Fermentation Optimization and Consumer Acceptance Evaluation of New York Apple Varieties as a Base for Hard Cider

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In the United States, fermented ("hard") cider production has increased rapidly in recent years (Figure 1). Fermented ciders offer lower alcohol (and therefore lower caloric content) than wine, a more approachable fruit-forward flavor profile than beer, and the added advantage of being gluten-free. With the creation of the farm cidery license and a new tax definition of cider, New York State is now extremely well positioned to be a national leader in hard cider production. State officials report that there has been a 600% increase in new cidery licenses since 2011. This growth in new businesses does not count the many existing wineries and breweries that have added hard cider to their product offerings. New York is also already one of the largest apple-growing states (second only to Washington), giving the growing cider industry a more than adequate supply.

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Unfortunately, the most common apples in New York (as well as the entire country) have been planted not with cider, but with the fresh market or processing in mind. "Customary" cider varieties have different chemical characteristics than those intended for eating out-of-hand, including higher levels of acidity and astringency. In fact, one traditional way of determining if an apple is a cider apple is to take a bite; if you can imagine taking another bite, it's not a true cider apple. Until the last few years, there has been almost no commercial production of these apples in the United States. The American market is relatively new to cider, however, and no strong or ingrained opinions have necessarily been formed regarding product preferences. Further, consumers have come to recognize and appreciate the apple varieties they are already buying as fresh fruit. Successful products based on eating apples exist in the marketplace now, and it seems reasonable to assume that there is space for more.

Relatively little work has been done regarding optimizing the fermentation and blending of eating/processing ("culinary") apples for cider production. There is little published data on what North American consumers expect or prefer when it comes to apple varieties and blends included in hard ciders. Before apple producers take on the risk of investing in new varieties, it would be prudent to evaluate the possibilities for, and consumer attitudes towards, products made from what is currently available. This work will highlight options for creating desirable fermented ciders from established apple varieties in New York.

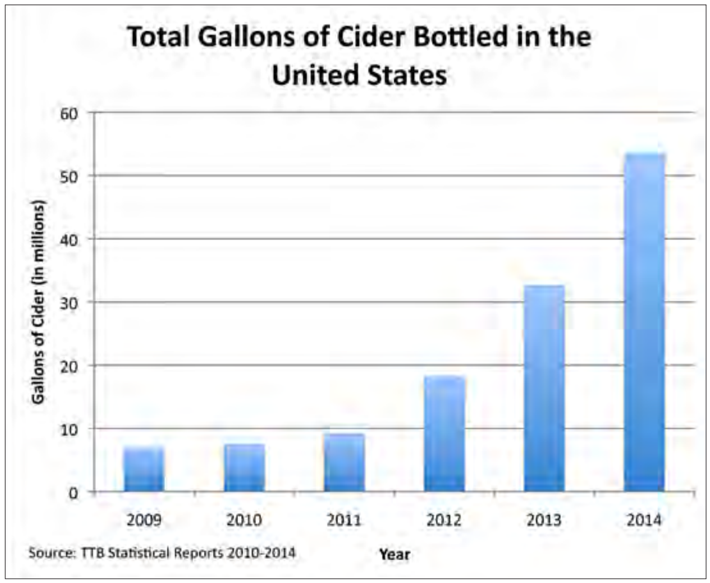

Figure 1. Total gallons of cider bottled in the U.S.

The objectives for this project were:

1. Characterization of popular commercial ciders
2. Single variety fermentations and evaluations
3. Consumer attitudes toward commercial ciders
4. Optimizing a cider based on data from objectives 1&3

Objective 1- Characterization of popular commercial ciders

Thirteen ciders were selected from ten different cideries, nine of which are located in New York State. The ciders were analyzed for pH, titratable acidity, individual organic acids, residual sugar, carbonation, ethanol and total phenolics

Table 1. Chemical Composition of Commercial Ciders.

Cider	pH	CO_2	TA (g/L)	Citric Acid (g/L)	Malic Acid (g/L)	Lactic Acid (g/L)	Acetic Acid (g/L)	Total Residual Sugar (g/L)	Sucrose (g/L)	Glucose (g/L)	Ethanol (%v/v)	Total Phenols per 100 ml
Cider 1	3.57	2.6	6.2	0.05	4.73	0.41	0.24	18	16.9	0.9	5.3	118
Cider 2	3.55	2.8	7.0	0.06	1.43	2.86	0.17	23	10.4	12.4	6.4	55
Cider 3	3.60	3.4	6.0	0.04	5.67	0.30	0.21	26	22.5	3.4	8.4	30
Cider 4	3.53	2.9	7.3	0.01	0.11	5.86	0.75	26	25.3	0.5	7.8	43
Cider 5	3.60	1.5	6.4	0.11	4.62	0.39	0.07	64	50.3	13.4	3.9	36
Cider 6	4.02	1.2	4.0	0.03	0.15	4.46	0.34	45	38.6	6.7	4	121
Cider 7	3.79	3.6	5.0	0.10	3.97	0.30	0.08	25	18.7	6.0	4.6	35
Cider 8	3.82	3.0	4.7	0.09	5.14	0.61	0.13	nd	nd	nd	4.6	56
Cider 9	3.69	2.3	5.3	0.08	3.92	0.63	0.27	nd	nd	nd	4.3	37
Cider 10	3.52	3.0	8.1	0.06	5.04	0.64	0.16	4	2.5	1.7	7.5	27
Cider 11	2.55	9.9	3.6	0.11	6.56	0.84	0.46	44	23.0	21.2	7.2	318
Cider 12	3.52	4.2	4.5	0.07	3.06	1.63	0.13	22	20.8	1.4	3.9	29
Cider 13	3.26	2.5	7.1	nd	3.45	nd	0.08	32	14.5	17.5	4.7	37

