Investigations Into Impacts of MOG on Aroma Compounds of Red Wine Cultivars

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Brock University
Materials Other Than Grapes (MOG)

• Has always been an issue since the advent of mechanical harvesting

• Continual improvements in harvester technology has reduced the problem significantly

• However—regions with cold winters that grow late-season red varieties (e.g. Cabernet Sauvignon) have, due to climate change, been harvesting fruit much later in the season than traditional late October

• The consequence has been mid-November harvests after hard frosts, and the incorporation of MOG into loads at very high levels

• This “frozen MOG” has led to issues of anomalous aromas--“floral taint” in late-season red wines
Possible Contributions From MOG
Initial Hypotheses

• Terpenes and other odorants

• Bitter taste compounds

• Malic acid increase from leaves and petioles

• Metal content (Na, K, Mg, Fe)

• Decreased anthocyanins and color intensity
• Reduced methoxypyrazines due to light freezing of grapes.

• Breakdown of glycosides in leaves, petioles, and fruit—and subsequent release of terpene and norisoprenoid aglycones—we are working on this.
Previous Literature With Petioles in Cabernet Sauvignon (Australia)

BER, PET = Unripe berries of petioles added to fermentations (% wt./volume)

I. Analysis of Commercial Wines

- Tanks of several Cabernet franc and Cabernet Sauvignon wines previously identified by the winemakers as having “floral taint” were sampled (3 x 500 mL) from Andrew Peller Ltd. (APL) and Arterra wineries.
- Several APL commercial wines both displaying/not displaying floral taint were likewise sampled.
- All with extracted using the Gerstel stir bar technology and subjected to GC-MS.
• Sensory analysis of 2015 commercial wines was carried out by ≈20 panelists using multidimensional sorting
C, P = Arterra, Peller; High, Med, Low = High, medium, low floral taint
### Aroma compounds in commercial Ontario red wines, 2015 vintage
(yellow-highlighted columns are likely above threshold; green rows = low floral taint samples)

