Production and Marketing Reports

Apple Market Expansion through Value-added Hard Cider Production: Current Production and Prospects in Vermont

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ADDITIONAL INDEX WORDS. fermented cider, cider apple cultivars, cider processing, fruit pricing

SUMMARY. Hard cider production has increased annually by 50% between 2009 and 2014 in the United States while apple (*Malus × domestica*) orchards managed exclusively for cider apples are rare. Cider apples have unique flavor, acid, and tannin characteristics suited to only hard cider production. Demand for fruit by cider makers represents an emerging market for apple growers and an opportunity to diversify their production and marketing systems. The goal of this study was to compare the fruit requirements of cider makers with present cider fruit availability in orchards to identify opportunities and challenges for the growth of both industries, and we surveyed cider makers and apple growers. Growers in our study saw a market expansion opportunity in the growth of popularity of hard cider, but present apple prices were identified as a key threat. Cider makers are also expanding their operations, all of those sampled anticipate increasing their production in the next five years, but maintaining adequate fruit supply was identified as a major threat. Cider makers and apple growers have both expressed interest in dual-purpose cultivars that may be sold to the fresh market or for cider making. Apple growers have expressed guarded interest in growing specialty cider cultivars while cider makers have expressed a strong interest in increased production of cider-specific cultivars. We conclude that there are a number of potentially beneficial opportunities, particularly in increased production of dual-purpose and specialty cider cultivars, as long as price and coordination issues can be resolved.

Hard cider production has increased dramatically in the

This project was funded through Vermont Working Lands Enterprise Fund Project no. 0220-WLEB-77.

We would like to thank the participating apple growers and cider makers for taking the time to fill out the survey.

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United States in recent years with an annualized growth rate of 50% between 2009 and 2014 and revenues totaling \$292.5 million in 2014 (Petrillo, 2014). The growth of the industry has been attributed partially to the craft beer movement,

subsequent expansion of consumers' palates, and knowledge of cider (Petrillo, 2014; Russel Lucha et al., In press). In 2014, there were 351 businesses producing cider in the United States and most of those cider producers were small in scale and were established within the last 10 years. For example, while four large producers produced 84.3% of the volume of cider, the other 347 or 98.9% of the producers produced only 15.7% of the output (Petrillo, 2014). Cider makers across multiple scales express plans to expand production (Peck and Miles, 2015). It is estimated that at current production levels, the U.S. cider industry requires an estimated 18 million bushel of apples per year (1 bushel = 40 lb = 18.1437 kg), representing ≈7% of all of the apples grown in the United States, and most large-scale producers use imported juice concentrate. According to the U.S. Association of Cider Makers (Denver, CO), large-scale cider makers produce over 500,000 gal/year. A recent study suggests that only a third of cider makers are producing any apples themselves, and mostly on a small scale (Peck and Miles, 2015). These factors represent a potential opportunity to increase sales of domestically grown apples to this expanding market.

Apple production for fresh markets and associated intensive management to produce high-quality fruit are fundamentally at odds with the needs of cider makers. Cider makers require multiple apple cultivars for their products, including lower-grade fruit from traditional commodity dessert cultivars (e.g., McIntosh and Cortland) as well as dual-purpose cultivars that may be sold to both the fresh market and to cider makers (e.g., Idared and Northern Spy) and specialty cider apple cultivars with unique flavor, acid, and tannin characteristics suited to only hard cider production including heirloom (e.g., Golden Russet and Esopus Spitzenburg) and bittersweet cultivars (e.g.,

Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.4047	acre(s)	ha	2.4711
3.7854	gal	L	0.2642
0.4536	lb	kg	2.2046
1.1209	lb/acre	kg·ha ⁻¹	0.8922

Dabinett and Fillbarrel) (Moulton et al., 2010; Valois et al., 2006). Presently, few orchards are managed exclusively for cider apples in the United States (Merwin et al., 2008), but processing apples grown for apple sauce, fresh juice, and similar products were valued at \$4.80 to \$5.60 per bushel in 2013 (Fruit Growers News, 2013). Data on total acreage of specialty cider cultivars planted is limited and does not appear in the U.S. Department of Agriculture (USDA) or other survey metrics. However, cidery operators have indicated that a shortage of specialty cider apples exists in the United States with an estimated 200–300 bearing acres of specialty cider apples out of ≈380,000 total acres of apples (Fruit Growers News, 2015a; USDA, 2012). In many seasons, pest outbreaks [e.g., apple scab (*Venturia inaequalis*) and codling moth (*Cydia pomonella*)] and/or environmental factors (e.g., frost, hail, and preharvest drop) reduce the value of commercial fresh market apples despite use of intensive management practices. Much of this damaged crop is salvaged via sales to fresh juice processors and in 2012 the average price was \$3 to \$4 per bushel, compared with \$17 to \$24 per bushel for fresh market fruit (USDA, 2013a). Demand for fruit by cider makers represents an emerging market for apple growers and an opportunity to diversify their production and marketing systems. Due to the rapid growth of the cider industry, the price of apples for cider making is expected to rise in response to increased demand, which could in turn affect cidery profitability (Petrillo, 2014). From the growers' perspective, planting new trees specifically for the cider industry represents a long-term investment that entails significant risk. Horticultural knowledge of cider apple cultivars, including potential yield, management needs, and regional adaptability is limited (Peck and Miles, 2015).

