EFFECT OF STORAGE CONDITIONS ON THE EVOLUTION OF BOTTLED WINES

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Introduction

Once bottled, wines do not cease to evolve. In fact, the opposite occurs. The storage conditions of wines after bottling influence their quality and potential for long term conservation.

Sensory and physiochemical analyses carried out on numerous wines on the retail shelves reveal quality problems, which could be linked to the storage conditions of the wines.

Thus, the technical service of Inter Rhone has carried out a trial with bottled wines in order to demonstrate the influence of the storage conditions on the evolution of different physio-chemical and sensory parameters.

Storage problems rarely occur in the winery. However, they are certainly more frequent during the shipping of bottles or during display on shelves. This observation has allowed selection of the storage conditions tested during this study.

Materials and methods

Four red wines with a different potential regarding their enological parameters and ageing potential, as well as one rosé wine were selected for this study: CDR red 2000, CDR red 1999, CDR Villages 1999, Vacqueyras red 1999 and CDR rosé 2000. Within one type of wine, all bottles came from the same bottling run. All the bottling runs were performed in the winery and the bottles were only briefly stored in the winery cellar before being transferred to trial conditions. All these wines originated from the Rhone Valley "Appellations d'Origine Contrôlée" geographical area.

Different environmental factors, such as the position of the bottle, the light intensity and the temperature were tested. The four different storage conditions selected for this trial were:

- stable low temperature (14°C), dim light, bottle horizontal: FCP
- stable high temperature (22°C), light, bottle upright: CDL
- variable temperature (15 to 25°C), dim light, bottle horizontal: VCP
- variable temperature (12 to 26°C), light, bottle upright: VDL

These conditions simulate certain storage conditions of bottled wines during shipping (VCP), display on shelves (CDL and VDL) or in the cellar (FCP). The FCP conditions were considered as the most advantageous and served as a control compared with the other environmental conditions.

The analyses were carried out after transferring the bottles to trial conditions (T0), and then, at the T+3, 6, 9, 12, 18, 24, 30 and 36 months stages. At each stage, a new bottle was opened for the analyses.

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The traditional enological parameters (alcohol content, total acidity, volatile acidity, pH, sugars, free and total SO_2 and heat test) were measured following official enological methods.

The analysis of phenolics (anthocyanins, Total Polyphenol Index, colour intensity and hue) was performed by UV/VIS spectrophotometry. The chromaticity was assessed with a chromameter in Lab/LCh colourspace.

The results are presented in the following way: for each wine and each stage, the residual value was compared with the initial value and expressed in percent. Then, the average percentages for each storage method were represented over time. Thus, the curves display the average residual values (in percent) compared with the initial value for each storage method.

The sensory analysis was performed with a varying number of tasters according to the tasting sessions, with a minimum of 12 panel members. The tasting data was standardized for each judge and attribute. The average of the values from the different judges was also calculated for each wine and each attribute. Each treatment was then ranked with the highest average obtaining a 4, and the lowest a 1. For each treatment, the average of the ranks obtained with the 5 wines was then calculated and a variance analysis allowed determination of the significance levels.

Before the sensory analysis, a panel had been recruited in order to taste the wines and define the most appropriate terms for their later assessment.

Results of the analytical parameters

The values of the main parameters analyzed at stage T0 are shown in Table 1. The four red wines had variable physiochemical profiles, specifically with regards to the phenolic potential.

Table 1: Values of the analytical parameters of the 5 wines after bottling (stage T0).

	CDR rosé 00	red CDR 00	red CDR 99	red CDRV 99	red Vacqueyras 99
Alc. (% volume)	13.4	13.5	13.2	14.2	13.4
Total acidity (g/l H2SO4)	3.91	2.99	3.74	3.8	3.45
pH	3.28	3.9	3.53	3.67	3.62
free SO_2 (mg/l)	23	27	24	26	13
Colour intensity	0.5	6.1	5.6	7.3	6.6
Shade	0.96	0.76	0.67	0.74	0.73
Anthocyanins (mg/l)	46	371	184	244	220
Total Polyphenol Index	11	45	40	55	44
Clarity (L)	89	67	70	63	66
Hue 1 (a)	13	31	32	36	35
Hue 2 (b)	11.1	7.3	9	11.6	9.8
Saturation (C)	17	32	33	38	36
Hue angle (h)	40	13	16	18	16

The amount of free SO_2 was significantly altered by the different storage conditions (Figure 1).

