Effect of Location and Cultivar on Metabolomic profile of Pennsylvania Red Wine Grapes

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Introduction

Hybrid wine grapes:

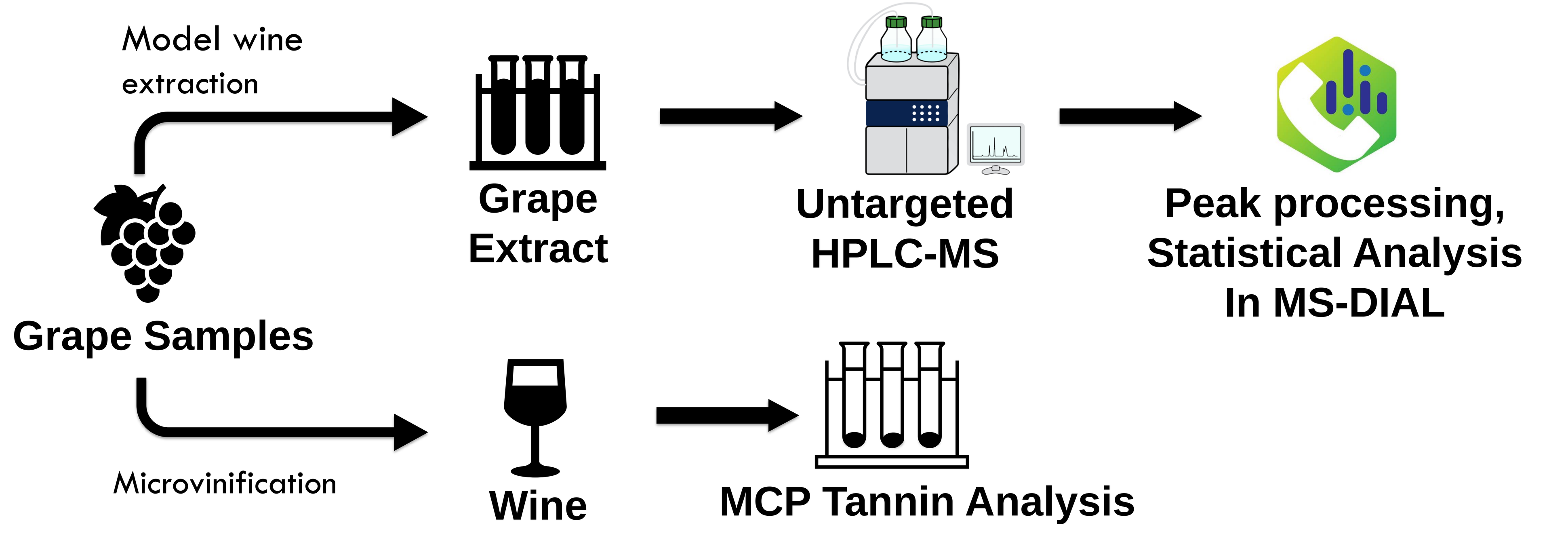
- Desirable growing properties – cold hardiness and resilience to common plant pests and pathogens[1,2]
- Crucial for the wine industries of PA, the Midwest, and Canada.
- **Q: How does hybrid grape chemistry compare to traditional *V. vinifera* cultivars?**

Regionality:

- Known to affect grape and wine chemistry, sensory properties[3]
- Used in marketing to attract novelty-seeking consumers
- PA has a diverse climate/geography
- **Q: How does growing location impact grape chemistry in PA wine grapes?**

Methods

Figure 1 : Experiment Flowchart



Grape Sampling

Figure 2: Grape Sampling Locations.

Location codes for each grape sample are overlaid on a map of Pennsylvania's plant hardiness zones. Chambourcin (Hybrid) and Cabernet Franc (V. vinifera) were collected for each location except for Location "HV"

