Phenolic and Sensory Evolution of Wines from Oxygenation (2017)

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Summary

This study examines the effect of oxygenation on wines. Cabernet Sauvignon grapes were harvested and, after completion of fermentation, wine was drained and pressed into two tanks. One tank was a control, and one tank received 40 mL O_2/L wine/month for 3 days, and this rate was then halved every 3 days until after malolactic conversion began, where it received micro-oxygenation at 0.5 mL O_2/L wine/month. A third set of grapes from the same block were picked 5 days later (after a large rain event), and then received flash détente. Since malolactic conversion completed so quickly for this treatment, its oxygenation could only be at 40mL O_2/L wine/month for three days after draining and pressing before switching to 0.5 mL O_2/L wine/month. The treatments between the control and oxygenated wines were similar, but the vinification of the flashed wine was different, marked by 10 days of fermentation (compared to 14 days for the other treatments, including a 3 day cold soak). The flashed wine also had slightly different additions made. No major differences are found in wine chemistry between the control and oxygenation treatment, except for slightly higher lactic acid in the treatment. The flashed wine had higher acidity, possibly due to differential tartrate adds. The oxygenated wine had higher rates of *S. cerevisiae* and several *Lactobacillus* species relative to the control, but lower acetic acid bacteria. The flashed wine had much lower levels of acetic acid bacteria and *Lactobacillus*, and lower levels of *S. cerevisiae* as well. However, it was higher in *O. oeni*. Color intensity lowered among the wines from November to April; however, the oxygenated wine may have had a slight increase in color intensity relative to the control over this time (although this was weak). The oxygenated treatment had higher color intensity than the control, and the flashed wine was highest. Phenolic parameters generally decreased from November to April, and oxygenation did not appear to have much effect on the phenolic parameters. The flashed wine was much higher in catechin and quercetin and was also higher in tannin. Although it was initially lower in anthocyanin (and higher in polymeric pigment), it ended up being higher in anthocyanin.

For the triangle test, of 26 people who answered, 12 people chose the correct wine (46%), suggesting that the wines were not significantly different. In general, people who answered correctly tended to prefer the oxygenated wine, although the preference trends were somewhat complex. For the descriptive analysis, there was a strong trend for the flashed wine to have higher overall aromatic intensity than the other wines (LSD=0.97). There was a slight trend for this wine to have higher Fruit Intensity and Body, and perhaps slightly lower Herbaceous/Green character (although it was similar to the oxygenated wine in this regard). The control wine tended to have higher Herbaceous/Green character, lower Overall Aromatic Intensity, and higher Astringency (although equal to Flash in this regard). The oxygenated treatment tended to have lower Bitterness and Astringency, and perhaps lower Body as well. More studies should be performed on oxygenation, with regard to timing, amount, and with regard to continuous vs discontinuous oxygenation.

Introduction

Different oxygenation regimes during fermentation are thought to affect the phenolic extraction, structure, and stability of finished wine. Aerating red wines during and after fermentation increases the amount of polymeric pigment in wines. Aerating younger wines tends to be more effective than older wines, since in younger wines the majority of phenolic compounds are still monomeric. However, too much aeration in a wine's life (especially later in its life) can cause precipitation of polymeric pigments and tannin (Zoecklein 2001a). Thus, finding ways to control the rate and timing of oxygenation throughout a wine's life is very important to achieving high quality wines.

Macro-oxygenation during fermentation may be a technique to alter these factors with greater control. Macro-oxygenation can be performed as a "single dose", bringing in around 6mg/L oxygen to fermenting must in a period of 1-4 hours. It can also be performed continuously, at 0.5mg/L per hour between 1.080 and 1.020 density (Deltel 2007).

Must exposed to oxygenation during fermentation often shows decreased levels of anthocyanins (Cheynier et al 1997), but it is unclear if this is due to increases in yeast population which binds anthocyanins or due to enzymatic oxidation. Additionally, exposing non-sulfited must to oxygenation early on results in losses of anthocyanins, phenolics, and hydroxycinnamic acids. This study did not investigate the formation of polymeric pigment, however (Castellari et al. 1998).

