HOW DISSOLVED CARBON DIOXIDE PROTECTS WINE FROM OXYGEN

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Basic Wine

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It is widely accepted that the presence of **dissolved carbon dioxide will help protect** the wine from oxygen pickup (and subsequent oxidation reactions). Often, wines with higher dissolved carbon dioxide content, such as perlé or sparkling wines, are considered to have sufficient protection and preventative measures to exclude direct contact between oxygen and the wine is neglected. **To what extent this protective mechanism is in force is not widely known.**

The gas-liquid equilibrium is not simple and is further complicated by the fact that **both oxygen and carbon dioxide are usually present in wine simultaneously**. Two studies focussed on the protective role of dissolved carbon dioxide and **how** the presence of this inert gas can stop oxygen from dissolving in wine[1,2]. The current blog post will summarize some of the main findings from these publications.

STUDY A

"Micro-oxygenation of wine in presence of dissolved carbon dioxide[1]"

STUDY B

"The protective role of dissolved carbon dioxide against wine oxidation: A simple and rational approach[2]" (open access)

Specific experiments using the simultaneous or individual injection of air and/or gaseous carbon dioxide were performed. In most cases, the experiments were performed on synthetic solutions, however, part of the results was validated using real wine[1].

STUDY A. OXYGENATION[1]

The researchers prepared two wines with **different dissolved carbon dioxide concentrations**:

1) a wine which was **initially free of carbon dioxide** (by sparging with nitrogen gas)

2) a wine which was **saturated with carbon dioxide** (1.4 g/L at 20°C)

Both wines were **oxygenated with pure oxygen** and the dissolved oxygen and carbon dioxide concentrations were monitored over time.

RESULTS

Results showed that there was a significant **decrease in the oxygen dissolution rates when carbon dioxide was present**. The oxygen dissolution decreased from 77% in the sample which had no initial carbon dioxide to 9% dissolution in the sample that was initially saturated with carbon dioxide. It is important to note that during this oxygenation process, the **carbon dioxide concentration progressively decreased** until it reached 0 g/L and eventually the wine was completely saturated with oxygen.

STUDY B. OXYGENATION WITH A CONSTANT SOURCE OF CARBON DIOXIDE[2]

In a second study, the **carbon dioxide** content of three litres of degassed synthetic solution (12% v/v alcohol, 5 g/L tartaric acid and pH 3.5) **was kept constant** by continuous injection of gaseous carbon dioxide. Simultaneously the wine was **oxygenated** by injecting synthetic air (20% oxygen and 80% nitrogen). The two gasses were injected using two separate porous diffusers and the liquid was continuously stirred. Different flow rates were tested. This scenario is **similar to a situation of active fermentation** (providing a continuous source of carbon dioxide) where the fermenting must is in contact with air.

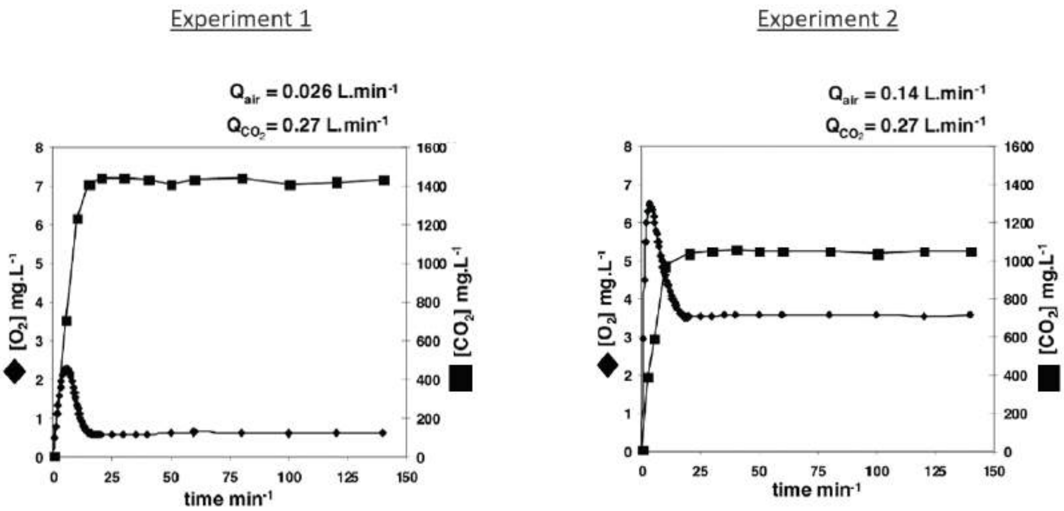
RESULTS

Results showed that the **greater the flow rate of the gas, the higher the final equilibrium concentration (concentration at which the amount of dissolved gas stabilised) was.**

In experiment 1, air was injected at a flow rate of **0.026 L/min**, while carbon dioxide was injected at a flow rate of **0.27 L/min** (Figure 1[2]). After about 25 minutes, the equilibrium concentrations were reached: **0.6 mg/L** for oxygen and **1430 mg/L** for carbon dioxide.

