Effect of SO_2 dosing on chemistry, sensory, and microbiology of barrel fermented Chardonnay (2020)

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Summary

Previous WRE studies in 2018 and 2019 have found chemical, sensory, and microbial advantages to adding a relatively high initial dose of SO_2 after the completion of malolactic fermentation in Virginia red wines. In the present study, a similar comparison was made for aging white wines after post-fermentation SO_2 doses of 75 ppm and 100 ppm. Lower doses were more likely to lead to wines aging below a target of 0.5 ppm molecular SO_2 and, in some cases, below an antioxidant target of 20 ppm free SO_2. Higher initial SO2 doses also led to lower numbers of acetic acid bacteria. Wines were not significantly different in a triangle test, indicating there was no discernable penalty to higher SO_2 use.

Introduction

Sulfur dioxide is a traditional, inexpensive additive used widely at many different stages of modern wine making to combat oxidation and microbial spoilage. Despite all that is known about the chemistry and interactions of SO_2 in wine, many practical questions remain for winemakers. In a series of experiments beginning in 2018, Kirsty Harmon from Blenheim Vineyards has been exploring the effects of adding low (30 ppm), high (75 ppm), and very high (100 ppm) levels of SO_2 post malolactic fermentation in red wines. The purpose of this study was to extend this exploration to the post-fermentation treatment of barrel fermented Chardonnay.

In 2018, a single lot of Cabernet Franc wine was divided into six treatments with varying barrel age (new vs. neutral), initial dose (30 ppm vs. 75 ppm) and timing of SO_2 addition (4 vs. 19 days after completion of malolactic fermentation). The free and total SO_2, SO_2 addition rates, volatile acidity and microbiological evolution were reported. The high initial dose led to higher total sulfur in each case. However, wines that received a high initial dose were also closer to the target of 0.5 mg/L target molecular SO_2 for a higher proportion of the aging period. Wines receiving high initial doses had lower overall accumulation of acetic acid during aging. New barrels had lower free SO_2 than their neutral counterparts on the same SO_2 schedule. They accumulated higher amounts of acetic acid and had high microbial populations of *Pediococcus* and acetic acid bacteria. Delaying SO_2 addition by two weeks decreased total sulfur levels for both high and low dose wines. These wines has higher acetic acid initially, but experienced very little acetic acid accumulation during aging. Of all the wines, the high, delayed dose was closest to the target SO_2 during aging. Though these wines were distinguishable from one another during sensory analysis, there was no significant preference for one wine over the other and no consistent trend in the differences (color, astringency, fruit or aromatic intensity).

Despite the relatively high rate of 75ppm SO_2 addition, none of the barrels in 2018 completed aging at or above the target of 0.5 mg/L molecular SO_2 without additions being made. In most cellars, this would mean they would be without adequate antimicrobial protection for several months. In 2019, this work was extended to explore the effect of a high (75ppm) vs. very high (100 ppm) dose of SO_2 at the end of malolactic fermentation. Three sets of barrels were treated, with one barrel per set receiving 75 ppm and one barrel receiving 100 ppm. The addition of 100 mg/L SO_2 allowed wine to age above a target of 0.5 mg/L without additional dosing during aging while 75 mg/L did not. Acetic acid accumulation during the aging period was low for all of the wines tested in 2019. In both experiments, wines with higher doses of SO_2 had higher anthocyanin concentration but this did not translate to clear trends in color intensity (by optical measures or sensory analysis) across vintages. In 5 of 6 sets compared over both vintages, tannins were higher in the wine with lower SO_2 doses.. The exceptional set was the new barrels, which may have contributed tannins of their own. Most notably, in the 2019 study, wines treated with 100ppm SO_2 were given significantly higher scores for aromatic intensity and nearly significantly higher scores for fruit intensity and overall wine quality when compared to wines treated with 75 ppm SO_2.

