REDUCTIVE WINEMAKING FOR WHITE WINES.

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Reductive winemaking is a technique that has become widely used in Australia and New Zealand to make white wine. The wines produced by reductive processes are usually fresh and vibrant, with varietal grape character as the primary aroma and flavour. In these wines, secondary characters, such as those caused by oak, malolactic fermentation and extended yeast lees contact, are avoided.

The style produced by reductive winemaking is sometimes called the "New World" style. The style usually differs from wines made by so-called traditional techniques. It has been clearly demonstrated, however, that it is possible to make wines of this style using reductive techniques anywhere in the world. Consumers in some markets have shown a preference for the clean, fresh fruit driven characteristics of the reductive style. This preference has been a part of the increase in the popularity in Australian and New Zealand wine around the globe.

Reductive winemaking became popular in Australia and New Zealand after student winemakers were influenced by the teaching of Brian Croser at Charles Sturt University in the late 1970s. Croser's teaching emphasised the expression of grape characters in wine. Since that time, the use of reductive winemaking has become well established for aromatic varieties such as Riesling and Sauvignon Blanc. However, it is also valuable when applied to varieties not normally regarded as aromatic, such as Chenin Blanc, Verdelho and Colombard. Distinctive wines made from these varieties using reductive techniques enjoy success in the Australian market place.

To ensure that we understand the technique of reductive winemaking, we must first understand the theory of reduction and its opposite state, oxidation. Reduction and oxidation are classically measured using redox potential. Redox potential is a measure of the ability of a material or medium to gain electrons. A standard electrode containing hydrogen gas is assigned a zero value in the redox scale. The unit of measurement in the redox scale is the millivolt (mV). Reducing environments have a negative redox potential. Oxidising environments have a positive redox potential. Wine usually has a positive redox potential. Reduced wine may have a redox potential of +200 mV, while aerated wine may have a redox potential of +400 mV.

During reductive winemaking, we are seeking to maintain a low redox potential throughout the entire process of crushing grapes, making wine and delivering wine to the consumer. While the impact of materials with oxidising potential, such as winery sanitisers, must be considered, the major cause of elevated redox potential in juice and wine is contact with oxygen from the atmosphere.

The interaction of oxygen from air with juice and wine is a two-stage process. At any one time, oxygen can dissolve in juice and wine up to a level at which saturation occurs. The concentration at which saturation is reached depends on temperature. At low temperature, more oxygen can be dissolved than at higher temperature. After oxygen becomes dissolved in juice and wine, it can react with susceptible wine components. The presence of catalysts and the temperature of the medium influence the speed of these reactions. Components in the wine become oxidised, and the dissolved oxygen concentration in the wine drops. If further air exposure occurs, oxygen can again be taken up until saturation is reached, and reaction with wine components takes place. Repeated saturations and reactions can take place until all susceptible wine components have become oxidised.

The impacts of oxidation on white wine are well known. The colour of the wine becomes brown or sometimes pink. There can be a loss of fresh fruit characters, especially aromas with reduced characteristics such as the thiols in Sauvignon Blanc. Secondary aroma characteristics such as acetaldehyde can be formed when extreme oxidation takes place.

In reductive winemaking, oxidation is the enemy. Fortunately, we have a number weapons in the war against oxidation. These weapons form the underlying principles of reductive winemaking. They are:

- Exclusion of air and oxidants.
- Removal of oxygen.
- Removal of oxidative catalysts.
- Addition of antioxidants.
- Temperature.
- Measurement and monitoring.

Exclusion of Air:

In the cellar, juice and wine must be kept separate from air during reductive winemaking to prevent the dissolution of oxygen. The tanks in use must provide an effective oxygen barrier. Stainless steel is the almost universal material of choice. The tanks should be maintained in full condition, and the tank seals must be intact and effective in preventing oxygen ingress. In general, the surface area of juice and wine during all operations and storage should be minimised to reduce the opportunity for air contact. Inert gas cover can be used to prevent product contact with air, using nitrogen, carbon dioxide or argon. Minimising transfers, racking and other cellar operations will reduce the risk of air contact. All equipment must be hermetically sealed to avoid air entrainment during pumping and processing.

Care must also be taken in the bottling hall to prevent air contact with wine. The type of filler and the way the filler is managed are important in making sure that air does not come into contact with wine. Inert gas dosing can be used in empty bottles prior to filling. The headspace in the bottle must not contain air after the closure is applied. The packaging materials that are selected, such as bottle closures and bag in box films, will have an impact on the entry of oxygen into packaged wine after filling. The storage conditions used after filling may also have an impact on the oxidative status of wine before it reaches the consumer.

Exclusion of Oxidants:

While contact with oxygen from air is the major cause of elevated redox potential in juice or wine, several materials used in the winery are powerful oxidants and can also provide a source of oxidation. Contact of product with residues of chlorine, ozone and hydrogen peroxide must be avoided if a reduced environment is to be retained. The use of hydrogen peroxide to wash corks introduces a further risk of oxidant contact with wine, although problems from this source are rare today due to the work of cork suppliers to improve washing techniques.