Cider makers have an array of options for apple procurement (Conner et al., 2012; Hobbs, 1996). Juice concentrate and processing apples are undifferentiated and widely available, suggesting that cider makers can procure them on spot markets. However, to obtain specialty cider apples, which have a narrow range of uses and lower

availability, cider makers would need to produce the apples themselves or enter into strategic partnerships. In the latter case, a variety of governance mechanisms are available including contracts, joint ventures, and direct investments. Strategic partnerships have drawn the attention of agri-food scholars due to their potential for creating mutual benefit among supply chain partners (Conner et al., 2012; Stevenson and Pirog, 2008).

Surveys of apple growers and cidery operators in Virginia revealed that in order to ensure availability of cider apples, 80% of the cidery operators were willing to enter into long-term financial arrangements whereas 22% of the apple growers surveyed would plant cider apple trees if they had contractual agreements with cider makers insuring fair market prices in the long term (Peck et al., 2012; Versen and Kelley, 2012).

Apple production is significant in Vermont. From 2009–13, the mean annual value of Vermont's apple crop was \$10.3 million (farm gate) derived from average annual production of 800,000 bushels of fruit grown on 2560 acres, with average yield of 330 bushels per acre (USDA, 2014). While Vermont's apple production measured in bushels ranked second among New England states over that period, its growers have received the lowest used price per bushel of fruit among the New England states (USDA, 2014). Few Vermont growers manage orchards specifically for production of processing fruit and the majority of apples are grown for fresh consumption (Vermont Tree Fruit Growers Association, 2011). Because of the state's lower population density compared with the rest of New England, the Vermont apple industry relies on wholesale market channels to sell the majority of its fruit. Presently, over half of Vermont apples are sold to wholesale markets through regional fruit brokers and direct store delivery routes (Bradshaw, 2013). Most of the 14 cider-making operations in Vermont currently purchase fruit from the spot market at similar prices to those paid by fresh juice processors, but cidery operators and orchardists report that specialty cultivars grown for cider production are increasingly being purchased by local cideries for \$6 to \$25 per bushel (B. Hodges, personal communication;

J. Heilenbach, personal communication). Some cider makers grow their own apples while other large cider makers purchase domestic and imported apple concentrate.

The growth of the cider industry is strong and the market opportunities for apple growers will likely continue to grow with it. However, researchers have identified current gaps of knowledge that could hinder the long-term growth of the cider industry including the current and future needs of the industry in terms of quantity of fruit purchased, preferred apple cultivars, and potential prices paid by cider makers to fruit growers (Russel Lucha et al., in press). Similarly, little is known of the types of fruit that apple growers are selling to the cider industry, the price received, and grower perceptions of future marketing opportunities.

The goal of this study was to compare fruit needs of cider makers with present cider fruit availability in Vermont orchards to identify opportunities and challenges for growth of both industries. Specifically, we wanted to better understand the cider fruit availability in Vermont orchards, the fruit needs of cider makers, and the opportunities and challenges for the growth of both industries.

Materials and methods

Two surveys were conducted for this project. The surveys included questions adapted from a similar study conducted in Virginia (Peck et al., 2012; Versen and Kelley, 2012) as well as questions designed by the authors. In the first survey, we asked apple growers about their production, sales, marketing channels, and plans to grow apples for the cider industry. In the second survey, we asked cider makers about their production, the types of apples they purchase, the prices they paid, their fruit requirements, and their sales of cider. The University of Vermont (UVM) Institutional Review Board reviewed and approved the survey instruments and methods used for the study.

The sample frame for the orchard survey comprised of commercial apple growers in the state of Vermont. Commercial producers were defined as members of the Vermont Tree Fruit Growers Association (VTFGA, Montpelier, VT) or as orchards with significant acreage (>5 acres) on the UVM Apple Program

mailing list but not included as members of VTFGA. A link to an online survey through LimeSurvey (version 2.0; The LimeSurvey Project, Hamburg, Germany) was sent to the UVM Apple Program listserv, which reaches ≈ 140 stakeholders in Vermont but we estimate from program mailing records and membership records of the VTFGA that there are ≈ 40 commercial orchards on that list. The survey opened on 25 Aug. 2014 and closed on 6 Oct. 2014. We sent e-mail invitations to the listserv and we prompted the members three times to respond to the survey during this period. We received 24 complete responses representing a response rate of 60% of the 40 commercial orchards (many orchards have multiple employees on the mailing list).

