Wine Cold Stability Assessments and Techniques

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Enology Professor

www.indianaquality.org
Cold Stabilization

Potassium Bitartrate!
Cooling/Freezing (w/seeding)
Electrodialysis
Metatartrate
Mannoproteins
Ion exchange
Fluidized bed
Cold Stabilization

Typically about 26 °F for 3+ weeks
Freezing point of wine

Roger Boulton
in: Principles and Practices of Winemaking
Cold Stabilization

Energy

- 25% of winery energy use
- Uninsulated tanks: 1,200 Wh/gal
- Insulated tanks: 22 Wh/gal
- Electrodialysis: 8 Wh/gal
- Ion exchange: ? Wh/gal
- Fluidized bed: ? Wh/gal

http://www.practicalwinery.com/sepct08/page1.htm
Cold Stabilization

Time

- Uninsulated tank w/out seeding
- Insulated tank w/seeding
- Electrodialysis
- Fluidized bed
- Ion exchange

Days

0  10  20  30  40  50

http://www.practicalwinery.com/sepoct08/page1.htm
ISSUES:

Crystallization rate proportional to:

• Agitation rate
• Smaller seed particle (nuclei) size
• Seed concentration
• Lower temperature
Cooling/Freezing

Standard jacketed tank

=> no/little agitation
Cooling/Freezing

Standard *cream of tartar* = large crystal size

Powdered KBT => source?
Cooling/Freezing

Polish stainless steel tank = few nucleation sites/volume
Cooling w/seeding

*Cream of tartar pricey/imported* => too few seed crystals used

4-15 g/L = 33-125 lb per 1,000 gal

= $112-418 = 2-8c per bottle
Cooling/Freezing

Poor heat transfer

= waste of energy
Cooling/Freezing (w/seeding)
Electrodialysis
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PG&E studies electrodialysis for cold stability

California's 1,100 wineries produce 500 million gallons of some of the world's finest wines. In the process, they consume around 40 gigawatt-hours (GWh) of electricity every year — the equivalent of powering 60,000 homes. More than 25% of this electricity is spent on stabilization, the final step in which wines are acidified through energy-intensive refrigeration.

As an alternative to refrigeration, some wineries are using electrodialysis, a technology developed in Europe in the early 1900s. The portable acid and a salt solution, water, calcium, and potassium are introduced between two ion-exchange membranes. Impurities are removed from solution.

PG&E commissioned two studies at California wineries, with the goal of determining the most energy-efficient method to stabilize wine. The first study, which took place at Fetzer Vineyards (Healdsburg, CA), compared the energy consumption of electrodialysis to that of cold stabilization. The second study compared the energy efficiency of cold stabilization at Fetzer Vineyards to that at another site, where cold stabilization was enhanced by seeding, using insulated tanks, and other factors.

Despite using more water, the electrodialysis process was found to be up to 65% more energy efficient than cold stabilization, using eight soft hours (SH) per gallon to stabilize the wine versus 22 to 1,200 SH per gallon for the cold stabilization process. (Other tasks are included in the analysis.) For insulated tanks, it is 65% to 1,200 SH per gallon. For insulated tanks, it is 65% to 1,200 SH per gallon.

PGE and Fetzer Vineyards: energy efficiency partners

These studies are part of PGE's emerging technologies (ET) program, focused on new, innovative, and energy-efficient solutions for households at home, and in industry. ET works with a wide range of customers who have opened their homes or businesses to host these studies.

Working with PGE, Fetzer Vineyards tested electrodialysis as part of the energy's goal of reducing greenhouse emissions and sustainable agriculture and winemaking methods. The model that achieved "Stars" was provided by Viñi Tecné (Napa, CA).

"We have been very pleased to participate with PGE in this electrodialysis study," says Ann Buepp, Fetzer sustainability manager. "With innovative technologies in sustainable farming practices, we hope this kind of information can be useful to others who are interested in saving energy and gaining efficiency benefits from new technologies, especially science behind cold stabilization.

As the final step before bottling, stabilization reduces the concentration of potassium bitartrate (cream of tartar) in wine. For customers, this means no "wine diamonds" will be visible at the bottom of a bottled bottle of wine. Fortunately, this is accomplished by chilling the wine to around 27°F for a period of 1 to 3 weeks, depending on how quickly the potassium bitartrate is crystallized.

http://www.practicalwinery.com/sepoct08/page1.htm
Tartaric acid is removed as the wine passes through an electric field and separates ions on anionic and cationic membranes.