Removal of Oxygen:

If oxygen does become dissolved in wine, it can be removed by sparging the wine with bubbles of inert gas. Oxidative damage can be limited if oxygen is quickly and effectively removed by this technique, before it has an opportunity to react with wine components. Dissolved oxygen in the wine enters the bubbles of inert gas during sparging and is dispersed to the atmosphere.

Removal of Oxidative Catalysts:

Several substances can increase the rate of reaction between oxygen and wine components. Removal of these substances reduces the rate of oxidation reactions. Enzymes such as polyphenol oxidase and laccase are strong oxidative catalysts. Polyphenol oxidase can be effectively managed by sulphur dioxide additions. Laccase requires thermal treatment for complete control. Treatment at 70° C for 30 seconds is sufficient to destroy laccase activity.

The role of metals in catalysing oxidation reactions is not well understood. It is suspected that copper and iron may enhance oxidation reactions under some conditions. Copper is an important tool in removing sulphide characters in reductive wines. Additions of copper should be carefully managed. The use of inert materials such as stainless steel for all wine contact surfaces will minimise iron and copper contamination in the winery. If copper or iron levels are high, treatment with potassium ferrocyanide can be considered.

Addition of Antioxidants:

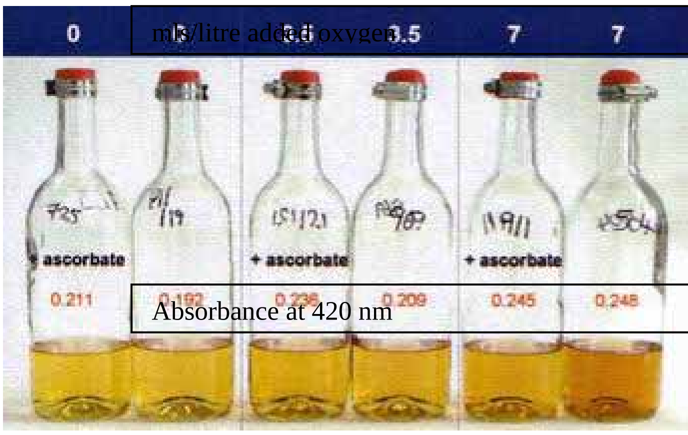
Several compounds used in winemaking are reductive and can react with oxygen by losing electrons. These compounds are known as antioxidants and are added to juice and wine to react with any oxygen that may become entrained. If the speed of the reaction between these compounds and oxygen is sufficiently rapid, oxygen is removed from solution and reactions between oxygen and other wine components will not occur. The products of the reaction of the antioxidant materials with oxygen do not have any negative organoleptic characteristics. These antioxidants are sacrificial in nature. The concentration of active antioxidant is decreased by reaction with oxygen. From time to time, it may be necessary to add further quantities of antioxidant if levels drop.

Sulphur dioxide (SO_2) is the most widely used antioxidant material and is universally used in reductive winemaking. SO_2 reacts with oxygen to form sulphate. Ascorbic acid and its optical isomer, erythorbic acid, also react with oxygen. The reaction forms hydrogen peroxide, which can then react with SO_2. The reaction of ascorbic acid with oxygen, and the subsequent reaction of hydrogen peroxide with SO_2, is more rapid than the direct reaction of oxygen with SO_2.

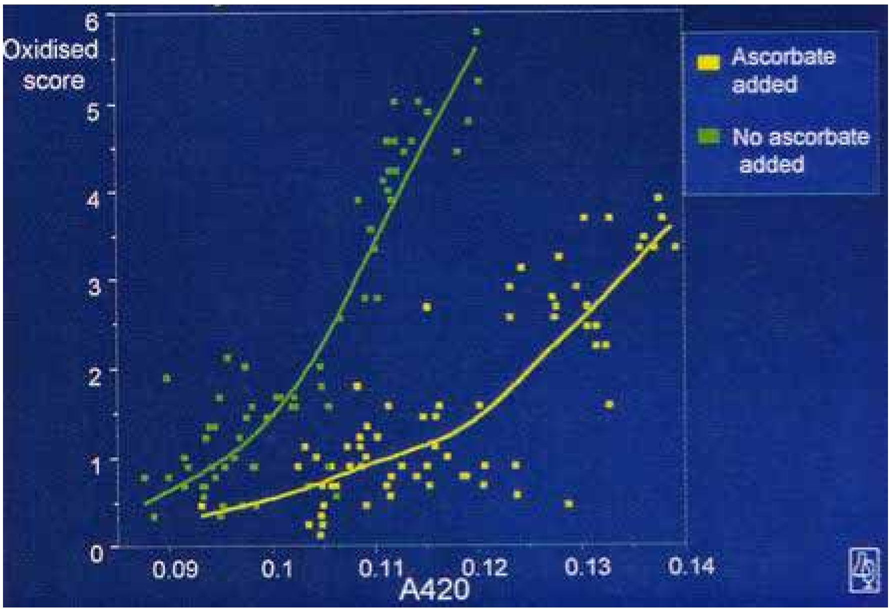
Tannin also has the ability to lose electrons and react with oxygen. However, tannin is not widely used as an antoxidant in white winemaking in Australia and New Zealand.