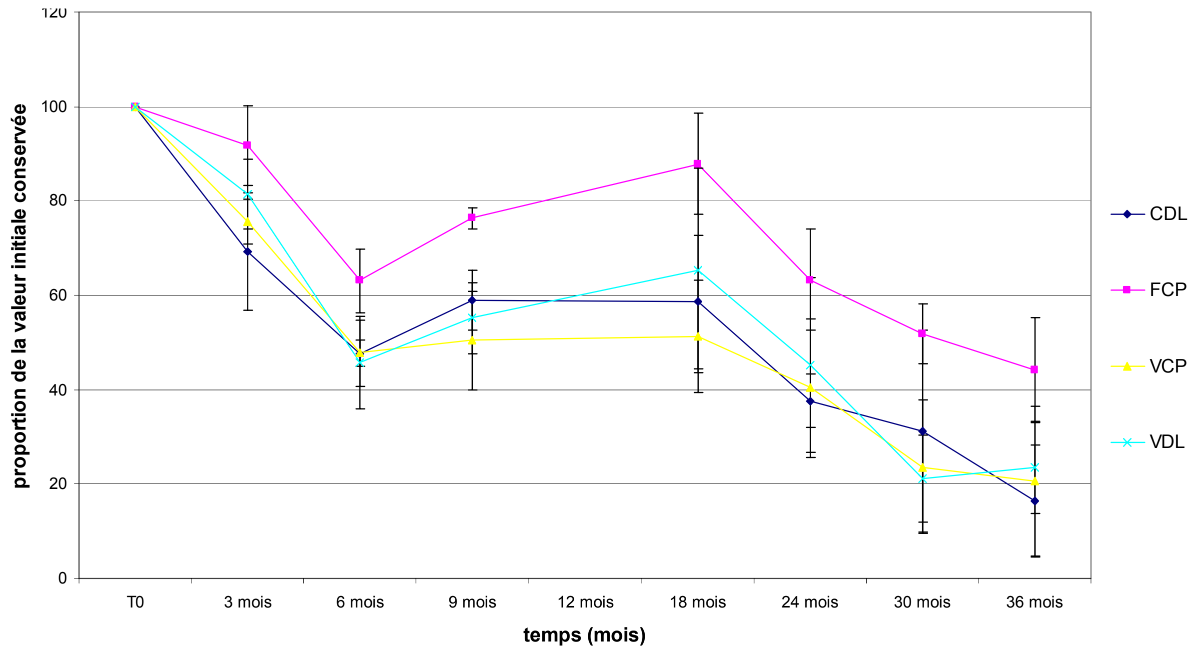

Figure 1: Free SO_2 (in % of initial value) for all wines during the 36 month storage period (Inter Rhone results)

X axis: Time (months)
Left y axis: Percentage of initial value remaining

A decrease of free SO_2 levels over the entire ageing process and under all storage conditions was observed. The most significant decrease occurred during the first 6 months with a minimum loss of almost 40%, and a further reduction from the T+18 months stage onwards.

The FCP conditions preserved the free SO_2 levels best during the trial, even after 3 years of storage. However, a decrease of 60% under the FCP conditions occurred, compared with 80% under the 3 other storage conditions. It was mostly during the first year that the difference between the FCP conditions and the other storage methods increased.

Subsequently, the free SO_2 levels decreased at the same rate. It could be observed that the VCP conditions led to a decrease of the free SO_2 levels that was similar to the decrease observed for the most unfavourable conditions. Thus, it seems that neither the bottle position, nor the light intensity played a major role in the evolution of this parameter, but rather the temperature.

If the free SO_2 levels in each wine at the T+18 months stage are considered, it can be seen that they are between 15 and 25 mg/l in the wines stored under the FCP conditions, and between 10 and 15 mg/l in the wines stored under the VDL, CDL and VCP conditions.

The latter values represent minimum levels required for wine protection. After 18 months, the free SO_2 levels continued decreasing and thus, the wines were more exposed to damaging oxidation.

Among the different parameters studied, those related to colour seemed to be most variable under the four conditions tested.

