Sparkling winemaking: Forming foam and flavour

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Introduction

1. Background
2. Foam terminology
3. Sparkling wine research studies by CCOVI in Ontario (Traditional Method)
   - Press fractioning
   - Bentonite use for sparkling wine production
   - Disgorging - Gushing
   - Dosage
Background to CCOVI research trials

- Growth in sparkling wine production in Ontario and across Canada - British Columbia, Nova Scotia, Quebec.
- Winemakers desire for information and options for each stage of winemaking.
- We started at the end stage: Dosage project came first!
- Projects include viticulture to finished sparkling wine.
- Remember: Do NOT treat grapes in the vineyard or the base wine in the same way you do a still white wine!
Sparkling wine research at CCOVI

Traditional Method

✓ Press fractions
✓ Bentonite + proteins
✓ Gushing
✓ Dosage

Traditional Method/Methode Champenoise

1. Grape picking & pressing
2. Settling & clarification
3. 1st Fermentation
4. Malolactic fermentation (if required)
5. Blending base wines
6. Bottling & liqueur de Tirage (yeast, nutrients, riddling agent & sugar)
7. 2nd Fermentation & aging on lees
8. Riddling
9. Disgorging & dosage (wine & sugar)
10. Closure & packaging

Bottling: Fielding Estate Winery
Disgorging: Millesime Sparkling Wine Processing Inc.
Foam terminology used in this webinar

- Foam height (FH): the height of foam upon pouring the wine.
- Foam stability time (FS): the time the bubbles take to entirely collapse/foam disappears.
- Various methods and equipment used for foam analysis (not included in this webinar)
Foam, bubbles and effervescence terminology

- Liquid/air or CO₂ interphase
- Collar
- Supersaturated solution/wine with CO₂
- CO₂
- Liquid/wine film
- Double layer (proteins/polysaccharides etc.)
- Bubble synthesis +
- Rising bubble = Effervescence

Photograph and diagram by Prof Richard Marchal, University of Reims, Champagne.
More to foam than CO₂!!!

**Proteins**
- Amino acids
- Lipids

**Polysaccharides**
- Glycerol
- Biogenic amines
- Polyphenols
- Ethanol
- Organic acids
- Sulfur dioxide

*Botrytis Cinerea/
gluconic acid*

Sour rot?

<table>
<thead>
<tr>
<th>Poor effervescence</th>
<th>Sustained effervescence</th>
</tr>
</thead>
</table>

Chemical composition, production processes and serving conditions that influence foam

Photograph by Prof Richard Marchal, University of Reims.

Grape variety
Pectic enzymes
Fining
Filtration

Glass type/care
Temperature
Proteins

- Low concentration in wine = principal compounds associated with foam properties of sparkling wines
- Base wines contain a grape-derived proteins while mannoproteins come from yeasts during lees aging

Highest foamability when grape & yeast proteins combined = suggesting a synergistic interaction between yeast mannoproteins and grape proteins (different molecular weights).
Important proteins

- Chitinase & grape thaumatin-like proteins (TLPs) important in recent foam studies & most abundant yet cause haze in white wines.

  Don’t bentonite fine your base wine!

- Ultra-filtered wines deprived of larger molecules did not produce any measurable foam (Aguié-Béghin et al. 2009)

  Don’t filter base wine to 0.45 microns!

Structure of haze forming proteins in white wines: *Vitis vinifera* thaumatin-like proteins (TLPs)

(Marangon et al. 2014)
Other foam affecting compounds

- **Ethanol**
  1) °Brix levels too high at harvest
  2) Incorrect sugar calculations at bottling for desired pressure level
  3) Check residual sugar levels before bottling
Other foam affecting compounds

➢ Acid type

✓ Tartaric acid - positive effect on foam height
✓ Malic acid - increases foam height but not stability
✓ Lactic acid - increases foam stability but not height
✓ Gluconic acid - effects height & stability

➢ Phenolic compounds
Other foam affecting compounds

Fatty acids and lipids
• Fatty acids have been found to only affect foam when the ethanol level is below 5% v/v %.

