Ascorbic Acid Effects on the Post-Disgorgement Oxidative Stability of Sparkling Wine

A. C. MARKS\textsuperscript{1} and J. R. MORRIS\textsuperscript{2}

Abstract. Post-disgorgement oxidative changes in bottle-fermented sparkling wines produced from Vitis vinifera and hybrid wine grape cultivars were examined with ascorbic acid and sulfur dioxide treatments added at disgorgement. Wines were stored 11 months at 21 °C before analysis. Acetaldehyde was highest and browning was lowest in the sulfur dioxide treatments. Ascorbic acid after the storage period was 52\% to 70\% of the original amount added. Increasing SO\textsubscript{2}, when ascorbic acid was used, had little effect on ascorbic acid stability. When SO\textsubscript{2} was used, there was no benefit from including ascorbic acid. Ascorbic acid treatments reduced browning over the controls in two of the six cultivars. An accelerated storage test showed that the ascorbic acid treatments had the highest potential for browning if exposed to high levels of oxygen and increased temperature.

Ascorbic acid has been utilized as an antioxidant in wine production with various degrees of success (3,5,15). However, little information is available regarding ascorbic acid use in bottle-fermented sparkling wine production. There is also a need for information concerning the stability of ascorbic acid in sparkling wine if it is to be used in commercial production.

Earlier work has shown that certain conditions favor ascorbic acid stability in solutions. These conditions include low pH, low phenolic levels, low O\textsubscript{2} concentration, and low SO\textsubscript{2} (7,14). Since bottle-fermented sparkling wines at time of disgorgement possess these qualities, they should be favorable media for ascorbic acid stability and use.

This study utilized both Vitis vinifera and hybrid wine grape cultivars. Hybrid grape use for sparkling wine production is increasing in the eastern United States, and information is needed regarding their oxidative stability when bottle-fermented. Hybrid wines appear more prone to oxidative changes than vinifera wines. Differences in phenolic composition, especially the flavanoid fraction, may account for differences in oxidation rates (8).

The main purpose of this study was to observe the effect of ascorbic acid on oxidation occurring after disgorgement compared to that of sulfur dioxide and to a combination of the two. Other objectives were to measure stability of the ascorbic acid in this medium, examine the phenolic levels in various cultivars, and observe the suitability of hybrids for producing sparkling wines.

Materials and Methods

Cuvees were produced from two V. vinifera cultivars (Chardonnay and Riesling) and from four hybrid cultivars (Cayuga White, Vidal, Chancellor, and Chardonel), all grown during the 1986 season. Hybrid vines were own-rooted and the vinifera cultivars were grown on SO\textsubscript{4} and 5BB rootstocks. Hybrid vines were cordon trained and spur pruned, and the vinifera\textsubscript{eas} were grown on a six-wire, vertical, multi-trunk renewed system and spur-pruned. Standard viticultural practices, such as disease and insect control, were conducted according to Arkansas Experiment Station recommendations.

Grapes were hand picked from each cultivar when closest to a predetermined harvest window of 17° to 19° Brix, 2.9 to 3.1 pH, and 9 to 11 g/L total acidity (tartaric acid equivalent). Deficiencies in soluble solids and/or acidity were corrected by addition of sucrose and tartaric acid, respectively, to levels of 18° Brix and 10 g/L total acidity. Whole clusters were pressed in a 100-L Willmes bladder press with 30 to 45 lb/in\textsuperscript{2} and four cycles of pressing. Juice yield was standardized for each cultivar at 0.5 L/kg grapes to minimize differences in phenolics due to processing technique. Sulfur dioxide was added at 50 mg/kg grapes at pressing, and the musts were cold-settled at 1.5°C for 16 hours. The next day, the musts were racked and inoculated with a 2\% (v/v) Pasteur Champagne (UCD #595) yeast starter culture. The yeast cultures were prepared from 20 g yeast/mL must, rehydrated in 40°C H\textsubscript{2}O for 15 minutes, added to 2\% of the volume of must to be fermented, and inoculated after a 24-hour incubation at 21°C. Fermentation and processing were carried out in 19-L glass carboys at a fermentation temperature of 21°C for the first 24 hours and then at 15°C until completion.