The cationic membrane allows positively-charged potassium ($\text{K}^+$) and calcium ($\text{Ca}^{2+}$) to pass through, while the anionic membrane allows negatively-charged tartrate to be removed.

Chamber #1 holds the wine. Chamber #2 contains a solution of potassium and calcium ions that have been extracted. Water flows through the second chamber, creating a brine solution made up of the potassium and calcium ions.

http://www.practicalwinery.com/sepoc09/page1.htm
Electrodialysis

Unstable Wine

Stable Wine

K^+  K^+  OH^-
Cooling/Freezing (w/seeding)
Electrodialysis
**Metatartrate**
Mannoproteins
Ion exchange
Fluidized bed
ISSUES:

- Only temporary stability
  
  Fine if wine is sold and consumed within 6 months

- Use not permitted in the US!

- 100 mg/L in Europe

⇒ Meta Tartraric Acid
Mixture of mono- and di-esters
Cooling/Freezing (w/seeding)
Electrodialysis
Metatartrate
Mannoproteins
Ion exchange
Fluidized bed
ISSUES:

- **Protein Additions**
  - 150-300 mg/L
  - **Timing**

  "It is essential to avoid any subsequent operations which affect the colloidal structure of the wine (blending, fining, pre-filtration, etc.)."

- **Aroma Scavenging?**

- **Magic?**

  "The microscopic observation of the potassium bitartrate crystal development in the presence or absence of Mannostab® shows that it prevents the preferential growth of certain crystal faces, flattening the shape of the crystals. The crystal only grows in a certain orientation, thus preventing it from precipitating."
Cooling/Freezing (w/seeding)
Electrodialysis
Metatartrate
Mannoproteins
Ion exchange
Fluidized bed
ISSUES:

• Nutrient stripping  
  Amino acids and vitamins

• Rise in T.A. (perceived tartness)  
  If cation exchange only

• Regeneration waste stream  
  Salinity
Wine Cold Stability Techniques

- Cooling/Freezing (w/seeding)
- Electrodialysis
- Metatartrate
- Mannoproteins
- Ion exchange
- Fluidized bed
© Roger Boulton, UC Davis

- Robert Bolan, M.S. 1996
  Development of a Fluidized-Bed Crystallizer for Wine Treatment

- David Hirzel, M.S. 2008
  Development of a Fluidized Bed for Crystallizing K Bitartrate from Wine
MARCH 2012
South America for Wine Professionals

The International Wine Industries of Chile and Argentina

Join Purdue's leading experts on Grape and Wine Production for an Extension adventure to Chile and Argentina, and an opportunity to explore and experience global viticulture and enology!

Schedule
Our group will travel to Santiago de Chile on March 9 and return on March 18. We will travel to several of the key wine production regions of Chile, including the Maipo, Casablanca, and Aconcagua Valleys. Stops will include visits to several of Chile's top wineries and vineyards (Viña Veramonte, Viñedos Organicos Emiliana, Viña Errázuriz). We will visit conventional, organic, and biodynamic farming operations. The group will have the opportunity to explore the magnificent scenery of Chile, from its Pacific Coast beaches to the Andes Mountains.

A day trip across the 22,841 ft high Andes will take us to Mendoza, Argentina, to explore the other center of the South American wine industry with visits to premier wine producers (Finca Decero, Catena Zapata, and Familia Zuccardi). We will stay in the old city of Mendoza, with its beautiful plazas and tree-lined streets, and plenty of opportunity to experience the vibrant culture of Argentina.

Program Information
The program is open to professionals in the Midwestern wine industry.
The enrollment is limited to 20 participants. Deadline for enrollment is November 30, 2011.
Cost for the Purdue Extension class South America for Wine Professionals is approximately $4,000 per person.

Interested? Contact Christian or Bruce!

