MAKING WINE WITH HIGH AND LOW PH JUICE

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Overview

- How pH changes during winemaking
- Reds → To adjust for high pH and how
- Whites → Early harvest due to poor conditions
  - Low pH
  - Low varietal character
- Deacidification of White wine juice
pH in Wine

- pH is the MOST important number in winemaking!
  - Microbial stability
  - Indirect stylistic effects

- White wine range  3.20-3.50
- Red wine range  3.40-3.70
What Changes pH in the Winery

- **Skin Contact**
  - *With reds skin contact can* $\uparrow$ pH.
  - *How much can depend on contact time*

- **Acids produced during fermentation**
  - *Weak organic acid will actually* $\uparrow$ pH

- **Malolactic Fermentation**
  - $\uparrow$ *pH due to malic to lactic conversion (increase by 0.2 typical)*

- **Bitrartrate stabilization**
  - $\uparrow$ *pH if above 3.65 (3.5-3.8)*
  - $\downarrow$ *if pH is below 3.65 (3.5-3.8)*
Titratable Acidity

- With strong acids pH and TA are about the same
- Grapes have weak organic acids, thus pH and TA differ.
- TA in relation to pH relates to perceivable acidity
  - Same TA will taste more sour at lower pH values
- Is TA a useful harvest parameter?
<table>
<thead>
<tr>
<th>What happens to pH and TA during:</th>
<th>pH</th>
<th>TA</th>
<th>Comments *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid synthesis in the berry</td>
<td></td>
<td>↑</td>
<td></td>
</tr>
<tr>
<td>Acid degradation (malate respiration or gluconeogenesis)</td>
<td>-- or ↑</td>
<td>↓</td>
<td>pH can remain constant if the ratio tartaric:malic rises; or it can rise if there is mineral uptake</td>
</tr>
<tr>
<td>Uptake of K or Na</td>
<td>↑</td>
<td>↓</td>
<td>TA falls while extent of exchange increases</td>
</tr>
<tr>
<td>Post-veraison rainfall</td>
<td></td>
<td>↓</td>
<td>TA falls as acidity is diluted in swollen berries, no change in pH</td>
</tr>
<tr>
<td>Wine dilution with water</td>
<td>--</td>
<td>↓</td>
<td>pH does not change because K and Na are diluted at the same degree as TA</td>
</tr>
<tr>
<td>Yeast fermentation (by itself)</td>
<td>↑</td>
<td></td>
<td>Weaker acids (e.g. succinic) are formed at the expense of stronger ones</td>
</tr>
<tr>
<td>Malolactic fermentation</td>
<td>↑</td>
<td>↓</td>
<td></td>
</tr>
<tr>
<td>Precipitation of potassium bitartrate</td>
<td>--,↑or↓</td>
<td>↓</td>
<td>Interesting case in which effect on pH depends entirely on original wine pH: if original pH&lt;3.8, then pH drops; if original pH&gt;3.8, then pH increases; and if original pH=3.8, then there is no change in pH</td>
</tr>
<tr>
<td>Extended skin contact</td>
<td>↑</td>
<td>↓</td>
<td>Skin is rich in K+ and there is more extent of exchange</td>
</tr>
<tr>
<td>Actual fermentation (weak acid formation and bitartrate precipitation combined)</td>
<td>↑ or ↓</td>
<td>↓</td>
<td>Depending on the extent of two opposing forces: weak acid formation dominates, which raises pH; or bitartrate precipitation dominates, which lowers pH</td>
</tr>
<tr>
<td>Wine contamination</td>
<td>--</td>
<td>↑</td>
<td>TA due to formation of acetic and other acids, but impact on pH is negligible due to wine buffering capacity</td>
</tr>
</tbody>
</table>

* Please read discussion in original text for further explanation

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In General

- pH will increase after fermentation
- Excess skin contact will increase pH
- pH will decrease after cold stabilization (assuming adjustment)

- Expectedly, TA will decrease and pH will increase during the winemaking process
Acidity Index

- Acid perception depends on TA > pH and buffering capacity
- Combined use of total acidity and pH

- Acidity Index = Total Acidity(g/L) – pH

- Only valid
  - $TA \rightarrow (3.8-7.5)$
  - $pH \rightarrow (2.6-4.0)$

- Estimated “balanced” wine
  - $Red: AI = 2.6$
  - $White: AI = 3.9$

Only a very rough guideline

Red Wines Harvest Parameters

- Maturity with moderate pH is the goal

“Maturity”

- Mature
  - Soft tannins
  - Smooth tannic structure
  - Round mouthfeel
  - Full bodied
  - Deep color

- Immature
  - Rough
  - Bitter
  - Herbaceous
  - Astringent
The Red Grape Harvest Decision

- With warm and wet viticulture environments harvest is not easy

- Two main harvest parameters
  - pH
  - “grape quality in the field”

