Amer J Enol & Vitic, 1991, Vol. 42, #4, pp. 354-357

Color of Riesling and Vidal Wines as Affected by Bentonite, Cufex° and Sulfur Dioxide Juice Treatments

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Browning has been controlled by sulfur dioxide (SO_2) in wine for many years, but other compounds also have the potential to reduce browning. Bentonite, Cufex and SO_2 were applied to juice from Riesling grapes Vitis vinifera L. and Vidal grapes, a French-American Hybrid to compare their effects on wine browning. Seven treatments (control, 35 mg/L SO_2, 70 mg/L SO_2, 120 mg/L bentonite, 240 mg/L bentonite, 90 mg/L Cufex and 150 mg/L Cufex) were applied to the juice. Two levels of SO_2 (0 and 20 mg/L) and two storage times (initial and 3 months at 37°C) were established on each of the seven treatments after fermentation was complete. The SO_2 juice treatments resulted in the least browning (absorbance at420 nm), and bentonite and Cufex treatments were also less brown than the control. Sulfur dioxide juice treatments and SO_2 at bottling increased green and reduced yellow color as was shown by lower Gardner Color Difference meter 'a' and `b' values. The addition of 20 mg/L SO_2 at bottling further decreased browning but was more effective in Riesling than in Vidal wines. Three months storage at 37°C increased browning almost two-fold as compared to initial readings.

KEY WORDS: bentonite, Cufex© sulfur dioxide, browning

Oxidative browning in wines is usually suppressed by the application of SO_2. However, in recent years health authorities have discouraged the use of sulfites in foods due to allergic reactions incurred by a small portion of the asthmatic population. This concern over sulfites has resulted in new food labeling laws requiring wines containing over 10 mg/L sulfites to be labeled (2,5). Alternatives to SO_2 have been sought, but to date no replacement has been found. However, several materials such as bentonite and Cufex® have the potential to perform some functions of SO_2.

Sulfur dioxide reduces browning in three ways: as an antioxidant, as a bleaching agent, and as an addition compound that reacts with active carbonyl groups to form stable compounds not susceptible to oxidation (10). In addition, SO_2 acts as an inhibitor of enzymatic oxidation.

Bentonite, a volcanic aluminum silicate clay with exchangeable cationic components, is used to reduce the protein content of wines (1,10). Bentonite adsorbs polyphenoloxidase (PPO), phenols, and positively charged molecules. Polyphenoloxidases are responsible for much of the browning in grape juices and fruits. Phenols are the main substrate for oxidation in wines (6), and adsorption of phenols in juice by bentonite may reduce browning potential.

Cufex is a sequestered complex of ferrous sulfate and potassium ferrocyanide in water. Its primary use in wines is to remove copper and iron (1,10). In a preliminary study (unpublished data) Cufex was added to juices in an attempt to inactivate PPO through chelation of copper. The levels of Cufex used had little effect on PPO activity. However, wines produced from these juices were less brown than controls. This difference may be due to the removal of the browning catalysts, copper and iron. Some winemakers have also noted that "blue finings," (Cufex-type compounds) may act as antioxidants in wines (9).

The objectives of this study were to (a) examine the effects of bentonite, Cufex, and SO_2 juice treatments on color quality in white wines and (*b*) determine if additional SO_2 at bottling would further affect color.

Materials and Methods

Riesling grapes, Vitis uihi fera L., and Vidal grapes, a French-American hybrid, were grown in the University of Arkansas Food Science Department vineyards. Bentonite was obtained from the Wine Lab (Napa, CA 94559), and a 5% slurry was prepared in boiling, deionized water and allowed to set for two days at 2°C prior to use. Cufex® (Finer Filter Products, a Division of Cellulo Co., Fresno, CA 93721) was obtained and used as a 10 % standardized suspension. Sulfur dioxide was added as potassium metabisulfite.

The study was arranged in a 2 X 2 X 2 X 7 factorial design with two cultivars (Riesling and Vidal), two levels of SO_2 at bottling (0 and 20 mg/L), two storage times (initial and three months at 37°C), and seven juice treatments (control, 35 mg/L SO_2, 70 mg/L SO_2, 120 mg/ L bentonite, 240 mg/L bentonite, 90 mg/L Cufex, and 150 mg/L Cufex). Treatments were replicated twice. The control treatment had no SO_2 or fining agents applied. The bentonite levels used were equivalent to 1 and 2 pounds per thousand gallons; levels commonly used in finished wine for protein stability.

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This research was conducted at the University of Arkansas.
Published with the approval of the Director of the Arkansas Agricultural Experiment Station.
Manuscript submitted for publication 9 January 1991.