Sulphur Dioxide (SO$_2$)
• Decreases foam height & stability

NO optimal concentrations of these compounds for sparkling white, rosé or red wines is available!
• Sugar and acid levels are important in sparkling grapes and the sugar to acid ratio (°Brix:TA g/L index)

• Ratio of 4:5.5 produces wines with optimal foamability.

• Grapes picked at more mature ripeness levels produce wines with less foaming ability

Press fractioning for quality sparkling wines....................
Making white sparkling wine from red grapes

- Cool temps/Press straight after picking
- Whole bunch pressing
- Gentle, gradual increase in pressure
- Low juice extraction
- Press fractioning

Champagne pressing (based on 4000kg grapes)

- Cuvee = 20.5hL
- Tailles = 5hL (1\textsuperscript{st} taille -3hL + 2\textsuperscript{nd} taille 2hL)
- 3\textsuperscript{rd} taille 1-2hL distillation
Optimising press fractions (Clone 115)

Press fractioning options

- Without press fraction separation:
  - All press fraction juice combined to produce one, low quality sparkling wine

- With press fraction separation:
  - First fraction (F1): Quality base wine, more blending options, aging
  - Second fraction (F2): 2nd label, more blending options, could be used in dosage, lower quality than F1
  - Third fraction (F3): 2nd label, more blending options, could be used in dosage, lower quality than F2
  - Fourth fraction (F4): Sell to local distillery for distillation $$$

Ontario Centres of Excellence
Where Next Happens
Press fractions
CLONE 115 (Dijon clone)
Experimental winemaking method

- Pinot noir - Clone 115
- Whole bunch pressed
- Wine taken from tap before hitting the tray - middle of each cycle
- No enzymes added
- 30 ppm SO2
- Winemaking in triplicate - no MLF
- Chemical analysis of juice & wine pH, TA (g/L), Brix, fre & total SO2, ethanol, Nitrogen, turbidity, glucose, fructose, residual sugar, malic acid, heat stability, tartrate stability, total phenolics, conductivity & potassium.
- EC118 both fermentations
- Tirage same for all fractions (calculated on residual sugar & target of 24 g/L for 2nd fermentation
Press fraction juice and wine composition

(Analysis at every stage of winemaking but pre-fermentation and pre-bottling data presented today)

### Press fraction juice analysis

<table>
<thead>
<tr>
<th>Press Fraction</th>
<th>Brix</th>
<th>TA (g/L)</th>
<th>pH</th>
<th>Total YAN (mg N/L)</th>
<th>Malic acid (g/L)</th>
<th>Turbidity (NTU)</th>
<th>Acetic acid (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PF1</td>
<td>18.5</td>
<td>8.3</td>
<td>3.12</td>
<td>153</td>
<td>3.9</td>
<td>267</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>PF2</td>
<td>18</td>
<td>7.5</td>
<td>3.19</td>
<td>154</td>
<td>3.6</td>
<td>297</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>PF3</td>
<td>18</td>
<td>6.3</td>
<td>3.39</td>
<td>160</td>
<td>3.4</td>
<td>261</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Significance: NS < 0.0001 0.0001 < 0.0001 < 0.0001 < 0.0001 NS
Press fraction juice and wine composition

(Analysis at every stage of winemaking but pre-fermentation and pre-bottling data presented today)

Press fraction base wine analysis (prior to bottling)