Taken as a whole, these studies indicate a single high rate of SO_2 addition at the completion of fermentation may be better at protecting wine from oxidation and microbial attack as well as preserving aromas. It may also be a less labor intensive strategy than multiple small additions for cellars with limited workers or in times when staff are not able to access the winery. No negative sensory effects were reported for higher doses in either study. Both of the previous studies were on aging red wines. In the present study, a similar comparison was made for aging white wines. Several considerations may be different for white wines than red wines. White wines generally have lower pH, and therefore can achieve a higher rate of molecular SO_2 with lower free SO_2 levels, somewhat diminishing risks of microbiological spoilage. Aging of white wines does not include concerns about anthocyanins, color, or tannin evolution, however, lack of tannins leads to more concern about oxidation and preservation of oxygen-sensitive aroma compounds. White wines also tend to be more delicate in their aromatics, leading to concerns about the perception of sulfites at higher levels. In this study, two separate lots of Chardonnay were designated for study, with one set of comparable barrels per lot. In each, one barrel received 75 ppm SO_2 at the completion of alcoholic fermentation while the other received 100ppm SO_2.

Methods

Grapes were whole cluster pressed up to 1.4 bar with the addition of 50 mg/L SO_2. During cold settling, 0.3 g/L bentonite was added to the juice to aid settling. When clear, juice was racked off bentonite and lees into a separate tank for chaptalization (18.5 g/L sugar for Seaview Chardonnay, and 20.6 g/L of sugar for Blenheim Chardonnay). After additions were fully dissolved, juice was transferred to oak barrels for fermentation. There were two barrels from the same cooper and year for each lot, one for each treatment. Juice was allowed to warm to approximately 50°F in barrel before inoculation with 0.089 g/L EC1118 yeast. Fermentation was monitored daily for each barrel. Sulfur dioxide was added 14 days after the completion of alcoholic fermentation (glucose/fructose <1.0 g/L by enzymatic analysis). For each lot, one barrel received 75 mg/L SO_2 while the other barrel received 100 ppm SO_2 using Effergran granulates (Enartis). Wine was aged on lees without stirring or racking. Samples were taken for the detection of microbes after five months of aging. SO_2 was monitored in-house and maintained at a target molecular SO_2 of 0.5 mg/L.

Modified sensory analysis was completed on these experimental wines. Due to social distancing restrictions at the time of COVID-19, wines were shipped to 40 panelists (all wine producers) in randomly numbered sample bottles. For each vineyard lot, tasters were presented with three wines, two of one type and one of another, and asked to identify which wine was different (a triangle test). There were four tasting groups with the unique wine in the triangle test balanced between groups. Tasters were then asked to score each wine on a scale of 0 to 10 for aromatic intensity, Chardonnay varietal character, volume/body, and perception to sulfur dioxide. They were also given open ended questions to describe the wines. Results for the triangle test were analyzed using a one-tailed Z test. Descriptive scores were analyzed using repeated measures ANOVA.

Results

The 2020 vintage was marked by low Brix accumulation coupled with relatively high pH values, as seen in Table 1. Fermentation proceeded steadily without difficulties in both treatments and both lots (Figure 1). Wine chemistry taken 2 months (Dec 11) and 5 months (March 23) after the initial addition of SO_2 is very similar between barrels in the same lot, with low volatile acidity in all treatments (Table 2). In January, both treatments from the Seaview Vineyard were aging at or above the target of 0.5 mg/L molecular SO_2 (Table 3, Figure 2) at that time, so no addition was made. The wine that received 75 mg/L, however, lost a considerable amount of free SO_2 during aging, and likely spent the intervening months below the target (Figure 2). After a small addition of 10 mg/L in January, the Blenheim Vineyards Chardonnay that received an initial dose of 100 mg/L was also above 0.5 mg/L molecular SO_2 in April. Even with an addition of 30 mg/L, the Blenheim Chardonnay that received 75 mg/L did not meet the target at either sampling event. A free SO_2 level of 20 or above is generally thought to convey antioxidant protection in white wines (Appendix A). The Seaview Vineyard Chardonnays were both above this benchmark in January, but the wine that received 75 mg/L initial SO_2 fell below it before testing in April (Figure 2). An initial addition of 75 mg/L SO_2 to the Blenheim

Chardonnay did not result in 20 mg/L free SO_2 initially, however this benchmark was likely reached with the additional 30 mg/L added in January.

Molecular SO_2 level determines the antimicrobial effectiveness of SO_2 in a wine. After five months, the microbial population in suspension in the barrels was measured (Table 4, Figure 3). Small differences in microbial population are often negligible in terms of overall effect on the wine. An order of magnitude difference, however, is notable. Wine in barrels that received 100 ppm had 5-10 times fewer acetic acid bacteria than those that received 75 ppm SO_2. *Brettanomyces* populations were low overall but were roughly halved by higher SO_2 additions.