Vinification: Fruits were harvested at similar maturity, cooled to 2°C, and 45-kg lots were cluster pressed in a Willmes bladder press (type 100) at 2 bars. The juice was collected in 18.9-L glass carboys that had been purged with carbon dioxide gas. Three pressings per lot were required to fill each carboy. Bentonite, Cufex, and SO_2 were added to the juice stream as it exited the press. The juices were mixed with a 10.2-cm, paddle-type stirrer and then cold settled at 2°C for 24 hours and racked. Sugars were adjusted to 20°Brix with cane sugar, and acids were adjusted with tartaric acid to 8.0 g/L (calculated as tartaric acid). The yeast nutrient Fermaid (Lallemand, Inc. Montreal, Canada H1W 2N8) was added at a rate of 0.26 g/L. The juice was inoculated with *Saccharomyces cereadsiae* strain Wädenswil 27 (Lallemand Inc.) at a rate of 0.23 g/L. Fermentation temperature was 15.5°C, and lees were stirred at three- to four-day intervals. The wines were racked and then cold-stabilized by storing at 2°C for three months. The wines were filtered through a 0.45μm filter, bottled in 375-mL bottles, and sealed with crown caps. Sulfur dioxide was added to one-half of the bottles as a 1.3% (w/v) solution of potassium metabisulfite. One milliliter of this solution was required per 375-mL bottle to achieve 20 mg/L SO_2. All juice and wine transfers were made under nitrogen or carbon dioxide gas.

Analysis: Wines were analyzed initially and following three months storage in the dark at 37°C. The pH was determined with an Orion model EA 920 expandable ion analyzer standardized to pH 4.0 and 7.0 with standard buffer solution. Titratable acidity was determined by diluting 5 mL of wine or juice to 126 mL with deionized water and titrating to pH 8.2 with 0.1 N NaOH. Acidity is expressed as percent tartaric. Alcohol was determined with a Dujardin-Salleron Model 360 ebulliometer. A Gardner Color Difference Meter (CDM) was used to measure tristimulus color (Hunter Lab) values (3,4). The CDM was standardized to a white plate having values of (L = 92.4, a = -1.0, b =1.0). The CDM's optical cup was filled with 50 mL of sample and covered with the white plate. Browning was determined as absorbance at 420 nm with a Bausch and Lomb Spectronic 20. Phenolics were determined by the Folin-Ciocalteu assay (10) and are expressed as gallic acid equivalents (GAE). Hubach tests (10) were performed for residual cyanide on all wines with negative results. Sulfur dioxide was determined by the aeration oxidation procedure (10).

Statistical analysis: All data were subjected to factorial analysis of variance. Duncan's multiple range test was used to separate means of main effects. Least significant difference was used to separate means of interactions. Both tests were conducted at the 5% level of significance.

Results and Discussion

Vidal wines had higher pH and higher acidity values than Riesling wines (Table 1). Wines made from S02-treated juices were lower in pH than the other treatments. Juice pH was not different among treatments (data not shown).

Table 1. Effects of juice treatment, storage time, cultivar, and sulfur dioxide at bottling on pH, acidity, and phenol content of Riesling and Vidal wines.

Main Effects	pH	Acidity % tartaric	Total Phenol (mg/L GAE*)
Juice Treatments			
Control	3.25a**	0.74b	231b
SO 35mg/L	3.17bc	0.74b	243a
SO 70mg/L	3.14c	0.78a	246a
Bentonite 120 mg/L	3.21ab	0.74b	230b
Bentonite 240mg/L	3.24a	0.76ab	225bc
Cufex 90mg/L	3.23a	0.74b	219c
Cufex 150mg/L	3.25a	0.74b	224bc
Storage Time			
Initial	3.20a	0.74a	232a
3 months (37C)	3.22a	0.75a	230a
cultivar			
Riesling	3.09b	0.73b	212b
Vidal	3.29a	0.76ab	244a
SO at Bottling			
none	3.22a	0.75a	230a
20ppm	3.20a	0.74a	233a

*Gallic acid equivalents.
**Main effects in columns separated by Duncan's multiple range test at the 5% level. Means in columns having the same letter(s) are not significantly different.

The pH difference became apparent only after fermentation. The lowering of wine pH after juice application of SO_2 has been observed by the authors in similar studies (unpublished data). The lower pH may be a result of the direct reduction of *o*-quinone by SO_2. This would yield *o*-dihydroxyphenols and sulfuric acid (10). The sulfuric acid produced could lower the pH without substantially affecting the titratable acidity. Acidity levels were similar across all treatments.

Total phenolics (Table 1) were higher in Vidal wines than in Riesling wines. The highest phenol levels were on the SO_2 juice treatments, and the 90 mg/L Cufex treatment had the least phenolics. Sulfur dioxide interferes with the Folin-Ciocalteu test, producing slightly higher total phenol values than normal (8). Sulfur dioxide is also reported to increase the extraction of phenolics from pulp and skin (7). These two factors probably account for the higher total phenol levels of the SO_2 treatments. The total SO_2 values in mg/L at bottling for,Riesling and Vidal wines averaged 1.7 and 1.2 for non-SO_2 treatments, 19.2 and 26.0 for the 35 mg/L SO_2 treatment, and 69.5 and 72.1 for the 70 mg/L SO_2 treatment, respectively. There were no significant differences in ethanol levels; they were 12.4% ± 0.2 % by volume, and residual sugars were less than 0.05% on all wines.