Figure 1. Output concentrations of dissolved gasses during the injection of synthetic air and carbon dioxide in a synthetic model wine solution using different flow rates.

Reproduced from publication (open access)*: Devatine, A., Chiciuc, I., Mietton-Peuchot, M. The Protective Role of Dissolved Carbon Dioxide against Wine Oxidation: A Simple and Rational Approach. *J. Int. des Sci. la Vigne du Vin* **2011**, *45* (3), 189–197.



In experiment 2, the flow rate of the air was increased to **0.14 L/min**, while the flow rate of carbon dioxide remained at **0.27 L/min**. In this experiment, the equilibrium concentration of the oxygen increased to **3.6 mg/L**, whereas the equilibrium concentration of carbon dioxide decreased to **1050 mg/L** when compared to experiment 1 (Figure 1[2]).

DISCUSSION AND CONCLUSION

- **The presence of dissolved carbon dioxide in wine strongly affects the efficiency to which oxygen is dissolved. A higher carbon dioxide concentration decreases the potential amount of oxygen that can be dissolved as well as the speed of which the oxygen is dissolved[1]**.

- In the case where there is **no continuous production of carbon dioxide**, but the wine has a **high initial dissolved carbon dioxide content**, the carbon dioxide can **protect the wine by reducing the rate of oxygen dissolution[2]**. The oxygen will, however, eventually, saturate the wine due to the **progressive removal of dissolved carbon dioxide** and therefore its protective effects. A higher initial carbon dioxide concentration will only **delay** oxygen saturation. In situations where **brief contact of air is experienced, a high dissolved carbon dioxide concentration will be able to protect the wine from excessive oxygen dissolution**.

- During fermentation, the **high concentration of dissolved carbon dioxide and the continuous formation of the gas provides complete protection against the dissolution of oxygen[2]**. In these conditions, the **amount of oxygen dissolved will depend on the rate of carbon dioxide production and the air flow rate. A high rate of carbon dioxide formation during fermentation might render micro-oxygenation completely inefficient[2].**

- There is a relationship between the **maximum possible dissolved oxygen in respect to a given dissolved carbon dioxide concentration**. The researchers[2] derived the following equation.

$$O_{2\ max} = -0.005*CO_2 + 7.9\ \text{mg/L}$$

This can be used as a guideline, however, keep in mind that many of these experiments were performed in **synthetic model wine solutions**. In a real wine situation, the reaction/consumption of oxygen by some wine compounds present could have a significant influence on the dissolved oxygen concentration.

- **Temperature will play a critical role** in the concentration of dissolved gas as the **solubility of gas increases as the temperature decreases**. Figure 2[2] shows a representation of the relationship between dissolved oxygen, dissolved carbon dioxide and temperature when a wine is in contact with air.

Figure 2. Graph of the maximum possible dissolved oxygen concentration in wine in contact with air as a function of dissolved carbon dioxide concentration at varying temperatures.

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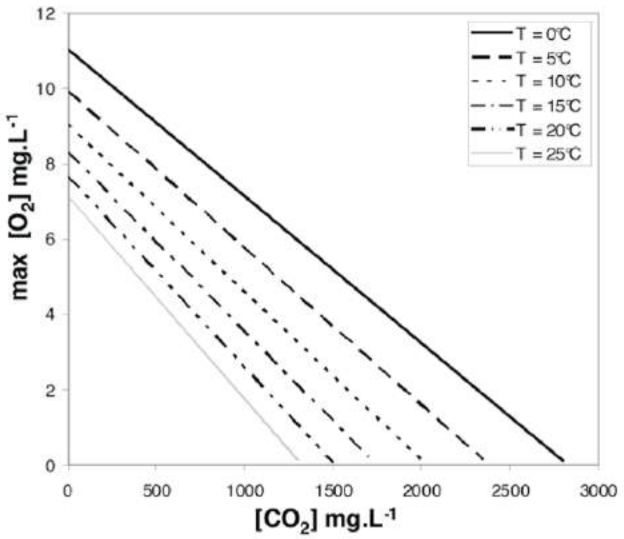

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