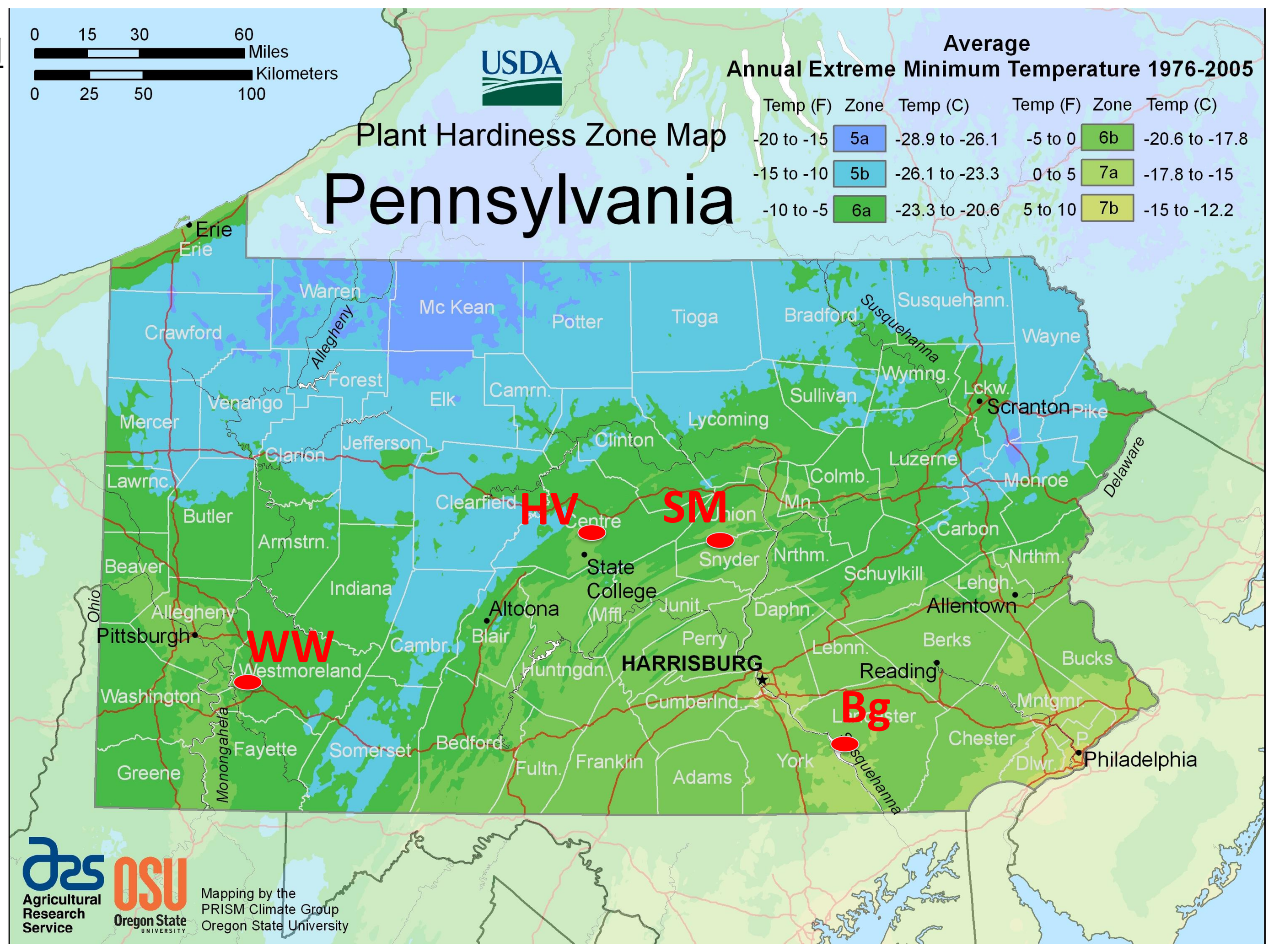


Table 1: Grape Sample Characteristics.