<table>
<thead>
<tr>
<th>Sample</th>
<th>β-lonone</th>
<th>α-lonone</th>
<th>β-Damascenone</th>
<th>Citronellol</th>
<th>Geraniol</th>
<th>cis Rose oxide</th>
<th>trans Rose oxide</th>
<th>γ-Terpinene</th>
<th>Limonene</th>
</tr>
</thead>
<tbody>
<tr>
<td>P6 Low</td>
<td>0.153±0.039</td>
<td>1.929±0.233</td>
<td>2.66±0.04</td>
<td>1.313±0.074</td>
<td>7.347±4.078</td>
<td>0.021±0.009</td>
<td>0.014±0.003</td>
<td>0.044±0.005</td>
<td>0.222±0.032</td>
</tr>
<tr>
<td>P7 Low</td>
<td>0.224±0.024</td>
<td>2.322±0.238</td>
<td>2.06±0.67</td>
<td>0.921±0.143</td>
<td>5.979±0.650</td>
<td>0.016±0.005</td>
<td>0.010±0.002</td>
<td>0.059±0.009</td>
<td>0.182±0.003</td>
</tr>
<tr>
<td>P8 Low</td>
<td>0.160±0.001</td>
<td>2.536±0.108</td>
<td>2.83±0.14</td>
<td>1.413±0.093</td>
<td>3.893±0.241</td>
<td>0.036±0.006</td>
<td>0.000±0.002</td>
<td>0.056±0.020</td>
<td>0.175±0.014</td>
</tr>
<tr>
<td>P9 Low</td>
<td>0.152±0.001</td>
<td>3.226±0.120</td>
<td>2.20±0.07</td>
<td>0.920±0.040</td>
<td>4.091±0.250</td>
<td>0.019±0.002</td>
<td>0.005±0.004</td>
<td>0.137±0.002</td>
<td>0.145±0.038</td>
</tr>
<tr>
<td>P10 Low</td>
<td>0.188±0.000</td>
<td>4.859±0.133</td>
<td>2.61±0.03</td>
<td>0.849±0.024</td>
<td>4.371±0.143</td>
<td>0.045±0.009</td>
<td>0.008±0.003</td>
<td>0.206±0.068</td>
<td>0.202±0.040</td>
</tr>
<tr>
<td>P3 Med</td>
<td>0.259±0.002</td>
<td>1.869±0.005</td>
<td>4.03±0.23</td>
<td>0.940±0.102</td>
<td>4.708±0.284</td>
<td>0.084±0.000</td>
<td>0.040±0.001</td>
<td>0.134±0.017</td>
<td>0.152±0.017</td>
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<td>P4 Med</td>
<td>0.238±0.026</td>
<td>1.675±0.182</td>
<td>3.39±0.06</td>
<td>0.922±0.015</td>
<td>4.976±0.271</td>
<td>0.034±0.005</td>
<td>0.016±0.001</td>
<td>0.087±0.007</td>
<td>0.176±0.028</td>
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<tr>
<td>P5 Med</td>
<td>0.259±0.006</td>
<td>1.792±0.164</td>
<td>4.38±0.07</td>
<td>1.361±0.027</td>
<td>6.347±0.312</td>
<td>0.022±0.000</td>
<td>0.007±0.006</td>
<td>0.104±0.013</td>
<td>0.137±0.011</td>
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<tr>
<td>C1 High</td>
<td>0.232±0.021</td>
<td>0.884±0.014</td>
<td>2.42±0.09</td>
<td>1.209±0.212</td>
<td>7.716±1.487</td>
<td>0.049±0.005</td>
<td>0.027±0.001</td>
<td>0.072±0.000</td>
<td>0.215±0.053</td>
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<tr>
<td>C2 High</td>
<td>0.244±0.042</td>
<td>0.662±0.084</td>
<td>2.18±0.31</td>
<td>0.928±0.141</td>
<td>6.870±0.566</td>
<td>0.058±0.020</td>
<td>0.033±0.012</td>
<td>0.065±0.058</td>
<td>0.183±0.040</td>
</tr>
<tr>
<td>P1 High</td>
<td>0.291±0.007</td>
<td>1.423±0.030</td>
<td>5.17±1.07</td>
<td>2.088±0.090</td>
<td>7.486±1.217</td>
<td>0.217±0.035</td>
<td>0.068±0.007</td>
<td>0.138±0.015</td>
<td>0.143±0.013</td>
</tr>
<tr>
<td>P2 High</td>
<td>0.274±0.039</td>
<td>1.504±0.318</td>
<td>2.46±0.03</td>
<td>0.957±0.114</td>
<td>5.033±0.350</td>
<td>0.111±0.025</td>
<td>0.026±0.003</td>
<td>0.080±0.009</td>
<td>0.115±0.014</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Threshold</th>
<th>Mean Low</th>
<th>Mean Med</th>
<th>Mean High</th>
<th>OAV</th>
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<td>450</td>
<td>0.007</td>
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<td>0.100</td>
<td>0.097</td>
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<td>0.100</td>
</tr>
</tbody>
</table>

