WA 46°N WINE

Washington State Wine Commission
Demonstration Research Grant Program
Final Report – Short Term Project 2022-23 Funding Cycle

PROJECT TITLE: Impact of acid timing on sensory perception

Project Duration: 1 year

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1. **Summary:** Three acid adjustment experiments were conducted during the 2022 vintage. Acid was added early at the fermentor and later post malo-lactic conversion or pre-cold stabilization for a red and white cultivar (Cabernet Sauvignon and Chardonnay). An additional acid adjustment experiment was conducted varying the malo-lactic conversion with Chardonnay.
2. **Objectives and Experiments Conducted to Meet Stated Objectives:**

Objective 1. Evaluate the impact of acid addition timing on wine sensory and basic chemistry were conducted.

a. Acid (2 g/L tartaric acid) was added to Chardonnay and Cabernet Sauvignon juices and musts at the fermentor (early) or post malo-lactic fermentation (late). Ion exchange (ion) was added to the trial which was not a part of the original grant, to provide practice using the ion exchange system and to provide additional acid data to the trial. Ion exchange was added to each trial as an equivalent to the late adjustment owing to the fact that the wines needed to be have very low solids to work with our ion exchange unit. Therefore there were four different treatments done in duplicate (Control, Early, Late, Ion) to high pH juice or must from Washington Chardonnay and Cabernet Sauvignon. Due to the high pH both Chardonnay and Cabernet Sauvignon could not be prevented from going through MLF.

Table 1 Basic Cabernet Sauvignon wine data from wines where 2 g/L tartaric acid was added early (at onset of fermentation), late and from ion exchange targeted to the late wine titratable acidity. Data presented here is for 14-days post ion exchange, 60-days post late addition, 210-days past early acid addition.

Treatment	pH	TA (g/L)	Malic acid (g/L)	RS (g/L)	Alcohol % (v/v)	Lactic acid (g/L)	Acetic Acid (g/L)
Control	4.274 a	4.02 b	0.07	0.17	11.67	1.85 ab	0.40
Early	3.944 b	4.44 b	0.06	0.25	11.83	1.70 b	0.36
Late	3.742 c	5.21 a	0.06	0.21	11.76	1.77 ab	0.39
Ion	3.762 bc	5.18 a	0.06	0.23	11.82	1.86 a	0.38
p-value	**0.001**	**0.001**	0.479	0.104	0.665	**0.040**	0.624

The results from the acid trial carried out on the Cabernet Sauvignon wines show a clear impact on pH despite not showing a consistent impact on titratable acidity. The results show that despite adding 2 g/L tartaric acid early there was no significant change in the titratable acidity 210-days later. We measured the early addition and there was a significant increase in titratable acidity (~1.3 g/L) but over time the titratable acidity declined to the same concentration as the control. The late addition and the ion exchange which were done more recently show a similar significant increase in titratable acidity (~1.3 g/L increase in titratable acidity) and a significant drop in pH (about a 0.5 pH units). The early addition also had a significantly lower pH than the control, but the pH change was smaller (about 0.3 units). There weren't any other appreciable changes to remaining basic chemistry of the wines. Though no formal sensory was carried out on this trial we did an informal sensory evaluation of the wines. The late and ion exchange wines were noticeably more sour than the control and early treatments. Given the disparity in pH and titratable acidity between the treatments the reasons seem obvious. The prevalent idea of acid integration discussed anecdotally by industry members may be explained by the dynamic changes in titratable acidity during fermentation and the early stages of aging. The observed losses in acidity is likely due to precipitation as potassium salts during this time period and precipitation of acids due to the higher amount of solids that are present in the wines. Stylistically the wines with acid added early will be less sour when released and benefit from the lower pH during fermentation whereas the wines with the acid added late will be likely perceived to be more sour, but more stable during barrel aging. Although as stated earlier it is unclear if the acid in the late and ion exchanged (which appear to be equivalent) will maintain the acidity. Hypothetically, it would seem more likely that the wines that have undergone ion exchange would be more stable due to the lower potassium concentrations. In this scenario we used the ion exchange to target a specific titratable acidity, which should be noted is not normally how the units are utilized (normally wines are adjusted to a target pH and the TA is a secondary target). In this case this worked very effectively though the obvious limitation of requiring low solids to use the small scale unit. Ion exchange units for juice are available but we don't have one. It took a significant amount of effort to find and purchase a small-scale ion exchange unit that would be equivalent to what is used in the wine industry. Ion exchange beads of more analytical grade such as used in chromatography are available but are cost prohibitive and may not be equivalent to industrially available resins.

The Chardonnay experiment with a malo-lactic fermentation was also performed (see Table 2). In this experiment lower pH and increased titratable acidity were observed in the early, late and ion exchange treatments. Similar dynamic changes occurred in the wines (as described in the Cabernet Sauvignon experiment) as they fermented and aged. The early addition wine increased the titratable acidity by ~2 g/L but finished at 4.43 g/L titratable acidity and were the same as the late addition and ion exchange treatments. The early addition had a lower pH by 0.3 units and the late had 0.7 units of change while the ion exchange was targeted to the mimic the pH of the early treatment wine (so 0.3 units). Sensory was performed on these wines and will be reported later in the report.