In a triangle test, 11 out of 25 respondents were able to distinguish the Seaview wines, indicating the wines were not significantly different ($Z=0.92$, $p=0.18$). Among those who were able to distinguish the wines, there were no significant differences in scores for aromatic intensity ($F=1.48$, $p=0.24$), Chardonnay varietal character ($F=0.48$, $p=0.50$), volume/body ($F=0.34$, $p=0.57$), or perception of sulfur dioxide ($F=0.96$, $p=0.34$). Only 22 respondents scored the Blenheim wines. In a triangle test, 9 out of 22 respondents were able to distinguish the Seaview wines, indicating the wines were not significantly different ($Z=0.53$, $p=0.30$). There were not enough correct answers to make descriptive scores statistically meaningful for these wines (Table 5).

Table 1: Initial juice and wine metrics for two lots of Chardonnay (in-house data)

	Juice		Wine	
Vineyard	Brix	pH	Alc	pH
Seaview	19.1	3.58	12.5	3.55/3.56
Blenheim	19.2	3.62	12.3	3.69/3.68

Figure 1: Fermentation kinetics for two lots of Chardonnay (in-house data)

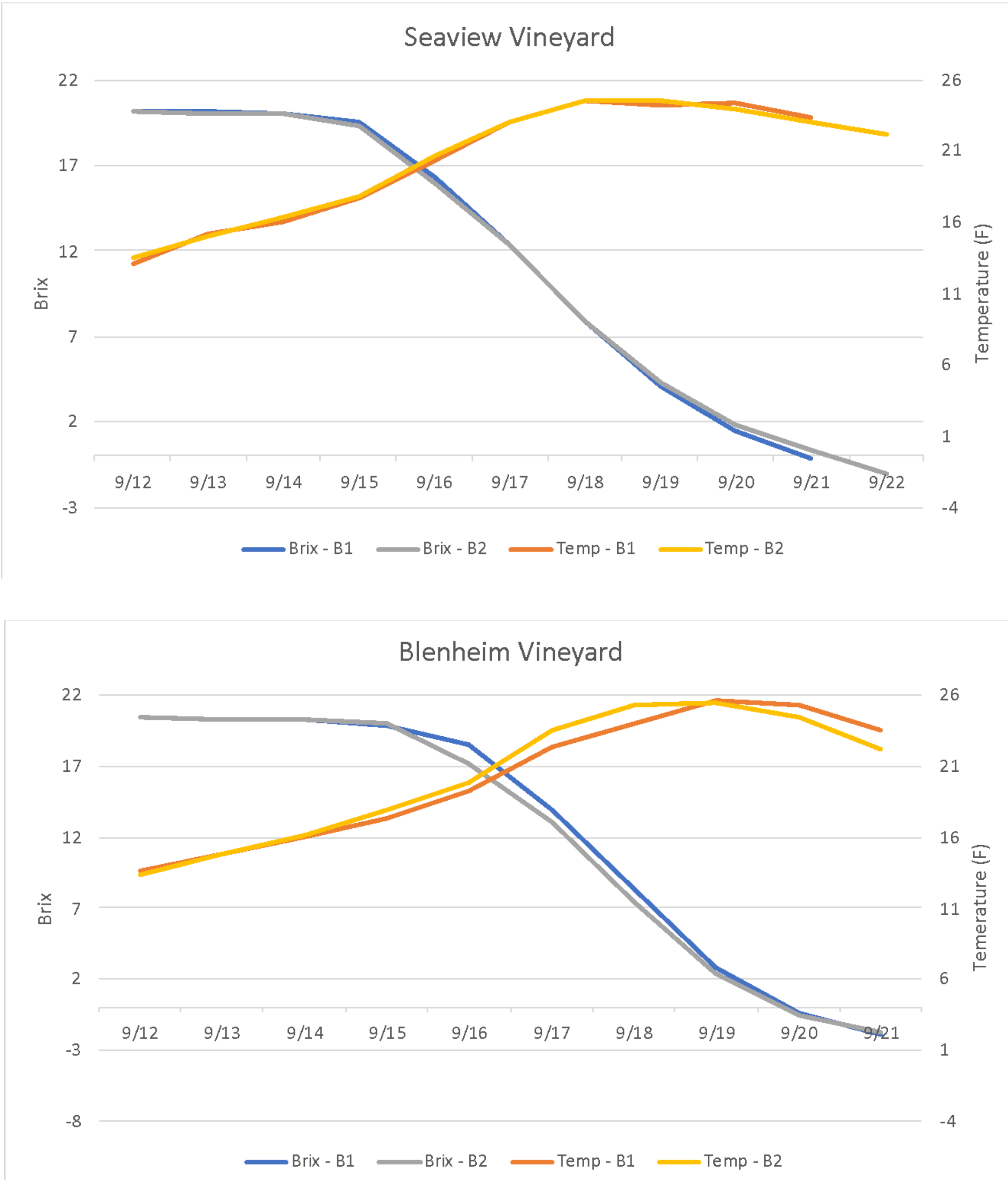


