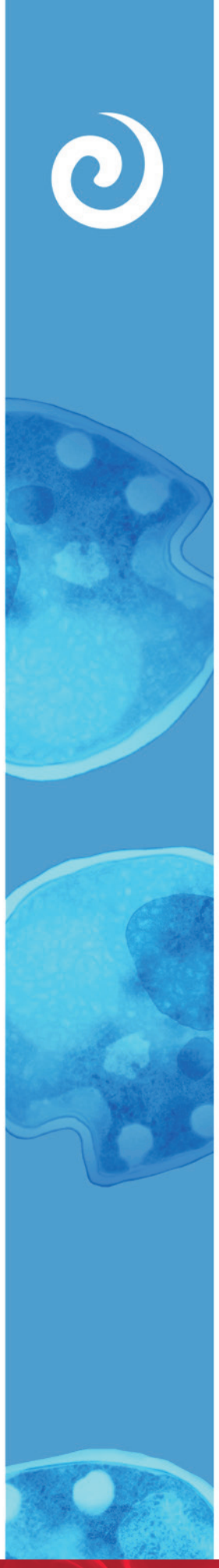

The oxygen consumption rate of an inactive dry yeast (IDY) selected to protect wine from oxidation

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Abstract

The oxygen consumption rate of a specific inactivated yeast (Pure-Lees™ Longevity, Lallemand) specially selected to protect wine from oxidation thanks to its high capacity for oxygen consumption was calculated using a non-destructive luminescence-based technique in a model solution, to which different concentrations of inactive dry yeast, sulphur dioxide or ascorbic acid were added. Results indicate that the specific inactivated yeast consumes oxygen at a similar rate to sulphur dioxide at the usual concentrations of use for both antioxidants.

Introduction

Ageing on lees, particularly white wines, is currently a widespread practice in winemaking [1]. The presence of lees in contact with the wine enriches the wine with polysaccharides and mannoproteins through the process of autolysis [2,3], which translates into increased mouth-feel [4,5] and, in the case of red wines, lower astringency [3,6]. Similarly, when it comes to sparkling wines, the presence of these macromolecules helps the incorporation of carbon dioxide gas and promotes foam stability [7,8]. Finally, the presence of mannoproteins aid the wine stability, helping to combat protein degradation [9] and prevent the appearance of tartaric acid salt crystals [10].

Another positive effect of the presence of lees on wine quality is their ability to lees consume oxygen [11,12], thereby protecting the wine from oxidation, both in terms of it's colour and it's aroma [4,13].

However ageing on lees, as well as being laborious, does entail certain risks such as the appearance of reduced aromas [4], increased production of histamines and other biogenic amines [14], or the development of problematic microorganisms such as *Brettanomyces/Dekkera* [14,15].

For this reason, the use of specific inactivated yeasts (SIY) has increased over the past few years as a source of mannoproteins and polysaccharides. SIYs enrich wines with these macromolecules without any of the aforementioned disadvantages [3,16]. More recently, it has been suggested that some SIYs may act to protect musts and wines from oxidation due to their high levels of glutathione [17], and also that some may directly consume oxygen [18].

Given the interest in looking for alternative antioxidants to sulphur dioxide for protecting wine from oxidation, the aim of this study is to evaluate the oxygen-consumption capacity of one SIY (Pure-Lees™ Longevity. Lallemand), which has been specially selected for its high capacity for oxygen consumption, when compared to the two most commonly-used antioxidant additives, sulphur dioxide and ascorbic acid.

Materials and methods

The oxygen-consumption rate is calculated using a non-destructive luminescence-based technique, as described by Pascual et al, (2017) [19]. Figure 1 shows the experimental protocol used in this study.

Sensors (PreSens Precision Sensing GmbH, Regensburg, Germany) were attached to the insides of transparent bottles (0.75 L) to measure dissolved oxygen.

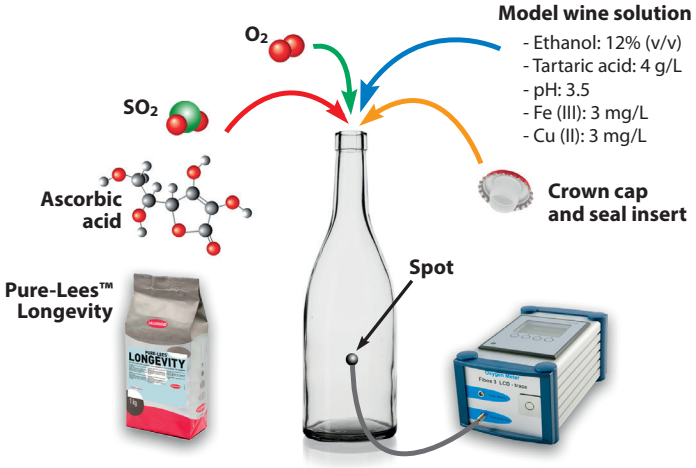

Figure 1. Experimental protocol to measure O_2 consumption in model wine by three different antioxidants.