After cold stabilization (3 weeks at 1.5°C), the cuvees were reinoculated for the secondary fermentation with the addition of 25 g/L sucrose and a 5\% (v/v) starter culture of Pasteur Champagne yeast and placed in crown-capped 750-mL champagne bottles. The cultures were prepared in the same manner as for the primary fermentations (20 g yeast/mL wine) to yield a cell concentration of 106 cells/mL wine in the bottles. Eleven months were allowed for the secondary fermentation before riddling, disgorging, and treatment.

\textsuperscript{1}Enologist, Hermannhof Winery, 330 E. First St., Hermann, MO 65041; \textsuperscript{2}University Professor, Department of Food Science, University of Arkansas, 272 Young Avenue, Fayetteville, AR 72703.

Treatments were applied immediately after disgorging, and the bottles were recapped. With four replications of each, the treatments were applied to the experimental units (bottles) as follows: (1) control (no treatment); (2) ascorbic acid, 50 mg/L; (3) ascorbic acid, 100 mg/L; (4) SO₂, 30 mg/L; and (5) ascorbic acid, 50 mg/L + SO₂, 30 mg/L. The ascorbic acid and SO₂ (as potassium metabisulfite) stock solutions were prepared immediately before use and kept in an ice bath during application. Headspaces were adjusted to a consistent level with base wine from each cultivar. After treatment, bottles were stored at 21°C for 10 months before chemical analysis. Before analysis or color measurement, all samples were decarbonated for 20 minutes in a Hotpack Model 633 vacuum chamber at 21°C. Although not performed in this study, the vacuum decarbonation step should be evaluated for possible loss of free SO₂ and acetaldehyde when analyzing these compounds.

Free and total SO₂ levels were measured by the aeration-oxidation (AO) method (2). Absorbencies at 420 nm and 520 nm were measured with a Bausch and Lomb Spectronic 20 spectrophotometer. Hue was calculated as the absorbance at 420 nm/520 nm and intensity as the absorbance at 420 nm + 520 nm (4). Color was measured with a Gardner Instruments XL10 CDM color difference meter with the meter standardized to a white plate value of L = 92.4, a =-1.0, b =1.0. Chroma was calculated as the square root of a² + b² and hue angle as the arc tangent of a/b (4).

Acetaldehyde levels were analyzed with an acetaldehyde enzymatic assay kit (Boehringer-Mannheim) and the method of McCloskey (6). A Varian 634-5031 LTV/vis double-beam spectrophotometer at 340 nm was used for the measurements. Ascorbic acid was measured with the BoehringerMannheim ascorbic acid enzymatic test kit based on the method of Beutler (1). Measurement was at 578 nm with a Varian 634-5031 spectrophotometer. Phenolic monomers were analyzed by the ultraviolet spectroscopy method (10,12,13). This method was used because sulfur dioxide interferes in the traditional Folin reagent test (11). This interference is especially magnified in low phenolic samples such as sparkling wines.

An accelerated storage test (9) was used to monitor potential for browning. An incubator oven (Fisher Econotemp Model SSG) set to 50°C was used for holding samples, and absorbance at 420 nm was read daily for four days. All data were subjected to analysis of variance, and a Duncan's multiple range test at the 5% level was used to separate treatment means.

**Results and Discussion**

In all cultivars, free SO₂ declined to low levels after the storage period (Table 1). Even in the SO₂ treatments, most of the SO₂ added became bound after 10 months in storage. This result illustrates the temporary nature of SO₂ when used as an antioxidant or antimicrobial agent.

Total SO₂ levels are presented in Table 2. Differences shown are accounted for by treatment addition. At typical sparkling wine pH levels (2.9 to 3.1), from 11 to 16 mg/L free SO₂ would be needed to obtain the desirable 0.8 mg/L.
molecular SO₂ oxidation and microbial control (16). For long-term sparkling wine storage, it appears that some type of addition (SO₂, ascorbic acid or other antioxidant) is necessary at the disgorging. The low, free SO₂ levels found in the SO₂ treatments, however, showed that longer-term oxidative stability in these samples would not appear likely.

Ascorbic acid stability after storage, as measured by remaining SO₂ was found in a range of 52% to 70% of the original amount added (Table 3). In comparing treatments 2 and 5 (ascorbic acid 50 mg/L and ascorbic acid 50 mg/L + SO₂ 30 mg/L) for five cultivars, the added SO₂ did not increase stability of ascorbic acid. Greater ascorbic acid stability with increased SO₂ was seen only for the cultivar Chancellor. The degree of ascorbic acid stability for these samples after the 11-month storage is higher than that reported in earlier studies (3,7,14). Based upon these results and the earlier studies, sparkling wines appear to be more conducive than still wines to ascorbic acid use.