The sample population for the cider makers' survey included all commercial cider makers in Vermont. We sent a link to an online survey to cider makers through direct e-mail invitations. We identified 14 cider-making operations by reviewing data from the Vermont Department of Liquor Control (State of Vermont, 2013). The survey opened on 25 Aug. 2014 and closed on 17 Sept. 2014. We sent e-mail invitations directly to cidery operators and we prompted potential participants two times to respond to the survey. We received eight complete representing a response rate of 57%.

We imported survey responses into the SPSS software (version 22; IBM Corp., Armonk, NY) and used descriptive and bivariate analysis to analyze the data. The Shapiro-Wilk

test was conducted to test the null hypothesis that the distributions of the two samples are normal. In both cases, we rejected the null hypothesis meaning that the data of the two samples are not normally distributed. Therefore, we used nonparametric tests because they do not require normal distribution of the data. We used the Spearman's rho to test correlation between two continuous variables such as number of acres and years in operations, and we used the Kruskal-Wallis H test to test the difference between two or more groups of an independent variable on a continuous scale such as years in operations and anticipated production changes. The results of the test are considered statistically significant if the *P* value is less than or equal to 0.1. Statistical significance means that the response to the same question by different groups is not likely to have happened by accident or by chance.

Results

APPLE GROWERS' SURVEY. Grower respondents reported growing apples on a total of 1039.5 acres representing 65.0% of the bearing acreage in Vermont (USDA, 2014). All respondents, except one who leases, reported owning their orchard; the average acreage of the owned orchards was 44.6 acres, ranging from 1 to 210 acres (Table 1). On average, the orchards have been in operation for 28.7 years and employ 2.6 full-time year-round employees, 2.7 part-time year-round employees, 9.2 full-time seasonal employees, and 12.3 part-time seasonal employees. In the sample, we

found a strong positive correlation between the size of the orchards measured by the number of acres and the number of years in operation ($r_s = 0.703$, $P < 0.01$), the number of full-time year-round workers ($r_s = 0.771$, $P < 0.01$), and the number of full-time seasonal workers ($r_s = 0.706$, $P < 0.05$). These findings mean that farms that have been in operation the longest are larger and either require more labor or have greater cash reserves to pay for labor.

Apple growers were asked about their 2013 crop and their anticipated 2014 crop (Table 1). Reported yield was higher in 2013 than what is expected in 2014. The average yield in 2013 was 302.0 bushels per acre, which is similar to the 2010 harvest and the expected average yield for 2014 was 217.3 bushels per acre, which is similar to the 2012 harvest (USDA, 2013b). The degree of fluctuation between years suggests that the Vermont apple industry follows a biennial production, which may present challenges in the supply chain for both growers and cider makers.

Growers sold their production through several market channels. The most dominant market channels were for on-farm sold as apple (75.0%) and as juice (65.0%) whereas 40% of the farmers sold to wholesalers and directly to stores. The largest proportion of fruits was sold on-farm as fresh apples (33.6% of each growers' production) followed by sales to wholesalers (18.4%), directly to stores (15.3%), and on the farm sold as juice (11.5%) (Table 2). On average,

Table 1. Characteristics of Vermont apple orchards including acreage, years in operations, number of employees, and production levels.

Orchard characteristics*	Respondents (no.)	Mean	Median	Minimum	Maximum	SD
Orchard size						
Area owned (acres)	23	44.6	15.0	1	210	62.4
Area leased (acres)	1	13.0	13.0	13	13	–
Total area (acres)	24	43.3	14.5	1	210	61.4
Time in operation (years)	22	28.7	18.5	0	100	28.6
Full-time year-round employees (no.)	16	2.6	1.0	0	10	2.8
Part-time year-round employees (no.)	15	2.7	1.0	0	20	4.9
Full-time seasonal employees (no.)	11	9.2	6.0	0	35	10.5
Part-time seasonal employees (no.)	14	12.3	5.0	0	54	17.6
Orchard production levels						
2013 yield (bushels)	23	18,914.9	2,200.0	0	100,000	33,056.7
2014 anticipated yield (bushels)	24	13,706.4	2,100.0	0	90,000	26,624.0
2013 yield (bushels/acre)	23	302.0	300.0	0	840	273.7
2014 anticipated yield (bushels/acre)	24	217.3	166.7	0	720	196.3

*1 acre = 0.4047 ha; 1 bushel = 40 lb = 18.1437 kg; 1 bushel/acre = 44.8340 kg·ha⁻¹.

growers reported selling through three different market channels. Comparing the number of bushels produced in 2013 to each market channel, we found a strong positive correlation between the numbers of bushels produced and sales made to wholesalers ($r_s = 0.875$, $P < 0.01$). This indicates that growers with greater production are more likely to sell to wholesale markets.