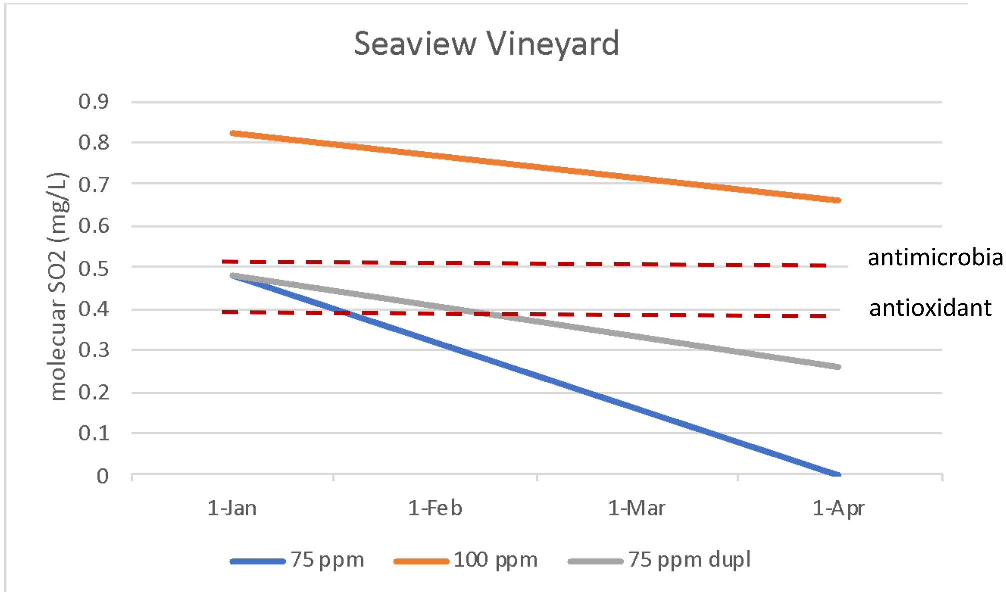
Table 2: Wine chemistry for two treatments of two lots of Chardonnay (ICV Labs)

Date	Batch	Treatment	Volatile Acidity (g/L)	pH	Titratable Acidity (g/L)	Malic Acid (g/L)	Alcohol (%)
12/11	Seaview	75 ppm	0.18	3.61	5.05	1.91	12.26
12/11		100 ppm	0.18	3.59	5.01	1.9	12.36
12/11	Blenheim	75 ppm	0.2	3.73	5.05	2.38	12.41
12/11		100 ppm	0.2	3.73	5.1	2.42	12.41
3/22	Seaview	75 ppm	0.23	3.6	4.97	1.9	12.37
3/22		100 ppm	0.24	3.59	5.01	1.88	12.51
3/23	Blenheim	75 ppm	0.24	3.73	4.99	2.23	12.6
3/22		100 ppm	0.23	3.72	5.11	2.47	12.57

Table 3: SO_2 chemistry (mg/L) for two treatments of two lots of Chardonnay (in-house data, ICV labs)

Date	Batch	Treatment	pH	free SO_2	mol SO2	target	addition
1/28	Seaview	75 ppm	3.54	26	0.48	0.5/26	0
1/28		100 ppm	3.54	45	0.82	0.5/26	0
1/28	Blenheim	75 ppm	3.68	14	0.19	0.5/38	30
1/28		100 ppm	3.68	32	0.43	0.5/38	10
4/6	Seaview	75 ppm	3.54	0/14	0	0.5/26	*35*
4/6		100 ppm	3.54	36	0.66	0.5/26	*0*
4/6	Blenheim	75 ppm	3.68	24/40	0.32	0.5/38	20
4/6		100ppm	3.68	44	0.59	0.5/38	*0*

