Sources in the bottling line operation responsible for dissolved oxygen entry in wine

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Introduction

The benefits and drawbacks of dissolved oxygen in wine can be discussed at great length. However, to extend the aging potential and prevent undesirable changes in the wine due to oxidation, a winemaker must recognize that in most cases oxygen is considered to be detrimental in the production of a high quality product.

Benefits of limited oxygen

In some cases, oxygen exposure in the must/juice otherwise known as hyperoxidation has been associated with stabilizing white wines from further browning oxidation during the vinification process. This enzymatic oxidation occurs in must/juice absent of sulfur dioxide (SO_2). During enzymatic oxidation, certain phenol groups react with oxygen to produce yellow quinones. These compounds in turn react with more oxygen to yield brown colored products. This process stabilizes further browning reactions in wine from this source (Ough, 1992). Although, the author of this text considers grape juice oxidation as being detrimental to producing wines of high quality, this oxidative process is not implicated for the most part in oxidative reactions occurring in wine.

Oxygen is also essential during the initial stages of alcoholic fermentation for healthy yeast propagation and fermentation. Residual oxygen is then completely removed by the increased production of carbon dioxide (CO_2) during the fermentation process.

Some controlled oxygen exposure may be beneficial in red wines during barrel aging. This increases phenol polymerization and improves color stability and softening of the palate in red wines (Zoecklein, 1995). A cellar procedure for controlled oxygen addition accomplished in red table wines known as micro-oxygenation is reported to reduce harshness and softens the palate. It is important to understand that micro-oxygenation is intended to avoid excessive accumulation of dissolved molecular oxygen in the must or wine that causes oxidation (Smith, 2002). However, the advantages of micro-oxygenation needs further research performed and should be performed by trained personnel only in recommending this technique.

Oxygen Elimination Prior to Bottling

Generally, oxygen is detrimental to wine quality especially from the end of fermentation through wine storage and bottling. The presence of oxygen during the latter stages of wine production can increase browning reactions, chemical and microbiological instability and the production of off aromas such as acetaldehyde.

Attention must be given during the vinification process to avoid those potential sources for oxygen pickup and prevent excess oxygen from dissolving into the wine. Key sources for oxygen pickup include: racking, excess headspace, pumping, filtration and bottling. Depending on temperature, dissolved oxygen levels can range from 6 to 9 mg/L in wine. Higher levels are expected at lower temperatures (Boulton et al., 1999). Since the rate of oxidation increases with temperature, it is critical to add the appropriate amount of SO_2 based on wine pH. Furthermore, when kept at low temperatures, such as during cold stabilization, protecting the wine from air and keeping tanks full is essential to minimize oxygen absorption in wines (Gallander, 1991). Other practices such as filling tanks from the bottom, inspecting for leaky pump seals and securing any loose hose connections on the inlet side are necessary to lowering oxygen pickup. Prior to bottling, excess oxygen in wines can be removed by using an inline sparger. This introduces an inert gas like nitrogen (N_2) or CO_2 through a porous stainless steel cylinder suspended in the wine. As the wine passes around the sparger, gas bubbles enter the product and displace the dissolved oxygen. The bubbles will rise to the top of the tank releasing the inert gas and oxygen. For this procedure, the use of CO_2 as an inert gas is less effective and may excessively carbonate (saturate) the wine prior to bottling; therefore, N_2 is preferred (Ough, 1992).

Oxygen Elimination at Bottling

Bottling is the last process where added dissolved oxygen can have a significant negative impact on the aging potential and quality of the wine being released directly to the consumer. Thus, extreme care must be employed in minimizing the amount of oxygen entry at bottling.

Oxygen has the potential to dissolve into the wine at every stage of the bottling process. A recommended level for total dissolved oxygen in bottled red wines should be below 1.25 mg/L and 0.6 mg/L for white, blush and rose wines (Fugelsang, 2009). Major sources of oxygen diffusion into wine at bottling occur during wine transfer, filtration, filling and headspace levels of the bottling tank, filler and bottle. Each process will be described in further detail below.

