NOMACORC®

RESEARCH UPDATE

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Nomacorc Research Helps Winemakers Manage Oxygen in Wine

Closure Leader

Nomacorc, which began ten years ago as a wine aficionado's solution to the pervasive problem of cork taint in wine, has grown to become the world's largest producer of alternative wine closures. Now manufacturing more than two billion still wine closures each year, Nomacorc is the leading closure brand in many countries, including France, Germany and the United States. Nomacorc's patented coextruded technology produces closures with the most consistent, controlled oxygen transfer rates (OTR) to ensure optimum wine preservation.

Global Research

In 2007, Nomacorc initiated fundamental research programs in partnership with world-renowned wine institutes to answer key questions about oxygen management and how wine develops after bottling.

> How does oxygen transfer through the closure influence a wine's chemistry and sensory attributes, particularly aroma, taste, structure and color?
>
> How does oxygen exposure and control at various stages in the winemaking process – particularly at bottling – affect closure performance and wine evolution?

Measurement Tools

In order to carry out this advanced research, Nomacorc, in collaboration with technology partner PreSens, developed an effective, nondestructive evaluative tool to accurately measure oxygen. Branded as NomaSense®, this specialized analytical equipment also has practical applications in the field. For example, it can be used by wineries to bring bottling lines under control, extending a wine's shelf life, improving bottle-aging consistency, and permitting closures to perform optimally.

Oxygen Management Leadership

The outcomes of Nomacorc's research initiatives are already changing industry perceptions and understanding of post-bottling wine development. The oxygen management expertise Nomacorc has gained is providing winemakers with practical tools and data to eliminate fault and produce more consistent, better-quality wines in alignment with winemaker intention.

Nomacorc structured its research collaboration with world-renowned academic partners to explore the full spectrum of the winemaking processes and their relationship with oxygen.

To date, the programs have produced detailed information about oxygen exposure levels during various winemaking stages (Universidad Católica de Chile), identified significant factors accelerating wine oxidation (University of California, Davis), characterized wine chemistry before bottling (Australian Wine Research Institute), determined the influence of bottling on wine development (Geisenheim Institute) and assessed the impact of OTR on post-bottle wine aging taking into consideration all of this collective knowledge (Institut National de la Recherche Agronomique).

Future Goals

Nomacorc is in the process of developing a scientific methodology from which to predict how oxygen management will influence wine development. In collaboration with Nomacorc, winemakers will be able to determine the optimum closure and associated OTR to achieve desired wine styles and shelf-life expectations. In addition, Nomacorc will use these research findings to develop next-generation products to help winemakers achieve their winemaking goals.

Universidad Católica de Chile
Measuring Oxygen's Impact on Wine Quality

Researchers from the Universidad Católica de Chile monitored dissolved oxygen patterns during each of the different winemaking stages to understand exactly when and how a wine is exposed to oxygen. The team is now investigating the amount of oxygen introduced at different winemaking steps. The results obtained will help wineries validate their processes and establishing controls to reproduce the desired oxygen exposure at various intervals. With this information, winemakers will soon be able to apply specialized winemaking techniques intentionally depending on the amount of oxygen their wine and varietal will need.

Preliminary Findings

- The Católica team developed a fully integrated winemaking setup to monitor oxygen in tanks during maceration and fermentation. They took advantage of NomaSense's separate sensors and dipping probes to measure oxygen at different locations and notably at different depths in the tank.
- During fermentation, oxygen gradients were found inside the tank, a result of imperfect mixing processes. This revealed that winemaking tanks are not homogeneous in terms of oxygen concentration.
- In this winemaking setup, the output pump contributed almost 70% of the oxygen supplied to the wine during the "pumping over" phase. The transfer of wine from the tank to the open tank only contributed 30% of the added oxygen.
- Delestage, an alternative method to "pumping over," showed to be much more effective in introducing oxygen in a homogeneous manner.

University of California, Davis
Primary factors influencing wine oxidation

Research initiatives at the University of California, Davis confirmed that higher temperatures and contact with metal ions during winemaking have a pronounced affect on oxygen levels in wine and can lead to premature oxidation in wine. This occurs irrespective of varying closure oxygen transfer rates (OTRs) and show that winemakers must control both temperature and metal levels during winemaking to prevent damage to wine.

Preliminary Findings

- Using NomaSense technology and the consistent OTR of Nomacorc closures, researchers measured both dissolved and headspace oxygen. Both dissolved and headspace oxygen were consumed faster at higher temperature levels. This effect was significantly more pronounced in red wine than in white wine.
- Both free SO2 and total SO2 were consumed faster at higher temperature levels.
- Temperature was responsible for an increase in optical density at 420 nm, often referred to as "browning," in both red and white wines. This occurs more quickly in red wines than white wines and proved a good indicator of oxidation.
- Dissolved oxygen was rapidly consumed when the concentration of iron and copper ions increased. This effect was evident even when free SO2 was doubled.
- Irrespective of closure OTR, wines oxidize more rapidly when exposed to increased temperatures and metal ion concentrations.