C, P = Arterra and Peller, respectively
All concentrations are in µg/L
OAV = Odor activity value
## Aroma compounds in commercial Ontario red wines, 2015 vintage
(yellow-highlighted columns are above threshold; green rows = low floral taint samples)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Ethyl hexanoate</th>
<th>Ethyl heptanoate</th>
<th>Ethyl octanoate</th>
<th>Ethyl nonanoate</th>
<th>Ethyl decanoate</th>
<th>Heptanol</th>
<th>Octanol</th>
<th>Phenethyl acetate</th>
<th>Phenethyl alcohol</th>
</tr>
</thead>
<tbody>
<tr>
<td>P6 Low</td>
<td>204.0±25.5</td>
<td>1.07±0.06</td>
<td>158.4±12.1</td>
<td>0.394±0.009</td>
<td>21.8±1.6</td>
<td>33.6±2.6</td>
<td>15.85±1.58</td>
<td>30.4±0.96</td>
<td>43039±1222</td>
</tr>
<tr>
<td>P7 Low</td>
<td>147.1±7.6</td>
<td>1.08±0.05</td>
<td>112.9±11.3</td>
<td>0.505±0.033</td>
<td>21.5±2.2</td>
<td>35.7±2.4</td>
<td>13.96±1.14</td>
<td>33.9±3.03</td>
<td>47142±7851</td>
</tr>
<tr>
<td>P8 Low</td>
<td>201.0±47.0</td>
<td>1.13±0.13</td>
<td>270.7±62.5</td>
<td>0.423±0.056</td>
<td>69.9±14.0</td>
<td>29.7±3.5</td>
<td>13.24±2.49</td>
<td>25.6±5.33</td>
<td>40914±4456</td>
</tr>
<tr>
<td>P9 Low</td>
<td>201.0±9.6</td>
<td>1.32±0.03</td>
<td>284.8±17.0</td>
<td>0.523±0.023</td>
<td>69.8±3.9</td>
<td>35.7±1.1</td>
<td>12.14±0.44</td>
<td>52.4±1.43</td>
<td>46305±2684</td>
</tr>
<tr>
<td>P10 Low</td>
<td>130.8±45.2</td>
<td>1.27±0.16</td>
<td>187.5±4.1</td>
<td>0.770±0.002</td>
<td>52.4±2.4</td>
<td>31.1±5.4</td>
<td>12.62±4.00</td>
<td>53.7±2.66</td>
<td>34148±1032</td>
</tr>
<tr>
<td>P3 Med</td>
<td>203.6±15.4</td>
<td>1.79±0.21</td>
<td>288.1±34.5</td>
<td>0.638±0.025</td>
<td>75.2±2.9</td>
<td>38.0±4.9</td>
<td>16.64±3.56</td>
<td>47.3±6.29</td>
<td>42635±1036</td>
</tr>
<tr>
<td>P4 Med</td>
<td>237.4±27.7</td>
<td>1.44±0.06</td>
<td>342.4±36.4</td>
<td>1.842±0.083</td>
<td>107.4±10.1</td>
<td>43.1±5.5</td>
<td>19.09±2.33</td>
<td>43.1±9.41</td>
<td>60569±1118</td>
</tr>
<tr>
<td>P5 Med</td>
<td>245.3±6.3</td>
<td>1.65±0.01</td>
<td>227.4±3.0</td>
<td>0.934±0.014</td>
<td>60.6±0.4</td>
<td>39.2±0.2</td>
<td>14.25±0.49</td>
<td>55.7±2.02</td>
<td>51031±1192</td>
</tr>
<tr>
<td>C1 High</td>
<td>222.6±33.8</td>
<td>1.63±0.13</td>
<td>399.3±29.3</td>
<td>0.857±0.025</td>
<td>143.0±6.0</td>
<td>40.4±0.1</td>
<td>13.98±1.48</td>
<td>47.2±3.21</td>
<td>40500±2510</td>
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<tr>
<td>C2 High</td>
<td>210.1±19.4</td>
<td>1.62±0.13</td>
<td>390.4±44.7</td>
<td>0.912±0.092</td>
<td>123.1±13.0</td>
<td>37.9±3.6</td>
<td>15.36±3.32</td>
<td>27.3±1.90</td>
<td>38734±6476</td>
</tr>
<tr>
<td>P1 High</td>
<td>251.4±22.5</td>
<td>1.41±0.10</td>
<td>352.6±34.9</td>
<td>0.649±0.050</td>
<td>113.9±11.1</td>
<td>44.0±2.4</td>
<td>17.65±0.02</td>
<td>37.7±3.70</td>
<td>46739±1406</td>
</tr>
<tr>
<td>P2 High</td>
<td>238.9±20.0</td>
<td>1.70±0.04</td>
<td>327.4±6.1</td>
<td>0.661±0.061</td>
<td>80.0±1.7</td>
<td>35.5±1.4</td>
<td>13.31±1.91</td>
<td>33.2±5.25</td>
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<tr>
<td>Threshold</td>
<td>5</td>
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<td>5</td>
<td>---</td>
<td>200</td>
<td>3</td>
<td>110</td>
<td>250</td>
<td>10000</td>
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<tr>
<td>Mean Low</td>
<td>176.8</td>
<td>1.17</td>
<td>202.8</td>
<td>0.52</td>
<td>47.1</td>
<td>33.2</td>
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<tr>
<td>Mean Med-High</td>
<td>229.9*</td>
<td>1.61*</td>
<td>332.5*</td>
<td>0.93*</td>
<td>100.5*</td>
<td>39.7*</td>
<td>15.75*</td>
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<tr>
<td>OAV</td>
<td><strong>45.98</strong></td>
<td><strong>0.73</strong></td>
<td><strong>66.5</strong></td>
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<td><strong>0.5</strong></td>
<td><strong>13.2</strong></td>
<td><strong>0.143</strong></td>
<td><strong>0.167</strong></td>
<td><strong>4.59</strong></td>
</tr>
</tbody>
</table>