The effectiveness of SO_2 in reducing browning is apparent from the low absorbance values at 420 nm (Table 2). The 70 mg/L SO_2 treatment was more effective than 35 mg/L SO_2 in reducing browning, and all treatments were less brown than the control. Wines stored for three months at 37°C were almost twice as brown as initial wines. The addition of 20 mg/L SO_2 at bottling decreased browning.

Table 2. Effects of juice treatment, storage time, cultivar and sulfur dioxide at bottling on color quality of Riesling and Vidal wine.

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Main Effects	Absorbance (420 nm)	Color Difference Meter L	a	b
Juice Treatments				
Control	0.133a*	45.9c	-1.9ab	12.9a
SO_2 35 mg/L	0.092c	47.8ab	-2.7c	10.6b
SO_2 70 mg/L	0.078d	48.5a	-2.9c	9.6c
Bentonite 120 mg/L	0.121b	46.0c	-2.0ab	12.5a
Bentonite 240 mg/L	0.116b	46.3bc	-2.3b	12.3a
Cufex® 90 mg/L	0.118b	44.7c	-1.9ab	12.4a
Cufex 150 mg/L	0.114b	45.9c	-1.8a	12.0a
Storage time				
Initial	0.079a	47.2a	-2.6b	9.5b
3 months (37°C)	0.142b	45.7b	-1.9c	14.0a
Cultivar				
Riesling	0.110a	47.1a	-3.1b	11.6a
Vidal	0.111a	46.0b	-1.7a	11.8a
SO_2 at bottling				
None	0.120a	46.1a	-1.9a	12.0a
20 ppm	0.101b	46.8a	-2.6b	11.5b

*Main effects in columns separated by Duncan's multiple range test at the 5% level. Means in columns having the same letter(s) are not significantly different.

The Gardner Color Difference Meter `L' value indicates the lightness or darkness of a sample with a value of 0 being black and a value of 100 being white. Small but significant differences were observed in the treatment 'L' values with the SO_2 treatments being the lightest (Table 2). The color of the wines was lighter initially than after storage. Riesling wines were lighter than Vidal wines, and the addition of SO_2 at bottling produced wines that were lighter in color than if no SO_2 was added. The CDM `a' and `b' values showed that SO_2 juice treatments were more green (lower `a' value) and less yellow (lower `b' value) than the other treatments. This effect was also seen when 20 mg/L SO_2 was added at bottling. During storage a large increase in `b' (yellow) 'and a small decrease in `a' (green) occurred with lower `L' values.

The interactive effects of cultivar, storage time and SO_2 on absorbance at 420 nm show that Vidal wine plus 20 mg/L SO_2 at bottling was less brown initially than Riesling under the same conditions (Table 3). The overall effect after storage for three months at 37°C was the opposite of that seen initially. Riesling wines were less brown after storage than Vidal wines when 20 mg/L SO_2 was added at bottling. The addition of 20 mg/L SO_2 at bottling did not benefit the Vidal wines. They exhibited the same degree of browning as the wines to which no SO_2 had been added at bottling. This may have due to the higher pH and greater phenol content of the Vidal wine (Table 1). Less SO_2 would have been in the more active molecular form in the Vidal wine than in the Riesling wine. This factor in conjunction with the higher phenol level would reduce the effectiveness of the SO_2 in preventing browning.

Table 3. The effects of cultivar, storage, and sulfur dioxide at bottling on color at 420 nm.

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Storage	SO_2 at bottling	Absorbance (420 nm)
	Riesling	
Initial	None	0.089
Initial	20 mg/L	0.077
3 months (37°C)	None	0.144
3 months (37°C)	20 mg/L	0.128
	Vidal	
Initial	None	0.095
Initial	20 mg/L	0.057
3 months (37°C)	None	0.148
3 months (37°C)	20 mg/L	0.142
LSD at 5%		0.015

Conclusions

Sulfur dioxide juice treatments produced wines with the least browning. Neither the bentonite nor Cufex juice treatments produced better wine color than the SO_2 treatment, but both produced better color than the control. Consequently, if a wine was produced without the use of SO_2, the addition of .bentonite or Cufex juice treatments should be considered. The addition of 20 mg/L SO_2 at bottling was effective in reducing browning after three months storage at 37°C in Riesling wine but not in Vidal wine. The reduced effectiveness of the SO_2 in the Vidal wine was probably due to a higher pH and phenol content.

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