Most oxygen during macro-oxygenation is consumed by the yeast (Deltel 2007). However, this aspect may also cause blooms of unwanted bacteria and yeast species and may increase volatile acidity. For example, aeration of wines which have an inoculum of *Brettanomyces* can promote growth (Zoecklein 2004), although this is commonly a concern towards the end of fermentation and during aging. Macro-oxygenation may help reduce sulfur off odors during fermentation without reducing fruit aromas or oxidizing the wine (Deltel 2007). However, it is very likely that aeration can also help keep sulfur compounds in solution, temporarily oxidizing these compounds to their less volatile disulfide forms.

Just after completion of red wine fermentation, limited oxygen exposure may have beneficial impacts on red wine phenolic attributes, such as by enhancing color stability, softening tannin, and providing body (Zoecklein 2001a). Aeration can also help reduce reductive aromas (although sometimes it may not effectively combat reduction), and integrate overall aromatic quality of the wine (Zoecklein 2000). Aeration both during and after fermentation can promote the formation of polymeric pigment, stabilizing color. Aeration after completion of fermentation is often referred to as micro-oxygenation. Aeration is more beneficial at these points due to the higher levels of phenolic compounds in the wine and the greater protection of the wine at this stage due to negative oxidation reactions. Oxidation reactions are promoted in both rate and extent by higher pH, and the formation of acetaldehyde through oxygenation can promote tannin-anthocyanin bridging resulting in stable pigment. The presence of sulfur dioxide can result in acetaldehyde binding, which may inhibit the formation of these acetaldehyde-based polymeric pigments. Thus, it is often recommended that sulfur dioxide be kept low during the course of micro-oxygenation treatments (Zoecklein 2001a). Research by Patrick Sullivan has suggested that micro-oxygenated wines had greater perceptions of fruit intensity, plushness, and less vegetative aromas (Zoecklein 2001b). The purpose of the present study is to investigate the role of oxygenation in helping to age Cabernet Sauvignon wine.

Results and Discussion

No major differences are found in wine chemistry between the control and oxygenation treatment, except for slightly higher lactic acid in the treatment. The flashed wine had higher acidity, possibly due to differential tartrate adds. The oxygenated wine had higher rates of *S. cerevisiae* and several *Lactobacillus* species relative to the control, but lower acetic acid bacteria. The flashed wine had much lower levels of acetic acid bacteria and *Lactobacillus*, and lower levels of *S. cerevisiae* as well. However, it was higher in *O. oeni*. Color intensity lowered among the wines from November to April; however, the oxygenated wine may have had a slight increase in color intensity relative to the control over this time (although this was weak). The oxygenated treatment had higher color intensity than the control, and the flashed wine was highest. Phenolic parameters generally decreased from November to April, and oxygenation did not appear to have much effect on the phenolic parameters. The flashed wine was much higher in catechin and quercetin and was also higher in tannin. Although it was initially lower in anthocyanin (and higher in polymeric pigment), it ended up being higher in anthocyanin.

Juice Chemistry			
	Brix	pH	TA (g/L)
Control	23.5	4.05	3.0
MacroOx	23.5	4.05	3.0
Pre-Flash	21.3		
Post-Flash	24.1	3.93	5.4

In House Data

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Wine Chemistry										
	Ethanol (%vol/vol)	Residual Sugar (g/L)	pH	TA (g/L)	Volatile Acidity (g/L)	Malic Acid (g/L)	Lactic Acid (g/L)	Total SO2 (ppm)	Free SO2 (ppm)	Molecular SO2 (ppm)
Control	13.49	<1	4.01	5.22	0.83	<0.15	1.62	87	43	0.42
Oxygenation	13.53	<1	4.01	5.13	0.58	<0.15	1.73	84	36	0.35
Flash + Oxygen	13.30	<1	3.85	5.77	0.75	<0.15	1.56	78	46	0.63
% Change Oxygenation	0%		0%	-2%	-30%		7%	-3%	-16%	-17%
% Change Flash + Oxygen	-1%		-4%	11%	-10%		-4%	-10%	7%	50%