C, P = Constellation (now Arterra) and Peller, respectively
All concentrations are in µg/L
OAV = Odor activity value
II. Analysis of Controlled Fermentations

• Controlled fermentations with Cabernet franc and Cabernet Sauvignon took place in November 2016 to 2018 involving several levels of frozen leaves and petioles
• The 2016 and 2017 wines were subjected to GC-MS analysis
• The 2018 wines will be likewise analyzed
Controlled Fermentations 2016-2018
(pictured: Dr. Jiaming Wang with 2017 fermentations)
2016 to 2018 controlled fermentations

Control 0.25 % leaves 0.5 % leaves 1 % leaves 2 % leaves

Control 0.5 % petioles 1 % petioles 2 % petioles 5 % petioles
GC-MS Terpenes

Citronellol

Geraniol

5% Petioles
2% Leaves
Control (0%) MOG

Nerol
GC-MS Rose Oxides

5% Petioles
2% Leaves
Control (0%) MOG

Cis-Rose Oxide

Trans-Rose Oxide
The “Smoking Guns” (and those loaded with blanks). Cabernet franc.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Important?</th>
<th>Compound</th>
<th>Important?</th>
<th>Compound</th>
<th>Important?</th>
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<tbody>
<tr>
<td>Isobutanol</td>
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<td>X</td>
<td>γ-Terpinene</td>
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<td>Terpinolene</td>
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<td>Heptanol</td>
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<td>Limonene</td>
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<td>Eugenol</td>
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</table>

**LEGEND**
- Green = above threshold with increasing relationship with increased leaves or petioles
- Orange = above threshold; no strong relationship with MOG levels
- Non-shaded = below threshold at all MOG levels, or thresholds not published
Aroma compounds in Ontario Cabernet franc wines 2016 and 2017. Terpenes--Linalool. Percent values are weights per volume leaves and petioles.

\[ y = 4.2448x + 7.2936 \]
\[ R^2 = 0.8475 \] **

\[ y = 2.571x + 6.6052 \]
\[ R^2 = 0.9881 \] ****

\[ y = 4.3437x + 9.1343 \]
\[ R^2 = 0.5855 \] **

\[ y = 1.8033x - 4.1534x + 8.3561 \]
\[ R^2 = 0.8089 \] ***

\[ y = 4.3437x + 9.1343 \]
\[ R^2 = 0.5855 \] **

\[ y = 1.8033x - 4.1534x + 8.3561 \]
\[ R^2 = 0.8089 \] ***

OAV=0.97

OAV=1.37

OAV=1.3

OAV=3.1

y = 15.109x + 6.4029
R² = 0.9868 ****

y = 7.799x + 5.7126
R² = 0.9912 ****

y = 6.2637x² - 18.142x + 36.828
R² = 0.8392***

y = 28.091x + 34.753
R² = 0.6723**

OAV=1.2

OAV=1.5

OAV=3.54

OAV=4.06
Aroma compounds in Ontario Cabernet franc wines 2016 and 2017. More terpenes--Citronellol. [Nerol (sweet), α-Citral (lemon), α-Terpineol (pine), and other terpenes responded similarly but had OAV < 1]
Aroma compounds in Ontario Cabernet franc wines 2016 and 2017. Still more terpenes—cis-Rose oxide.