When transferring wine to the bottling tank, it is advisable to purge the tank and transfer lines with N_2 or CO_2 prior to filling. If any headspace is present after filling, it is important to use an inert gas on the surface to prevent oxygen from dissolving into the wine. Often, a mixture of N_2 and CO_2 can be beneficial especially for white wines. Maintaining a slight but constant pressure over the headspace is recommended. Although CO_2 levels ranging from 300 – 600 mg/L can enhance a young white or light red wine (Peynaud, 1984), caution must be used that excessive pressure may cause too much CO_2 absorption providing a noticeable tactile sensory perception and possible bubble formation. In addition, excessive CO_2 levels can cause an increase in pressure possibly pushing the cork out after bottling. Therefore, the use and monitoring of CO_2 in the wine prior to bottling by Carbodoser is beneficial in adjusting concentrations up or down accordingly for these purposes. The Carbodoser is a relatively simple technique involving a glass tube measuring the amount of CO_2 out-gassed from a fixed volume of wine. Comparing actual results with a calibration curve provides the concentration of CO_2 in mg/L of wine.

Wine filtration prior to bottling is another source for oxygen pickup. During filtration, it is important to operate the filtration unit according to the manufacturer's directions making sure all connections and pads are tight to prevent oxygen entry. Purging of air from the filter pads and transfer lines is also a recommended practice.

Wine entering the filler bowl is typically one of the most problematic sources for oxygen pickup. The filler bowl should also be covered with an inert gas to reduce oxygen pickup. Depending on the type of filler used, filling of wine into bottles can increase the levels of dissolved oxygen by 0.5 to 2.0 mg/L (Peynaud, 1984). The length of the fill spouts as well as the type and force of the jet may influence the amount of dissolved oxygen. Therefore, it is advisable that filling tubes be as long as possible depending on the bottle. Providing vacuum prior to filling and flushing with 2 to 3 volumes of N_2 has been reported to lower oxygen absorption at bottling (Boulton, et al., 1999).

After filling, bottle headspace is another source of oxygen absorption. This is due, in part, to the variability of the bottle headspace, which is influenced by such factors as, wine temperature, solubility of gases in the wine, bottle size and shape. To help reduce oxygen ingress at this stage, the injection of an inert gas such as N_2 or CO_2 can reduce the amount of oxygen in the headspace. According to Peynaud (1984), a small amount of CO_2 supplied to the bottle headspace will help replace the oxygen and diffuse into the wine causing a depression which also helps prevent the problem of wine leakage due to expansion. In addition, a bottling line supplied with vacuum filler is also effective in reducing the amount of oxygen in the headspace. Similarly, a controlled dosage of liquid N_2 into the wine after filling is another good option in flushing oxygen from bottle headspace for screw-cap operations (Crochiere, 2007).

The corking machine may vary on whether it supplies a vacuum or not prior to cork insertion. According to Crochiere (2007), if set up properly supplying a vacuum at corking can help reduce the amount of oxygen absorption into the wine.

Whether using inert gas sparging, pulling a vacuum, liquid N_2 dosing or a combination of these procedures, it is advisable to keep the time and distance from the filler to the corking machine as short as possible. In addition, if there is an interruption in the bottling line process, down time may cause the inert gas to escape allowing oxygen to concentrate back into the headspace of the bottle. Therefore, if a bottling line stoppage has occurred, it is advisable to remove all bottles in question and dose them again or discard them from the bottling line.

The last important item of the bottling process that influences oxygen absorption in wine and ultimately affects aging potential is the closure. Today, there are many wine closures available each having different properties. Two major functions affecting oxygen pickup in bottled wine include closure recovery time from compression and the rate of oxygen permeation. Lopes et al., (2007) indicated that the level of oxygen permeation is lowest for screw caps and “technical” corks, intermediate for conventional natural cork stoppers, and highest for synthetic closures. Further, they showed that differences in oxygen pickup varied among grades of each closure. This variability could then provide an explanation for bottle to bottle variation. This finding was in agreement with the results reported by Crochiere (2007). Both studies reported the need to be more consistent in production standards of each type of closure as it relates to compression recovery and oxygen ingress rates.

In conclusion, oxygen incursion at bottling can have a significant negative impact on wine quality and aging potential. Therefore, the recognition and knowledge of how one can control or limit the amount of oxygen entry at bottling is critical.

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