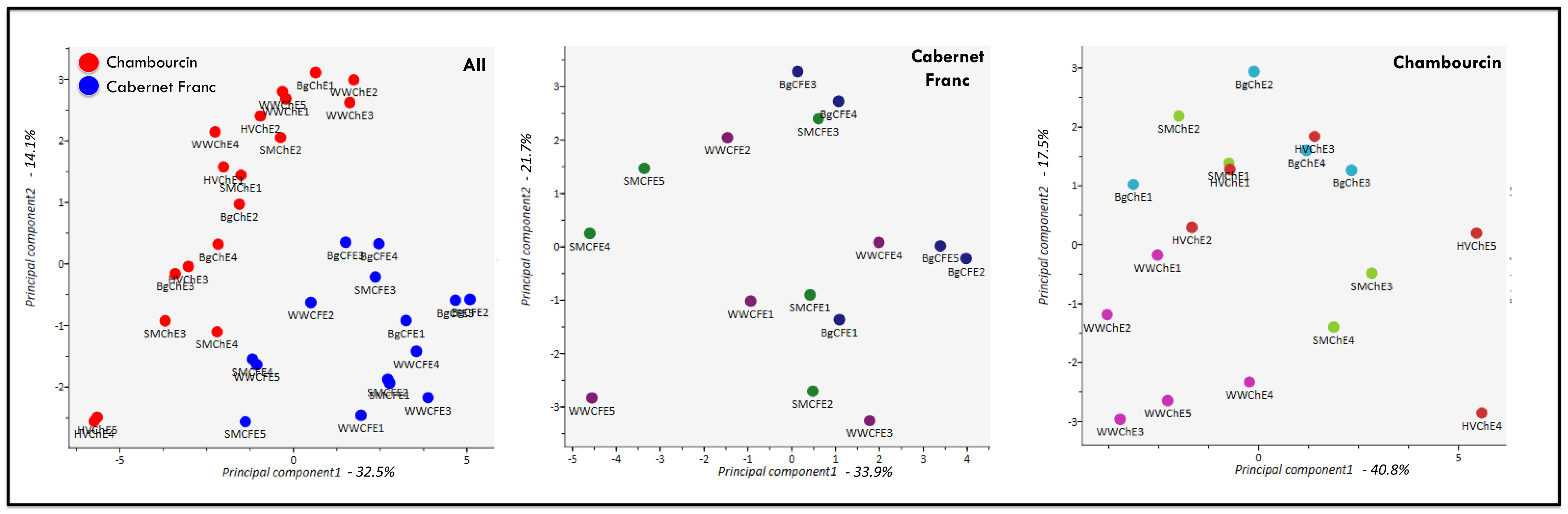
Basic environmental and chemical characteristics of each grape sample are displayed. Cumulative Degree Days (CDD) were calculated using a base temperature of 50°F. Temperature and Precipitation data were sourced from in-vineyard weather stations or through NOAA Online Weather Data[8].

Location	Variety	Vintage	GDD (°F)	Cumulative Precipitation (in.)	Extreme low (°F)	°Brix	pH	Size (g/grape)
BG	Chambourcin	2022	3753	36.8	16.5	23.6	3.22	2.73
BG	Cabernet Franc	2022	3753	36.8	16.5	23.1	3.74	1.46
HV	Chambourcin	2021	3077	34.1	20.7	19.5	3.27	2.89
SM	Chambourcin	2022	3177	25.3	14.3	24	3.17	1.43
SM	Cabernet Franc	2022	3177	25.3	14.3	23.9	3.51	1.29
WW	Chambourcin	2022	3151	25.2	16.7	24.6	3.21	1.92
WW	Cabernet Franc	2022	3151	25.2	16.7	22.8	3.63	1.34

Results - Metabolomics

Figure 3 : Principal Component Analysis(PCA) of grape metabolites.

Peak intensity data from HPLC-MS analysis was used to construct PCA plots for all grape extracts(A), Cabernet Franc grape extracts(B), and Chambourcin grape extracts(C). Peak data was normalized, mean-centered, and log-scaled prior to analysis. Samples are color coded according to cultivar in plot A, and by location in B and C.



Tables 2-4: VIP Compounds.

Partial-least-squares-regression (PLSR) was performed to identify variables important in prediction (VIP) - the compounds most important for distinguishing between cultivars(A) or locations (B,C).

A

m/z	RT (min)	Tentative ID	Fold change (max/min)	VIP Score
477.1046	7.77	Isorhamnetin-3-O-glucoside	99.2	3.32
505.0992	7.95	Quercetin 3-(6-O-acetyl-beta-glucoside)	59.5	2.57
315.0511	11.95	Isorhamnetin	54.0	2.31
449.1094	8.28	Flavanomarein	23.5	2.17
627.1569	1.704	Cyanidin-3,5-di-O-glucoside	160.2	2.07

B

m/z	RT (min)	Tentative ID	Fold change (max/min)	VIP Score
449.1089	6.91	Eriodictyol-7-O-glucoside	10.23	2.65
653.1721	1.95	Malvin	>1000	2.65
609.1829	8.43	Hesperidin	>1000	2.6
609.1465	1.45	Cyanidin-3,5-di-O-glucoside	>1000	2.5
593.1515	7.36	Kaempferol-3-O-rutinoside	37.81	1.7

C

m/z	RT (min)	Tentative ID	Fold change (max/min)	VIP Score
609.1845	10.43	Hesperidin	355	4.79
955.2152	7.76	Isorhamnetin-3-O-glucoside	543.82	3.71
145.0621	1.06	Glutamine	10.17	2.03
609.1467	6.52	Delphinidin-3-rutinoside	7.34	1.61
479.0833	5.44	Myricetin-3-galactoside	10.42	1.57