These sensors were fixed to the centre of the inside of the bottle, which was filled with a model solution composed of 12% ethanol, 4 g tartaric acid/L, 3 mg/L of iron (III) and 0.5 mg/L of copper (II). The pH was adjusted to 3.5. This solution was saturated with oxygen by bubbling air through it for 10 minutes. To these bottles, 0, 50, 100 and 150 mg/l of SO_2 or ascorbic acid was added, or 200, 400 and 600 mg/L of the specific inactivated yeast (Pure-Lees™ Longevity. Lallemand). The bottles were then hermetically sealed and kept at a constant temperature of 20°C. Oxygen concentration was measured for the first time one hour later, and was then measured periodically until oxygen consumption was complete.

Results

Figure 2 shows oxygen consumption by SO_2, ascorbic acid and the specific inactivated yeast over time. These graphs clearly show that all three antioxidants (SO_2, ascorbic acid and the specific inactivated yeast) do consume oxygen over time.

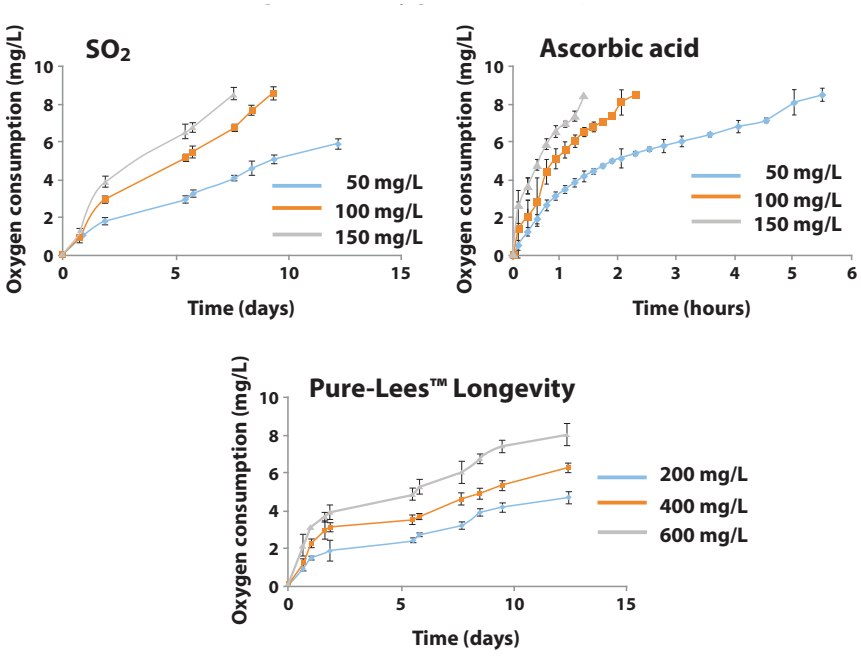

Figure 2. Oxygen consumption of three different antioxidants

It should be noted that ascorbic acid consumes oxygen much more rapidly than SO_2 and the specific inactivated yeast, as the time scale on this graph is hours, whereas the other antioxidants are measured in days.

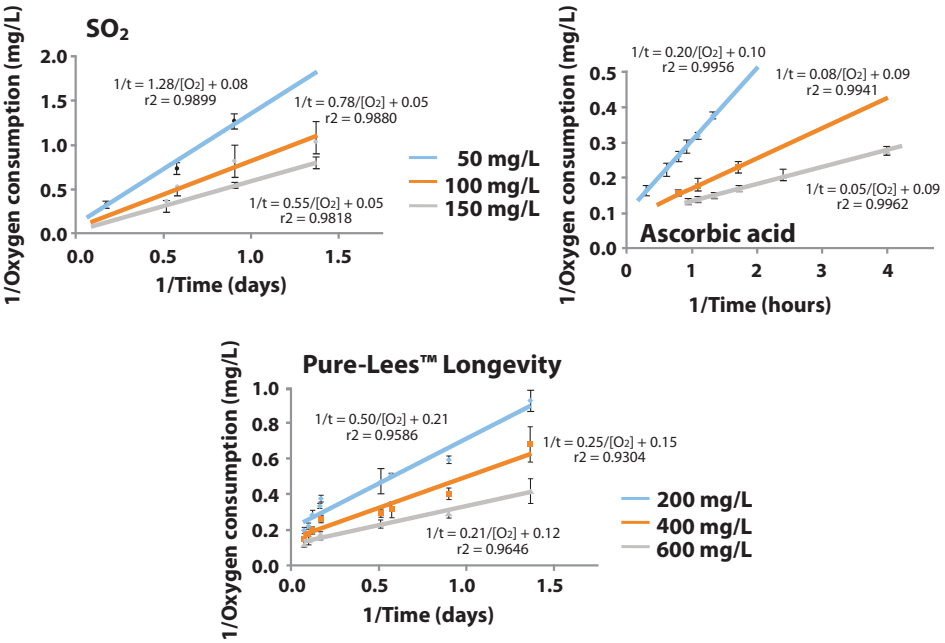

Figure 3. Modelling of oxygen consumption by three different antioxidants

With the aim of modelling and parametrizing the kinetics of oxygen consumption, different models of adjustment were tried. Representation of the inverse oxygen consumed compared to inverse time was the model that provided the best linear adjustment. **Figure 3** demonstrates the results obtained. It can be seen that excellent linear regression coefficients were obtained, which confirms that this mathematical model works well. Using this model, the following equation can be established.