Ascorbic acid has been the subject of considerable study in Australia in recent years. The work of Peng et al (1998) showed that absorbance at 420 nm (A420) was increased by the presence of ascorbic acid in white wine. This work led to suspension of ascorbic acid by some winemakers in Australia. New research by AWRI, however, demonstrates that even though A420 is increased by the presence of ascorbic acid in some white wine samples after oxygen contact, the total amount of colour formed is lower. Ascorbic acid appears to prevent an increase in absorbance at wavelengths higher than 420 nm.

This phenomenon is demonstrated by the following illustration. Oxygen in varying amounts was added to bottles of white wine with and without ascorbic acid. The colours and absorbance at 420 nm of the wines were compared after 15 months. At lower oxygen addition rates, the A420 was higher in the bottles with ascorbic acid, but the colour apparent to the eye was no higher. At the highest oxygen addition level, the A420 of the wine without ascorbic acid was slightly higher, but the colour apparent to the eye was much higher. This information shows that although ascorbic acid may not have a large influence on A420, use of ascorbic acid will result in a wine of lower total colour over time.



Other work has shown that ascorbic acid is valuable for the retention of freshness and prevention of the development of oxidised character in white wine. The following illustration shows the tasting scores given for oxidation in a population of the same white wine. The tasting scale used was 0-9, where a wine with a 0 score was judged to have no oxidation character while a wine with a score of 9 was considered to be grossly oxidised. These results show that when wines have the same absorbance at 420 nm, those with added ascorbic acid have a lower score for oxidised character.



It must be remembered that ascorbic acid forms a peroxide intermediate when it reacts with oxygen. This intermediate reacts quickly with free SO_2. If no free SO_2 is present in the wine, however, this radical can react with wine components and promote oxidation. When ascorbic acid is used, it is essential that free SO_2 is present. A minimum free SO_2 level of 10 ppm should ensure that ascorbic acid reaction products are effectively scavenged.

In Australia, ascorbic acid has been found to be especially valuable in preventing pinking in white wine. When the results of Peng et al were released in 1998, several Australian winemakers stopped using ascorbic acid. Severe pinking problems were encountered in wines from the 2000 vintage. Wines made by those winemakers who had continued the use of ascorbic acid were considerably less affected by pinking than wines made without ascorbic acid.

Ascorbic acid and its optical isomer, known as isoascorbic acid or erythorbic acid, can be used interchangeably under Australian winemaking regulations. Reference will be made only to ascorbic acid throughout this paper.

Advantage can also be taken in reductive winemaking of biological antioxidants. Yeast cells are powerful oxygen absorbers during active growth. Yeast cells can also absorb oxygen after active fermentation has been completed. Wine on yeast lees is usually highly reductive.

Temperature:

The temperature of juice and wine will have an impact on the rate at which oxygen is dissolved and the rate at which oxidation reactions occur. At lower temperatures, juice and wine has more capacity to dissolve oxygen before saturation is achieved. However, the rate of reaction between oxygen and wine components at low temperatures is much slower than at high temperatures. Working cold may result in an elevated capacity to dissolve oxygen, but the impact of the dissolved oxygen is much lower than at high temperatures. When working reductively, the best strategy is to minimise temperature and keep the juice and wine protected from oxygen ingress.

Measurement and Monitoring:

When making wine using reductive techniques, it is extremely important to know the status of oxygen and antioxidant concentrations in juice and wine at all times. Redox potential measurement is rarely used as a quality control tool in Australia, although there is renewed interest in the measurement as a true indicator of the reductive or oxidative status of wine. Oxygen is routinely measured, either in samples taken to the laboratory or in situ, using accurate dissolved oxygen meters. To obtain value from dissolved oxygen measurement, it is essential that air contamination of the samples is avoided.

The concentration of antioxidants in juice and wine is also measured carefully. SO_2 is analysed using the aeration/oxidation method. Ascorbic acid is usually measured using iodine titration. Browning is estimated using absorbance at 420 nm, but the effects of ascorbic acid must be considered with this measure, as described earlier. Also, it must be remembered that browning is an indicator that oxidation has occurred. If an increase in A420 is detected, it is too late. Oxidation reactions have occurred in the wine. A corrective fining can be applied to remove the brown colour, but the reductive style will have been compromised.

Equipment has recently been developed in Australia that allows the measurement of absorbance in unopened bottles of white wine (Skouroumounis et al 2003). This measurement can be used to compare the oxidative status of populations of bottled product, which can provide information on closure performance.

Accurate measurements can only provide useful data when they are carried out at critical points in the winemaking process. The results must provide timely information that allows decisions to be made before oxidative damage to the wine occurs. In contrast to the European model of regional wine laboratories, most Australian wineries have a laboratory on site. An analyst works hand in hand with the winemaker, ensuring that relevant and accurate information is available at all times.

These techniques are the basic tools of reductive winemaking.

If you want to read the entire article, including the application of these tools to winemaking in practice, from the grape to the consumer, please contact us: edit.eng@vinidea.net