Figure 2: SO_2 chemistry over time for two treatments of two lots of Chardonnay



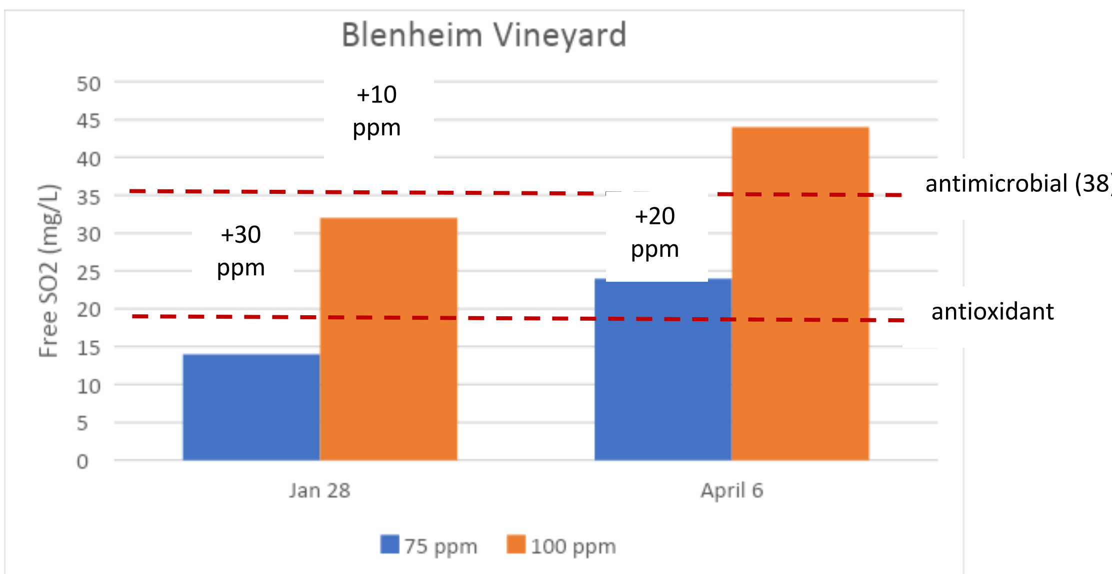


Table 4: Microbial population in two treatments of two lots of Chardonnay after five months (ETS labs)

Vineyard	Treatment	Acetic Acid Bacteria	*Brettanomyces bruxellensis*	*Oenococcus oeni*	*Saccharomyces cerevisiae*	*Zygosaccharomyces* species
Seaview	75 ppm	278000	1060	580	13200	0
	100 ppm	24600	510	210	16600	0
Blenheim	75 ppm	145000	950	12300	4930	40
	100ppm	26500	340	820	26300	0

Figure 3: Microbial population in two treatments of two lots of Chardonnay after five months (ETS labs)