Geographically, most sales took place within the county of operation (69.7% of the individual growers' production), Vermont other than the county of operation, (18.1%) or New England (15.7%). All of the producers reported that they sold apples within their county of operation, followed by selling within the rest of the state (36.8%), region (30%), and 10% sold apples in the rest of the United States. Comparing the number of bushels produced in 2013 and where the sales took place, we found a negative correlation between the numbers of bushels produced and selling within the county ($r_s = -0.503$, $P < 0.05$) and a positive correlation between the number of bushels produced and

selling within New England ($r_s = 0.654$, $P < 0.05$). These results suggest that higher volume producers tend to sell to markets farther away from the point of production.

Within the next 5 years, 9.5% of the growers anticipate their production to decrease, 33.3% anticipate their production to stay the same, 38.1% anticipate their production to increase, and 19.0% anticipate their production to greatly increase. The terms related to anticipated production changes were self-defined. We compared the growers' anticipated production changes with the size of their orchard and their present production to test the null hypothesis that there is no difference between the anticipated production changes in the next 5 years and their size and current production levels. The Kruskal-Wallis H test was statistically significant for the independent variables: farm acreage, 2013 and 2014 yield, and years in operation ($P < 0.05$, 0.01, 0.01, and 0.01 respectively) indicating that there is a difference in the anticipated production in the next 5 years and production

characteristics (Table 3). In particular, based on the average acreage, yield, and years in operation, growers who anticipate to greatly increase their production appear to be smaller and/or beginning their operations. The average number of years in operation for growers anticipating increased production was 1.7 compared with 29.2 years for the overall average, and the average yields in 2013 and 2014 were lower than the sample mean for these farmers. In contrast, growers who anticipate their production to stay the same or decrease appear to be better established because their acreage is higher than the sample average and they have been in operation for ≈ 50 years compared with the sample average of 29.2 years. We found a strong positive correlation ($r_s = 0.780$, $P < 0.01$) between the number of bushels produced in 2013 and 2014, and the number of years in operation, indicating that the yields of longer-established growers are higher than for growers with fewer years in operation.

Six of the growers surveyed had sold apples to cider makers while

Table 2. Market channels used by growers to sell Vermont apples and geographic locations of apple sales (respondents n = 20).

Market channels	Growers who sell through each market or location (%)	Mean apples sold through each channel or location (%)
Apple sold through each market (%)		
On the farm sold as apples	75.0	33.6
On the farm sold as juice	65.0	11.5
To wholesalers	40.0	18.4
Directly to stores	40.0	15.3
To sweet cider processors	35.0	7.6
To cideries	30.0	8.4
Other	15.0	5.1
Apple sold through each location (%)		
Within county	100.0	69.7
Vermont, beyond county	36.8	18.1
New England	30.0	15.7
Rest of the United States	10.0	0.5
Do not know	15.0	3.7

Table 3. Anticipated production of Vermont apple growers in the next 5 years compared with farm characteristics including acreage, yield, and years in operation.

Production changes	Respondents (no.)	Mean area (acres) ^z	2013 mean yield (bushels/acre) ^z	2014 mean yield (bushels/acre)	Mean time in operation (yr)
Greatly increase	4	6.5	1.1	9.6	1.7
Increase	8	26.5	160.5	148.3	17.6
Stay the same	7	94.7	507.8	343.8	50.3
Decrease	2	40.0	720.0	421.8	51.5
Total	21	46.7	306.1	213.1	29.2
$\chi^2(2)^y$		7.9*	15.4**	12.2**	12.7**

^z1 acre = 0.4047 ha; 1 bushel/acre = 44.8340 kg·ha⁻¹.

^yResults of Kruskal-Wallis H test; * $P \leq 0.05$, ** $P \leq 0.01$.

three growers who had not sold to cider makers reported that they were interested in selling to cider makers in the next 5 years. Of the growers who had sold to cider makers, four entered a handshake/verbal agreement with their buyer(s) while one of the growers reported using all their apples in their own cider.

The proportion of apples sold to cider makers ranged from 0% to 100% of the total production with an average of 8.4% of production sold to cider makers. Growers sold 13 different cultivars to cider makers. 'McIntosh' was sold by three growers while 'Macoun', 'Cortland', and 'Empire' were sold by two growers. These cultivars represent commonly grown dessert apples in Vermont and are not generally produced specifically for cider production (VTFGA, 2011).