\[ y = 0.0548x + 0.0205 \]
\[ R^2 = 0.9924 **** \]

\[ y = 0.2009x - 0.0051 \]
\[ R^2 = 0.9925 **** \]

\[ y = 0.216x^2 - 0.0606x + 0.2939 \]
\[ R^2 = 0.8163*** \]

\[ y = 0.1318x^2 + 0.1085x + 0.2057 \]
\[ R^2 = 0.9379**** \]

- **Y = 5.2336x + 2.597**
  - $R^2 = 0.9791$ ****

- **OAV = 2.2**

- **Y = 2.2649x + 3.2763**
  - $R^2 = 0.9847$ ****

- **OAV = 2.4**

- **Y = 17.232x + 2.4743**
  - $R^2 = 0.9021$ ****

- **OAV = 7.63**

- **Y = 0.799x**
  - $R^2 = 0.9372$ ****

- **OAV = 4.40**

- **Y = 17.232x + 2.4743**
  - $R^2 = 0.9021$ ****

- **OAV = 4.40**

\[ y = -0.1003x^2 + 0.5099x + 0.1709 \]
\[ R^2 = 0.9924 \] ****

\[ y = 0.0081x + 0.145 \]
\[ R^2 = 0.9298 \] ***

\[ y = 0.7917x + 0.5123 \]
\[ R^2 = 0.8655 \] ***

\[ y = 0.0417x^2 - 0.1698x + 0.4819 \]
\[ R^2 = 0.301 \]
Aroma compounds in Ontario Cabernet franc wines 2016 and 2017. Higher alcohols--Hexanol. [Octonol (moss, nut, mushroom) responded similarly but OAV < 1]

\[ y = 128.91x^2 + 419.2x + 1408.4 \]
\[ R^2 = 0.8475 \]

\[ y = 86.635x + 1216.8 \]
\[ R^2 = 0.8515 \]

\[ y = 572.05x^2 - 2931.8x + 7800.4 \]
\[ R^2 = 0.4444 \]

\[ y = 1311.1x + 7697 \]
\[ R^2 = 0.2142 \]
Aroma compounds in Ontario Cabernet franc wines 2016 and 2017. Salicylates—Methyl salicylate. [Ethyl Salicylate (wintergreen, mint) responded similarly]

\[
y = 0.5148x^2 + 0.0362x + 2.434 \\
R^2 = 0.9567 \ *
\]

\[
y = 10.757x^2 - 17.719x + 33.631 \\
R^2 = 0.1982
\]

\[
y = 3.6122x + 3.4367 \\
R^2 = 0.9887 \ *
\]

\[
y = 4.8128x^2 - 10.717x + 27.166 \\
R^2 = 0.8289 \ *
\]
2016 PCA Cabernet Sauvignon
Continuing Activities- 2016 to 2018 Wines

- GC-MS and chemical analysis of 2018 Cabernet Franc and Cabernet Sauvignon wines (ongoing under supervision of Dr. Lan)

- Sensory analysis for both varieties (descriptive analysis) for 2016 and 2017. The 2016 wines are undergoing descriptive sensory analysis.

- Conventional wine composition
2017 to 2019 Seasons
Still lots of work to do...

• Combined leaf and petiole treatments with different yeast strains (CSM, EC1118, FX10)
• Field trials involving different harvest treatments
  • Hand Harvest
  • Machine Harvest
  • Leaf removal prior to harvest (mechanical)
  • Machine Harvest with Opti-Sorting
  • Machine Harvest using Gregoire GR8 (2018 only)
  • Machine Harvest followed by optical sorting table (2017 only)
• Need to perform: GC-MS on all 2018 wines (115 fermentations), basic analyses, and sensory analysis
2017 Fermentation setup
Impact of Yeast Strains 2017

Control

Concentration (ug/L)

γ-terpinene terpinolene trans-linalool oxide nerol oxide cis-rose oxide

trans-rose oxide limonene cis-linalool oxide nerolidol β-citral

Concentration (ug/L)

