THE DIVERSE FUNCTIONS OF OXYGEN – FIRST PART

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- To stabilize and develop the taste and aroma of ripe berries.
- To control a complete and smooth alcoholic fermentation.
- To limit the occurrence of sulphur aromas (odours of garlic, onion, rubber, tin can, etc.)

These are three key objectives of a well devised and properly realized Mediterranean vinification. Oxygen plays a direct role in each one of these objectives. Sometimes positively, and sometimes negatively.

Some practical facts in order to prevent certain winemaking mistakes:

- Oxygen is soluble in must and wine. It is always present in the air, which surrounds the tanks, the pipes, the connections between pipes, the presses. Oxygen is always more concentrated in the air than in must and tank filled wines: Therefore, it will always tend to dissolve therein. This is also true for a carbon dioxide saturated must during vigorous alcoholic fermentation. This dissolution is extremely fast: the must in the receiving trays of a pneumatic press is already completely saturated with oxygen. Oxygen always abounds in winery air, even when the latter is enriched witch carbon dioxide.
- An air or oxygen bubble, which bursts on the surface of must or wine means gas, which escapes from the liquid: this bubble has transferred little or no oxygen to the liquid. The colder musts and wines are, the more oxygen they can dissolve: up to approximately 10 mg/l.
- When must and wine are in movement and in thin layers, the oxygen dissolution is faster. It is a voluntary Venturi effect when a stainless steel coupler with a frit is used or when the pipe couplers are slightly loosened. It is an involuntary Venturi effect when the valve of a pump is worn or when the thread of pipe couplers is damaged. Whether voluntary or involuntary, the result is the same. An open stream of wine, which sprays into a tub during pumping over, dissolves oxygen quite well, and even more if the drop is considerable.

For about ten years, the ICV has studied different techniques for oxygen protection, or, on the contrary, techniques for oxygen addition under Mediterranean conditions. These techniques are reviewed below.

Protecting the grapes and musts during the pre-fermentation stages

The Mediterranean grapes have characteristics, which render them particularly sensitive towards oxidation reactions and browning.

These characteristics are the increased cellular maturity of the pulp, with a high concentration of oxidisable phenolic acids and high pH values. Until the onset of fermentation, these musts and grapes have to be protected against oxidation. Oxygen does not react directly with SO_2. Thus, SO_2 does not influence the dissolution of oxygen in the must. SO_2 is effective since, from the beginning, it prevents the chain reactions, which create brown compounds and destroy the majority of varietal aromas. It is an error to believe that any contact of grapes and musts with air could be avoided in the winery. However, homogenous and successive sulphite additions to the must have to constantly ensure a minimal and efficient presence of SO_2. This is called the "internal" protection of the must. In case of mechanical harvest, this protection has to begin in the receiving bin of the harvester. The addition of CO_2 to the grapes and the must, and the covering of the must by CO_2 are effective complements to SO_2: they make SO_2 more efficient by limiting the contact with air. This is the "external" protection. It can not replace the internal protection, but completes it.

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Supplying oxygen to yeasts

JM Sablayrolles of INRA in Montpellier has shown that oxygen added to fermenting must was used by yeasts, and that different enological yeasts could have varying needs. Added at 14.8°Brix, the oxygen assists yeasts to produce survival factors, and thus, better resist the difficult conditions present at the end of fermentation. Since 1991, ICV has integrated this oxygen addition in its fermentation recommendations. Looking back, it can be said that this is a key factor for ensuring a smooth and complete fermentation. This is true for both white and red wines.

The optimum quantity is between 5 and 10 mg/l. The technical solutions: pumping over the entire must with a fritted stainless steel coupler, a precise injection of pure oxygen with a diffuser, or pumping over the entire must after spraying into an open tub. The last solution, often not quite as effective, requires two additions: either on the same day, or a pumping over on two successive days. Stirring up the tank content with an aeration pipe does not add enough oxygen. The pipe produces big bubbles intended to stir up the liquid. The re-suspension of yeast is always interesting at this stage, but the yeast won't produce survival factors.

