Oxidative or Reductive?
The Role of Oxygen in the Evolution of Red Wine

Peter Bell
and
Nova Cadamatre MW

SWE Annual Conference 2018

Dr Jamie Goode
A whole chapter

10 Oxygen management and wine quality

Oxygen is not a necessary component for grapevine and yeast growth, nor for the development of wine quality. However, the exposure of wine to oxygen can have a profound influence on its character and evolution over time.

In the context of wine production, oxygen exposure affects the chemical and microbiological processes that define the wine's evolution. Oxygen can lead to oxidation and the development of undesirable off-flavors, such as metallic or sulfur compounds. It can also contribute to the development of secondary aromas, which can add complexity and depth to the wine.

Managing oxygen exposure is crucial in ensuring that the wine maintains its desired characteristics and evolves in a desired manner. This involves controlling the levels of oxygen that come into contact with the wine during various stages of production, from fermentation to bottle aging.

Managing oxygen exposure requires careful consideration of several factors, including the type of oxygen source, the timing and duration of exposure, and the wine's sensitivity to oxygen.

Total Dioxide: The total dioxide content is determined by titrating the dioxide content of a wine sample with hydrochloric acid. This measurement provides insight into the wine's ability to withstand oxidation, which is an important characteristic in maintaining its integrity and flavor profile.

Reduction Potential: The reduction potential of a wine is a measure of its oxidative stability. A wine with a lower reduction potential is more susceptible to oxidation, which can lead to the development of off-flavors.

These parameters are often monitored and controlled during wine production to ensure that the wine develops favorably and maintains its desired characteristics over time.

Managing Oxygen Exposure

By controlling oxygen exposure, winemakers can enhance the wine's quality and ensure that it evolves in a way that aligns with their desired outcomes. This involves a combination of technical and sensory evaluations, as well as the application of best practices in winemaking and wine storage.

In conclusion, oxygen management is a critical aspect of wine production that requires careful consideration and control. By optimizing oxygen exposure, winemakers can produce wines that are true to their intended character and maintain their quality over time.
“So what sorts of reactions happen when wine is exposed to oxygen? This is where it gets a bit complicated.”

Dr Gavin Sacks, Cornell University
Gavin: Things ARE a bit complicated. There are just a few things that no one disputes...

1. Oxygen facilitates fermentation
It prevents stuck fermentations...

(especially in high sugar musts)

...by increasing kinetics and ethanol tolerance
Gavin, cont’d

2. Oxygen suppresses production of acetate esters by decreasing the activity of enzymes that produce them

Key esters give “red fruits” aromas to wine
Beaujolais: lots of acetate esters

Gavin, cont’d

3. The macro-oxygenation effect does something, but...
during fermentation, yeasts consume oxygen *instantly*
Acetaldehyde
(key molecule in this discussion):
during fermentation there’s always
as much of it as there is ethanol

Here it is

\[
\begin{align*}
\text{H}_3\text{C} & \quad \text{O} \\
\text{C} & \quad \text{H}
\end{align*}
\]
But...

How long does it stick around to react with phenolics before it’s reduced to ethanol?

Gavin:
“I’m suspicious of oxygen increasing the lifetime of acetaldehyde during fermentation.”
But...

At the end of fermentation, oxygenation will make a difference in terms of building acetaldehyde.

And that’s when you have more polymeric pigments and tannins, especially if you employ things like extended maceration.
Building Polyphenol Content in Reds

1. Cold soak

2. Bleeding (saignée)

3. Extended maceration

along with...

Fermentation temperature
+
Enzymes
The Role of Acetaldehyde in Polymerization of Phenolic Groups

What about limiting oxygen after completion of fermentation?
1. Less acetaldehyde generation
   (oxygen oxidizes ethanol)

2. Retention of volatile sulfur compounds that would otherwise be oxidized or lost by entrainment
Hydrogen sulfide

\[
\begin{array}{c}
\text{S} \\
\text{H} & \text{H}
\end{array}
\]

“Reductive” winemaking
...is very loosely defined

At its most basic, it’s the (near) exclusion of oxygen during winemaking
What is the role of H$_2$S in the evolution of ‘reductive’ red wines?

Is it a ‘marker’ chemical, or does it actually participate in desirable reactions?
But first – what does a reductive red wine smell like?

Glass #7
Rotten Eggs

Toasty / Roasty / Meaty
“I love young wines that start out very reductive like this, because by the time they’ve gone through élevage and bottling, then you’ve got this lovely ‘ghost’ of reduction. So you don’t say, ‘This is reduced.’ But it’s got this lovely framing to the wine that comes from having these volatile soft compounds in there at some stage, and then they’ve developed into something different.”

H$_2$S is generated during fermentation, generally when yeasts are stressed.
Stress:

Nutrient deficiency
and/or
hot, fast fermentation

Even at sub-threshold levels, H$_2$S
reacts with other compounds
...and it will react with some oak extractives*, even at ppb (H₂S) and ppt (oak) levels, to make new compounds

*lactones, phenols, aldehydes

Reduction is usually a temporary state but it can persist in bottled wine for several years
Current thinking: treating with copper is a BAD idea

Let’s taste.
<table>
<thead>
<tr>
<th>Wine</th>
<th>pH</th>
<th>TA</th>
<th>Alc %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fox Run Cab franc ‘15</td>
<td>3.71</td>
<td>6</td>
<td>12.7</td>
</tr>
<tr>
<td>240 Days Cab franc ‘15</td>
<td>3.65</td>
<td>5.5</td>
<td>12</td>
</tr>
<tr>
<td>Fox Run Cab franc ‘16</td>
<td>3.76</td>
<td>6.2</td>
<td>12.5</td>
</tr>
<tr>
<td>240 Days Cab franc ‘16</td>
<td>3.8</td>
<td>6.3</td>
<td>13</td>
</tr>
<tr>
<td>Fox Rub Cab franc barrel sample ‘17</td>
<td>3.63</td>
<td>7.4</td>
<td>12.1</td>
</tr>
<tr>
<td>240 Days Cab franc barrel sample ‘17</td>
<td>3.6</td>
<td>7.1</td>
<td>12.7</td>
</tr>
<tr>
<td>Fox Run Lemberger tank sample ‘17</td>
<td>3.45</td>
<td>7.7</td>
<td>12.3</td>
</tr>
</tbody>
</table>