Effect of yeast strain on smoke-derived volatile phenols and thiophenols

Megan Meharg[1], Thomas Collins[1], Mackenzie Aragon[1], and Caroline Merrell[2],

1: Washington State University TriCities, Richland WA, USA; 2: Jackson Family Wines, Sonoma, CA, USA

Introduction

Smoke exposure to grapes during the growing season increases concentrations of volatile phenols and thiols that impart economically detrimental smoky, ashy, and medicinal characteristics (Kennison et al. 2008; Tomasino et al. 2023).

Volatile phenols are sequestered in the grape and leaves in the form of glycosides (Hayasaka et al. 2010).

The precursors are released into the final product by microbiological enzymes and acid hydrolysis (Caffrey et al. 2019).

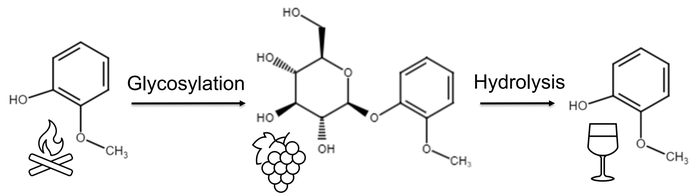

Figure 1 Process of glycosylation of guaiacol into guaiacol B-D-pyranoside and hydrolysis.

Methods

Fruit was subjected to 36 hours of experimental hardwood and softwood pellet smoke in built smoke houses (n=3). Control fruit was treated similarly without smoke (n=3).

Separate fermentations were carried out for seven commercially available yeast strains for smoke and control fruit (n=3).

Gas Chromatography-Mass Spectrometry (GCMS) with a DVB/CAR/PDMS fiber in SIM mode and Liquid Chromatography Orbitrap MS were utilized to quantify smoke-derived volatile phenols and thiophenols, respectively.

Statistical Analysis was performed using RStudio and Tukey's Honest Significant Difference Test ($p<0.05$).

Acknowledgements

In acknowledgement of the work of Jackson Family Wines, Mackenzie Aragon, Dr. Tom Collins and the Smoke-affected grapes and wine team at the WSU Wine Science Center.

Caffrey A, Lerno L, Rumbaugh A, Girardello R, Zweigenbaum J, Oberholster A and Ebeler SE. 2019. Changes in smoke-taint volatile-phenol glycosides in wildfire smoke-exposed Cabernet Sauvignon grapes throughout winemaking. Am J Enol Vitic 70:373–381. DOI: 10.5344/ajev.2019.19001.

Hayasaka Y, Baldock GA, Pardon KH, Jeffery DW and Herderich MJ. 2010a. Investigation into the formation of guaiacol conjugates in berries and leaves of grapevine *Vitis vinifera* L. cv. Cabernet Sauvignon using stable isotope tracers combined with HPLC-MS and MS/MS analysis.

Kennison KR, Gibberd MR, Pollnitz AP and Wilkinson KL. 2008. Smoke-derived taint in wine: the release of smoke-derived volatile phenols during fermentation of Merlot juice following grapevine exposure to smoke. J Agric Food Chem 56:7379–7383.

Tomasino E, Cerrato DC, Aragon M, Fryer J, Garcia L, Ashmore PL and Collins TS. 2023. A combination of thiophenols and volatile phenols cause the ashy flavor of smoke taint in wine. Food Chemistry Advances 2:100256.

Yeast selection had a significant impact on the concentrations two thiophenol compounds. Between strain differences were not observed for smoke-derived volatile phenols.

Results

Concentrations of volatile phenols demonstrated elevated concentrations of studied compounds in smoke-effected wines. Between strain analysis indicated that of the strains evaluated, no differences were observed for the quantified compounds.

Table 1: Effect of yeast strain on smoke-derived volatile phenols of experimentally smoked and control Vitis vinifera Merlot in 2022. Values represent means ± standard deviation (n=3). Data represented in concentrations (ug/L) determined by Gas Chromatography-Mass Spectrometry. REV, Revelacion; 4-MG, 4-methyl guaiacol; 4-EG, 4-ethyl guaiacol; 4-EP, 4-ethyl phenol; loq, below the limit of quantification; ns, non-significant; n.d., not detected.

