

Final Technical Report

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## Goals and Objectives

The hard cider industry in Michigan and throughout the United States has been growing rapidly, and now represents a significant portion of the craft beverage sector. The highest quality hard ciders are made from specialized varieties of apple called cider apples. These differ from common, culinary apples by containing very high levels of sugars, acids, and/or phenolics (tannins). Currently, in Michigan and elsewhere throughout the U.S., cider apples are in short supply, because many of the traditional, famous cultivars, originally sourced from Great Britain and western Europe, do not grow and produce well under Michigan conditions. Michigan cider producers need reliable and quality sources of apples, and growers who want to initiate or expand cider apple operations need reliable information about which existing cultivars will be most profitable. In addition, the Michigan industry badly needs new cultivars with traits optimized for our climate, including resistance to fire blight and other common diseases, late bloom that escapes spring frosts, rapid maturity, and retention of ripened fruit. Finally, as hard cider becomes firmly established in the U.S., consumers are demanding more diversity in taste and style. Red ciders are becoming very popular, and novel, red-juiced apple cultivars present an attractive opportunity for Michigan growers and producers. We have launched a large variety trial of cider apples and have begun to collect production and fruit quality trait data from these varieties. We have also identified two cultivars of red-juiced apples that make excellent red ciders, and have initiated a small breeding project, called Michigan PureRed, to develop improved, red-juiced cider apples.

The goals of this anticipated three-year project were to continue data collection from the cider variety trial, make existing data available for Michigan apple growers to assist in variety selection, continue development of red-juiced cultivars, and initiate a small breeding program for new and improved cider apple cultivars, through the following specific objectives:

1) Collect data on production, disease resistance and fruit/juice characteristics for apple cultivars with potential for hard cider production in Michigan. This step exploits the previously developed MSU GLCAC, and the USDA Apple Cultivar Collection located in Geneva, NY. The existing MSU Cider Apple Trait Database ([ciderapples.msu.edu](http://ciderapples.msu.edu)) was to be further developed as a tool to provide growers with information about cider apple cultivars and planting recommendations.

2) Continue development of red-juiced apple cultivars for hard cider use. With MCBC support, we sought to continue our ongoing Michigan PureRed project to develop deeply red-juiced cultivars with high production and good disease resistance. This project has already produced 'Black Diamond', with egg-sized fruit containing anthocyanin levels approaching that of blueberry. This cultivar was to be propagated for regional trials.

3) Implement a small breeding program for Michigan-optimized cider apples. We proposed to immediately start developing cultivars that produce fruit with high levels of acids, and/or high levels of phenolics. Few such cultivars exist, and ready availability of improved cultivars could quickly expand the cider industry.

### **Results, Conclusions and Outcomes**

Regarding the evaluation work, we first evaluated 66 cider apple cultivars from MSU for growth and production, and disease traits, and biochemically analyzed juice from 50 of these. We evaluated an additional 144 cultivars from the USDA Malus germplasm collection in Geneva, NY and analyzed juice from 61 of these. Evaluations were done in the field and in the laboratory at MSU East Lansing (see data table at end of report). Collaborator Chris Gottschalk performed the biochemical analyses of the juice at the USDA lab in Kearneysville, WV.

Based only on production characteristics, we have already identified numerous cultivars that are likely to be unsuitable for Michigan. One is apparently extremely susceptible to fire blight and/or winter injury, while several others show fire blight sensitivity to some degree. At least 18 additional cultivars have shown premature fruit drop and will not be useful for Michigan growers. Finally, five cultivars bloomed relatively early, prior to the typical date of last frost, and are thus unsuitable for Michigan production. In contrast, we have tentatively identified some cultivars that could be suitable for hard cider production in Michigan, although this requires additional data.

In an ongoing collaboration with Left Foot Charley winery in Traverse City, we provided over 2,000 lbs. of red-juiced apples for industrial trials of hard cider production. This was made into a commercial product that is now available for purchase ([https://shopcidere.com/left\\_foot\\_charley/otterson\\_apple\\_cider\\_42871](https://shopcidere.com/left_foot_charley/otterson_apple_cider_42871)).