Table 2 Basic wine data for Chardonnay wines that have undergone malolactic fermentation where acid has been adjusted where 2 g/L tartaric acid was added early (at onset of fermentation), late and from ion exchange targeted to the late wine titratable acidity. Data presented here is for 14-days post ion exchange, 60-days post late addition, 210-days past early acid addition.

Treatment	pH	TA (g/L)	Malic acid (g/L)	RS (g/L)	Alcohol % (v/v)	Lactic acid (g/L)	Acetic Acid (g/L)
Control	3.869 a	3.74 b	0.01 b	0.38 b	13.35 a	2.03 a	0.13
Early	3.500 b	4.43 a	0.04 b	0.33 b	13.11 ab	1.87 b	0.15
Late	3.141 c	4.71 a	0.26 a	0.46 a	12.74 b	1.74 c	0.13
Ion	3.510 b	4.43 a	0.02 b	0.35 b	13.11 ab	1.96 ab	0.12
p-value	**0.001**	**0.005**	**0.003**	**0.015**	**0.145**	**0.007**	0.276

b. An additional Chadonnay experiment was carried out on account of some erronenous sulfur dioxide additions added at the press at our cooperators facility. We used this as an opportunity to evaluate the impact of the malo-lactic conversion on acid adjustment and thus these were not inoculated for the malo lactic fermentation (No MLF). Therefore we had an additional four Chardonnay wines for the experiment made in duplicate (Control, Early, Late, Ion).

Table 3 Basic wine data for Chardonnay wines that have not undergone malolactic fermentation where acid has been adjusted where 2 g/L tartaric acid was added early (at onset of fermentation), late and from ion exchange targeted to the late wine titratable acidity

Control	pH	Titratable acidity	Malic acid	Residual sugar	Alcohol	Lactic acid	Acetic Acid
Control	3.72 a	4.72 b	3.00 a	1.00 b	12.00 a	0.02	0.17 b
Early	3.35 a	5.95 a	2.90 b	1.83 a	11.93 a	0.02	0.20 a
Late	3.35 a	6.11 a	1.67 d	0.78 b	11.91 a	0.02	0.16 b
Ion	2.67 b	6.55 a	2.83 c	0.90 b	11.54 b	0.01	0.17 b
p-value	**0.013**	**0.010**	**<0.0001**	**0.002**	**0.010**	0.381	**0.008**

The results of the Chardonnay wine without malo-lactic fermentation are different to what was observed in the MLF Chardonnay and Cabernet Sauvignon experiments (table 3). In this case the changes in acidity were ~1.7 g/L and there were no large shifts titratable acidity as the wine fermented and aged. Essentially the early and late additions of acid were equivalent (no differences between TA and pH for the early or late addition, which were statistically different from the control). A healthy drop in pH (~0.37 units) was also observed. The ion exchange pH was very low and this likely is due to the targeting rather than titratable acidity of pH. This wine is effectively ruined given the pH is so low so we consider this a mistake that we won't repeat. We speculate that the higher buffering capacity due to the wine having both malic and tartaric acids present which caused this significant change to occur. We suggest that ion exchange is not advisable under these circumstances. There were some inconsistencies in the malic acid for the late addition which under initial inspection suggested that malo-lactic fermentation may have taken place, however the low lactic and acetic acids suggest otherwise.

c. Sensory was carried out on the Chardonnay, but not the Cabernet Sauvignon wines. We did a quick descriptive analysis of the wines with 16 panelists and only a single training session. Normally we train the panelists over 5-6 sessions, however we took advantage of a large number of students attending our sensory certificate program and did a limited panel. Further we combined all of the wines into one panel which included the higher acidity no ML wines with the lower acidity ML wines. With the limited training it made it difficult for the panelists to find the differences in acidity we were hoping to see. An ANOVA of the intensity ratings of sour showed differences between the no ML wines and ML wines, but not any of the acid additions. Despite this the panelists our principal component analysis (PCA) of the sensory data is shown in figure 1. The PCA is primarily separated by the stonefruit and sulfur dioxide attributes which were inversely related to each other along the X-axis. Generally non-ML wines were described more as sulfur dioxide than the wines that had undergone malo-lactic fermentation. The sour attribute explained the vertical axis which was primarily associated with wines that not undergone malo-lactic fermentation. In future we plan to re-evaluate the wines but each experiment separately from each other.

