PURDUE UNIVERSITY

PURDUE EXTENSION

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Commercial Winemaking Production Series

Use of SO_2 in High-pH Wines

Sulfur dioxide dosage

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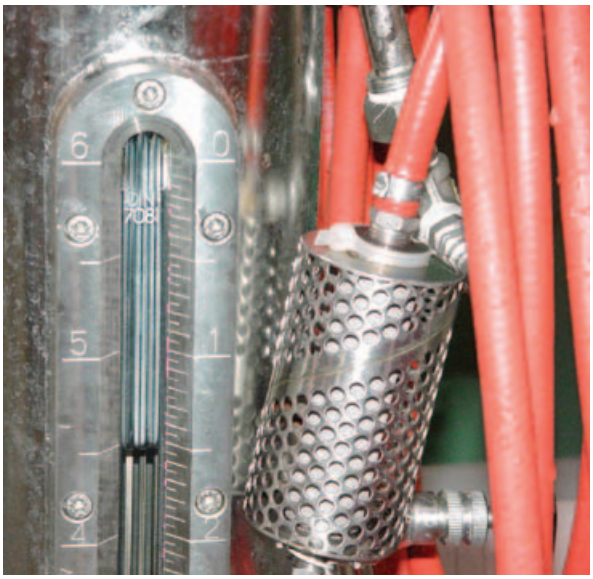
Wine pH and alcohol

How much free sulfur dioxide (SO_2) must a winemaker add or measure to prevent malolactic fermentation or *Brettanomyces* growth if a wine's pH is 3.95? The answer is between 79 and 112 mg/L, depending on the alcohol content of the wine. The requirements for free SO_2 concentrations in wine increase exponentially with pH, so at pH 4.0 they are 10 times higher than at pH 3.0. This does not leave room for rule-of-thumb or routine sulfite additions/adjustments. Sulfites added to wine in the form of either SO_2 gas or potassium metabisulfite salt exist essentially in two forms: ionized bisulfite (free SO_2) and sulfur dioxide gas (molecular SO_2).

Much of the sulfites that the winemaker adds to juice at crush or to wine post-malolactic is bound up by acetaldehyde, glucose/glucosides, and metabolic acids of microbial origin. Only a very small fraction (0.7 percent to 7 percent) of the nonbound sulfites in wine is present in the molecular (gas) form, but this is *exponentially* dependent on the wine's pH. Only this form actually kills unwanted bacteria and non-*Saccharomyces* yeasts. The vast majority (93 percent to 99 percent) of sulfites exist as the ionized bisulfite form that can bind additional acetaldehyde that forms during aging. Equally important, bisulfite can destroy the vitamin thiamin, which is essential for the growth of *Brettanomyces* yeast and certain wine bacteria. Only proper concentrations of free SO_2 provide additional capacity to bind more products of oxidative aging, to cleave thiamin, or to kill unwanted SO_2-sensitive microbes. *Brettanomyces* thrives at higher pH, at temperatures greater than 55˚F, in larger ullages, and at residual yeast nutrient levels. Luckily the thiamin break-up — given proper amounts of free bisulfite — occurs faster at a higher pH. Ethanol acts synergistically and enhances the bacteria-killing effect of molecular SO_2, so high-alcohol wines require less SO_2 protection (see dosage charts based on wine alcohol content below).



SO_2 gas dosing unit

The information in this publication is based on material from *Winemaking Problems Solved*, edited by Christian Butzke, Woodhead Publishing Ltd.

Table 1: Free sulfur dioxide required at a measured wine pH and for wines around 12 percent alcohol by volume (equal to 0.85 mg/L molecular SO_2).

Free SO_2 (mg/L) required at wine pH																			
3.0		3.1		3.2		3.3		3.4		3.5		3.6		3.7		3.8		3.9	
3.00	13	3.10	16	3.20	20	3.30	25	3.40	32	3.50	40	3.60	50	3.70	63	3.80	79	3.90	100
3.01	13	3.11	16	3.21	20	3.31	26	3.41	32	3.51	41	3.61	51	3.71	64	3.81	81	3.91	102
3.02	13	3.12	17	3.22	21	3.32	26	3.42	33	3.52	42	3.62	52	3.72	66	3.82	83	3.92	105
3.03	13	3.13	17	3.23	21	3.33	27	3.43	34	3.53	43	3.63	54	3.73	68	3.83	85	3.93	107
3.04	14	3.14	17	3.24	22	3.34	28	3.44	35	3.54	44	3.64	55	3.74	69	3.84	87	3.94	110
3.05	14	3.15	18	3.25	22	3.35	28	3.45	35	3.55	45	3.65	56	3.75	71	3.85	89	3.95	112
3.06	14	3.16	18	3.26	23	3.36	29	3.46	36	3.56	46	3.66	57	3.76	72	3.86	91	3.96	115
3.07	15	3.17	19	3.27	23	3.37	29	3.47	37	3.57	47	3.67	59	3.77	74	3.87	93	3.97	117
3.08	15	3.18	19	3.28	24	3.38	30	3.48	38	3.58	48	3.68	60	3.78	76	3.88	95	3.98	120
3.09	15	3.19	19	3.29	25	3.39	31	3.49	39	3.59	49	3.69	62	3.79	78	3.89	98	3.99	123
3.10	16	3.20	20	3.30	25	3.40	32	3.50	40	3.60	50	3.70	63	3.80	79	3.90	100	4.00	126
Molecular SO_2 :		0.85		mg/L		@ 12% alcohol by volume													

Table 2: Free sulfur dioxide required at a measured wine pH and for wines around 14 percent alcohol by volume (equal to 0.6 mg/L molecular SO_2).