		Free Volatile Phenolic Compounds 2022 (ug/L)						
	Yeast	Guaiacol	4-MG	o-Cresol	4-EG	p-Cresol	m-Cresol	4-EP
Control	58W3	3.6 ± 1.8	n.d.	n.d.	n.d.	n.d.	loq	2.7 ± 0.2
	EC	3.4 ± 1.7	n.d.	n.d.	n.d.	n.d.	loq	2.7 ± 1.0
	Flav	2.2 ± 1.1	n.d.	n.d.	n.d.	n.d.	loq	4.9 ± 1.7
	GRE	4.7 ± 2.4	n.d.	n.d.	n.d.	n.d.	loq	3.6 ± 0.8
	QA	3.1 ± 1.6	n.d.	n.d.	n.d.	n.d.	loq	3.5 ± 1.7
	Rev	4.6 ± 2.4	n.d.	n.d.	n.d.	n.d.	1.2 ± 1.3	3.2 ± 0.9
	VIN	3.9 ± 2.0	n.d.	n.d.	n.d.	n.d.	loq	3.0 ± 0.9
	p-value	ns	ns	ns	ns	ns	ns	ns
Smoke	58W3	21.1 ± 2.7	8.6 ± 1.4	2.8 ± 0.5	3.0 ± 0.5	3.8 ± 0.7	3.2 ± 0.7	2.2 ± 0.5
	EC	24.6 ± 5.7	11.6 ± 2.5	4.0 ± 1.0	4.3 ± 1.0	5.3 ± 1.2	4.7 ± 1.4	3.6 ± 1.1
	Flav	22.8 ± 3.8	10.3 ± 1.6	3.9 ± 0.5	3.8 ± 0.5	4.6 ± 0.9	5.0 ± 0.8	3.6 ± 1.0
	GRE	21.4 ± 2.9	9.2 ± 1.6	3.2 ± 0.6	3.4 ± 0.7	4.0 ± 0.9	4.2 ± 0.8	2.2 ± 0.3
	QA	20.8 ± 2.3	9.3 ± 1.1	3.2 ± 0.5	3.3 ± 0.3	4.1 ± 0.4	3.4 ± 0.6	2.3 ± 0.3
	Rev	23.7 ± 4.3	10.0 ± 2.0	2.9 ± 0.7	3.7 ± 0.8	4.1 ± 0.9	3.8 ± 1.0	2.4 ± 0.8
	VIN	22.4 ± 6.5	10.2 ± 3.4	4.0 ± 0.2	3.8 ± 1.4	4.7 ± 1.5	4.2 ± 1.7	2.6 ± 1.0
	p-value	ns	ns	ns	ns	ns	ns	ns

Discussion

Quantification of thiophenols using a reducing agent yielded significant differences between smoke and control wines for Thiophenol ($p = 0.00445$) and Thioanisole ($p = 0.0247$). This confirms the previous research on the discovery of smoke-derived thiophenols. However, the wines tested in this experiment did not observe differences between smoke and control for thiocresol and thioguaiacol.

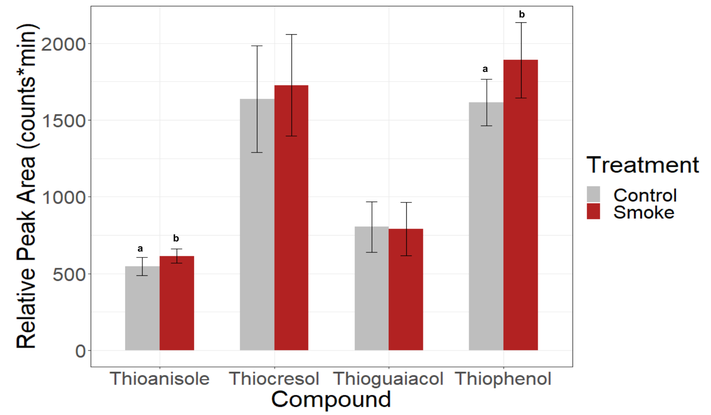

Figure 2 Effect of smoke treatment on concentrations of reduced thiophenols in 2022. Bars represent mean Relative Peak Area in counts*min and standard deviation (n=21). Counts*min as a qualitative analysis. Data were analyzed separately for each compound. Lowercase letter indicates differences determined by Tukey's honest significant difference test at confidence 95%.

Significant differences were found between QA23:Revelacion and QA23:58W3 yeast strains for thiocresol. For thioguaiacol, significant differences were determined between Flavia and ICV GRE.

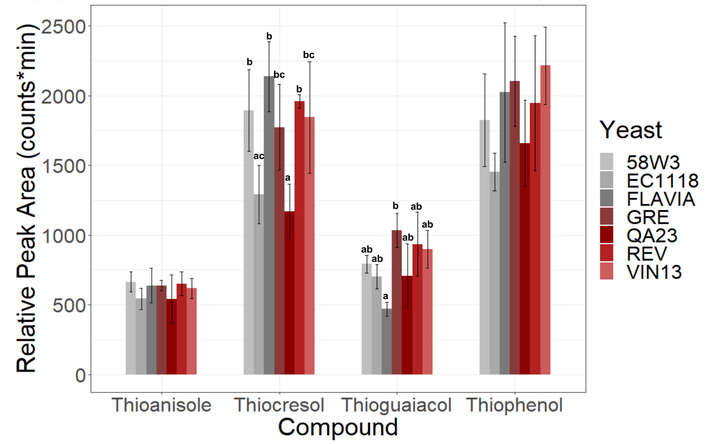

Figure 3 Effect of yeast strain on concentrations of reduced thiophenols in smoked wine in 2022. Bars represent mean Relative Peak Area in counts*min and standard deviation (n=3). Data were analyzed separately for each compound. Lowercase letter indicates differences determined by Tukey's honest significant difference test at confidence 95%.