Apple growers were asked which cultivar of apple they would prefer to grow in blocks managed specifically for hard cider production. They listed 21 different apple cultivars with Baldwin, McIntosh, and Northern Spy listed by three growers and Ida Red and Roxbury Russet listed by two growers. Cultivars listed as a number one choice by at least one grower included Fillbarrel, Ida Red, Jonagold, McIntosh (by two growers), and Wickson. Of these, McIntosh

and Jonagold are commodity dessert cultivars; Baldwin, Ida Red, and Northern Spy are dual-purpose cultivars; and Fillbarrel, Roxbury Russet, and Wickson are specialty cider cultivars (Table 4) (Merwin et al., 2008; Moulton et al., 2010; Proulx and Nichols, 2003; Valois et al., 2006). Differences in fruit disposition, however, may have affected choice of cultivar for cider production. Out of the six growers who identified cultivars that they would consider growing for hard cider, the smaller grower who used 100% of his apples for his production was interested in growing a mix of dual-purpose apples (four cultivars listed) and specialty cider (five cultivars listed). The other growers who ranged in size between 40 and 210 acres listed a mix of dessert and dual-purpose cultivars and two specialty cider cultivars. It is likely that the grower cidery prefers to grow specialty cider cultivars because those are limited in supply, whereas dessert fruit may be more easily and cheaply obtained. On the other hand, large wholesale-market producers are likely interested in managing existing acreage of commonly grown cultivars specifically for cider production by reducing labor and input costs required to grow blemish-free fruit for the fresh market. Further costs

savings could be realized for cider fruit production over the fresh market if postharvest inputs and practices including refrigeration, cold storage atmosphere modification, packing, and transport could be reduced or eliminated. The total combination of input reductions across the production and marketing chain may make cider apple production profitable given price reductions in labor and inputs compared with the fresh market.

Differences were observed in reported prices received and target prices for apples sold to cider makers. For the purposes of the survey, we define target price for the growers as the price that would cover their costs of production and provide an adequate profit margin; growers self-reported the price received for cider apples as well as their target price. The price paid by cider makers was lower than the target price of growers for specialty cider/bittersweet apples and tree-picked dessert cultivars and it was equal for dessert cultivar culls from fresh market packing lines (Table 5). The average price difference represented a potential loss of \$5.45 per bushel for specialty cider/bittersweet cultivars and a loss of \$2.25 per bushel for orchard-run dessert cultivars. Growers wish to sell drops to cider makers, but target price is above packing line culls. This is because growers would need to shift labor from harvesting higher-valued fruit to picking up drops during the growing season, whereas packing line culls are already harvested with the main dessert fruit crop and thus, do not represent a separate labor activity.

When asked about threats and opportunities for the industry in the next 5 years, growers identified seven threats: climate change and changing weather patterns (35.3% of producers), foreign imports (29.4%), overproduction (23.5%), fruit prices

Table 4. Apple cultivars identified by growers as favored for cider apple production organized in categories based on marketing or juice characteristics and the number of times it was reported by growers.

Dessert cultivars (no. of growers reporting)	Dual-purpose cultivars (no. of growers reporting)	Specialty cider cultivars (no. of growers reporting)
McIntosh (3)	Baldwin (3)	Bulmer's Norman (1)
Cortland (1)	Northern Spy (3)	Fillbarrel (1)
Empire (1)	Ida Red (2)	Kingston Black (1)
Gala (1)	Hudson's Golden Gem (1)	Medaille D'Or (1)
Jonagold (1)	Liberty (1)	Muscadet Dieppe (1)
Macoun (1)	Roxbury Russet (2)	Orleans Reinette (1)
Mutsu (1)		Wickson (1)
Zestar! (1)		

Table 5. Prices received by apple growers, target prices, and average price difference per bushel for apple cultivar categories sold to cideries.

Apple cultivar category	Respondents (no.)	Price received (\$/bushel) ^a			Target price (\$/bushel)			Avg price difference (\$/bushel)
		Mean	Minimum	Maximum	Mean	Minimum	Maximum	
Specialty cider/bittersweet	2	8.25	4	12.5	13.7	10	17.5	-5.45
Dessert cultivar orchard run	2	5.75	4	7.5	8.0	6.0	10.0	-2.25
Dessert cultivar packing culls ^b	1	7.5	7.5	7.5	7.5	7.5	7.5	0
Dessert cultivar drops	1	-	-	-	7.5	7.5	7.5	-

^a1 bushel = 40 lb = 18.1437 kg, \$1/bushel = \$0.025/lb = \$0.0551/kg.

^bFruit rejected from commercial packing lines for cosmetic blemishes or low fruit color.

and cost of production (17.6%), regulations (11.8%), uncertainty around growth of the cider industry (5.9%), and change in consumer tastes (5.9%). Four opportunities identified for the industry in the next 5 years were: growing apples for hard cider (55.5%), increased demand (27.8%), direct marketing (22.2%), and new apple cultivars (11.1%).

CIDER MARKERS SURVEY. Eight cider makers responded to the survey representing $\approx 60\%$ of the Vermont producers. The major cidery in the state, which is the second largest producer in the nation, is substantially larger than the other respondents, and may be considered an outlier as its responses to production-related questions skew the average response upward. Therefore, in reporting the cidery survey results we present the median as a better representation of the central tendency. The maximum values are not presented for cider makers to ensure confidentiality of the largest producer's responses.

Cider makers have been in operation for a median of 4.5 years and employ 2.0 full-time employees and 3.8 part-time employees (Table 6). These numbers indicate that the Vermont cider industry is fairly small, which is similar to the industry at the national level apart from a few major producers (Petrillo, 2014).

