Mechanical Harvest of Cider Apples

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Cider, also referred to as 'hard cider,' is fermented apple juice and is the fastest growing segment of the liquor industry in the U.S. today with sales increasing 54% each year from 2007 through 2012. In this two-year study (2011 and 2012) we compared a mechanical over-the-row small fruit harvester to hand harvest for cider variety 'Brown Snout' grown on a tall spindle system. We measured weight of picked fruit, time to pick fruit, tree damage, and quality of juice pressed from fresh and stored fruit.

Methods

An experimental cider apple orchard was established at Washington State University Northwestern Washington Research and Extension Center at Mount Vernon in 2002 specifically to test an over-the-row small fruit harvester. 'Brown Snout' was planted at 4 feet in-row and 16 feet between-row spacing. The experimental design was a randomized complete block split plot. The main plot was rootstock, M27 and EMLA9, and the subplot was harvest method, hand and machine; there were 9 trees per subplot.

Trees were trained to a wire trellis system with post height of 6.5 feet. The harvester was an over-the-row raspberry harvester Littau Model OR0012, Lyndon, WA. Prior to harvest, groundfalls were removed from all plots. Fruit was harvested from hand-pick plots then from mechanically-picked plots. Fruit remaining on trees as well as fruit knocked to the ground were then retrieved in mechanically-picked plots. Harvest efficiency was calculated by comparing weight of fruit picked in hand and mechanically-harvested plots. After harvest, the number of damaged spurs and limbs were counted for four trees in each plot.

After harvest, two boxes in 2011 and three boxes in 2012 were randomly selected from each plot. Each year, one box was pressed immediately after harvest and the other boxes were pressed after 3 weeks in cold (32^{o}F) storage in 2011 and 2 and 4 weeks cold storage in 2012. Prior to pressing, fruit damage was assessed by selecting 100 fruit at random from each box and recording the number of fruit bruised, cut, and split (half). Each year, fruit was milled and pressed in a basket cider press (Standard Correll Large, Veneta, OR).

From each plot, 500 ml of juice was collected and analyzed for ^{o}Brix, pH, specific gravity, malic acid and % tannins. Brix was measured by placing 2-3 drops of the juice sample onto a digital refractometer. Juice pH was measured for each sample using a digital pH meter. Specific gravity was measured with a hydrometer. Total acidity was measured by titrating with sodium hydroxide (NaOH) to a reading of 8.1, recording the volume (ml) of sodium hydroxide added, and calculating malic acid was using the equation: Malic acid ($g \cdot l^{-1}$) = ml NaOH x 0.536. Percent tannins were measured using the Lowenthal titration method. For each sample, 1 ml of juice was added to 150 ml distilled water mixed with 5 ml of indigo carmine solution and titrated with a solution of 0.005 M potassium permanganate ($KMnO_4$) just until it turned yellow.

Results

There were no significant differences due to rootstock and data was pooled each year. On average over two years, the weight of fruit picked by machine was 70% (harvest only) and 87% (harvest plus fruit remaining on trees and fallen on ground) that of hand harvest. On average for the two years, total labor was 23 hours for hand harvest and 5 hours for mechanical harvest. Hand harvest labor was 3 times greater in 2011 than in 2012, due to heavier fruit set in 2011. Mechanical harvest labor was the same both years as the same number of people (3) were required to operate the harvester. Cost per acre for labor was 4 times greater for hand harvest ($383) than for machine harvest ($92).

Mechanical harvest resulted in two times the number of damaged spurs and broken limbs than hand harvest, however, these differences were not significant.All fruit were bruised for hand and mechanical harvest, and mechanical harvest resulted in 10% cut fruit and 4% fruit cut in half on average. There were no differences due to harvest method in ^{o}Brix, pH, specific gravity, malic acid (g/l), or tannins (%) of fruit crushed and pressed immediately after harvest. When fruit was stored for 3 weeks (2011) and 2 and 4 weeks (2012), ^{o}Brix and specific gravity increased with storage.

Juice Quality of Cider Apples

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Juice characteristics (% tannin, °Brix, pH and malic acid) were analyzed for 74 cider apple varieties (13 American, 31 English, 27 French and 2 German) grown at Washington State University Mount Vernon Northwestern Washington Research and Extension Center (WSU NWREC) from 2002 to 2013. Juice was analyzed using standard analytical methods practiced in cider making (Lea, 2008; Mitchell 2005).