Results from ICV in Late April

Wine Microbiology									
	Acetic Acid Bacteria (cells/mL)	L brevis, hilgardii, and fermentum (cells/mL)	L plantarum, casei, and mali (cells/mL)	L kunkeei (cells/mL)	O oeni (cells/mL)	Pediococcus sp. (cells/mL)	B bruxellensis (cells/mL)	S cerevisiae (cells/mL)	Z bailii (cells/mL)
Control	1600000	<10	8400	<10	7400000	50	<10	7930	<10
Oxygenation	350000	<10	17600	<10	4300000	40	<10	41500	10
Flash + Oxygen	15000	<10	220	<10	>10000000	<10	<10	1480	<10
% Change Oxygenation	-78%		110%		-42%	-20%		423%	
% Change Flash + Oxygen	-99%		-97%					-81%	

Results from ETS in Early May

November Wine Color Profile					
	A420	A520	A620	Hue (420/520)	Intensity (420 + 520 + 620)
Control	0.348	0.520	0.133	0.669	1.001
Oxygenation	0.369	0.553	0.140	0.667	1.062
Flash + Oxygen	0.383	0.513	0.179	0.747	1.075
% Change Oxygenation	6%	6%	5%	0%	6%
% Change Flash + Oxygen	10%	-1%	35%	12%	7%

Results from ICV in Late November

Color Profile					
	A420	A520	A620	Hue (420/520)	Intensity (420 + 520 + 620)
Control	0.294	0.390	0.102	0.754	0.786
Oxygenation	0.324	0.425	0.111	0.762	0.860
Flash + Oxygen	0.337	0.469	0.125	0.719	0.931
% Change Oxygenation	10%	9%	9%	1%	9%
% Change Flash + Oxygen	15%	20%	23%	-5%	18%

Results from ICV in Late April

November Wine Phenolic Profiile				
	Catechin (mg/L)	Polymeric Anthocyanins (mg/L)	Tannin (mg/L)	Total Anthocyanins (mg/L)
Control	9	40	590	357
Oxygenation	9	40	595	348
Flash + Oxygen	38	37	760	337
% Change Oxygenation	0%	0%	1%	-3%
% Change Flash + Oxygen	322%	-8%	29%	-6%

Results from ETS in Late November

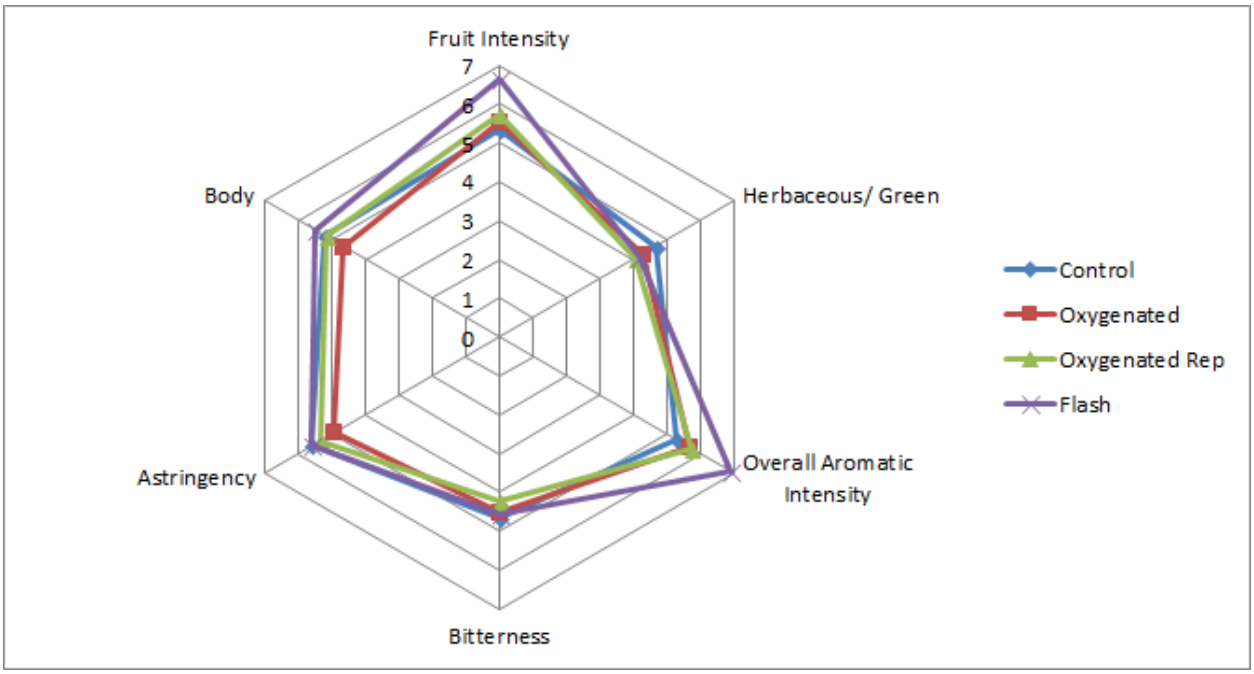
Phenolic Profile					
	Caffeic Acid (mg/L)	Caftaric Acid (mg/L)	Catechin (mg/L)	Epicatechin (mg/L)	Gallic Acid (mg/L)
Control	6	22	16	15	26
Oxygenation	6	22	16	14	26
Flash + Oxygen	5	35	45	31	21
% Change Oxygenation	0%	0%	0%	-7%	0%
% Change Flash + Oxygen	-17%	59%	181%	107%	-19%