The responding cider makers produced a total of 9,036,600 gal in 2013 and expected to produce

9,041,200 gal in 2014, a 0.05% increase. When removing the largest cider marker, which is also the most established producer, the number of gallons produced was expected to increase by 8.1%. The median production for 2013 and 2014 is 1350.0 gal. The data are positively skewed above the 1.0 threshold (skewness statistic = 2.82) and is considered to be a substantial skewness. Seven of the survey respondents intend to increase their production within the next 5 years and one respondent anticipates to greatly increase their production. Increase and greatly increase were self-defined by the respondents. However, the Kruskal–Wallis H test did not reveal a difference ($P \leq 0.1$) between current level of production and projected growth.

On average, 65.7% of cider was sold through wholesalers. This high proportion can be explained by requirements that alcoholic beverage be sold to a wholesalers with specific license to resell alcohol (Vermont Department of Liquor Control, 2015a). Any direct sales to consumers must take place on premise or at regulated events such as farmer's markets and the cidery must hold a retail license (Vermont Department of Liquor Control, 2015b). We found no correlation between the quantity of cider produced in the past year and selling to wholesalers ($r_s = -0.111$, $P = 0.812$) or direct to consumers ($r_s = -0.200$, $P = 0.800$) indicating that the

volume produced does not appear to determine how cider makers distribute their products.

Geographically, the sales occurred within the county of operation (5.0% of the production), Vermont beyond the county of production (35.0% of the production), New England (30.0% of the production), or the rest of the United States (15.0% of the production). There was no correlation between the volume produced in the past year and selling within the county of operation ($r_s = -0.775$, $P = 0.225$), rest of the state ($r_s = -0.618$, $P = 0.191$), region ($r_s = -0.783$, $P = 0.118$), or country ($r_s = 0.300$, $P = 0.624$). This indicates that geographic location does not significantly determine how cider makers distribute their production.

In 2013, four of the respondents purchased apples, two used a mix of purchased apples and apples from their own orchard and two only used apples from their own orchards. Four of the respondents purchased whole apples while two of the respondents bought apple juice. The median quantity of apples purchased was 450.0 bushels (Table 7). Growers who used apples from their own orchard reported that these apples represented a median of 45.0% of the fruits used for their cider production. In the sample, we found a strong positive correlation between the quantity of fruit purchased and the number of years in operation

Table 6. Operational life, employee number, production level, and market channel characteristics of Vermont cider makers (respondents $n = 8$).

	Mean	Median	SD
Cidery demographics			
Time in operation (years)	7.9	4.5	8.1
Full-time employees (no.)	25.1	2.0	65.6
Part-time employees (no.)	3.8	2.0	4.5
Cider production in gallons²			
2013 cider production	1,129,575.0	1,350.0	3,180,145.8
2014 anticipated cider production	1,130,150.0	1,350.0	3,179,915.4
Cider market channels (as % of total cider produced)			
Sales to wholesalers	65.7	75.0	41.7
Direct sales to consumers	33.6	20.0	41.9
Other	0.7	0.0	1.9
Location of customers (as % of total cider produced)			
Within county	12.1	5.0	26.6
Vermont, beyond county	36.4	35.0	34.5
New England	30.0	30.0	25.2
United States outside New England	20.8	15.0	20.8
International	0.6	0.0	1.1

²1 gal = 3.7854 L.

Table 7. Mean and median quantity of fruit procured as apple or juice by cideries in 2013.

Apple purchase	Respondents (no.)	Mean	Median	SD
Apple purchased in 2013 (bushels) ^z	4	2,525.0	300.0	4,516.9
Apple juice purchased in 2013 (gal) ^z	2 ^y	300,750.0	300,750.0	423,203.4
Total amount of apple purchased (bushels)	6	41,783.3	450.0	97,172.0
Apples in cider from own orchard (%)	4	47.7	45.0	52.0

^z1 bushel = 40 lb = 18.1437 kg; 1 gal = 3.7854 L.

^yOne respondent reported only purchases of apple juice sourced from Vermont orchards, and not juice sourced from other states or countries.

Table 8. Apple cultivars purchased by cideries in 2013 organized in categories based on marketing or juice characteristics and the number of times it was reported by cider makers.

Dessert cultivars (no. of cideries reporting)	Dual-purpose cultivars (no. of cideries reporting)	Specialty cider cultivars (no. of cideries reporting)
McIntosh (2)	Golden Russet (2)	Kingston Black (2)
Empire (1)	Northern Spy (2)	Reine des Reinettes (2)
Honeycrisp (1)	Ashmead's Kernel (1)	Wild Apples (2)
Jonagold (1)	Calville Blanc (1)	Hewe's Virginia Crab (1)
Mutsu (1)	Cox's Orange Pippin (1)	Mixed bittersweet (1)
Pinova (1)	Hudson's Golden Gem (1)	
	Ida Red (1)	
	Roxbury Russet (1)	
	Esopus Spitzenburg (1)	

($r_s = 0.941$, $P < 0.01$) indicating growth in production over the years.

