# Michigan *PureRed* - Red-Juiced Apple Cultivars for Hard Cider Production

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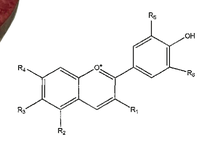
Michigan State HORTICULTURAL Society

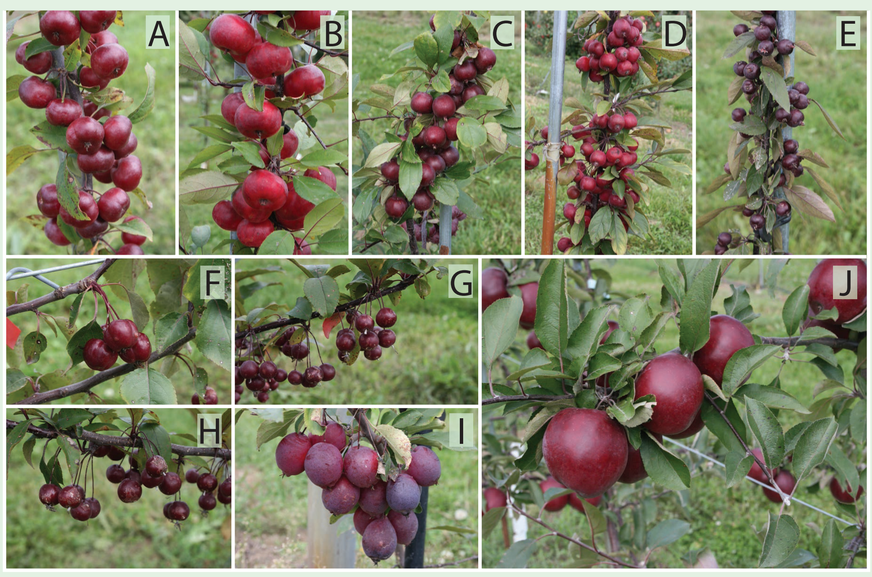


Hard cider is a rapidly growing sector of the Michigan adult beverage industry. Some non-commercial apple cultivars produce red juice, and our preliminary work has shown that several of these can produce excellent cider and that consumers are likely to be attracted to these. However, none of these cultivars is perfectly suited to Michigan growing conditions. The goals of this project are the identification and characterization of existing red-juiced cultivars optimal for Michigan production, marker-assisted selection for improved cultivars, and genetic studies to identify loci contributing to intense juice color that may be useful in future targeted breeding strategies.

**For most apples, beauty is only skin deep**. However, rare apple varieties produce red pigments - called anthocyanins - in the fruit flesh as well as the skin. These apples produce red juice, which can be commercialized as novel hard ciders. Additional applications include juice products, natural colorants, and neutraceuticals.

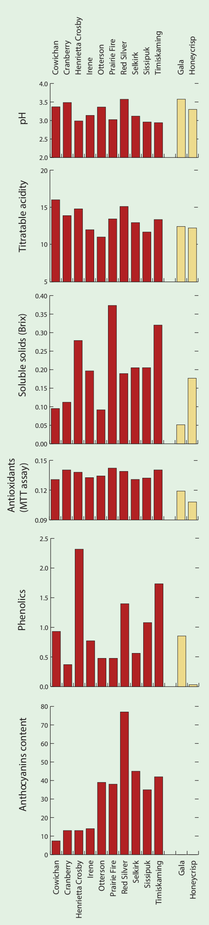
## Identification and characterization of existing red-juiced cultivars optimal for Michigan production

In 2011-2013, we assessed apple cultivar collections in the U.S., Canada, England, and China for red-juiced individuals, and identified over 100. We selected a subset of ten based on potential vigor, intensity of juice color, resistance to disease, and fruit size, and propagated these at the MSU Clarksville research station. Based on their growth and production over the period 2013-2016, we selected three varieties, 'Irene', 'Otterson', and 'Cranberry' for further trials including commercial hard cider making. 'Otterson' has already been used in commerical hard ciders, with excellent results.




