NOMACORC®

RESEARCH UPDATE

MAY 2011

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 2 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 co-extrusion technology produces closures with the most consistent, controlled oxygen transfer rates (OTRs) 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 do oxygen exposure and control at various stages in the winemaking process – particularly at bottling – affect closure performance and wine evolution?

Measurement Tools

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 that 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 improved our knowledge on oxygen exposure during various winemaking stages (Pontificia Universidad Católica de Chile), identified significant factors accelerating wine oxidation (University of California, Davis), characterized the effect of wine composition on post-bottling evolution (The 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 (Institut National de la Recherche Agronomique).

2010-2011 Research Focus

After several years of solid research on the effects of oxygen exposure on wine development in the bottle, research efforts in 2010 focused on improving understanding of the concept of "wine oxygen demand." To get to the core of the key question – Which key factors determine the amount of oxygen that each wine needs to express its full potential, without displaying obvious sensory faults? – Nomacorc capitalized on a research platform that includes partners in five major wine-producing countries.

Different winemaking practices were applied to wine production from several grape varieties across the different countries. The wines created were then submitted to different highly controlled oxygen regimes, using the NomaSense technology to constantly monitor oxygen evolution during bottle storage. The results generated by the different partners have advanced the research to a pivotal point in progression toward the goal of providing winemakers with knowledge and actionable solutions to improve wine quality and create specific wine styles. Nomacorc is now using this scientific database to develop an applied methodology to predict wine development in the bottle and design tailored oxygen management strategies from the grape to the glass.

Key Research Findings

Closure Selection to Modulate Aroma Development of Red Wine During Bottle Storage

During the last four years, research trials have been carried out to investigate the effects of oxygen exposure on red wine development during bottle storage. It is generally accepted that red wine benefits from continuous exposure to small amounts of oxygen, because oxidation of phenolic compounds results in increased color stability and better mouthfeel properties. The results of our studies indicate that, along with oxygen's effects on wine phenolics, variations in oxygen exposure during bottle storage – in particular, those introduced by the use of closures with different OTRs – have a dramatic impact on wine aroma development in the bottle.

By studying the behavior of Grenache, Shiraz, Carmenere and Cabernet Sauvignon wines under different oxygen regimes, these studies have indicated that OTR has a key influence on the development of red berry attributes. During a defined time frame (typically two to four years for these studies), different aroma profiles can be obtained from the same wine (Figure 1). In particular, researchers identified an optimal range of OTRs to promote the expression of red and dark fruits, chocolate, and spice attributes (Profile B) while avoiding the dominance of reduced (Profile A – lower OTR) or aged (Profile C – higher OTR) characters. Based on this knowledge, our closure development strategies are focused on the creation of a range of products able to provide a range of OTRs that allows avoiding faults and promotes optimum aroma expression.

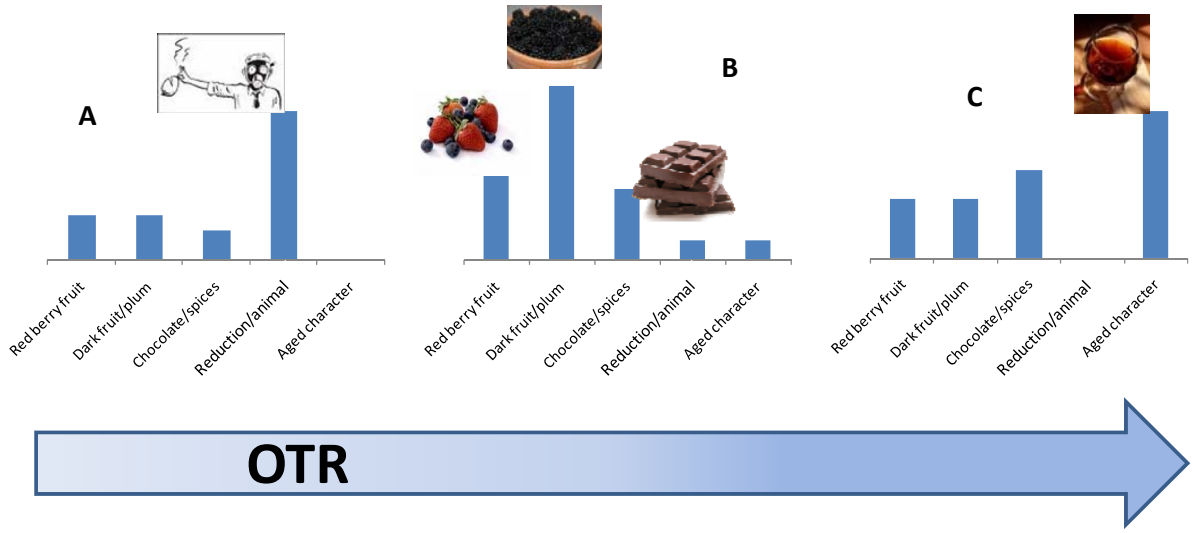

Figure 1. Red wine aroma profiles that can be achieved by using closures with different OTRs.