Twenty-one different apple cultivars were purchased in 2013, and six cultivars (Golden Russet, Kingston Black, McIntosh, Northern Spy, Reine des Reinettes, and wild apples) were purchased by two different cider makers. Additionally, two cider makers purchased 10 cultivars of apple, one cidery purchased four cultivars, and one cidery purchased only one cultivar. Apple cultivars purchased by cider makers include dessert, dual-purpose, and specialty cider cultivars (Table 8) (Merwin, 2008; Proulx and Nichols, 2003; Valois et al., 2006).

Specialty cider apples were the most expensive type of apples (Table 9). The three cider makers that purchased these apples paid an average of \$19.0 per bushel while the lowest price paid for dessert cultivars was \$4.30 per bushel. Dessert fruit were purchased as orchard run (i.e., directly from the field without post-harvest grading) or as culled fruit that were rejected from packing lines postharvest. None of the cider makers reported purchasing dessert fruit that had dropped before harvest.

The geographic origin of apples mattered as 62% of the cider makers responded that it was "very

important" that the apples came from Vermont and 25.0% responded that Vermont sourcing was "important." Additionally, 42.9% responded that it was "very important" that apples came from New England and 42.9% responded that it was "important." None of the cider makers reported entering into formal business agreements with apple orchards. Handshake agreements and repeated purchases were the methods used by four cider makers to secure apples while two cider makers call orchards for availability. The main difficulty faced by cider makers when purchasing apples was limited supply of specialty cider/bittersweet apples. Two cider makers reported not having difficulties and one of these two cider makers grows the apples it uses and while the other has limited needs due to its small size. Cider makers expressed concerns due to projected growth and potential inability to source the apples they need at a price they can pay.

Cider makers listed 27 different cultivars they would prefer to source locally. Kingston Black was the most popular cultivar as it was listed by five cider makers. The next most popular cultivars, which were mentioned by four cider makers were Wickson, Ashmeads Kernel, Dabinett, Esopus

Spitzenberg, and Golden Russet (Table 10). Cider makers expressed interest in a wider variety of specialty cider apples than dessert or dual-purpose cultivars.

When asked about threats and opportunities in the next 5 years, cider makers identified three main threats: low quality cider (71.4%), apple supply (57.1%), and competition (28.6%). Two opportunities identified were the development of new cider products and the improved quality of ciders (75.0%) and growth of the market for cider (37.5%).

Discussion

The goal of this research project was to assess the fruit needs of Vermont cider makers and present cider fruit availability in Vermont orchards, and to identify opportunities and challenges for the growth of both industries. First, we found that Vermont continues to have a robust apple production industry. Growers in this sample report yields follows the averages for the state (USDA, 2014); and most anticipate increased production in the future. Growers in our sample were more likely to sell to local markets than within the state as a whole (USDA, 2014). They see opportunity in the growing popularity of hard cider, while receiving adequate prices is a key threat. Finally, on average, the prices they receive are below their target prices for all types of apple cultivars. Second, the Vermont cider industry is fairly small that is similar to the industry at the national level apart from a few major producers (Petrillo, 2014). Cider makers' operations are also growing, with the majority of the sample anticipating increasing production. These cider makers see opportunity in the growth of the hard cider's popularity and increase in product quality. Adequate fruit supply was identified as a major risk. Cider makers pay an average price above the growers' mean target price

Table 9. Prices paid by cideries to growers for categories of Vermont apples based on marketing or juice characteristics.

Prices paid	Respondents (no.)	Mean (\$/bushel) ^z	Median (\$/bushel)	SD
Specialty cider	3	\$19.00	\$20.00	\$1.70
Dessert (orchard run)	2	\$4.30	\$4.30	\$3.80
Dessert cultivar packing cull ^y	1	\$5.00	\$5.00	–

^z1 bushel = 40 lb = 18.1437 kg; \$1/bushel = \$0.025/lb = \$0.0551/kg.

^yFruit rejected from commercial packing lines for cosmetic blemishes or low fruit color.

Table 10. Apple cultivars favored by cideries to purchase locally for cider production organized into marketing or juice characteristics and the number of times it was reported.

