



Viticulture, enology and marketing for cold-hardy grapes



Frontenac and Marquette Berry Skin and Pulp Characterization During Ripening

Northern Plains Biostress Laboratory
Brookings, SD 57007

Anne Fennell
South Dakota State University

Background and Rationale: The cold climate cultivars Frontenac and Marquette are complex hybrids that combine characters of the European wine grape (*V. vinifera*) and North American *Vitis* species. The ripening process and chemical and molecular character of many of the European cultivars are well described; however, these characteristics are not well described for the emerging cold climate cultivars. The objective of this study was to characterize the berry ripening processes in Frontenac and Marquette at the gene and chemical level, providing baseline information that may be used in combination with traditional Brix, pH and TA measures for identifying biomarkers for signature varietal characters and optimal ripeness.

Treatments:

- Frontenac and Marquette berries sampled at veraison, 20, 22, 24 °Brix.
- Wine made from 22, 24 °Brix.
- Frontenac, Marquette, La Crescent and St. Croix berries sampled for volatiles from veraison to harvest at weekly intervals.

Methods:

- Frontenac and Marquette berry skin and pulp gene expression (transcriptome), chemical profile (metabolome) and flavor and aroma (sensory) analyses. In 2012 and 2013 berries were collected from NE1020 replicated trial at 5 time points from veraison to harvest. Four replicates were collected at each time point and pH, Brix, TA and seed maturation observed. RNA was extracted from all samples.
 - Transcriptome analysis was conducted using RNA sequencing (RNASeq) and comparisons on skin and pulp and cultivars conducted to identify differentially expressed genes to provide skin and pulp characters.
 - Wine was made using UMN standard protocol at Prairieberry Winery, Hill City, SD.
 - Skin and pulp samples were provided to UMN for metabolite analysis (Hegeman lab). Whole berries were provided for sensory analysis (Vickers lab).
- Four replicates of single berry volatiles were collected at 5 time points for Frontenac, Marquette, La Crescent and St. Croix in SD. Volatiles and berries were transferred to Somchai Rice at Iowa State University for analysis.

Results:

- Berry development was monitored from veraison to harvest for pH, Brix and TA as well as seed maturity. Frontenac seed maturity was about 7 days slower than Marquette in both 2012 and 2013 (Fig 1) and harvest.
- Wines were made at two time points 22 and 24 Brix in 2013 and will be transferred to UMN for berry and wine sensory analysis.

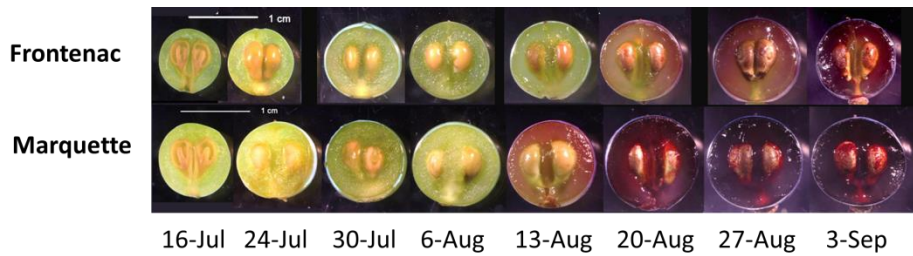


Fig 1. Frontenac and Marquette berry development monitored weekly from 30 days post bloom to September 3 (~20°Brix).

- Gene expression was analyzed in pulp and berry at harvest. Three other time points (veraison, 20 and 24 Brix) are currently being analyzed. A comparison of pulp, skin and cultivars indicates gene expression in common and unique to tissue or cultivar (Fig 2). Skin samples show a greater number of genes expressed over pulp between the two cultivars. There are relatively equal numbers of uniquely expressed genes between cultivars.

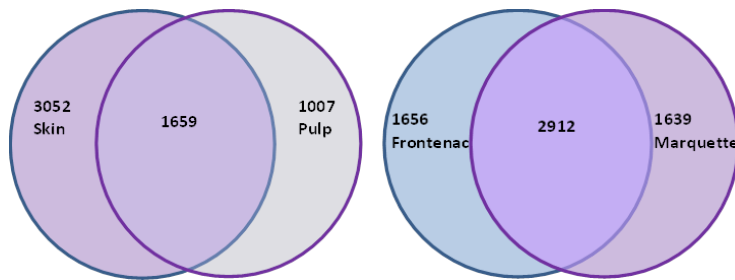


Fig 2. Numbers of differentially expressed (up or down regulated) genes between skin and pulp or between cultivars. Intersection of circles indicates number of genes that are modulated in common within a tissue or cultivar comparison.

- Stilbene synthase genes, (enzyme involved in synthesis of the antioxidant resveratrol), were expressed only in the berry skin. More stilbene synthase genes were expressed in Frontenac than Marquette.
- Terpenoid biosynthesis related genes were differentially regulated between skin and pulp and between cultivars with the greatest differences occurring in the berry skins. Genes up regulated in monoterpene biosynthesis predominated in the berry skin of both Frontenac and Marquette. Expression of genes in the taxol and menthol biosynthesis pathways were characteristic of Marquette berry skin. Frontenac showed an up regulation of genes in the geranyl diphosphate biosynthesis pathway which is known to produce many volatiles found in plant resins, such as genes related to citrus flavor/aroma synthesis.

Short summary:

Distinct patterns of gene expression are noted between skin and pulp and between cultivars when skin and/or pulp are compared. Differential expression of genes related to the monoterpene biosynthesis pathway, which contributes to the flavor and aroma character of grape berries, were detected between Frontenac and Marquette skins. The gene expression and metabolite (volatile and chemical) results will be used to identify flavor and aroma biomarkers for mature fruit signature characters of the cultivars.