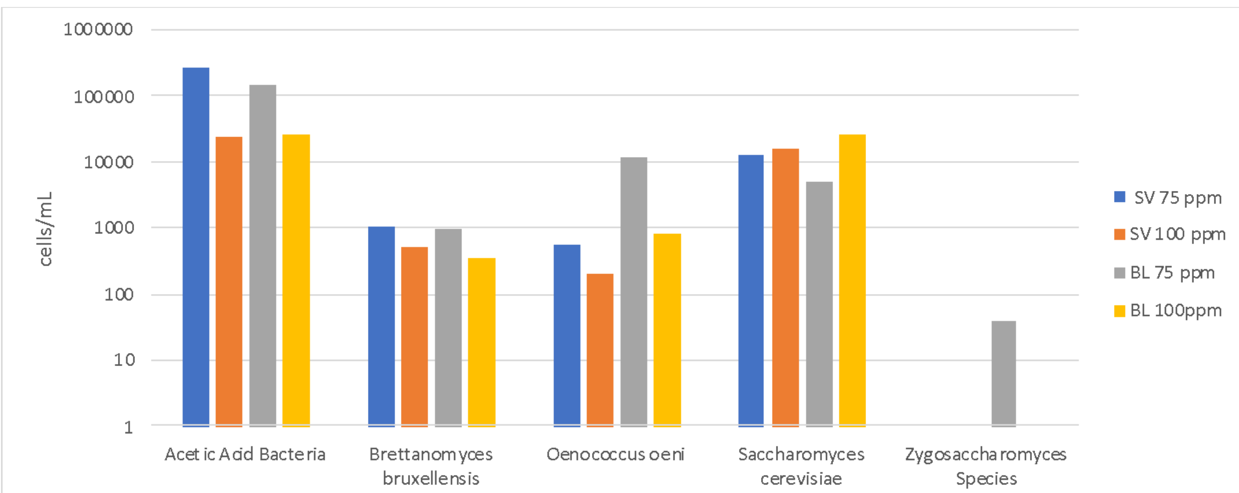


Table 5: Statistical analysis for descriptive scores from blind sensory analysis of Chardonnay

	Seventy Five		One Hundred			
Descriptor	Mean	SD	Mean	SD	F	P
Aromatic Intensity	5.8	1.66	6.6	1.21	1.48	0.24
Chardonnay Characteristic	6.7	1.62	6.4	1.36	0.48	0.50
Volume/Body	6.3	1.42	6.0	1.41	0.34	0.57
Perception of SO2	4.2	1.54	4.8	1.66	0.96	0.34

Appendix A: Compilation of SO_2 recommendations (with separate reference list)

Effect	SO_2 level needed	Ref(s)
Antimicrobial (fungicide, bacteriocide)	Generally: 0.6 ppm molecular for reds, 0.8 ppm molecular for whites	5
Against yeast	Varies: up to 100 ppm free (Saccharomyces, Klockera, Candida); 0.8 - 1.5 ppm molecular	8
Against ML bacteria	10 ppm **tota**l slows, 50-80 total ppm prevents ML (0.6 ppm molecular); 50 gh/L inhibits ML, even if bound	5,8
Against Acetic Acid Bacteria	0.9 ppm molecular, >50 ppm free	8
Against Brett	0.3 ppm molecular to inhibit activity	3
	0.825 ppm molecular to eliminate viability (10,000 fold decreae in viable Brett)	8
Antioxidant	Target 20-40 ppm free during aging	3
Against enzymes at crush	20-80 ppm depending on fruit (50 ppm to healthy juice reduces PPO by 90%); 35 ppm will inhibit tyrosinases at crush	2,8
Red Wine oxidation	Risks below 10 ppm free	6
White Wine oxidation	Risks below 20 ppm free	6
Wine made from rotten grapes	Risks below 30 ppm free due to laccase	6
Guidelines		
SO_2 level	**Activity/Operation**	
150-200 ppm	General total sulfur limits for fine wine (sensory)	5,7
350 ppm	Legal limit of total sulfur	8
Aging (Free SO_2)		
20-30 ppm	Red wine aging; 0.6 molecular if done with ML, tannins allow antioxidant, 0.5 may be target if pH so high it is hard to achieve	6
30-40 ppm	White wine aging, 0.8 molecular to prevent ML, oxidation	6

40-80 ppm	Sweet wine aging	6
Bottling (Free SO_2)	Generally 0.4-0.8 ppm molecular	3
Targets		
10-30 ppm (0.3-0.6 ppm molecular)	Red wine	*6,7,8*
20-30 ppm (0.4-0.8 ppm molecular)	White wine	*6,7,8*
30-50 ppm (0.8-1.2 ppm molecular)	Sweet wine	6
Additions		
50-70%	Proportion of SO_2 added to juice that binds to sugar, rest binds aldehydes and ketones	8
50-67%	Proportion of free SO_2 vs. bound; lower for initial additions, higher for subsequent additions	6,7
Operations		
8-10 ppm	Extra addition during bottling to offset oxygen intake due to filtration, racking	7
5-6 ppm free	Needed to offset O_2 in headspace of bottle (or, sparge bottles)	8
Other numbers		
>100 ppm	Amount of SO_2 addition needed to slow fermentation at crush, less if lower pH	1
10-30 ppm	Amount of SO_2 produced by yeast during fermentation	6
5ppm	Loss per month during normal barrel aging	7
8-10 ppm	Free SO_2 lost in bottle in the first year	7
Timing		
3-4 days	Time needed for bisulfite binding, lag time for SO_2 re-testing	7
5 days	Time needed for degradation of acetaldehyde post fermentation	5

Appendix 1 References

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