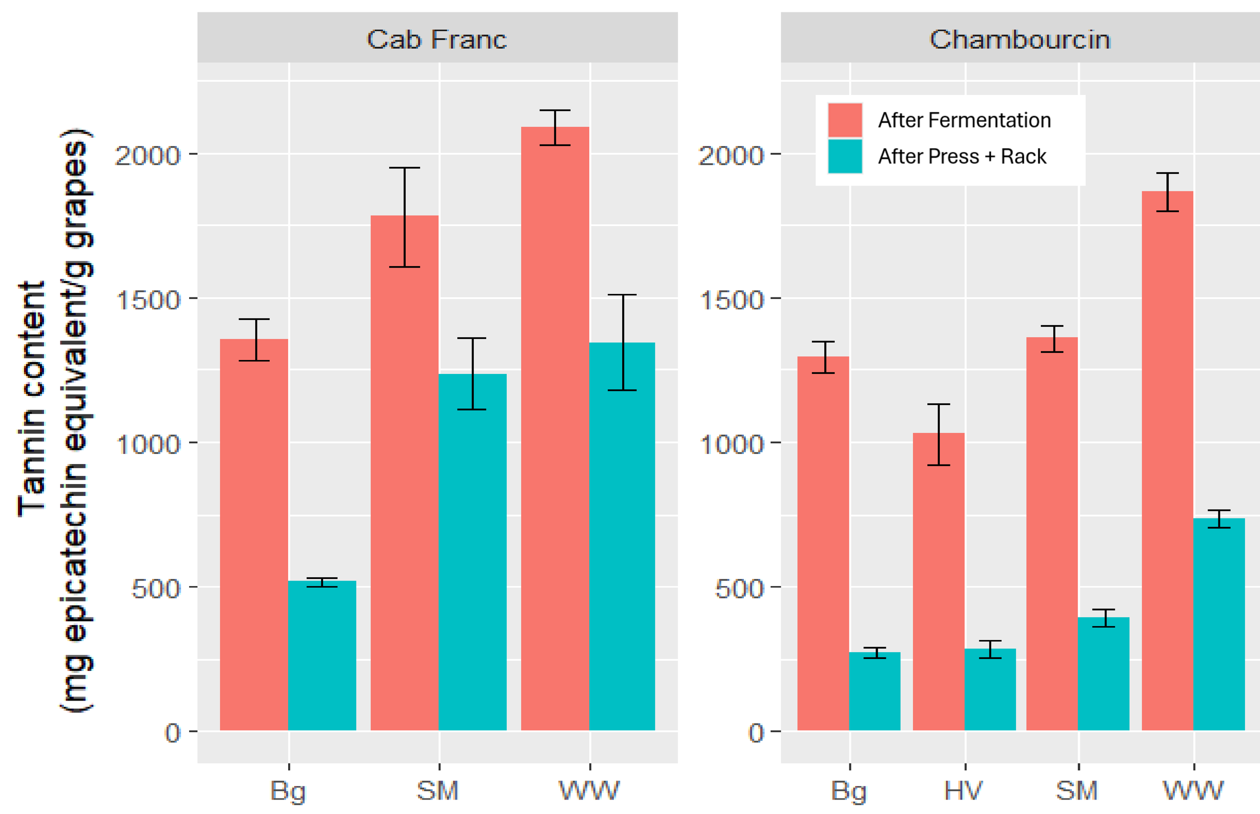


Figure 4: Winemaking Extractable Tannin Content.

Methyl-cellulose-precipitable tannins were measured in wine samples at the end of fermentation and after pressing and racking steps. Winemaking was performed in triplicate, and the 95% confidence interval was calculated for each sample set.

Conclusions

- Grape metabolomic profile **separated primarily by cultivar.**
- **Within cultivar,** samples **grouped loosely by location.**
- **Small phenolic compounds** were most important for separating cultivar and location groups.
- Hybrid wine tannins were comparable to *V. vinifera* during winemaking, but major losses were observed **after pressing** and racking
- Future studies should examine whether location effects are consistent **across vintages**

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2.Jones DS, McManus PS. Susceptibility of Cold-Climate Wine Grape Cultivars to Downy Mildew, Powdery Mildew, and Black Rot. Plant Dis. 2017 Jul;101(7):1077–85. Gómez-Plaza E, Olmos O, Bautista-Ortín AB. Tannin profile of different Monastrell wines and its relation to projected market prices. Food Chem. 2016 Aug 1;204:506–12.
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