The potential for winemakers to use closure OTR to enhance the expression of red berry fruit attributes in wines is of great interest, because this characteristic is often considered a preferential attribute in red wines.

The INRA research team explored the evolution of this particular attribute in Grenache wines over time (Figure 2). Early in wine life, expression of red fruit aromas decreases, possibly due to the masking effect of other wine aroma components. After this initial period (which in this particular study was five months in 375 mL bottles, approximately equivalent to ten months in standard bottles), red berry aromas increased. By both reducing the initial loss and promoting late enhancement, higher OTR resulted in wines with increased red berry aromas.

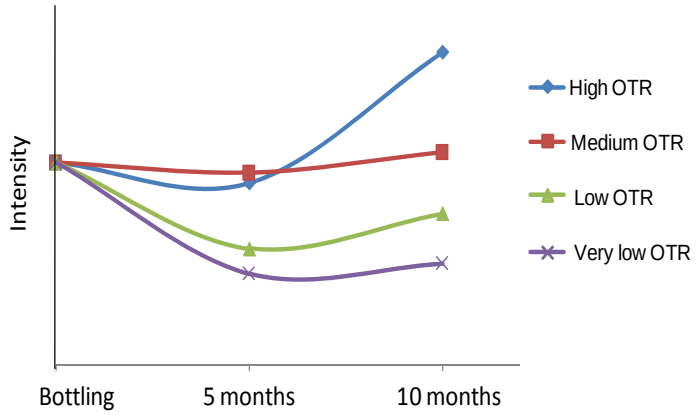

Figure 2. Evolution of red berry attributes of Grenache red wines as a function of oxygen exposure during bottle storage.

The chemistry behind these trends still needs to be established. Interestingly, it was often observed that increases in the intensity of the red berry attribute coincided with decreases in the intensity of reductive off-flavors, suggesting that these two sensory characters might act in an antagonistic way (Figure 3). Therefore, one way in which higher OTR closure might promote red berry aromas is simply by preventing the accumulation of compounds supporting reductive off-flavors, such as hydrogen sulfide and methyl mercaptan (Figure 3).

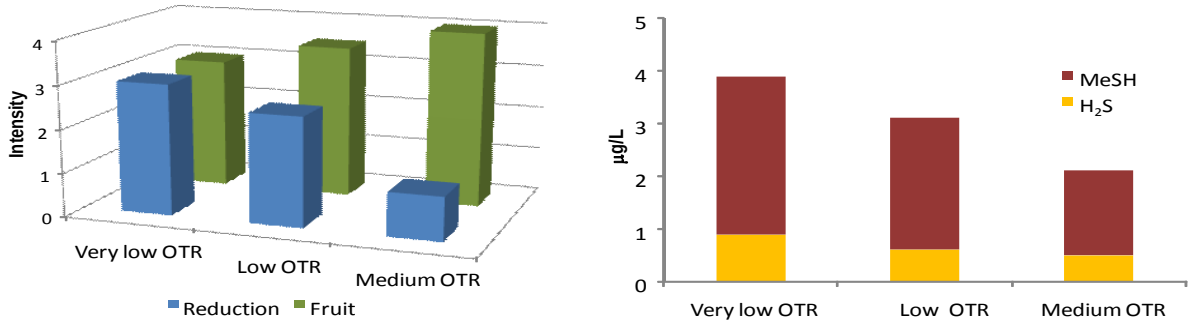

Figure 3. Effect of oxygen exposure in the bottle on Shiraz aroma profile and content of volatile sulfur compounds.

Although the positive correlation between OTR and the intensity of red berry aromas was observed in several trials carried out by different research partners, the extent of this effect appeared to depend somewhat on wine type. In particular, it was observed that in wines with high phenolic content, the effects of oxygen exposure on red berry aromas were less marked, at least over the time periods studied (one to two years in 375 mL bottles).

This latest set of studies has clearly shown that, during bottle storage of red wine, exposure to adequate amounts of oxygen is key to the development of attractive sensory features such as red berry, plum and chocolate characters. Therefore, the benefits of careful oxygen management are not limited to the control of aroma defects such as reduction and oxidation. By applying oxygen management strategies, particularly by selecting closures with the right OTR, it is also possible to enhance sensory attributes that are positively linked to consumer preference.

