Research Note

Effects of Acetaldehyde and Tannins on the Color and Chemical Age of Red Muscadine (Vitis rotundifolia) Wine

C. A. SIMS* and J. R. MORRIS

A red muscadine wine treated with 300 or 600 mg/L acetaldehyde had less browning, greater color intensity, and greater chemical age (levels of anthocyanin-tannin polymerization) than an untreated wine. Tannic acid had no major effect on browning or chemical age, but increased color intensity as compared to the control. A commercial "tannin" increased browning slightly, but did not affect color intensity or chemical age.

Muscadine grapes (Vitis rotundifolia) are widely planted in the southern US for wine production. Wines made from the better cultivars of muscadine grapes possess a unique, fruity flavor that many people in the South enjoy. Red muscadine wines have adequate to excellent color initially, but brown and lose color intensity rapidly during marketing. This severe color instability limits the shelf-life and hinders the acceptability of wines produced from the red muscadine grape.

Several factors contribute to the color instability of red muscadine wine, including cultivar (2,6,8), anthocyanin composition (1,2,8,13), pH (16,17), and processing and storage conditions (3,7,8). Red muscadine grapes contain only the diglucoside anthocyanins (1) which have been shown to brown to a greater extent than the monoglucoside anthocyanins (15). Sims and Morris (16) have recently reported that the color instability of red muscadine wines was related to a low degree of anthocyanin-tannin polymerization. Anthocyanin-tannin polymerization is a normal maturation reaction in most red Vitis vinifera wines (4,5,10,12,21,22) and helps stabilize the color of these wines (18,25).

Red muscadine wines may lack the necessary tannin species for normal anthocyanin-tannin polymerization, or perhaps the diglucoside anthocyanins are not readily incorporated into these complexes.

Acetaldehyde has been shown to increase the spectral color and anthocyanin-tannin polymerization in red Vitis vinifera wines (5,9,11,19,23,24). Various tannin fractions and flavonoids have also been shown to increase anthocyanin-tannin polymerization and improve the color stability (25). The objectives of this research were to determine if acetaldehyde and commercial tannin preparations would promote anthocyanin-tannin polymerization and improve the color stability of red muscadine wine.

Materials and Methods

Red wine was made from the red muscadine grape cultivar Noble.

The grapes were machine harvested and crushed within 12 hours after harvest. One hundred mg/L SO2 was added as potassium metabisulfite, and the must was fermented in 30-liter food-grade polyethylene containers with Montrachet yeast at about 25°C. The must was pressed at 2° to 3°Brix (6% - 7% ethanol), the °Brix adjusted to 22% based on the initial °Brix, and the wine was fermented to dryness (10% - 11% ethanol). The wine was racked periodically, cold stabilized for one month at 0°C, and the treatments established.

A control and six treatments consisting of 300 and 600 mg/L acetaldehyde, 500 and 1000 mg/L tannic acid ("wine tannin", Aceto Chemical Co., Flushing, NY), 500 and 1000 mg/L "tannin" ("natural grape tannin", unknown composition, Wines Inc., Akron, OH) were established. All mixing was done under a blanket of nitrogen to limit oxidation. All treatments were replicated twice. The wines were bottled in 400-mL round wine bottles, sealed with screw-on closures, and analyzed after zero and eight months of storage at 20°C.

The pH was determined with a glass electrode and a Corning Model 130-pH meter that had been standardized to pH 4.00 and 7.00 with standard buffer solutions. Titratable acidity was determined by diluting 5 mL of wine to 125 mL with deionized water and titrating to pH 8.2 with 0.1 N NaOH. Titratable acidity is reported as milliequivalents (meq) of acid. The tristimulus color of the wine was determined using a Gardner color difference meter (CDM) that had been standardized to a dark red plate (CDM b values have been used in previous research (16,17) to monitor browning.

The color characteristics and chemical age (level of polymeric anthocyanins) were determined by the method...

---

*Research Assistant and Professor, Department of Food Science, University of Arkansas, Fayetteville, AR 72703.

Published with the approval of the Director of the Arkansas Agricultural Experiment Station.

The authors thank Post Winery, Altus, Arkansas, for its financial support of this research. This research conducted at University of Arkansas, Fayetteville.


Copyright © 1986 American Society for Enology and Viticulture. AJEV 36:163-165
of Somers and Evans (22) using a Varian (Series 6345) double-beam spectrophotometer. A slit width of 1.0 nm was used for all determinations, and a 1- or 10-mm pathlength was used, depending on the particular determination. All absorbances were corrected to the 10-mm pathlength.

For statistical analysis, all data within each storage time were subjected to factorial analysis of variance. Duncan's multiple range test was used to separate means of the main effects.