In the evaluation of existing, red-juiced cultivars, we identified three additional large-fruited selections with dark red juice, strong phenolics content and excellent disease resistance. These were propagated in 2021 for further evaluations but based on preliminary observations are likely to be competitive or outperform the existing elite cultivars Otterson and Robert's Crab.

We also invested in future cultivar development efforts through the initiation of pre-breeding lines. In spring of 2022, we carried out numerous new crosses between elite red-juiced cultivars and eight standard cultivars: Rosalee, McIntosh, Gala, Golden Delicious, Honeycrisp, Fuji, Empire, and Pink Lady, and all were successful. The fruit will be harvested shortly and seeds recovered. Selected progeny of these crosses will serve as parents for generation of elite varieties.

This is the first year of production for a new cultivar that we generated, tentatively called 'Strawberry Punch', which has the strong production and disease resistance characteristics of 'Gala' but contains high acids. There are three additional selections with good phenolics content and we have propagated these. If these perform well in the next 3-4 years, MSU will seek plant patents.

We are now maintaining open-pollinated progeny of ten cultivars with good potential for Michigan cider production: 'Cap of Liberty', 'Court Royal', 'Dabinett', 'Muscadet de Dieppe', 'Stembridge Cluster', 'Stoke Red', 'Sweet Alford', 'Virginia Crab', 'Wickson', 'Wickson Crab'. These will also serve as pre-breeding lines for further cultivar development work.

We have not yet finished populating this data into the project website [ciderapples.msu.edu](http://ciderapples.msu.edu), because the site platform maintained by MSU was changed and the original intended features are no longer supported. We intend to maintain efforts to refine the site and upload this data from the 2021 season, as well as the data from the current (2022) season.

### Time Span

Grant period, 1/21/2021-8/1/2022; project activities carried out 4/20/21-8/1/22.

### Work Accomplished/ Methods

The following protocols were used in the cultivar evaluations:

- **Bloom time** - bloom was recorded weekly spanning the period of natural bloom, from late April to mid-May
- **Disease including fruit defects** - foliage, whole plant and fruit afflictions were noted through observations every 2-3 weeks in the field. Damage was photographed for identification by plant pathology experts.
- **Subjective fruit maturity (SFM)** This was done during the period of natural ripening, from late July through the end of October. Softening, starch, sugar, acids, phenolics, flavor were assessed, on three fruit from separate trees. Use previous data as guide.
- **% drop at SFM** - The total fruit number per tree both on tree and on the ground was estimated for each tree.
- **Yield** - was derived from averaged fruit weight and fruit number/tree.
- **Fruit weight** - was averaged from 5 fruit from each of 5 trees.
- **Juice yield** - was determined as extracted juice volume from 250 g fruit tissues.
- **Juice biochemistry** - including soluble solids, acid (TA, pH), and tannin content was determined using analytical techniques.
- **Storability** - was assessed from 6-12 fruit after 60 d cold storage.
- **Stem girth and crown spread** - was assessed at the end of the season.

Standard techniques were used for crossing and seedling/plant growth. Seeds were subjected to 8 weeks of stratification, then grown to a height of ~ 1.5 m in a controlled environment room. Plants will be placed in the cold for 8 weeks to induce dormancy, and then propagated in winter through grafting.

### Communication Activities, Accomplishments and Impacts

Some results of the project were communicated to apple growers and cider producers at the 2021 Great Lakes Fruit, Vegetable and Farm Market Expo in Grand Rapids, December 2021. Technical data related to the evaluations are available through the project website, [ciderapples.msu.edu](http://ciderapples.msu.edu). The project was highlighted through popular press in Michigan (several news outlets) in 2021, e.g. "MSU professor changing cider's taste, breeding Red-Fleshed Apples for juice", [WZZM213.com](http://WZZM213.com) Grand Rapids, March 5 2021; "Red-fleshed apples could keep Michigan cider makers in the black", Great Lakes

Echo, March 30 2021; "An MSU researcher wants to get red-fleshed apples to grow in Michigan", Lansing State Journal, Feb 24 2021.