Dessert cultivars (no. of cideries reporting)	Dual-purpose cultivars (no. of cideries reporting)	Specialty cider cultivars (no. of cideries reporting)
Cortland (1)	Ashmeads Kernel (4)	Ashton Bitter (1)
McIntosh (1)	Calville Blanc (1)	Bittersweet (1)
Organic empire (1)	Cox's Orange Pippin (1)	Chisel Jersey (1)
Pinova (1)	Esopus Spitzenberg (4)	Dabinett (4)
	Golden Russet (4)	Ellis Bitter (2)
	Liberty (1)	Foxwhelp (1)
	Lodi (1)	Kingston Black (5)
	Northern Spy (3)	Major (1)
	Roxbury Russet (1)	Orleans Reinette (1)
		Reine des Reinette (1)
		Somerset Redstreak (1)
		Stoke Red (1)
		Wickson (4)
		Yarlington Mill (2)

for specialty cider apples but lower than the growers' target price for dessert apples. This confirms that cider makers prefer specialty cider apples cultivars and their willingness to pay for these apples is higher than their willingness to pay for dessert apple cultivars. Finally, cider makers and apples growers have both expressed interest in dual-purpose cultivars for cider making. Apple growers have expressed limited interest in growing specialty cider cultivars while cider makers have expressed strong interest. Planting new apple cultivars is a long-term investment and commitment that apple growers most likely will not undertake unless they have the assurance that cider makers will buy the apples when the trees start producing. This is particularly acute given the limited sales opportunities for bittersweet cultivars: growers would be at grave risk if cider makers chose not to buy these highly specialized apples. This implies a need and opportunity for partnerships between apple growers and cider makers. Contracts are one method of governing the partnerships. A similar study in Virginia

found that 80% of the cider makers who were surveyed would be willing to enter into long-term financial arrangements to secure specialized apples while 22% of the surveyed growers would plant cider apple trees if they had a contractual arrangement with cider makers insuring fair market prices in the long term (Peck et al., 2012; Versen and Kelley, 2012). Joint ventures, shared investments, and other governance mechanisms can ensure all parties are committed to long-term and mutually beneficial partnerships.

Our results suggest implications for future research. First, there is opportunity for mutually beneficial trade in specialty cider apples. There is unfortunately a mismatch in cider makers' preferred cultivars and current production. We can reference that virtually none of the specialty apple cultivars desired by cider makers were grown in a significant quantity in Vermont according to a recent industry survey (VTFGA, 2011). Increased assurance of future purchases from cider makers, in the form of contracts or even formal partnership

involving shared investment would accelerate the realization of this opportunity. Contracts in the cider industry in France and England have been used for decades and ≈90% of cider apples are grown under contracts (Capper, 2014; La France Agricole, 2011). Contracts vary in length from 18 to 30 years and terms usually include how prices are determined, the cultivar orchards are growing, and the growing and harvest practices (Capper, 2014; Conseil de la Concurrence, 2007). It is common for cider makers to purchase the entire production of an orchard (Smith, 2008). These long-term contracts aim to cover the producing life of orchards and offer financial stability to the growers and ensure cider makers access to the apple cultivars they want in the quantities that they need. These long-term contracts, which usually aim to be mutually beneficial, are thought to encourage improvements in growing practices and waste management (Smith, 2008). Future research to better understand grower and buyer perceptions and behaviors could inform mechanisms to spur contracts and partnerships, which are acceptable and beneficial to both parties. Second, as identified in other studies, research into specific management regimes for cider apples can lower production costs for growers and help them maintain a competitive position in the marketplace (Peck and Miles, 2015). An area of inquiry to reduce labor costs and address the barrier of access to adequate labor in is mechanical harvesting. Most of the cider apples are mechanically harvested in Europe. A team of researchers in the Washington State has worked on retrofitting a raspberry harvester to harvest apples (Miles and King, 2014). Finally, though not addressed in this study, the role of nurseries is important to consider as they need to be able to provide these apple cultivars and

present supplies are substantially shorter than demand (Fruit Growers News, 2015b).

Conclusions

This study compares current and prospective production and sales of apples in Vermont with cider makers' demand for apples. We find a number of potentially beneficial opportunities, particularly in increased production of dual-purpose and specialty cider cultivars, as long as price and coordination issues can be resolved. As Vermont cider makers increase their production, the potential for "exporting" on a regional and national scale should generate economic activity and support significant orchard acreage, jobs, investment, and possibly impact the Vermont brand image while supporting entrepreneurial activity via tasting rooms and smaller specialty cider makers that market more to retail and in-state customers.

The major limitation of our study is a nonrepresentative sample. Even though the response rates from apple growers and cider makers can be considered high, the actual number of responses was small. Another limitation is the lack of peer-reviewed articles on this relatively new topic; hence, some of our baselines and assumptions are the educated opinions of industry stakeholders rather than published research. Nevertheless, our study begins to explore a fairly new industry in a state that has seen a growth in terms of the number of cider makers' operations and that is home to one of the largest cider producers in the United States. Associated to the relative young age of the industry, many questions need to be explored and answered. This includes the type of apple cultivars with desired characteristics for the cider industry and that can be grown in Vermont. In addition, regulatory changes in response to implementation of the Food Safety Modernization Act may affect cider apple supply because fruit for cider making are exempt from the law, and thus an increased supply of cider fruit may become available as growers adapt to the new regulations (U.S. Food and Drug Administration, 2011). Consequently, researchers will need to pay particular attention to the costs associated with growing these new

cultivars to ensure economic viability of both the apple growers and the cider makers.

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