- We worry about
  - Increasing pH
  - Onset of rot
  - Dilution of berries due to water
High pH Happens

- Often a high pH > 3.6 is inevitable in reds

- The decision then is what route to take
  - *Low pH winemaking*
  - *High pH winemaking*

- The implications are...
  - *Stability*
  - *Stylistic choice of high pH wine*
Low pH Red Winemaking

- Always make major adjustments pre-fermentation
- Tartaric Acid
  - Most prominent acid in grapes
  - Most common acid to acidify juice/wine
  - Strongest of the acids found in grape juice…less needed
- Malic Acid
  - Will not precipitate like tartaric will
  - Will contribute to malolactic fermentation
  - Only L-malic will ferment
- Citric Acid
  - Never add before primary fermentation – bacterial metabolism
  - Good for final acid adjustment to finished wine
Low pH Red Winemaking

- 1 g/L of tartaric will lower pH 0.1 units
- Keep in mind how pH will change through winemaking:
  - **Fermentation** (0.1 unit)
  - **Skin contact** (0.05-0.2 units) Due to K in the grape skins
  - **ML fermentation** (0.1 - 0.3)
  - **Cold stabilization**

- Adjustment down to pH 3.35 of juice = finished wine pH of 3.2-3.9!
Low pH Considerations

- SO$_2$ has antimicrobial effect at lower pH values due to molecular SO$_2$
- Overall stability and aging...longer life span
- Fresh for the “modern” wine drinker
  - Vibrant color
  - More fruit forward = less oxidation
- New world style is fresh...and maybe tart (variety dependent?)
- Goes well with fruit forward stylistic techniques
  - (co-inoculation, tannin additions, shorter aging time)
High pH Red Winemaking

- Why?!?
- Stylistic approach is key
- Acidic “fresh” wines may be popular but “traditional” reds are desirable
- Effects of high pH reds
  - Less microbial stability
  - Less color stability
  - More round, soft mouthfeel
SO₂ has three main forms in wine
Stability through SO$_2$

- The molecular form inhibits microbes
- Loss of cell viability and inhibition of growth
- Rules of thumb
  - 0.5 ppm molecular SO$_2$ is sufficient if pH is not too high
  - 0.8 ppm molecular SO$_2$ is preferrable in unhealthy wine
Stability through SO$_2$

- Microbial stability is the largest factor
  - Sulfur dioxide is pH dependent
  - Molecular (free) sulfur dioxide
At High pH Free SO$_2$ is not the goal

- Above pH 3.6 we will not reach a good level of free molecular SO$_2$
- Oxidation is a large factor though!
- Oxidation of phenolics generates H$_2$O$_2$ leading to further oxidation
- Bisulfite is the largest scavenger of peroxide
- Bisulfite also inhibits enzymatic oxidation
- Add 15-20 ppm “free” to keep oxidation down
Living with Microbes

- We must consider all factors to allow microbes to flourish

- What do they need?
  - Nitrogen content
  - Temperature
  - Oxygen
  - Control agents?
Living with Microbes - Nitrogen

- Without sufficient molecular $\text{SO}_2$ microbial stability must be gained in different ways.

- Always run YANs to determine perfect nutrient amount
  - *Never make a general addition for fear of excess nutrients*
Nitrogen Requirements

- Depends on...
  - Yeast strain needs and Brix

- Low N Strains: Sugar (g/L) x 0.75
- Medium N Strains: Sugar (g/L) x 0.90
- High N Strains: Sugar (g/L) x 1.25

1º Brix ≈ 10 (g/L)

- Rule of Thumb
  - 150 mg/L = 21 degrees Brix
  - 200 mg/L = 23 degrees Brix
  - 250 mg/L = 25 degrees Brix
Living with Microbes - Temperature

- Careful of cool fermentations due to competition
- Fear the cold soak
- Tank fermentation is better for temp control
- Lower barrel room temps between 55-60
  - *Always sterile filter if kept at cool temps*
Living with Microbes - Oxygen

- High pH wines require less oxygen
  - Possible browning
  - Growth of unwanted organisms
- Very mindful barrel topping
- Gas reds in tank more regularly
Living With Microbes – Cellar Procedures

■ Strong “fast” yeast strain selection
■ Co-inoculation vs. sequential of ML bacteria
■ How much SO₂ to add and when
  – Don’t be afraid of high initial additions (depending on color)
  – Stay on top of barrel maintenance
■ Tannin addition to make up for intensity
■ Sterile filtration
Living With Microbes – Control Agents

Scott Labs:
- Lysozyme – LAB
- Bactiless – AAB and LAB
- No Brett Inside
- Velcorin
  - Kills yeast, bacteria and molds
  - Requires $74,000 dosing machine

- None of these replace SO$_2$
- Check on legalities if exporting
- All depend on microbial load and dosing
Extremely High pH...over 4.0

- “Plastering”
  - Calcium sulfate (gypsum) in combination with Tartaric Acid
  - Calcium sulfate removes H+ from tartaric acid
  - Thus lowers pH without affecting TA
  - 1 g/L of gypsum lowers pH 0.09 units (approximately)
  - Legal limit of sulfate = no more than 2.0g/L

- **Trial:**
  - Add gypsum up to approximately 1.5g/L ...Test
  - Add Tartaric Acid for further adjustment

- Not common b/c slow precipitation and some bitter aftertaste
Bringing it all together!