In all cultivars, acetaldehyde was highest in the SO₂ treatments 4 and 5 (Table 4). These differences, although significant, are not great enough to be of a commercial concern. This result may have been due to increased acetaldehyde production by viable yeast cells remaining at the time of treatment. Ascorbic acid addition at 50 mg/L resulted in higher acetaldehyde than the control for only one cultivar - Chardonnay. Increasing ascorbic acid to 100 mg/L resulted in higher acetaldehyde than the 50 mg/L level for the cultivar Cayuga.

The results from absorbance and color analyses are presented in Tables 5 and 6. For all cultivars, absorbance at 420 nm was lowest for treatments 4 and 5, which indicated less browning. There was no difference in absorbance at 420 nm between treatments 4 and 5, showing no added benefit in regard to browning for including ascorbic acid when SO₂ was used. There was some reduction in browning over the controls with ascorbic acid treatments 2 and 3 for Cayuga and Chancellor. Hue, the ratio of absorbance at 420 nm to absorbance at 520 nm, can be used as a browning indicator with higher values indicating less browning. Based upon hue, results varied with each cultivar, and no consistent trends were observed. Color intensity was lowest for treatments 4 and 5 in all cultivars, indicating SO₂ to be most effective in this parameter. Color intensity was reduced by the ascorbic acid treatments in the cultivars Cayuga and Chancellor.

The data from the Gardner Color Difference Meter are shown in Table 6. In Chardonnay, Riesling,
Cayuga, and Vidal the chroma values indicated the least yellow color for treatments 4 and 5. The only ascorbic acid treatment that resulted in less yellow color than the control was ascorbic acid 100 mg/L in Cayuga. For Chancellor, all treatments reduced red color over the control, with treatments 4 and 5 giving the most reduction. Hue angle can be used as a color change indicator, which is particularly useful for white grape cultivars. As color changes from green-yellow to yellow, hue angle decreases (4). Riesling and Cayuga showed the greatest hue angle increases for treatments 4 and 5, which indicated less browning according to this parameter in the white cultivar. In Vidal, only treatment 5 increased hue angle.

Riesling, Vidal, and Chardonnay had low flavonoid phenolic levels (Table 7). Non flavonoids were highest in Vidal and lowest in Chancellor. Total phenolic levels were highest in Cayuga, Vidal, and Chancellor.

Results from the accelerated storage tests are shown in Table 8. After heating for two days, differences among the treatments became evident. The treatments containing ascorbic acid browned to a much greater degree than the control. Treatment 4 (SO2 only) had the least browning potential of all cultivars as measured by this method. The harsh conditions of this test (high heat and oxygen saturation) would probably never be encountered by bottled sparkling wines, but the test does show the potential for ascorbic acid to accelerate oxidation if used without considering the factors affecting its stability. If adverse factors are present, such as high phenolics and high O2 concentration, ascorbic acid degradation would generate H2O2, which can act as a potent oxidant. Under such conditions, ascorbic acid use would be detrimental to the oxidative stability of the product.

Conclusions

The sparkling wines in this study were favorable media for ascorbic acid stability. Increased SO2 added at disgorging had little effect in decreasing oxidation resulting from ascorbic acid addition except in the cultivar Chancellor. This would indicate a possible need for including SO2 with ascorbic acid addition to "blanc de noir" style sparkling wines made from this red hybrid grape.

Sulfur dioxide additions were most effective in reducing browning as measured by absorbance and color difference meter. There was no added benefit for including ascorbic acid when SO2 was used in the dosage. Ascorbic acid did reduce browning (as measured by absorbance at 420 nm) over the controls in two of the six cultivars. Observed differences in phenolic composition would seem to account in part for differences in cultivar behavior relative to ascorbic acid. The drawback to use of sulfur dioxide was higher acetaldehyde levels in the wines, which could be detrimental to the aroma of a sparkling wine if found at high enough levels and with low SO2 to have minimal binding of the acetaldehyde by SO2.

Under conditions of long storage and exposure to high heat, sparkling wines containing ascorbic acid would have high browning potential. These conditions need to be avoided if ascorbic acid is used. The results from this study show that ascorbic acid may be successfully used in sparkling wines from certain cultivars. Expected benefits in aroma due to lower acetaldehyde levels with use of ascorbic acid rather than SO2 indicates a need for sensory work to examine this factor.
Literature Cited