β-damascenone α-ionone β-ionone

CSM EC1118 FX10

0.1 0.2 0.3 0.4 0.5 0.6

NS a

NS a

NS

0 5 10 15 20 25 30 35 40 45 50

0 1 2 3 4 5 6

0 5 10 15 20 25 30 35 40 45 50

0 1 2 3 4 5 6

0 10 20 30 40 50

0 5 10 15 20 25

0 5 10 15 20 25 30 35 40 45 50

myrcene linalool geraniol α-terpineol α-citral citronellol nerol eugenol

β-damascenone α-ionone β-ionone

CSM EC1118 FX10
Impact of Yeast Strains 2017

2% Leaves

- limonen
- v-terpinen
- terpinolene
- cis-rose oxide
- trans-rose oxide
- nerol oxide
- beta-citral

Concentration (ug/L)

- CSM
- EC1118
- FX10

- nerolidol
- alpha-citral
- myrcene

Concentration (ug/L)

- CSM
- EC1118
- FX10

- linalool
- cis-linalool oxide
- geraniol
- nerol
- citronellol
- alpha-terpineol
- eugenol

Concentration (ug/L)

- CSM
- EC1118
- FX10

- beta-damascenone
- alpha-ionone
- beta-ionone

Concentration (ug/L)
Impact of Yeast Strains 2017

5% Petioles

- γ-terpinene
- terpinolene
- nerolidol
- trans-rose oxide
- limonene
- myrcene
- nerol oxide
- α-citral
- β-citral
- cis-rose oxide
- α-ionone
- β-ionone
- β-damascenone

Concentration (ug/L)
## Yeast Effects Summary
Blue= Control; Green= 2% leaves; Red = 5% Petioles

<table>
<thead>
<tr>
<th>Compound</th>
<th>CSM</th>
<th>1118</th>
<th>FX-10</th>
<th>Compound</th>
<th>CSM</th>
<th>1118</th>
<th>FX-10</th>
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<tbody>
<tr>
<td>γ-Terpinene</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>Myrcene</td>
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<td>↓</td>
<td>↓</td>
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<tr>
<td>Terpinolene</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>Linalool</td>
<td>↑</td>
<td>↔</td>
<td>↓</td>
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<tr>
<td>trans-Linalool oxide</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
<td>Geraniol</td>
<td>↑</td>
<td>↓</td>
<td>--&gt;</td>
</tr>
<tr>
<td>Nerol oxide</td>
<td>↑</td>
<td>↓</td>
<td>↓</td>
<td>α-Terpineol</td>
<td>↑</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>cis-Rose oxide</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>α-Citral</td>
<td>↑</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>trans-Rose oxide</td>
<td>---</td>
<td>---</td>
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<td>Citronellol</td>
<td>↓</td>
<td>↑</td>
<td>↓</td>
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<tr>
<td>Limonene</td>
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<td>↓</td>
<td>↑</td>
<td>Nerol</td>
<td>↑</td>
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<td>↑</td>
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<tr>
<td>cis-Linalool oxide</td>
<td>↔</td>
<td>↑</td>
<td>↓</td>
<td>Eugenol</td>
<td>↑</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Nerolidol</td>
<td>↑</td>
<td>↔</td>
<td>↓</td>
<td>β-Damascenone</td>
<td>↑</td>
<td>↓</td>
<td>↓</td>
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<tr>
<td>β-Citral</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>α-Ionone</td>
<td>↑</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>β-Ionone</td>
<td>↑</td>
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<td>↓</td>
<td></td>
<td>↑</td>
<td>↓</td>
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</tr>
</tbody>
</table>
Harvest Treatments

Not shown
- Hand harvest
- Gregoire G8 mechanical harvester (2018 only)
- Optical sorter (2017 only)
2017 Fermentations and materials removed per load at de-stemming

HAND HARVEST

MECHANICAL HARVEST

MECHANICAL HARVEST PRECEDED BY LEAF REMOVAL

MECHANICAL HARVEST “OPTI”