<table>
<thead>
<tr>
<th>Press fraction</th>
<th>Alcohol (% v/v)</th>
<th>TA (g/L)</th>
<th>pH</th>
<th>Total YAN (mg N/L)</th>
<th>Residual sugar (mg/L)</th>
<th>Malic acid (g/L)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>PF1</td>
<td>10.6</td>
<td>7.7</td>
<td>2.9</td>
<td>10.3</td>
<td>0.12</td>
<td>3</td>
<td>NS</td>
</tr>
<tr>
<td>PF2</td>
<td>10.6</td>
<td>6.8</td>
<td>3.1</td>
<td>11.6</td>
<td>0.12</td>
<td>3</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>PF3</td>
<td>10.7</td>
<td>6.0</td>
<td>3.4</td>
<td>14.5</td>
<td>0.23</td>
<td>3</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>
Accelerated oxidation analysis of base wines (2014).
The absorbance at 420nm was measured over the course of 30 days.
Phenolic compounds in press fractions (Pinot noir clone 115)

Press fraction 1: Sparkling wine with highest acidity, lowest pH, light colour and highest foam stability.

Press fraction 2: Sparkling wine with medium acidity, medium pH and medium colour.

Press fraction 3: Sparkling wine with lowest acidity, highest pH and darkest colour.

Taille musts produce intensely aromatic wines – fruitier in youth than those made from the cuvee but far less age-worthy.

Grape must colour change during pressing

South of England, Chardonnay – 09/2010

Kemp et al. 2012
Chardonnay must analysis (UK) during pressing: pH and TA (g/L)

Kemp et al. 2012
Pressing

Considerations

- Press type
- Press size
- Press cycles
- Pressing level per fraction
- Grape variety
- Health of grapes
- Mechanical or manual harvesting
- SO₂ addition level at press
- Initial grape ripeness
- Whole bunch pressing
- Grape temperature at picking & pressing
Bentonite and proteins at bottling impacts foam stability

Pinot noir:
Mariafeld clone

100L
No bentonite

First fermentation

100L
Vitiben (Sodium bentonite) 1g/L

Second fermentation

T1: No bentonite EC1118 yeast
T3: + bentonite in at bottling only. EC118 yeast
T5: + bentonite juice only. EC118 yeast
T8: + bentonite in juice and at bottling. EC118 yeast

*Bentonite used: Vitiben pre-fermentation and Inoclar 2 at tirage*
Bentonite impacts foam

Time elapsed for dissipation of foam. Analysis of variance (ANOVA) with mean separation by Tukey’s Post Hoc (p<0.05). Uppercase letters indicate differences between treatments. Error bars represent standard deviation. (Onguta, Kemp, Van der Merwe & Inglis. 2016).
Bentonite use in sparkling wine
Sensory analysis of sparkling

The effect on sensory characteristics of sparkling wines from bentonite use at different stages of production.
### Issues at disgorging: GUSHING

#### Bottle handling & disgorging environment

- Light (UV)
- Ambient temperature
- Seasonal timing of disgorging
- Rough handling before disgorging
- Angle of the bottle
- Neck freezing too fast
- Rapid movement of wine from cold room to warm room

#### Wine composition

- Grape variety
- Vintage variation
- Protein instability
- Wine temperature and dosage temperature
- High bottle pressure
- Tartrate crystals
- Calcium crystals
- Inconsistent mixing during tirage
- Undissolved sugar in the dosage after addition
- Yeast (from inadequate riddling/disgorging)
- High phenolic concentration
- Turbidity
- Malolactic fermentation in bottle

#### Packaging materials

- Cork dust
- Glass imperfections in the bottle
- Dust in the bottle

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*Kemp et al. (2015)*
Dosage project

Aims & objectives
• Effect of wine used to make the addition influences wine flavor and foam
• Impact of sugar on foam and flavor

Dosage calculation

Millilitres of dosage required = \( \ldots \text{mL} \)

(Bottle volume mL) (Desired sugar level g/L)

(Sugar concentration of stock solution)
**Wine that had dosage added to it**

**Wines used for dosage treatments (RS 300g/L)**

**Treatment wines (20mls dosage at RS 8g/L)**

- **Zero-dosage (RS 1g/L)**
  - ZD
- **Brut**
  - BS
- **Pinot noir 2009**
  - PN
- **Unoaked Chard**
  - UC
- **Oaked Chard**
  - OC
- **Vidal Icewine**
  - IW
- **Brandy**
  - B
Standard chemical parameters at 5-15 weeks after disgorging

