Study, in real-life conditions, of liquid and oxygen transfers through a barrel when aging a wine in a cellar

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Study context

The supply of oxygen to wine is a key element for the sensory and chemical properties improvement of the beverage. During maturation of wine in oak barrel, multiple transfer phenomena between the surrounding air, the wood and the liquid occur. To ensure the appropriate oxygenation of wine, it is necessary to study these transfers according to the anatomy of the oak wood and the cellar environmental conditions.

This work focuses on transfers of liquid and oxygen through barrels under real conditions in cellar thanks to an original experimental device. This was made possible with the partnership between CentraleSupélec (academic laboratory), Chêne & Cie (private R&D department of a cooperage) and Château Phélan Ségur.

Experimental device and conditions

Four 225L Taransaud barrels, M toast, 27 mm thick stave. Franck Phélane 2016 red wine, Saint-Estèphe appellation (Bordeaux, France).

Results: Transfer phenomena vs. cellar conditions

Liquid migration (a)
Impregnation front stabilized after 40 days. Slightly over 2L of wine are impregnated in the wood.

Evaporation of wine (b)
The first 40 days: Neglectable wine evaporation After 40 days: Significant evaporation (about 40 mL/day).
→ Decreases with higher humidity
→ Increases with higher temperature

Pressure drop in barrels
Intern pressure (c)
Decreases due to wine impregnation and evaporation

Effect of cellar humidity (d)
Negative linear correlation between external relative humidity and intern pressure.
→ Intern volume variation?
→ Effect on oxygen supply?

Oxygen rate (e)
Pressure drop inside the barrels is a driving force for oxygen entry.
After filling barrels, the oxygen consumption by wine is rapid, and then vary between 20 µg/L and 50 µg/L.

Air percolation (f)
An increase in humidity in the cellar leads to a strong decrease in pressure in the barrel. Above a pressure threshold a percolation occurs: an abrupt introduction of a large amount of air (bubbling).
Depending on head space volume, the oxygen brought by percolation vary between few µg/L and 1 mg/L of wine.

Conclusions

- Implementation of an original instrumentation in cellar.
- Decreasing of wine volume inside the barrel mainly due impregnation (during the first 40 days) and evaporation (after).
- The external relative humidity is a key factor of cellar conditions which impact transfer phenomena of liquid and gas.
- The percolation threshold is achieved with an increase of humidity in the cellar.

Perspectives

- Other transfer phenomena should be taken into account such as the oxygen diffusion through wood.
- These results will be compared to the results obtained on the stave scale in the laboratory.