Results from ETS in Early May

Phenolic Profile								
	Malvidin glucoside (mg/L)	Monomeric Anthocyanins (mg/L)	Polymeric Anthocyanins (mg/L)	Quercetin (mg/L)	Quercetin Glycosides (mg/L)	Tannin (mg/L)	Total Anthocyanins (mg/L)	Resveratrol (cis and trans) (mg/L)
Control	183	303	32	2	17	518	335	0.3
Oxygenation	177	292	33	<1	16	526	325	0.2
Flash + Oxygen	168	334	36	4	80	668	370	0.4
% Change Oxygenation	-3%	-4%	3%		-6%	2%	-3%	-33%
% Change Flash + Oxygen	-8%	10%	13%	100%	371%	29%	10%	33%

Results from ETS in Early May

For the triangle test, of 26 people who answered, 12 people chose the correct wine (46%), suggesting that the wines were not significantly different. In general, people who answered correctly tended to prefer the oxygenated wine, although the preference trends were somewhat complex. For the descriptive analysis, there was a strong trend for the flashed wine to have higher overall aromatic intensity than the other wines (LSD=0.97). There was a slight trend for this wine to have higher Fruit Intensity and Body, and perhaps slightly lower Herbaceous/Green character (although it was similar to the oxygenated wine in this regard). The control wine tended to have higher Herbaceous/Green character, lower Overall Aromatic Intensity, and higher Astringency (although equal to Flash in this regard). The oxygenated treatment tended to have lower Bitterness and Astringency, and perhaps lower Body as well. More studies should be performed on oxygenation, with regard to timing, amount, and with regard to continuous vs discontinuous oxygenation.



	Control	Oxygenated	Flash	Total Votes
Most Preferred	27%	45%	27%	11
Second Most Preferred	44%	11%	44%	9
Least Preferred	36%	36%	27%	11

Methods

Cabernet Sauvignon grapes from the same block were harvested, destemmed, and crushed into one tank on October 8, 2017 for cold soak and fermentation. At this time, the musts received 40ppm sulfur dioxide, 83g Lafase Fruit, 40g/hL Tanin VR Supra, and 2g/L Boise Frais. Both tanks received a 3 day cold soak (and received 100g/hL tartaric acid on the third day), were then warmed for a day, and inoculated the following day with F15 at 15g/hL with GoFerm at 20g/hL. On October 18, 50g/hL tartaric acid was added as well. Wines were drained and pressed on October 25, and two days later were racked into stainless steel tanks. At this racking, the treatment block was split off from the control. The control

wine was racked again on October 30, and malolactic conversion commenced. The control wine was racked and returned after the completion of malolactic conversion (November 29), and 50ppm sulfur dioxide was added. An additional 50ppm sulfur dioxide was added to the control 2 days later. On January 12, 20ppm sulfur dioxide was added to the control wine.