(tannin). The selected ciders were made with both traditional cider varieties and apples grown more widely in New York. The ciders ranged from a pH of less than 3.3 to just over 4.0, although most were between pH 3.5 and pH 3.8. The titratable acidity (TA) levels ranged from 4.5 g/L to 9.9 g/L and the organic acid profiles show that at least two ciders appear to have undergone malolactic fermentation. No cider had acetic acid levels anywhere near the legal limit of 1.5 g/L. The ciders had a wide range of residual sugar (RS), from completely dry (no sugar detectable) to more than 60 g/L (6%), with a mean of approximately 3%. Carbonation and alcohol levels were also highly variable (Table 1).

Initial impressions suggest that there is no single chemical profile or style that defines these ciders. One unifying characteristic was the relatively low levels of total phenolics. The one exception was the cider made from a blend of traditional cider apples, which had nearly three times more tannin than the cider with the next highest amount and six times more than the median concentration. We were curious about whether this stark difference in total phenols would be a positive, negative, or have no effect on consumer preference in blind tastings.

Objective 2- Consumer attitudes toward commercial ciders

A two-part panel was designed to gauge (1) consumer awareness and preferences related to apple varieties, including traditional cider varieties and better known apples available in grocery stores, and (2) preferred cider characteristics in a blind tasting. A station was set up in a winery tasting room where both wine and cider is sold. The targeted audience was people who are open to trying cider but who have not already formed strong beliefs. These people may or may not have consumed cider previously, but are not already regular cider drinkers. The first part of the survey consisted of a paper questionnaire that asked people whether or not they were familiar with certain apple varieties, and how they would feel about these varieties in a fermented cider. The next part consisted of a blind tasting of four ciders presented in random order. One cider was made exclusively from one traditional eating/processing apple; one was made from a blend of eating/processing apples; one was made from an apple that has been adopted for cider in NY; and the last was made from a blend of traditional cider apples.

While the ciders had a wide range of residual sugar (RS) as initially bottled (Table 2), the level of RS was adjusted for the tasting to remove sweetness as a variable. While no strong preferences or trends seemed to appear from the questionnaire, the most preferred cider was the blend of cider apples, the cider with the highest total phenols. We inferred from this finding that while consumers may not have strong recognition of high-tannin cultivar names, they do seem to like the astringency that they provide. New York apples can produce ciders with optimal levels of sugar and acid, while final alcohol, RS, and carbonation are all adjustable by the cider maker. If consumers seem to prefer ciders with tannin, low-phenols ciders can in principle be supplemented with tannin from other sources. With the exception of one concentrate that has undergone a special extraction process, the only tannins available commercially are sourced from grapes, wood or nuts.

Objective 3 - Single variety fermentations and evaluations

In the fall of 2014, six different apple cultivars were fermented in duplicate. Four of the cultivars — Empire, Jonagold, Idared, and McIntosh — are among the most commonly grown apples in New York, while two more were sourced from Dr. Susan Brown's Cornell apple breeding program. These apples are thought to have characteristics more resembling "traditional" hard cider varieties. The commercially available varieties were fermented with two different yeast strains (Lallemand DV10 and R-HST, Scott Labs) for a total of four fermentations, while the quantity of available apples limited the research lots to just one strain (DV10). The apples were milled and pressed, and then the juice was divided into equivalent containers for fermentation, and SO2 was added in the form of potassium metabisulfite. The juice was inoculated with yeast after 24 hours.

All of the ciders had a pH at or below 3.5 (Table 3), which was optimal. Microbial spoilage risk is much lower when pH is below 3.5, and SO2 is more effective, allowing for lower doses. The experimental cultivars had the highest sugar levels and also the highest titratable acidity and greatest malic acid content. The combination of higher potential alcohol and also higher acidity are potentially positive traits for cider apples, but both of these characteristics are also adjustable in the cider-making process. Yeast assimilable nitrogen measurements (YAN) were below the recommended level for healthy fermentation (150–250 mg/L), which is much like what we observe in New York grapes. As a result, the juices were all supplemented with a mixture of organic (Go-Ferm, Fermaid-K) and inorganic nitrogen (diammonium phosphate) sources roughly one-third of the way through fermentation. The fermentations were carried out in a room with an ambient temperature of 16°C, and no sugar remained after 21–28 days.