Specific Outcomes From the Individual Research Institutes

Pontificia Universidad Católica de Chile (Chile)

- Closures with specific OTRs can strongly affect the development of Carmenere wines during bottle aging. In Carmenere Varietal, closures with lower OTRs, such as screw caps, led to the development of reductive aromas. Conversely, higher OTRs resulted in increased red berry aromas. In Carmenere Reserve, wines sealed with lower-OTR closures exhibited more intense aromas of caramel, violet and dried fruit, while higher-OTR closures promoted expression of berry fruits and tobacco aromas. The outcome of a given OTR on wine development depends not only on the OTR of each closure but also on the wine varietal.

- Researchers developed a model based on analytical parameters related to wine antioxidant capacity, which predicted the ability of a wine to consume oxygen.

- In Carmenere wines, the concentration of transition metals iron, copper and manganese did not affect oxygen consumption rate.

The Australian Wine Research Institute (Australia)

- The aroma, color composition and sensory properties of Shiraz wines can be effectively modulated by OTR selection. Over a period of 20 months in 375 mL bottles (roughly equivalent to 40 months in standard-size bottles), jam, berry and chocolate attributes can be enhanced by exposure to very small amounts of oxygen during bottle storage.

- In red wines, development of reductive off-flavors during bottle storage is linked to accumulation of the sulfur compound methyl mercaptan (MeSH). Other sulfur compounds such as H_2S and dimethyl sulfide (DMS) also play a role.

- The antioxidant glutathione (GSH), often found at higher concentrations in wines aged on lees and/or supplemented with specific fermentation additives, increases the stability of compounds contributing to the varietal aroma of Sauvignon Blanc wines. However, in certain wines, occurrence of high levels of GSH can have negative sensory implications. This is due to the concomitant positive effect of GSH on certain compounds responsible for reductive off-flavors. Post-bottling oxygen exposure and closure selection can help winemakers retain the beneficial effects of GSH on varietal aromas and at the same time control reductive off-flavors.

Institute National de la Recherche Agronomique (Montpellier, France)

- In Grenache red wines, proanthocyanidins and hydroxycinnamic acid concentrations decrease during aging in the bottle, regardless of closure OTR.

- Across two different vintages and for both Grenache red and Grenache rosé wines, color intensity increased with increasing OTR.

- Loss of free SO_2, flavan-3-ol monomers and the conversion rate of anthocyanins to new pigments, including sulfite-bleaching-resistant pigments, can be affected by OTR.

- The proportion of anthocyanins to tannins can affect OTR influence on color development during bottle storage.

- Vitisin A can be considered an oxidation marker, with its concentration increasing in wines that were submitted to micro-oxygenation and/or sealed with closures having higher OTR.

- OTR can be used to control the development of phenolic compounds during bottle aging, allowing "winemaking in the bottle."

Geisenheim Institute (Germany)

- The amount of oxygen present in bottle headspace affects wine development during bottle storage. In Riesling wine stored for 14 months in 375 mL bottles, low headspace oxygen preserves SO_2 but can lead to excessive accumulation of the off-flavor compound H_2S. The effects of oxygen management at bottling can still be observed after long periods of storage, regardless of the type of closure.

- Because they affect post-bottling wine development, oxygen variations at bottling lead to different wines. When consumers were presented with wines bottled with different amounts of oxygen and with varying closure OTRs, preferences were not univocal. This highlights the great potential for basic oxygen management at bottling to create different styles of wines for specific consumer segments. In the case of a 2-year-old Riesling wine, three consumer segments were identified. One segment showed only moderate preference for wines exposed to low oxygen at bottling and during storage; the other two segments showed strong and opposite preference, with these same wines being strongly liked or disliked depending on the consumers' segment.

- For some, closure type is believed to affect consumers' purchasing decisions regardless of wine characteristics, origin and actual quality. In a survey of 300 individuals, a higher rate of acceptance was reported for synthetic closures compared to screw caps, for which a higher degree of rejection was observed.

University of California, Davis (United States)

- Winemaking techniques influence the outcomes of oxygen management strategies, including closure selection.

- In a Chardonnay wine, formation of the oxidation marker acetaldehyde during bottle storage depended on complex interactions between OTR and winemaking procedures. Aging on lees, either in stainless steel or in tanks, reduced the formation of acetaldehyde in the bottle.

- Wines aged on lees in stainless steel tanks were found to be very responsive to closure OTR, and the combination of lees aging and lower OTR decreased oxidative spoilage compounds. These results show a first example of how oxygen management strategies (e.g., the choice of OTR) can enhance the outcomes of other winemaking operations (e.g., aging on lees) that are commonly carried out in the winery to achieve distinct wine styles.

- A comparative study on the effects of lees aging, storage in barrel or steel, and bottle aging with varying OTRs on Chardonnay aroma profile revealed that OTR is the second-most-effective variable after the storage container.