 SORTINGS

MECHANICAL HARVEST + OPTICAL SORTING
Impact of Harvest Strategies 2017 - Terpenes and Norisoprenoids

Concentration (ug/L)

- CONTROL
- MECHANICAL HARVEST
- MH + LEAF REMOVAL
- OPTI HARVEST
- MH + OPTICAL SORT

Graphs showing the concentration of various compounds under different harvest strategies.
Impact of Harvest Strategies 2017-Alcohols and esters

**hexanol**
- CONTROL
- MECHANICAL HARVEST
- MH + LEAF REMOVAL
- OPTI HARVEST
- MH + OPTICAL SORT

**heptanol**
- CONTROL
- MECHANICAL HARVEST
- MH + LEAF REMOVAL
- OPTI HARVEST
- MH + OPTICAL SORT

**octanol**
- CONTROL
- MECHANICAL HARVEST
- MH + LEAF REMOVAL
- OPTI HARVEST
- MH + OPTICAL SORT

**hexyl acetate**
- CONTROL
- MECHANICAL HARVEST
- MH + LEAF REMOVAL
- OPTI HARVEST
- MH + OPTICAL SORT

**ethyl heptanoate**
- CONTROL
- MECHANICAL HARVEST
- MH + LEAF REMOVAL
- OPTI HARVEST
- MH + OPTICAL SORT

**phenethyl acetate**
- CONTROL
- MECHANICAL HARVEST
- MH + LEAF REMOVAL
- OPTI HARVEST
- MH + OPTICAL SORT

**ethyl nonanoate**
- CONTROL
- MECHANICAL HARVEST
- MH + LEAF REMOVAL
- OPTI HARVEST
- MH + OPTICAL SORT

**ethyl decanoate**
- CONTROL
- MECHANICAL HARVEST
- MH + LEAF REMOVAL
- OPTI HARVEST
- MH + OPTICAL SORT

**ethyl isobutyrate**
- CONTROL
- MECHANICAL HARVEST
- MH + LEAF REMOVAL
- OPTI HARVEST
- MH + OPTICAL SORT

**isobutyl acetate**
- CONTROL
- MECHANICAL HARVEST
- MH + LEAF REMOVAL
- OPTI HARVEST
- MH + OPTICAL SORT

**isoamyl acetate**
- CONTROL
- MECHANICAL HARVEST
- MH + LEAF REMOVAL
- OPTI HARVEST
- MH + OPTICAL SORT

**ethyl caproate**
- CONTROL
- MECHANICAL HARVEST
- MH + LEAF REMOVAL
- OPTI HARVEST
- MH + OPTICAL SORT

**ethyl octanoate**
- CONTROL
- MECHANICAL HARVEST
- MH + LEAF REMOVAL
- OPTI HARVEST
- MH + OPTICAL SORT
Possible Contributions From MOG

• Terpenes and other odorants √
  - Confirmed by GC-MS

• Bitter taste compounds √
  - Bitterness was partly used in multidimensional sorting to distinguish the wines

• Malic acid increase from leaves and petioles √
  - Acidity was likewise used by tasters to distinguish wines

• Metal content (Na, K, Mg, Fe) ?
  - Under investigation (Barry Cameron, Univ. of Wisconsin, Milwaukee)

• Decrease in anthocyanins and color intensity √
  - Preliminary lab data (e.g. OD 520, total anthocyanins) clearly show this
Tentative Conclusions

• “Floral taint” associated with frozen MOG is due primarily to several terpenes (linalool, geraniol, cis- and trans-rose oxide, citronellol, nerol), methyl and ethyl salicylate, and β-ionone

• Several esters and other aliphatic compounds also appear to be related—including phenethyl alcohol; ethyl heptanoate, octanoate, nonoate and decanoate; hexanol, octanol

• However—some of these, although very responsive, may be below threshold. But, (a) Most thresholds have been measured in water and are much lower in alcohol, and (b) There are lots of interactions between chemicals that we don’t fully understand.
Thanks!
More Thanks

Thanks to our interns Chao Wang (l) and Yuan Zhang (r) during 2017 vintage