in regular atmosphere. The primary benefit of MCP for most apple varieties is the retaining of firmness. However, Honeycrisp is one of the few apple varieties which you do not show a difference in firmness between treated and untreated 1-MCP samples. Nonetheless, because of the expected maintenance of acidity, most storages treat their Honeycrisp with 1-MCP.

Please see the Tables 1 and 2 below for the summary of the acidity data for all the samples at all sampling periods.

Discussion

Although we are awaiting comprehensive data analysis by the Dando lab for the second year samples, we were able to successfully measure acid levels in a wide range of Honeycrisp samples. The samples divided up very well into three acid categories. As expected, the acidity declined over time while fruits were in storage. However, there was no benefit of MCP on final acidity levels in both years.

Students sampling fruit from different acid levels as part of a sensory analysis at the Dondo lab at Cornell have consistently preferred the higher acid samples to the lower acid samples. This should mirror overall consumer preference and is an exciting development.

It is interesting to note that the percent acid of each sample at each acid level differs significantly across both years. A hypothesis is that in 2024 we had adequate moisture and good fruit maturation weather resulting in more fruit with acceptable flavor and thus higher acid levels. In 2025 we had large periods of drought in which the trees and the fruit were stressed.

Another more anecdotal observation is that Honeycrisp orchard blocks that have very uniform trees and good pruning and good crop loads have more even maturity (which is not something new) but tend to have higher acid levels. In contrast, trees with variable crop loads or heavy crop loads and less dwarfing rootstocks tend to have lower acid levels at harvest. There were some samples that retained most of their acidity throughout the 120 day period, but all declined over time. It is known that acid levels will always decline over time. The reason for a rise in some of the samples at some samplings is because at each sampling, we are doing destructive sampling and not sampling the same apples. We are sampling apples from the same harvest during subsequent testing periods, but not the same apples so there will be some inherent variation.

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