$$1 / [O2] = a / t + B.$$

This equation describes the relationship between oxygen consumed and the time function which allows for, after carrying out the first derivative and considering the baseline (time zero), the calculation of the oxygen consumption rate (OCR) which corresponds to the inverse of the equation slope. These calculations can be seen in **Figure 4.**

1. Solve for $[O_2]$ *2. First derivative* *3. For t = 0*

$$\frac{1}{[O_2]} = \frac{A}{t} + B \Rightarrow [O_2] = \frac{t}{A + Bt} \Rightarrow \frac{d[O_2]}{dt} = \frac{A}{A^2+2ABt + B^2t^2)} \Rightarrow \frac{d[O_2]}{dt} = \frac{1}{A} = TCOt_0$$

Figure 4. Calculation of the baseline (time zero) oxygen consumption rate (bOCR)

With the slopes obtained through applying this model of adjustment it is possible to calculate the relationship between concentration of SO_2, ascorbic acid or specific inactivated yeast and the baseline oxygen consumption rate (bOCR). **Figure 5** illustrates the result.

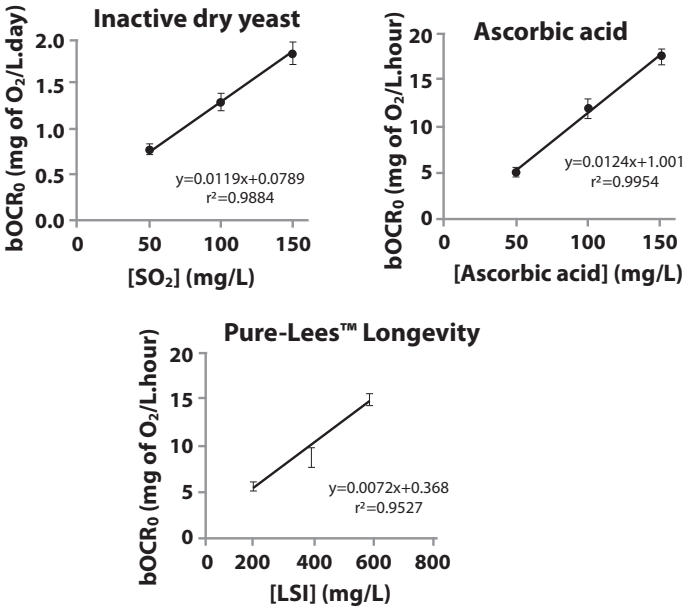

Figure 5. Oxygen consumption rates (bOCR0) for SO_2, ascorbic acid and specic inactivated yeast

The results demonstrate that there is a good linear relationship between oxygen consumption and the concentration of the three antioxidants. The slopes of the regression lines correspond to the oxygen consumption rates as reflected in **Table 1**. In this table, it can be seen that ascorbic acid has a much higher oxygen consumption rate than sulphur dioxide or specific inactivated yeast (around 300 times faster). However, it should be taken into account that ascorbic acid generates hydrogen peroxide, and its use without the addition of SO_2 can generate greater oxidation after a certain length of time [20]. However, the specific inactivated yeast Pure-Lees™ Longevity consumes oxygen when applied at 40g/hL at a rate of 0.29 mg of oxygen/day. This value is very similar to sulphur dioxide at a dose of 20 mg/L (0.24 mg of oxygen/day), meaning that its efficacy can be considered to be equivalent to that of SO_2 at its usual levels of use.

Table1. Oxygen consumption rates (OCR) for SO_2, ascorbic acid and specific inactivated yeast

Antioxidant		Oxygen consumption rate (OCR)		
		mg O_2/day		
Ascorbic Acid	mg O_2/mg Ascorbic acid.day	[Asc. Ac] = 50 mg/L	[Asc. Ac] = 100 mg/L	[Asc. Ac] = 150 mg/L
	2.976	148.8	297.6	446.4
SO_2	mg O_2/mg SO_2.day	[SO_2] = 20 mg/L	[SO_2] = 40 mg/L	[SO_2] = 60 mg/L
	0.0119	0.24	0.48	0.71
Pure-Lees™ Longevity	mg O_2/mg SIY.day	[SIY] = 20 mg/hL	[SIY] = 40 mg/hL	[SIY] = 60 mg/hL
	0.0072	0.14	0.29	0.43

Conclusion

The results show that the specific inactivated yeast Pure-Lees™ Longevity consumes oxygen in a model medium at a similar rate to sulphur dioxide, and therefore could be a good alternative to SO_2 and a means to reduce the levels of SO_2 used during winemaking, while still protecting wine from oxidation.

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