Faculty:
Dr. Christian Bultzke Enology Professor bultzke@purdue.edu
Dr. Bruce Bordelon Viticulture Professor bordelon@purdue.edu
ISSUE:
Testing stability @ 32 °F for 5 days to assess stability for shelf-life of wine?
ISSUE:
Testing stability of slushie at 0°F to assess wine stability at 32°F?
Cooling
Freezing
Conductivity

ISSUE:
Testing stability at same temperature as stability is desired at (e.g. 32 °F)
Davis Conductivity Test

- Stirred, KBT-seeded sample of wine
- Temperature-controlled => choose $T$
- Conductivity probe:
  - Conductivity down => unstable
  - Conductivity stable => stable at $T$
  - Conductivity up => stable at and below $T$
- Results are wine-specific!
Davis Conductivity Test

- Conductivity probe:
  - Ranges: 100 µS to 1.0 mS and 1.0 to 10 mS
  - Accuracy: 0.5% or better
- Seed crystals: 1.5 g powdered KBT per 100 mL
- T-controlled, refrigerated water-bath
- Magnetic stir bar => read again after 20 min

Source:
Roger Boulton, Sinclair S. Scott Chair in Enology and Chemical Engineering in: *Principles and Practices of Winemaking*
Davis Conductivity Test

• Final conductivity of sample = target for whole tank
• No magic number to shoot for = wine-specific
• Look for changes of less than 3 to 5%
• Keep conductivity records of older vintages

Source:
Roger Boulton, Sinclair S. Scott Chair in Enology and Chemical Engineering in: Principles and Practices of Winemaking
## Potassium Salt Additions

<table>
<thead>
<tr>
<th>Salt</th>
<th>K⁺</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitartrate</td>
<td>+200</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>+660</td>
</tr>
<tr>
<td>Sorbate</td>
<td>+268</td>
</tr>
<tr>
<td>Metabisulfite</td>
<td>+50</td>
</tr>
</tbody>
</table>

=> Cold stability compromised!

=> For bottled-fermented *sparkling wine dosage* use SO₂ gas dissolved in water, not potassium metabisulfite.
Potassium Bitartrate Stability

G / L Bitartrate

Temperature (° F)

Alcohol (%)
Potassium Bitartrate Stability

- g/L Bitartrate
- Alc (%vol)
- T (°F)

+200 mg/L
Cold Stability Issues

Wine Cold Stability Issues

"Cold stabilizing" means to rid a wine of unstable potassium bitartrate (cream of tartar), the naturally occurring salt of the grape's tartaric acid, the major contributor to a wine's perceived tartness. Since potassium bitartrate is more soluble in water than in alcohol, the amount soluble in wine is smaller than the one in grape juice. However, due to the presence of colloidal materials in wine, such as mammoproteins, pectins and other polysaccharides, the unstable bitartrate may not precipitate unless the wine is chilled or aged significantly in tank or barrel which might not be appropriate for a particular wine style.

In litigious countries, the deposit of the harm- and tasteless potassium bitartrate as visible crystals on the bottom of the bottle or wine glass may cause the consumer to mistake those "wine diamonds" for glass splinters. While only an aesthetical issue that requires wine consumer education more than winemaker intervention, it has raised concerns about potential financial law suits. Thus, the winemaker stabilizes the wine to simulate what would happen if a wine consumer is putting a bottle of (white) wine into a very cold refrigerator to chill it down to, for example, 32°F.

Since the solubility of potassium bitartrate is also much reduced at lower temperatures, the winemaker usually chooses to "cold" stabilize a wine at a temperature just above the freezing point of the individual wine. This is a giant waste of energy and a sad example of unnecessary over-processing of a natural product. The wine's freezing point is related most importantly to its alcohol content. The approximate freezing point of wine at 10% ethanol by volume is 20°F, at 12% it is 23°F, and 21°F at 14%. This means that the winemaker has a maximum stabilization window of 6 to 11°F which translates into a solubility difference for potassium tartrate of between 200 and 300 mg/L, equal to 41 to 62 mg/L of potassium.
Bob Kreisher, Ph.D.
President

Bob was born and raised in Indianapolis. He graduated from Purdue University the year it started its Enology and Viticulture program, completely unaware of this development. After many years in university administration, teaching, and consulting, Bob moved to California to help with the organizational design of an emerging winery. Meanwhile, Bob developed a keen interest in developing technologies of winemaking that are gentle and cost-effective to allow cutting edge cellar techniques that enhance the expression of terroir and winemaking, rather than reducing wines to similarity. After intensive research into available and emerging technologies, Bob formed MNA with Mariana Brown. In his spare time, he enjoys cooking, film, hiking, gardening, travel, and spending time with his family and friends.