### **Budget Narrative**

This project was conducted consistent with the budget proposed by the principle investigator and approved by the State of Michigan. No matching funds or additional sources of funding were sought nor contributed to the work described herein.



Red-juiced selections under trial at the MSU-Clarksville Research Station

**Table.** Results of juice biochemistry analyses for 2021 for 108 representatives of 86 cultivars.

	<b>Brix</b>	<b>Malic</b>	<b>Tannin</b>
Amere de Berthecourt_GEN_M7-11-65	17.0	1.8	1900
Annie Elizabeth_GEN_E7-10-7	10.7	5.0	571
Arkansas Black_CRC_11-5	14.1	5.5	547
Ashmead's Kernel_CRC_10-3	14.2	10.8	715
Belle Sans Pepin_GEN_M7-8-13	12.6	3.4	444
Ben Davis_GEN_E7-3-87	14.1	4.2	552
Bisbee Giant Winesap_GEN_M7-17-95	12.6	2.2	538
Blanquina_GEN_E7-18-67	14.4	5.3	801
Blenheim Orange_GEN_M7-4-71	15.3	6.2	363
Brown's Apple_CRC_06-3	11.7	10.1	777
Bulmer's Norman_CRC_09-3	12.1	2.6	1535
Calville Blanc_GEN_B9-1-8	12.9	5.6	747
Calville Blanc_GEN_E7-3-3	12.7	5.1	692
Cap of Liberty_CRC_06-6	13.1	2.9	1286
Chestnut Crab_CRC_02-4	15.9	7.6	733
Chestnut Crab_CRC_04-4	18.1	8.7	760
Chestnut Crab_GEN_M7-2-51	14.0	4.3	258
Cidergold_PA	14.4	5.0	2120
Cimitiere_CRC_07-5	14.0	1.9	1757
Cortland_GEN_B9-1-11	12.3	3.9	241
Cortland_GEN_M7-4-105	16.0	3.3	312
Court Royal_GEN_M7-2-31	13.4	1.7	601
Cox's Orange Pippin_CRC_07-4	15.7	8.2	500
Cox's Orange Pippin_GEN_M7-4-53	14.9	6.7	359
Cranberry Row 22_CRC_Row22	15.1	13.1	1615
Dabinett_CRC_07-6	14.2	1.7	1728
Doux Normandie_CRC_12-2	11.6	2.8	1684
Dunkerton Late Sweet_CRC_10-4	17.3	2.0	445
Esopus Spitzenburg_CRC_09-5	16.3	6.9	540
Fall Russet_GEN_M7-27-59	10.8	4.8	431
Fillbarrel_CRC_09-4	17.4	3.7	2446
Fillbarrel_GEN_M7-2-25	18.3	3.4	2697
Frequin Tardive de la Sarthe_GEN_M7-16-49	13.4	2.7	517
Golden Harvey_GEN_M7-16-85	16.4	8.4	355
Goldrush_CRC_12-5	15.2	7.2	338
Gravenstein Washington Red_GEN_B9-1-36	12.9	4.9	361
Gravenstein Washington Red_GEN_M7-3-49	12.0	4.6	280
Gravenstein_CRC_03-4	12.6	8.0	784
Grimes Golden_GEN_M7-3-91	15.8	7.9	154
Haralson_CRC_11-1	16.3	5.4	922
Honey Gold_CRC_04-5	11.8	3.5	359
Honeygold_GEN_M7-4-77	13.4	3.2	116
Hyslop Crab_CRC_09-1	17.3	5.1	2287
Ingram_GEN_M7-11-81	12.9	1.6	432
Jonagold_GEN_E7-2-29	15.5	4.3	295
Jonagold_GEN_E7-2-87	16.9	4.0	243
Jonagold_GEN_M7-29-81	13.7	3.7	234
King of the Pippens_CRC_08-3	15.7	7.3	911
Le Bret_CRC_10-5	17.2	1.7	647
Le Bret_GEN_M7-18-15	16.2	1.6	512
Liberty_GEN_B9-1-52	13.1	4.0	269
Liberty_GEN_M7-3-1	14.3	3.8	291
Marin Onfroy_CRC_07-1	15.8	3.4	1977