**Existing red-juiced apple cultivars identified as having good potential for Michigan production, and propagated at the MSU-Clarksville research station.** A, 'Red Silver'; B, 'Irene'; C, 'Henrietta Crosby'; D, 'Timiskaming'; E, 'Cowichan'; F, 'Selkirk'; G, 'Sissipuk'; H, 'Prairie Fire'; I, 'Cranberry'; J, 'Otterson'. Trees were maintained under minimal-input conditions.

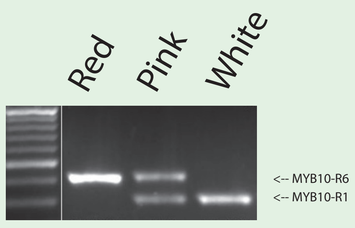
**Evaluation of juice qualities for existing red-juiced apple cultivars propagated at the MSU-Clarksville research station.** Analyses included pH and titratable acidity, soluble solids, antioxidant capacity, phenolic content, and anthocyanin (pigment) levels.




**Assessment of red-juiced cultivar 'Otterson' for hard cider production.** The first large production of 'Otterson' fruit from the MSU-Clarksville site was in 2016. This cultivar is vigorous, disease-free and produces abundant tennis-ball sized fruit. Fruit produces bright red juice with good color stability over time. In 2016 and 2017 this was commercialized in products from Short's Brewing and Left Foot Charlie. Ciders made from juice of our apples has already won gold, silver, and bronze medals at the Great Lakes International Cider & Perry Competition (researcher and cidermaker, Chris Gottschalk).

## Marker-assisted selection for improved cultivars

Researchers in New Zealand analyzed a red-juiced cultivar, 'Redfield', and found that the trait was caused by a genetic allele called MYB10-R6. We found that this allele is pervasive among red-juiced cultivars, and that it acts in a semidominant manner. Based on this information, we designed a molecular marker for the MYB10-R6 allele. This marker can be used to predict the presence of this allele, and thus to predict juice color, even in seedlings. We crossed red-juiced cultivars to create six populations to produce selections with potentially better production, deeper red juice color, better taste, and improved postharvest qualities. The total of 17 populations is now being evaluated at the MSU-Clarksville site.




**Simple marker-assisted selection.** Seedlings from populations segregating for the MYB10-R6 allele are analyzed by polymerase chain reaction (PCR) and gel electrophoresis. Presence of the MYB10-R6 allele in the seedling is evident from a slightly larger PCR product. If the seedling contains the normal MYB10-R1 allele, the PCR product is smaller. Seedlings that are heterozygous produce both PCR products.

### Populations generated

Ruby Jon x Cranberry
Northern Spy x Kaz (USDA selection)
Northern Spy x Irene
Cranberry x Otterson
Otterson x Cranberry
Cranberry x Dolgo
Robert's Crab x (OP)
Red Silver (OP)
Irene (OP)
Henrietta Crosby (OP)
Timiskaming (OP)
Cowichan (OP)
Selkirk (OP)
Sissipuk (OP)
Prairie Fire (OP)
Cranberry (OP)
Otterson (OP)

## Genetic studies to identify loci intensifying juice color

We found that apple genotypes isogenic for MYB10-R6 exhibit a wide range of juice color, from light pink to dark red. This hints at the presence of an important genetic enhancer that we refer to as ENH-MYB10-R6. This enhancer could be a single loci, or many loci with small effects. We also identified a single apple variety, 'Pink Pearl', that does not contain the MYB10-R6 allele, yet still has red juice. This suggests that genes other than MYB10 might make an important contribution to juice color. In further work, we generated isogenic populations segregating for ENH-MYB10-R6, and we will map and identify this genetic loci. We also are investigating the genetic nature of red juice in 'Pink Pearl', with the hopes of combining this locus with MYB10-R6 to further further enhance juice color.

Our long-term goal is to provide Michigan growers with reliable, profitable, and veratile red-juiced varieties for hard cider and other commercial uses.

**Development goals:**

- -Minimal input/maintenance
- -Suitable for organic production
- -High-density production
- -Harvested mechanically
- -High anthocyanin content
- -Innate resistance to common disease
- -Excellent storage/processing traits