**Results and Discussion**

The addition of 500 mg/L "tannin" increased the total phenolics (gallic eq.) by about 230 mg/L, while 1000 mg/L "tannin" increased the total phenolics by about 500 mg/L (Table 1). Tannic acid added at the rate of 500 mg/L increased the total phenolics by 350 mg/L, and tannic acid at 1000 mg/L increased the total phenolics by about 820 mg/L. Total phenolics decreased during storage, but the same differences among treatments were present after eight months. The decrease in total phenolics during eight months was greater in wines treated with acetaldehyde than in the other wines. This larger decrease in phenolics due to acetaldehyde could have been due to the formation of phenolic polymers large enough to precipitate. Other researchers (11,12,14,23,24) have noted that acetaldehyde-linked phenolic polymers can become large enough to precipitate. The treatments did not have any effect on pH, but tannic acid slightly increased titratable acidity (Table 1).

All wines decreased in color intensity during eight months. However, both concentrations of tannic acid and acetaldehyde increased the color intensity of the red muscadine wine initially and after eight months as compared to the control as shown by higher absorbance at 520 nm and visual intensity ratings (Table 2). Although acetaldehyde did slightly increase the loss of phenolics during eight months, it did not increase the loss of absorbance at 520 nm, indicating no greater loss of anthocyanins in wines treated with acetaldehyde. A subsequent analysis of the wines a few months later may have shown increased loss of anthocyanins in wines treated with acetaldehyde.

Wine treated with 1000 mg/L tannic acid had similar absorbance at 520 nm as wine treated with acetaldehyde. However, acetaldehyde increased the visual intensity to a greater extent than tannic acid. The "tannin" did not affect the color intensity (Table 2). Several other researchers (5,11,19) have reported an increase in color intensity of red wine upon the addition of similar levels of acetaldehyde.

There was very little browning in the wine initially, but after eight months the wines that had been treated with acetaldehyde were less brown than the other wines as shown by CDM b values and visual browning ratings (Table 2). The wines treated with acetaldehyde also had a higher chemical age after eight months than the other wines, which indicates that acetaldehyde promoted polymerization of anthocyanin with tannins (Table 2). The high concentration of acetaldehyde (600 mg/L) increased the chemical age to a greater extent than the low concentration (300 mg/L). The "tannin" did not significantly affect the chemical age, but it did slightly increase browning as shown by higher CDM b values. This

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total Phenols (mg/L gallic acid eq.)</th>
<th>pH (meq) Init.</th>
<th>pH (meq) 8 mo</th>
<th>Acidity (meq) Init.</th>
<th>Acidity (meq) 8 mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>15000*</td>
<td>1205d</td>
<td>3.25a</td>
<td>3.25a</td>
<td>0.43c</td>
</tr>
<tr>
<td>500 mg/L Tannin</td>
<td>1729d</td>
<td>1538c</td>
<td>3.25a</td>
<td>3.25a</td>
<td>0.43c</td>
</tr>
<tr>
<td>1000 mg/L Tannin</td>
<td>2000b</td>
<td>1733b</td>
<td>3.26a</td>
<td>3.26a</td>
<td>0.43c</td>
</tr>
<tr>
<td>500 mg/L Tannic Acid</td>
<td>1850c</td>
<td>1571c</td>
<td>3.25a</td>
<td>3.25a</td>
<td>0.44b</td>
</tr>
<tr>
<td>1000 mg/L Tannic Acid</td>
<td>2317a</td>
<td>1971a</td>
<td>3.25a</td>
<td>3.25a</td>
<td>0.45a</td>
</tr>
<tr>
<td>300 mg/L Acetaldehyde</td>
<td>1557a</td>
<td>1171d</td>
<td>3.26a</td>
<td>3.26a</td>
<td>0.43c</td>
</tr>
<tr>
<td>600 mg/L Acetaldehyde</td>
<td>1508e</td>
<td>1133d</td>
<td>3.26a</td>
<td>3.25a</td>
<td>0.43c</td>
</tr>
</tbody>
</table>

2 Means within storage separated by Duncan's multiple range test at the 5% level. Means followed by the same letter are not significantly different at the 5% level.

Results and Discussion

The addition of 500 mg/L "tannin" increased the total phenolics (gallic eq.) by about 230 mg/L, while 1000 mg/L "tannin" increased the total phenolics by about 500 mg/L (Table 1). Tannic acid added at the rate of 500 mg/L increased the total phenolics by 350 mg/L, and tannic acid at 1000 mg/L increased the total phenolics by about 820 mg/L. Total phenolics decreased during storage, but the same differences among treatments were present after eight months. The decrease in total phenolics during eight months was greater in wines treated with acetaldehyde than in the other wines. This larger decrease in phenolics due to acetaldehyde could have been due to the formation of phenolic polymers large enough to precipitate. Other researchers (11,12,14,23,24) have noted that acetaldehyde-linked phenolic polymers can become large enough to precipitate. The treatments did not have any effect on pH, but tannic acid slightly increased titratable acidity (Table 1).