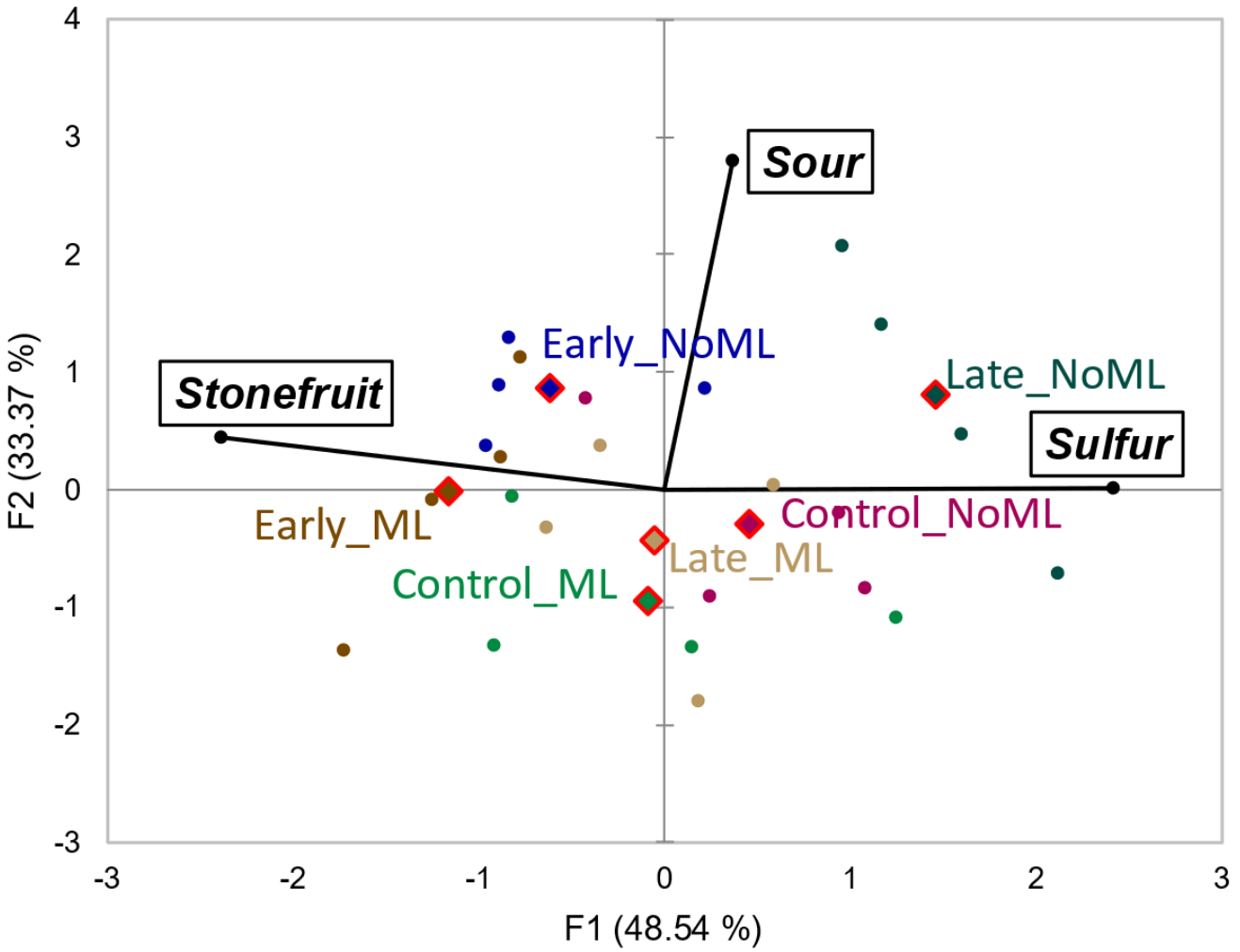

Figure 1 Principal component analysis of sensory data from acid adjusted (2g/L early and late) Chardonnay wines that have eitehr undergone malo-lactic fermentation or not (ML or no ML).

3. Major Research Accomplishments and Results by Objective:

- **a.** The effectiveness of acid addition on high pH wines that had undergone malolactic fermentation was impacted by timing. The changes seen in the early addition were not observed closer to bottling whereas the late additions were obvious. The use of ion exchange to target wine titratable acidity and match pH worked effectively for the wines that had undergone malolactic fermentation. The use of ion exchange may prevent further changes in wine acidity over time due to lower concentrations of potassium (ppt. of KHT).
- **b.** Early and late additions of acid on high pH wine that has not undergone malolactic fermentation were equivalent. Ion exchange on wines to target titratable acidity is difficult to achieve with reasonable results for the pH. Further research is necessary to understand the profound changes we observed.
- **c.** Formal sensory results were compromised by not training the panel long enough and including too many wines in the evaluation. Informal evaluation showed obvious changes in sourness which were related to changes in concentration for the wines that had undergone malolactic fermentation. The late acid additions were obviously more sour than the early additions as much of the acid that had been added early was gone.

4. **Research Presentations:** This is a very short project but we plan to present any relevant findings at a WAVEx seminar, in WSU course teachings
5. **Research Success Statements:** Wine acidity has been identified as one of the principal chemical and sensory wine attributes to be impacted by climate change. Understanding how to alter our wines to achieve the sensory and chemical outcomes is key to remaining competitive on the global wine market.
6. **Funds Status:** Funds were spent on an undergraduate intern salary.