The Oxygenated treatment was also racked on October 30 and November 29. It was then racked into a different aging vessel on January 18, and again on January 23. On these days the wine received 24ppm and 13ppm sulfur dioxide adds, respectively.

A third treatment, involving flash détente, was also used. After about 1 inch of rain the remaining of the block was harvested and run through Flash Détente on October 13. Due to the nature of Flash Détente, very different procedures were followed. At crush, 10kg Tanin VR Color was added (in approximately 3215 Gallons of wine), 3mL/100kg Thermoliquide was added, and on the same day as crush F15 at 15g/hL with 20g/hL GorFerm. Fermaid was added at 25g/hL on October 16, and on October 18 50g/hL tartaric acid was added. The wine was drained and pressed on October 24 and racked twice over the next three days. Malolactic fermentation occurred and completed on November 10, after which the wine was centrifuged an 60ppm sulfur dioxide was added. On November 21, an additional 24ppm sulfur dioxide and 150g/hL Tartaric acid were added. The wine was racked again on January 23.

Red wine phenolic panels were tested by an outside lab before malolactic conversion and post-malolactic conversion primarily looking for the tannin/anthocyanin ratio. Dissolved oxygen was monitored occasionally in house.

The treatments for each tank were:

1) Tank 1: Control: 2 Pump over/ Day (with air). After primary fermentation Drain/Press and malolactic allowed to finish.

2) Tank 2: Oxygenation: 2 Pump over / Day (with air). After primary fermentation Drain/Press. Oxygen rate 40 ml/l/month prior to malolactic fermentation for 3 days (beginning on October 27), then 20 ml/l/month for 3 days, then 10 ml/l/month for 3 days, then 5 ml/l/month for 3 days, then 2.5 ml/l/month for 3 days all depending on A/T ratio and reactive tannins. Malolactic was allowed to finish, and afterwards post-malo oxygen rate was 0.5 ml/l/month

3) Tank 3: Flash + Macro Oxygenation: 2 Pump over / Day (with air). After primary fermentation Drain/Press. Oxygen rate of 40 ml/l/month was prior to malolactic fermentation for 3 days (beginning on October 25). Malolactic fermentation finished early, and right after the post-malolactic oxygen rate was 0.5 ml/l/month

These treatments were achieved by Vivelys Visio Oxygen diffuser through aeration stones placed into the bottom of the fermenters prior to filling.

All other treatments between wines were equal.

This study was tasted on May 30. For the triangle test and preference analysis, anybody who did not answer the form were removed from consideration for both triangle, degree of difference, and preference. Additionally, anybody who answered the triangle test incorrectly were removed from consideration for degree of difference and preference. Additionally, any data points for preference which

did not make sense (such as a person ranking a wine and its replicate at most and least preferred, when they correctly guessed the odd wine) were removed. The flashed sample was ignored for triangle testing (but not for preference or descriptive analysis), and only the control vs the oxygenated samples were compared.

In order to balance the data set to perform statistical analysis for descriptive analysis, any judge who had not fully completed the descriptive analysis ratings were removed. In order to then make the amount of judges between groups equivalent for the analysis which included the flashed wine, one judge from group 3 was eliminated. This resulted in a final data set of 3 groups, each with 6 judges (considered as replications within groups, and groups were considered as assessors). Data was analyzed using Panel Check V1.4.2. Because this is not a truly statistical set-up, any results which are found to be statistically significant ($p<0.05$) will be denoted as a “strong trend” or a “strong tendency,” as opposed to general trends or tendencies. The statistical significance here will ignore any other significant effects or interactions which may confound the results (such as a statistically significant interaction of Judge x Wine confounding a significant result from Wine alone). The descriptors used in this study were Fruit Intensity, Herbaceous/Green, Overall Aromatic Intensity, Bitterness, Astringency, and Body.

References

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