All wines decreased in color intensity during eight months. However, both concentrations of tannic acid and acetaldehyde increased the color intensity of the red muscadine wine initially and after eight months as compared to the control as shown by higher absorbance at 520 nm and visual intensity ratings (Table 2). Although acetaldehyde did slightly increase the loss of phenolics during eight months, it did not increase the loss of absorbance at 520 nm, indicating no greater loss of anthocyanins in wines treated with acetaldehyde. A subsequent analysis of the wines a few months later may have shown increased loss of anthocyanins in wines treated with acetaldehyde.

Wine treated with 1000 mg/L tannic acid had similar absorbance at 520 nm as wine treated with acetaldehyde. However, acetaldehyde increased the visual intensity to a greater extent than tannic acid. The "tannin" did not affect the color intensity (Table 2). Several other researchers (5,11,19) have reported an increase in color intensity of red wine upon the addition of similar levels of acetaldehyde.

There was very little browning in the wine initially, but after eight months the wines that had been treated with acetaldehyde were less brown than the other wines as shown by CDM b values and visual browning ratings (Table 2). The wines treated with acetaldehyde also had a higher chemical age after eight months than the other wines, which indicates that acetaldehyde promoted polymerization of anthocyanin with tannins (Table 2). The high concentration of acetaldehyde (600 mg/L) increased the chemical age to a greater extent than the low concentration (300 mg/L). The "tannin" did not significantly affect the chemical age, but it did slightly increase browning as shown by higher CDM b values. This

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Abs. @ 520 nm</th>
<th>Visual Intensity</th>
<th>CDM b</th>
<th>Visual Browning</th>
<th>Chemical Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>3.03c</td>
<td>2.41c</td>
<td>7.0c</td>
<td>4.6c</td>
<td>8.1 a</td>
</tr>
<tr>
<td>500 mg/L Tannin</td>
<td>3.10c</td>
<td>2.45c</td>
<td>7.0c</td>
<td>4.6c</td>
<td>8.1 a</td>
</tr>
<tr>
<td>1000 mg/L Tannin</td>
<td>3.11c</td>
<td>2.47c</td>
<td>7.0c</td>
<td>4.6c</td>
<td>8.0 a</td>
</tr>
<tr>
<td>500 mg/L Tannic Acid</td>
<td>3.26b</td>
<td>2.61b</td>
<td>7.6b</td>
<td>5.2b</td>
<td>8.1 a</td>
</tr>
<tr>
<td>1000 mg/L Tannic Acid</td>
<td>3.44a</td>
<td>2.66ab</td>
<td>7.7b</td>
<td>5.4b</td>
<td>8.1 a</td>
</tr>
<tr>
<td>300 mg/L Acetaldehyde</td>
<td>3.40a</td>
<td>2.76a</td>
<td>8.0a</td>
<td>6.1 a</td>
<td>8.0 a</td>
</tr>
<tr>
<td>600 mg/L Acetaldehyde</td>
<td>3.41a</td>
<td>2.74a</td>
<td>8.0a</td>
<td>6.2a</td>
<td>8.1 a</td>
</tr>
</tbody>
</table>

Means within storage time separated by Duncan's multiple range test at the 5% level. Means followed by the same letter are not significantly different at the 5% level.

Rated on a scale of 1-10 with 1=very light red color and 10=dark red color.

Rated on a scale of 1-10 with 1=severe browning and 10=no browning.

This is a measure of the level of polymeric anthocyanins.

Table 1. Effects of tannin, tannic acid, and acetaldehyde on the total phenolic level, pH, and acidity of red muscadine wine initially (Init.) and after eight months.

Table 2. Effects of tannin, tannic acid, and acetaldehyde on the color of red muscadine wine initially (Init.) and after eight months.
increased browning due to "tannin" was not evident to the sensory panel, however.

Other researchers (5,9,11,19,23,24) have shown that acetaldehyde increases polymerization of anthocyanins with tannins. It has been suggested that this increased polymerization may be responsible for the increased color intensity of red wine treated with acetaldehyde (5,19). The lower browning rate of red muscadine wine treated with acetaldehyde may have been due to increased anthocyanin-tannin polymerization. Although the addition of acetaldehyde is not legal and would not be desirable from flavor and health standpoint, variable quantities of acetaldehyde are normally present in wines as a result of the oxidation of ethanol coupled with the oxidation of various phenolics (26). Thus, practices that increase the production of acetaldehyde may enhance the polymerization of anthocyanins with tannins and improve the color stability of red muscadine wine, provided that oxidation is not too severe and that anthocyanin-tannin polymers do not become so large as to precipitate. In addition, other conditions and practices that increase the polymerization of anthocyanins with tannins may improve the color stability of red muscadine wine.

Literature Cited