- pH range: 3.08 (UC) - 3.3 (ZD)
  \{higher pH in wines with sparkling wine dosages\}
- TA (g/L): 7.9 - 8.2
- Residual sugar (g/L): 1.1 - 8
- Alcohol (% v/v): 12.3 (ZD, UC) - 12.9 (B)
- Free SO₂: 3 - 5ppm
- Total SO₂: 53 - 59ppm
- Dissolved oxygen (DO mg/L): 3.1 (IW) - 6.6 (ZD)

Cork MUST be at least 24mm inside the bottle!
Wines 15 weeks after dosage addition in wines with RS 8g/L

PCA biplot of sparkling wines with different dosages at 15 weeks after disgorging
Influence of *dosage* on foam stability

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Time for foam to elapse (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brut Zero-<em>dosage</em> wines</td>
<td>168</td>
</tr>
<tr>
<td>Pinot noir 2009</td>
<td>76</td>
</tr>
<tr>
<td>Unoaked Chardonnay</td>
<td>64</td>
</tr>
<tr>
<td>Brut + sugar</td>
<td>50</td>
</tr>
<tr>
<td>Brandy</td>
<td>49</td>
</tr>
<tr>
<td>Vidal Icewine</td>
<td>43</td>
</tr>
<tr>
<td>Oaked Chardonnay</td>
<td>42</td>
</tr>
</tbody>
</table>

Highest foam height & stability in zero-*dosage* wines
Dosage trial sensory results

- **A-Not A test** (Bi 2006, Kim et al. 2012)
- **Difference between each wine and the control/Brut with oaked Chardonnay dosage** (ZD not included)
- **63 correct answers from a total of 80 = 74% correct answers**

<table>
<thead>
<tr>
<th>Sureness rating (R index value)</th>
<th>Very sure</th>
<th>Sure</th>
<th>Unsure</th>
<th>Very unsure</th>
<th>Total</th>
<th>R-index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2</td>
<td>8</td>
<td>6</td>
<td>0</td>
<td>16</td>
<td>80</td>
</tr>
<tr>
<td>Not A</td>
<td>27</td>
<td>28</td>
<td>6</td>
<td>3</td>
<td>64</td>
<td>73</td>
</tr>
</tbody>
</table>

- An R index of 50% = identical samples
- An R index of 100% are completely different
Sparkling wine dosage

Sugar \{8g/L (+/-2)\}

- 5 weeks later....
  - Lower levels of aromatic alcohols

Zero-dosage \{0g/L\}

- 5 weeks later....
  - Higher levels of some ethyl esters

- 15 weeks later....
  - No difference in aroma compounds

- Lower foam height & stability
- Higher foam height & stability
Chemical composition considerations: Acidity, pH, phenolics etc..

- Different anthocyanin-to-flavanol ratio in Tempranillo (Monagas et al. 2005)
- High pH values in Spain (Monagas et al. 2005)
- Polysaccharides, oligosaccharides and nitrogenous compound were found to be higher in Tempranillo sparkling wines (Martínez-Lapuente et al. 2017)
Future studies

• Final year of leaf removal study
• Final year of clone study
• + yeasts, YAN (mg N/L) source for 2\textsuperscript{nd} fermentation, specific flavours, aging projects
Different viticulture for sparkling grapes!

Juice colour differences from different timings & severities of leaf removal on Pinot noir (clone 667) for sparkling wine from a Niagara-on-the-Lake vineyard, Ontario in 2016.
Acknowledgements

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• Fielding Winery - Bottling & Millesime - disgorging
• All grape pickers: Stephanie Van Dyke, Jim Willwerth, Mary Jasinski, Jen Kelly, Andréanne Hebert-Hache, Thomas Willwerth, Tom Willwerth.
References


Thank you for your attention.
Any questions?