In white and rosé winemaking, this addition is not in contradiction to the pre-fermentation protection from oxygen, if applied at the right time. Fully fermenting yeast would consume the oxygen added almost instantly. Thus, it would not participate in oxidative reactions, even if no active SO_2 were left in the fermenting must. The fragile varietal aromas are perfectly preserved, and even better expressed, since oxygen additions limit unpleasant sulphur aromas.

These oxygen additions are all the more necessary for the yeast given that the other fermentation parameters are difficult. Amongst these parameters, some are typical for white and red Mediterranean musts: low yeast available nitrogen and high sugar concentrations. Others are due to the technology: highly clarified musts without addition of fine sediments, low temperatures, no yeast stirring at the tank bottom. After the 1994 vintage, the ICV has emphasized the advantages of an additional and earlier oxygenation, at around 19.4°Brix. In highly clarified musts with high sugar concentrations (over 13% potential alcohol), which are fermented under 17°C, this oxygenation helps to reduce the risk of volatile acidity development with certain yeasts.

Oxygen addition during alcoholic maceration in red winemaking

In red winemaking, yeast have particularly high oxygen requirements. The must conditions are difficult: low nitrogen content and high sugar concentrations. Temperature peaks above 28°C strongly affect yeast survival and the completion of the fermentation. This is true no matter when the temperature peak occurs.

During maceration, oxygen also participates in complex reactions. It contributes to colour stabilization and chemical modifications of tannins. These modifications generate more stable and also rounder tannins. Must aeration during maceration reduces the development of malodorous sulphur compounds. These compounds also cause bitterness and aggressive tannins. In order to control the colour quality, the tannins, and the purity of the grape aromas, it is necessary to establish the correct extent and schedule of aerations. Please refer to the experimental results, below. There are different methods available for aeration of a red wine tank during maceration: pumping over the entire must volume with an open tub, pure oxygen injection into the tank under the cap, or complete delestage of the entire tank. The latter would be accompanied either by injection of pure oxygen to the separated liquid phase, drainage (by spraying) of the entire tank into an open tub, or by pumping the must back into the tank using a fritted stainless steel coupler. Cap punching ("pigeage", mechanical cap submersion) is a good method for maceration, but it does not oxygenate the must during the fermentation.

In the case of vintages rich in tannins, with rather thick and hard skins, these tannins would thus have to be stabilized and smoothened during maceration in order to avoid gustative harshness. This harshness is commonly encountered with such skins.

A customized aeration program starts early on, that is, as soon as the cap has formed. For macerations shorter than 6 days, it is advisable to aerate every day. For long macerations, it is suitable to aerate every day during the active phase of fermentation. Afterwards, the schedule has to be adapted according to the results of tastings. With *Botrytis* affected grapes, it is desirable to macerate only briefly (2 to 3 days) with concurrent aerations. These aerations finish upon devatting and as long as the laccase remains active: negative browning test of the wine. As long as the aerations take place during macerations which do not exceed 4 days, there are only positive effects: more vivid and stable colour, less earthy or mouldy odours.

Protecting white and rosé wines after fermentation.

Regular oxygen additions to red wines during ageing.

In the second part of "The diverse functions of oxygen", which will be published shortly.

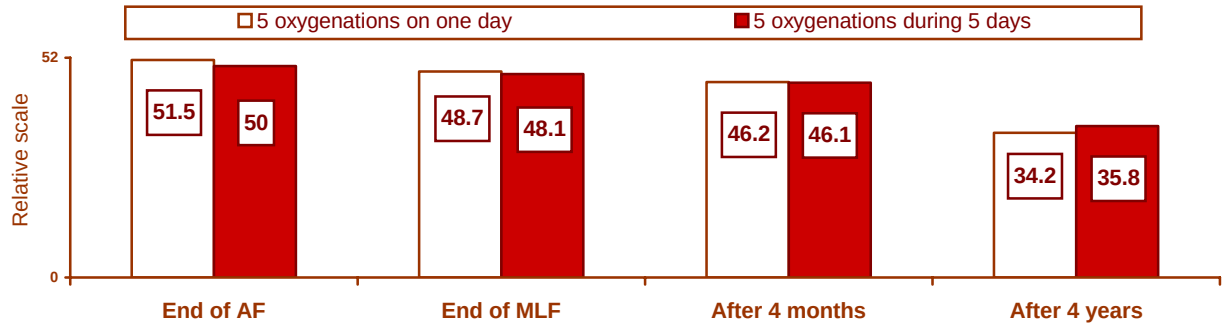
An experimental demonstration

The Syrah harvest was distributed evenly in two identical vats.