Australian Wine Research Institute (AWRI)
Influence of copper fining on white wine preparation

Initial results of research programs in progress at the Australian Wine Research Institute (AWRI) confirm that the way a wine is prepared for bottling dramatically influences the way the wine develops after bottling.

Researchers explored the impact of copper addition and glutathione (GSH) on sulfur compounds. Surprisingly, their results indicate that most winemakers need to reassess whether copper additives are beneficial to their preferred winemaking style.

Preliminary Findings

- AWRI researchers invested significant efforts to control bottling lines and achieve very low oxygen exposure during bottling. NomaSense technology was used to monitor oxygen exposure during bottling in addition to post-bottling oxygen consumption.
- Glutathione (GSH), which is naturally produced in the fermentation process, may protect against the loss of good volatile thiols that are responsible for varietal character but enhances hydrogen sulfide, which produces the "rotten egg" aroma formation. This effect becomes even more pronounced when wines are copper-fined.
- Copper fining at bottling should really be called copper addition because research shows that some copper remains in the wine. When considered with results from the UC Davis study, this means wine will be more sensitive to oxidation.
- Copper addition often has negative effects on wine, including reducing the levels of good thiols. As a result, the copper addition negatively affects wine color in both white and red wines.
- The hydrogen sulfide or "rotten egg" aroma that forms under reductive conditions can actually be enhanced by copper addition. In other words, copper addition does not offer long-term protection against the development of reduced aromas.
- A wine can exhibit both reduced and oxidized characteristics simultaneously.

Geisenheim Institute
Importance of Controlling Bottling to Manage Wine Development

Early results from the Geisenheim Research Center demonstrate that improper oxygen control during bottling can seriously compromise a wine's shelf life as well as its post-bottling development.

Using NomaSense measurement equipment, the Geisenheim research determined that the headspace in fact represents a significant reservoir of oxygen that contributes to wine evolution. In order to use a closure's oxygen transfer rate (OTR) to enhance a wine's development, winemakers first have to control bottling conditions.

Preliminary Findings

- Geisenheim researchers bottled the same Riesling wines with different oxygen content in the headspace (varying both volume and oxygen concentration) while keeping the same dissolved oxygen levels in all bottles. The bottles were closed under both Nomacorc closures and short skirt screw cap closures.
- Using NomaSense technology, researchers measured dissolved and headspace oxygen as well as oxygen ingress through the two types of closures over one year of bottle storage.
- Researchers also developed the concept of total consumed oxygen (TCO) by integrating dissolved oxygen (DO), headspace oxygen and oxygen ingress. This provides a total picture of the oxygen that reacts within a bottle of wine.
- Winemakers measuring only dissolved oxygen underestimate the risk of oxidation in their wines because the oxygen entrapped in the headspace will dissolve into wine and react with the wine.
- Wine evolution and notably free SO2 drop can only be predicted based on TCO and not solely on DO.
- The combination of controlled bottling and a closure with the appropriate OTR enables winemakers to effectively manage the wine aging process and minimize the occurrence of fault and inconsistency.

Institut National de la Recherche Agronomique (INRA)
Influence of Oxygen Transfer Rate through Closures on Post-Bottling Wine Development

Initial results of the research project currently underway at the Department of Enology Science at the Institut National de la Recherche Agronomique (INRA) show that wine closure oxygen transfer rate (OTR) is more important to advantageous wine development than micro-oxygenation after ten months in the bottle. Once winemakers identify the appropriate amount of oxygen for their desired winemaking outcome, they will be able to match the closure OTR to a wine varietal's need.

Preliminary Findings

- Researchers made wine from the same Grenache grapes using different methods including varied polyphenol extraction and micro-oxygenation treatments. Wines were closed using Nomacorc closures with different oxygen transfer rates. Combining winemaking techniques, closure choice and storage conditions, researchers managed to create 16 potentially different wines.

- Researchers monitored wine aging using color, polyphenol, sensory and chemical data analyses. By all metrics, oxygen transfer through the closure altered the wines' chemical development and sensory attributes.

- Color development in red wine is an accurate indicator of oxidation and a better indicator than free SO2, a common industry standard. This outcome is consistent with findings from the UC Davis research.

  After 10 months of aging, oxygen transfer rates become the primary influence on wine evolution over time, overriding the influence of other oxygen exposures that occurred during winemaking such as micro-oxygenation or during bottling.

- Another important outcome of this research is the revelation that even when no oxygen is added to a wine, the wine will still evolve. It is wrong to think that a wine made "ready to drink" will stay "as is" in absence of oxygen.

- Researchers also found that micro-oxygenation, applied to stabilize red color prior to bottling, can be ineffective in the long term if the OTR of the closure is not adapted appropriately to provide adequate oxygen post-bottling to maintain the effects of micro-oxygenation.
- These results prove that the OTR of a closure is a critical tool for winemakers to control wine evolution even after bottling.