The ciders were first evaluated to compare the yeast strains and see if there was a perceived difference, and if the difference was significant. A randomized triangle test was conducted, wherein panelists received three samples, two of which were the same. If the panelists can accurately identify the odd sample more frequently than chance would dictate, the results are considered significant and there is a strong probability that the samples are sensorially different. In this case, panelists could successfully distinguish between the yeast strains in each of the ciders. One reason for the easily identified difference was probably a sulfur-like off-aroma in many of the R-HST fermentations, and as a result, the research group preferred the ciders made from the DV10 yeast and made from a base blend with equal amounts of each apple cultivar. This blend was then used in trials to optimize sweetness and tannin levels.

Table 2. Chemistry and preference rank for commercial ciders evaluated by consumers.

	Acidity as Malic Acid (g/L)	Ethanol (%v/v)	Carbonation (Volumes of CO2 @ 20°C)	Residual Sugars (g/L)	Total Phenols per 100 ml	Consumer Relative Preference
Commercial Cider #1	5.6	7.2	2.6	44	318	1
Commercial Cider #2	4.6	7.5	3.0	4	27	2
Commercial Cider #3	4.0	4.7	2.5	32	37	3
Commercial Cider #4	2.6	4.0	1.2	45	121	4

Table 3. Chemistry of experimental ciders produced in 2014.

	Juice Analysis			Cider Organic Acid Profile (after fermentation)				
Variety	BRIX	pH	TA (g/L)	Malate (g/L)	Lactate (g/L)	Acetate (g/L)	Citric (g/L)	Total Phenols per 100 ml
SKB 1	14.6	3.34	7.7	7.8	0.4	0.12	0.11	34
SKB 2	14.6	3.30	11.9	9.5	0.4	0.04	0.12	31
Empire	12.6	3.48	5.9	6.4	0.5	0.07	0.13	25
Jonagold	12.1	3.50	4.9	5.2	0.3	0.12	0.07	38
Ida Red	12.7	3.37	7.0	7.0	0.3	0.09	0.05	31
McIntosh	11.3	3.31	7.2	7.0	0.4	0.04	0.06	32

Table 4. Consumer preferences in paired evaluation trial.

Consumer Preference: Tannin Levels in Cider			Consumer Preference: Sugar Level in Cider		
Pair	Tannin (mg/L)	Preference	Pair	Sugar (g/L)	Preference
1	0		1	10	
1	**75**	**Strong Preference**	1	**20**	**Strong Preference**
2	75	No Preference	2	20	
2	150		2	**30**	**Strong Preference**
3	150	No Preference	3	30	
3	225		3	**40**	**Slight Preference**
4	225	No Preference	4	40	No Preference
4	300		4	50	

Objective 4- Optimizing a cider based on data from objectives 1&3

Most of the commercially available powdered tannin products are designed for use in red wines, where the sensory matrix is less delicate than in cider. An initial group of four tannins were added at the same rate to a base cider, and an informal panel of eight experts was convened to pick the most suitable tannin for further trials. The group chose Enartis Tan UVA, a product sourced from white grape seeds. A two-factor, paired-preference test was then designed using a fixed level of carbonation. For sweetness, the tannin level would be fixed in mid-range (150 ppm) while tasters compared stepped levels of RS from 1 to 5%. The tannin trial set sweetness at mid-range (3% RS) and stepped from 0 to 300 ppm addition in 75 ppm increments (Table 4).

Results showed that tasters clearly preferred 2% RS to 1%, and 3% over 2%. There was only a slight preference for 4% over 3%, and no real difference between 4 and 5%. There are many factors that would influence the appropriate sugar level in other ciders, including acid, alcohol and tannin level, but a range of 3 to 4% RS may provide a good starting point for those looking to produce ciders with common New York apples. The tannin trial showed a strong preference only between 0 and 75 ppm. There was no clear trend among the higher treatments, which may indicate that large additions are unnecessary (though not detrimental, as far as could be seen in this trial).

Future work

In 2015, we procured two high-tannin cider cultivars, Dabinett and Harry Masters Jersey, for processing and fermentation. We plan to compare the effect of blending small amounts of these ciders with that of adding powdered tannins. We plan to continue the sensory trials, both in tasting rooms and in controlled laboratory spaces. We also plan to evaluate methods for creating a powdered tannin product sourced from apples.

Summary

As cider production and demand increases, it follows that demand for the necessary apples will also grow. We hope that apple growers in New York will be able to find profitable markets for all of their fruit, and that this new source of demand will have a favorable impact on prices. Evidence suggests that there are many possibilities for apples already available in New York State. Cider producers currently have plenty of supply, but not a lot of information about the best ways to make cider from these apples. Our goal is to provide new and established cideries with a "roadmap" regarding cider production with New York varieties, be it fermentation conditions, tannin adjustment, or blending. There are many different production paths toward ciders that consumers will enjoy, and there is no single correct answer. While tannin is lacking from most apple cultivars that are currently in the ground, there are ways to produce successful products from those apples, with and without tannin. The most essential characteristic that any cider can possess is balance. Balance among elements is almost always more important than the absolute amount of any single component.

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