McClintock Grimes_GEN_E7-9-11	14.7	4.2	396
Mettais_GEN_M7-32-89	14.0	1.2	1612
Michelin_CRC_06-4	16.0	16.0	1865
Middleton Fameuse_GEN_M7-5-37	10.5	3.7	193
Mollie's Delicious_GEN_M7-10-61	11.8	1.7	345
Monroe_GEN_B9-3-11	12.4	2.7	87
Monroe_GEN_M7-5-21	15.2	4.8	289
Muscadet de Dieppe_CRC_06-2	14.3	2.3	1387
Muscadet de Dieppe_GEN_M7-2-65	15.5	1.6	1203
Nehou_GEN_M7-21-85	13.8	2.1	786
Otterson (Left Foot Charley shipment)_CRC_LFC	10.8	8.2	1531
Otterson_CRC_11-2	13.0	8.3	2036
Otterson_GEN_M7-26-57	12.3	5.9	1085
Paragon_CRC_02-5	14.6	5.1	828
Paragon_GEN_M7-25-35	15.2	5.2	551
Perico_GEN_E7-18-79	12.5	4.4	720
Rambo-Red Summer_GEN_B9-3-39	11.5	3.2	285
Rambo-Red Summer_GEN_M7-4-49	12.0	4.2	220
Reine de Pommes_CRC_11-3	17.2	3.1	2642
Rhode Island Greening_CRC_12-1	15.5	10.7	1069
Ribston_GEN_E7-5-57	13.7	7.4	422
Robert's Crab_CRC_06-5	11.5	8.1	1707
Rosemary Russet_GEN_B9-3-56	14.8	14.5	533
Roxbury Russet_CRC_01-2	16.7	7.2	881
Roxbury Russet_CRC_09-6	16.4	6.7	604
Saint Martin_GEN_M7-9-67	15.4	2.2	729
Sergeant Russet Golden Delicious_GEN_E7-5-77	15.6	5.5	347
Smokehouse_GEN_M7-5-93	11.8	3.6	172
Snow_GEN_M7-5-89	12.0	3.0	151
Solarina_GEN_M7-36-97	10.3	2.4	1216
Spartan_CRC_03-5	12.8	5.0	809
Spartan_GEN_M7-4-51	12.2	3.0	282
Splendor(Stark)_GEN_M7-8-111	11.8	2.5	557
Stembridge Cluster_CRC_08-5	13.7	6.5	1000
Stoke Red_CRC_08-6	15.7	8.8	2526
Sweet Alford_CRC_06-1	15.6	2.2	1016
Sweet Coppin_CRC_08-4	14.2	3.5	970
Tardive Forestier_CRC_07-3	14.8	3.2	2813
Turley_GEN_M7-17-31	12.6	4.2	403
Virginia Crab_CRC_05-1	17.5	7.9	2529
Virginia Crab_GEN_M7-3-35	16.5	5.3	1345
Virginiagold_CRC_13-1	14.1	7.0	307
Virginiagold_GEN_B9-3-63	9.7	2.3	297
Virginiagold_GEN_E7-7-79	10.9	5.9	144
Wagener_GEN_E7-4-89	11.1	5.1	102
Wealthy Double Red PC-310_GEN_M7-3-23	13.2	4.5	316
Wickson Crab_CRC_09-2	15.4	8.5	69
Wickson_GEN_M7-25-33	14.3	12.8	123
Winesap_GEN_M7-3-109	11.7	3.3	387
Winter Banana_CRC_02-3	13.5	4.3	893
Xuanina_GEN_E7-21-61	11.6	5.6	609
Yellow Bellflower_CRC_11-6	15.1	6.6	761
Yellow Bellflower_GEN_E7-3-103	12.2	3.7	339
Yellow Newtown_GEN_M7-3-107	12.7	3.9	204