Apples are classified into 4 categories based on the Long Ashton Research Station (LARS) system developed in Bristol, England in 1903 and published by the Cider Advisory Committee in1956 (Table 1). We will compare juice analysis at WSU NWREC to juice analysis recorded at LARS. If results are similar, growers may be able to use the LARS juice analysis data base to select varieties for cider production. If results differ, growers may need to test cider apples grown at each location.

Methods

At harvest, 15-25 ripe fruit were randomly collected for each variety, and stored up to 1 week in cold storage at 32°F (0°C). From 2002 to 2012, fruit were milled and pressed in a basket cider press (Standard Correll Large, Veneta, OR); in 2013 the fruit samples were chopped in a shredder (Zambelli Enotech, Camisano Vicentino, Italy) and pressed in a bladder press (Enotechnica Pillan, Camisano Vicentino, Italy), a more efficient processing method. Juice samples were collected in 500 ml plastic bottles and frozen (5°F; -15°C) until harvest of all varieties was completed. Juice samples were thawed to 60°F (15.6°C) and analyzed for tannins (%), °Brix, pH, and malic acid ($g \cdot L^{-1}$).

Tannins were measured using the Lowenthal method of permanganate titration, the standard procedure used at LARS (Lea, 2008). Total tannin (%) was calculated by the formula: $T = (X-Y)/10$ where X is the amount of indigo carmine solution used to titrate the juice sample and Y is the amount of indigo carmine solution used to titrate a blank sample. Brix was measured by placing 2-3 drops of the undiluted juice sample onto a digital refractometer. Juice pH was measured for each sample (undiluted) using a digital pH meter. Total acidity was measured by placing 25 ml of juice sample and 100 ml distilled water in a 250 ml beaker, stirring with a magnetic stir bar, and titrating with 0.2 M solution of sodium hydroxide (NaOH) to reach 8.1 pH. The volume (ml) of sodium hydroxide added was recorded and malic acid was calculated using the equation: Malic acid ($g \cdot l^{-1}$) = ml NaOH x 0.536.

Results

Cider apple variety classification based on juice analysis at WSU Mount Vernon NWREC from 2003 to 2012 is presented in Table 2. Also included is the country of origin of each variety. Juice analysis from 2003 through 2012 is presented on-line at http://extension.wsu.edu/maritimefruit/Documents/CiderJuiceProtocol2013.pdf. Juice analysis varied slightly each year for each variety, and it is necessary to analyze juice each year for cider making.

Table 1. Cider variety classifications defined by the Long Ashton Research Station, Bristol, U.K.

Type	Tannin (%)	Acid (%)
Sharp	< 0.2 Low tannin	> 0.45 High acid
Bittersharp	> 0.2 High tannin	> 0.45 High acid
Bittersweet	> 0.2 High tannin	< 0.45 Low acid
Sweet	< 0.2 Low tannin	< 0.45 Low acid

Table 2. Cider varieties at WSU Mount Vernon NWREC, their origin[1], and type classification based on mean data from juice analysis 2003-2012.