- Vinification protocol:
  Destemming – crushing – addition of selected enzymes (1 g/hl) – sulphiting (5 g/hl) – yeast addition (20 g/hl, strain ICV-GRE) – maximum temperature 28°C – cap punching once daily – devatting 6 days after cap formation, and thus, after 6 cap punchings – drainage and pressing, blending first pressings – aerated racking 24 h after devatting – second aerated racking, 48 hours after the first racking – direct inoculation of selected lactic acid bacteria – aerated racking 24 hours after completion of malolactic fermentation – sulphiting (3 g/hl). Bottling in December.

  The first tank was oxygenated 5 times on the day it reached 14.8°Brix. Each addition occurred by injection of 10 mg/l.

The second tank was oxygenated once every day for 5 days by injection of 10 mg/l.



Study carried out by the R&D department of the ICV
Jointly financed by ICV, ONIVINS, Conseil Régional Rhône Alpes within the framework of the state/regional contract plan, enological experimentation

Figure 1: Effect of the aeration schedule on polyphenols in red Syrah wine.

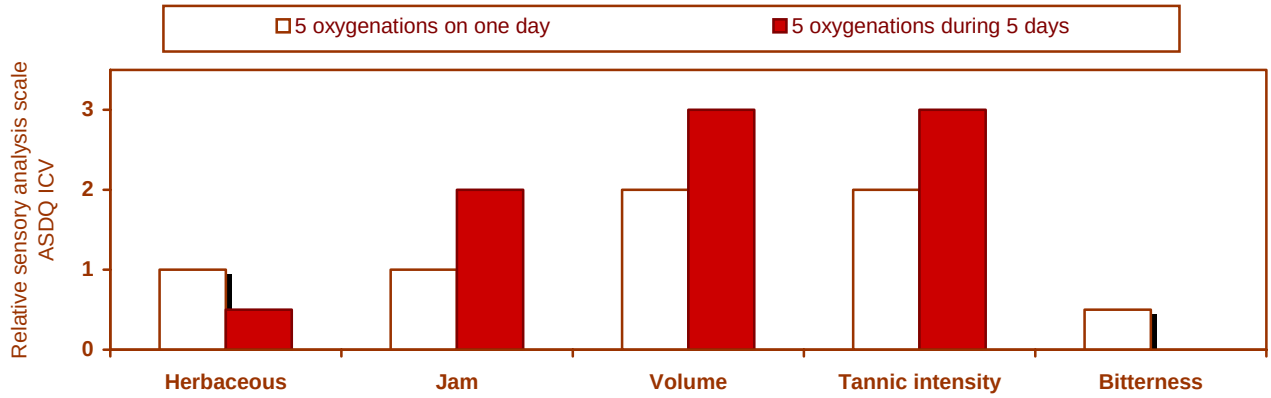


Figure 2: Effect of the aeration schedule on the sensory profile of red Syrah wine after 4 years bottle ageing.

Comments

The two tanks received exactly the same overall oxygen quantity. In this vinification, the mature grapes, the shape of the tank and the cap punching operations have optimized the diffusion of stable colour and tannins. The regular distribution of oxygen additions led to a better stability of the polyphenols compared with carrying out the additions on one single day, as shown by the measurements realized over time in Figure 1.

After 4 years, this increased chemical stability translates into significant sensory differences: Figure 2. The wine produced by regular oxygen additions during maceration is fruity and intense, with smooth tannins: strong aromas of red fruit jam, big volume, strong tannic intensity without bitterness. This is the typical profile of a commercially well-positioned red wine in the mid range.

The wine produced with a concentrated addition of oxygen displays a less Mediterranean profile, with vegetal characters and appears more diluted and aggressive in the mouth.