Free SO_2 (mg/L) required at wine pH																			
3.0		3.1		3.2		3.3		3.4		3.5		3.6		3.7		3.8		3.9	
3.00	9	3.10	11	3.20	14	3.30	18	3.40	22	3.50	28	3.60	35	3.70	44	3.80	56	3.90	70
3.01	9	3.11	11	3.21	14	3.31	18	3.41	23	3.51	29	3.61	36	3.71	46	3.81	57	3.91	72
3.02	9	3.12	12	3.22	15	3.32	19	3.42	23	3.52	29	3.62	37	3.72	47	3.82	59	3.92	74
3.03	10	3.13	12	3.23	15	3.33	19	3.43	24	3.53	30	3.63	38	3.73	48	3.83	60	3.93	76
3.04	10	3.14	12	3.24	15	3.34	19	3.44	24	3.54	31	3.64	39	3.74	49	3.84	61	3.94	77
3.05	10	3.15	13	3.25	16	3.35	20	3.45	25	3.55	31	3.65	40	3.75	50	3.85	63	3.95	79
3.06	10	3.16	13	3.26	16	3.36	20	3.46	26	3.56	32	3.66	41	3.76	51	3.86	64	3.96	81
3.07	10	3.17	13	3.27	17	3.37	21	3.47	26	3.57	33	3.67	42	3.77	52	3.87	66	3.97	83
3.08	11	3.18	13	3.28	17	3.38	21	3.48	27	3.58	34	3.68	42	3.78	53	3.88	67	3.98	85
3.09	11	3.19	14	3.29	17	3.39	22	3.49	27	3.59	35	3.69	43	3.79	55	3.89	69	3.99	87
3.10	11	3.20	14	3.30	18	3.40	22	3.50	28	3.60	35	3.70	44	3.80	56	3.90	70	4.00	89
Molecular SO_2 :		0.60		mg/L		@ 14% alcohol by volume													

SO_2 requirements

The requirements for free SO_2 are not a stylistic option for the winemaker. Nor is it a good practice to routinely add "only" 20 or so parts of free SO_2 to each and every wine. If the winemaker decides not to follow the charts above, he or she might just as well not add any SO_2 at all, as it will not make much difference.

Aging potential

In recent decades, the increased demand for wines made from very ripe fruit has led to the production of wines with very high pH values (greater than 3.8). While the preference for wines that appear softer at a younger age due to a lack of acidity is understandable, the rules for SO_2 additions remain the same. Unfortunately, because of the exponential nature of the relationship between acidity and SO_2, high-pH wines require the addition of excessively high amounts of free sulfites. At these concentrations, the winemaker may believe that the sensory threshold for sulfur dioxide will be exceeded.

The fear that the pungent, metallic odor of a freshly-lit-match, a characteristic of SO_2 gas, will overpower the wine's varietal character and mask its fruitiness can lead the winemaker to avoid the proper dosage according to the chart. Interestingly, the sensory attributes of SO_2 are related to the volatile molecular form whose concentration remains intentionally the same at any of the recommended doses. More importantly, the smell of SO_2 is very closely related to the wine's temperature, so tasting it straight from the barrel at 54˚F (12˚C) vs. from the bottling tank at 68˚F (20˚C) will make quite a difference, as the warmer temperature releases approximately 50 percent more molecular SO_2 into the headspace of the tasting glass.

Certainly, though, a high pH reduces the ageabilty of a wine because oxygen uptake — and thus the major oxidative aging reactions, particularly browning — is accelerated. This must be considered especially if the wine is made for lengthy barrel and bottle aging prior to release as required by law in certain appellations. This should be of particular concern to regions that are experiencing elevated natural cellar temperatures due to global warming.

Acidity adjustments

Ideally, the winemaker could adjust the pH of the wine without significantly changing its perceived acidity and mouthfeel. However, lowering of the pH without noticeably increasing the titratable acidity (T.A.) of the wine is only possible by using strong inorganic acids such as hydrogen chloride. This, however, is illegal. The winemaker's repertoire is usually and rightfully comprised of the acids naturally occurring in grapes. The dated techniques of ion exchange and electrodialysis for pH adjustments have not been widely adopted by the premium wine industry, leaving the modern winemaker with few options. These include modest acid additions at crush to bring the pH below at least 3.8 based on predictive modeling; a partial, earlier picking and back-blending of more acidic lots; and (field-)blending with varietals — including hybrids — that can retain more acid. Another alternative is to suggest changes to the code that regulates local winemaking practices.

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