Sharp	Bittersharp	Bittersweet	Sweet
Bramley's Seedling-E	Breakwell Seedling-E	Amere de Berthcourt-F	American Forestier-F
Brown's Apple-E	Cap of Liberty-E	Bedan de Parts-F	Bouteville-F
Court Pendu Plat-F	Foxwhelp-E	Blanc Mollet-F	Brown Thorn-F/E
Court Pendu Rose-F	Hewes VA Crab-A	Bramtot-E	Crow Egg-A
Finkenwerder H'prinz-G	Kingston Black-E	Brown Snout-E	Granniwinkle-A
Golden Russet-A	Lambrooke Pippin-E	Bulmer's Norman –F/E	Peau de Vache-F
Grimes Golden-A	Reine des Hatives-F	Campfield-A	Smith's Cider-A
Grindstone-A	Stoke Red-E	Chisel Jersey-E	Sweet Alford-E
Harrison-A		Cimitiere-F	Sweet Coppin-E
Maude-E		Coat Jersey-E	Taylor's-E
Redstreak-E		Dabinett-F/E	Track Zero-A
Ribston Pippin-E		Domaines-F	
Roxbury Russet-A		Doux Normandie-F	
Skyrme's Kernel-E		Dymock Red-E	
Taliaferro-A		Frequin Audievre-F	
Tom Putt-E		Frequin Rouge-F	
Whidbey-A		Frequin Tardif-F	
Zabergau Reinette-G		Harry Masters' Jersey-E	
		Jouveaux-F	
		Kermerrien-F	**Bittersweet (continued)**
		Major-E	Nehou-F
		Marie Menard-F	Red Jersey-E
		Marin Oufroy-F	Reine des Pommes-F
		Medaille D'Or-F	Ross Nonpariel E
		Mettais-F	Royal Jersey-E
		Michelin-F	Stembridge Jersey-E
		Muscadet de Dieppe-F	Vilberie-F
		Muscat de Bernay-F	Yarlington Mill-E

[1] A= America; E=England; F=France; G=Germany.

Characteristics of Varietal Ciders

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Varietal ciders produced at WSU Mount Vernon NWREC in 2011 and 2012 were described by trained cider evaluators using objective sensory evaluation methods (Mitchell, 2006). A primary goal of this study is to assist cider makers in selecting varieties for cider production. A secondary goal is to establish an evaluation protocol and a panel of trained cider experts to characterize cider prior to final production and marketing to help establish high quality cider production.

Methods

In 2011, 8 cider apple varieties were harvested and selected for bottling and 4 varieties were selected in 2012. Each year, juice samples were collected at time of pressing, frozen until January, then analyzed for °Brix, pH, specific gravity, malic acid, and % tannins. Cider was fermented immediately after pressing using a standard protocol (http://extension.wsu.edu/maritimefruit/Documents/CiderFermentationProtocol2013.pdf), and bottling was done from February to May 2012 and May to June 2013. Ciders were evaluated May 2012, January 2013 and September 2013. In 2012, 3 sessions included a total of 19 panelists (Port Townsend, WA, 5 evaluators; Wenatchee, WA, 7 evaluators; Salem, OR, 7 evaluators). In 2013, 1 session was held at Wenatchee with a total of 4 panelists evaluating 4 ciders.

Results

Results of juice analysis are presented in Table 1, while results of the panel evaluations are presented on-line at http://extension.wsu.edu/maritimefruit/Documents/CiderCharacteristics2013.pdf. For juice analysis and panel evaluation of 24 other cider and dessert apples evaluated 2003-2010, see WSU Extension publication PNW621 *Hard Cider Production & Orchard Management in the Pacific Northwest* (https://pubs.wsu.edu/).

Table 1. Juice analysis of selected cider apples harvested and pressed at WSU Mount Vernon NWREC in 2011 and 2012.

Cv.	Date Tested	Brix	pH	Specific Gravity	Malic Acid g/liter	Tannin %
Blanc Mollet	11/16/11	11.5	4.19	1.048	1.50	0.22
Chisel Jersey	11/16/11	13.0	4.04	1.052	2.25	0.32
Golden Russet	11/16/11	14.1	3.41	1.060	5.15	0.10
Harrison	11/16/11	13.7	3.38	1.057	5.63	0.13
Hewes Virginia Crab	11/16/11	15.0	3.13	1.062	7.84	0.29
Major	11/16/11	13.0	4.13	1.052	1.77	0.23
Mettais	11/16/11	12.9	4.32	1.052	1.93	0.26
Zabergau Reinette	11/16/11	13.6	3.45	1.056	5.09	0.12
Granniwinkle	1/24/13	10.6	3.62	1.043	3.40	0.07
M 9 rootstock	1/17/13	8.0	4.17	1.032	1.20	0.17
M27 rootstock	2/6/13	11.9	3.89	1.046	2.30	0.27
Steib NZ Concentrate	11/22/13	14.3	3.62	1.058	5.95	0.08
Highest (of all cvs. tested)		***16.5***	***4.56***	***1.069***	***10.18***	***0.32***
Lowest (of all cvs. tested)		***8.0***	***2.79***	***1.032***	***1.07***	***0.05***