- Techniques of low and high pH winemaking can both be used for the end goal.
- The important point:
  - pH of reds ready for bottling should be 3.6-3.7
  - TA of reds ready for bottling should be 5-7 g/L

- Difference is style is about the pH at and after primary fermentation.
Questions?
Whites With Low pH

- Harvesting early can result in low pH and immature fruit

- Results:
  - Great for sparkling wine production
  - Increased acidity may result in deacidification
Deacidification

- Not a common adjustment to wine but has serious implications

- pH range 3.19-3.29 = upwards pH adjustment
  - Malolactic Fermentation = associated flavor changes
  - Calcium Carbonate (CaCO$_3$) – will remove tartaric acid in the form of calcium tartrate. Acceptable in small additions.
  - Can cause calcium tartrate instability – will result in precipitation of fine crystals over long periods of time...months after bottling!
Deacidification

- Potassium carbonate ($K_2CO_3$) or potassium bicarbonate ($KHCO_3$)
  - Potassium bicarbonate is more commonly used
    - Slightly weaker than potassium carbonate
    - Produces less $CO_2$

- Double Salt Method:
  - Reduction of both tartaric and malic acids
  - Deacidify a portion of the juice with all of the addition and add back to main lot. Treat 20%-30% of total. Has to be above pH 4.5
Double Salt Deacidification

- Name comes from the double salt – calcium tartrate malate

- Formed at a pH > 4.5, Maximum at 5.1, thus, only a portion of wine can be treated

- Take 20%-30% of wine and treat with calculated amount of calcium carbonate for entire batch.
  - Allow precipitation of salt crystals and then filter before blending back
  - Advantages:
    - Better sensory results and uniform acid removal
    - Can be used with high pH and high TA b/c it removes both malic and tartaric acids
## Calculate Deacidification

### TA Reduction

<table>
<thead>
<tr>
<th>Lower</th>
<th>Add</th>
<th>Salt</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 g/L TA</td>
<td>0.9 g/L</td>
<td>( \text{KHCO}_3 \text{ potassium bicarbonate} )</td>
<td></td>
</tr>
<tr>
<td>1.0 g/L TA</td>
<td>0.6 g/L</td>
<td>( \text{K}_2\text{CO}_3 \text{ potassium carbonate} )</td>
<td></td>
</tr>
<tr>
<td>1.0 g/L TA</td>
<td>0.67 g/L</td>
<td>( \text{CaCO}_3 \text{ calcium carbonate} )</td>
<td></td>
</tr>
</tbody>
</table>
Calculate Deacidification

pH Increase

The wine solution is buffered, thus, pH increase may not directly change with TA

Always run test trials when deacidifying
Deacidification

- Perceivable acidity is the most important thing.
- Consider both TA and pH values in this case.
- Actual pH and TA change depends on the juice buffering capacity
  - *Calculations are approximations*
- Consider acidity changes throughout the winemaking process.
Method of Addition

- Always conduct lab trials!!

- Too much of any salt may contribute to a salty taste.

- Conduct the trials below and up to calculated addition of salt.
Potassium Bicarbonate Trial

<table>
<thead>
<tr>
<th>Rate of addition of KHCO$_3$ (g/L)</th>
<th>pH</th>
<th>Titratable acidity (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (Control)</td>
<td>2.94</td>
<td>10.2</td>
</tr>
<tr>
<td>1</td>
<td>3.15</td>
<td>9.4</td>
</tr>
<tr>
<td>2</td>
<td>3.29</td>
<td>8.3</td>
</tr>
<tr>
<td>3</td>
<td>3.50</td>
<td>7.0</td>
</tr>
<tr>
<td>4</td>
<td>3.76</td>
<td>5.7</td>
</tr>
</tbody>
</table>
Low pH Summary

- Early harvest may force low pH issues
- Potassium bicarbonate is the best agent to add
- Always run trials to see affect on TA and pH
High pH Summary

- Can adjust pH with risk of increasing tartness
  - Adjust downward of 3.5 with tartaric acid

- Can maintain high pH with improved microbial control
  - Alternative...a combined approach

- SO$_2$ will always be beneficial even at a high pH

- We have microbial control agents if needed
Questions?