The anthocyanin content decreased strongly between the beginning and the end of the trial, but this decrease differed according to the storage condition. The FCP treatment allowed conservation of the highest anthocyanin levels during the trial (45% of the initial value at the T+36 months stage). Under the three other storage conditions, only 20% of the initial values were preserved after 36 months (Figure 2).

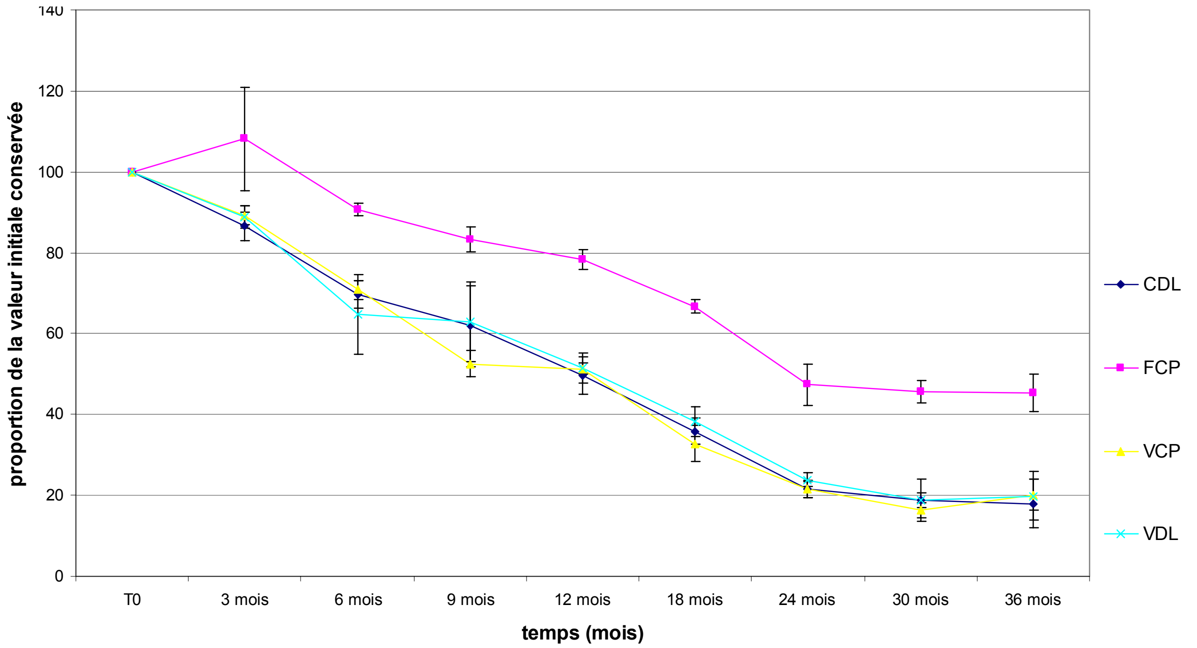

Figure 2: Evolution of the anthocyanins (% of the initial value) in all wines over the 36 month storage period. (Inter Rhone Results)

X axis: Time (months)
Left y axis: Percentage of initial value remaining

The decrease of anthocyanin levels was not linear over time. Under the ideal storage conditions (FCP), the anthocyanin concentration decreased more slowly than under the other storage methods during the first year. After one year, an average of 80% of bleachable anthocyanins remained in the FCP treatment compared with an average of only 50% under the other storage methods.

Afterwards, the decrease of bleachable anthocyanin concentrations continued at comparable rates up to 24 months. Overall, the levels remained stable between 24 and 36 months of storage, with 45% of the initial concentration remaining in the FCP treatment, and only 20% remaining in the other treatments. However, this decrease does not mean that the anthocyanins precipitated or were degraded. The anthocyanins can also bind to form new pigments, which are no longer detected by the bleachable anthocyanin method.

The temperature was the only parameter distinguishing the treatments FCP and VCP, and the evolution of the wines under these two conditions was very different. These results show that temperature plays an essential role in the decrease of anthocyanin levels. Note also that there was no difference between the VCP and the VDL treatments. Thus, it seems that the bottle position and its exposure to light had a smaller effect than temperature.

Figure 3 represents the evolution of the colour intensity of all wines during the 36 months storage according to the storage conditions.

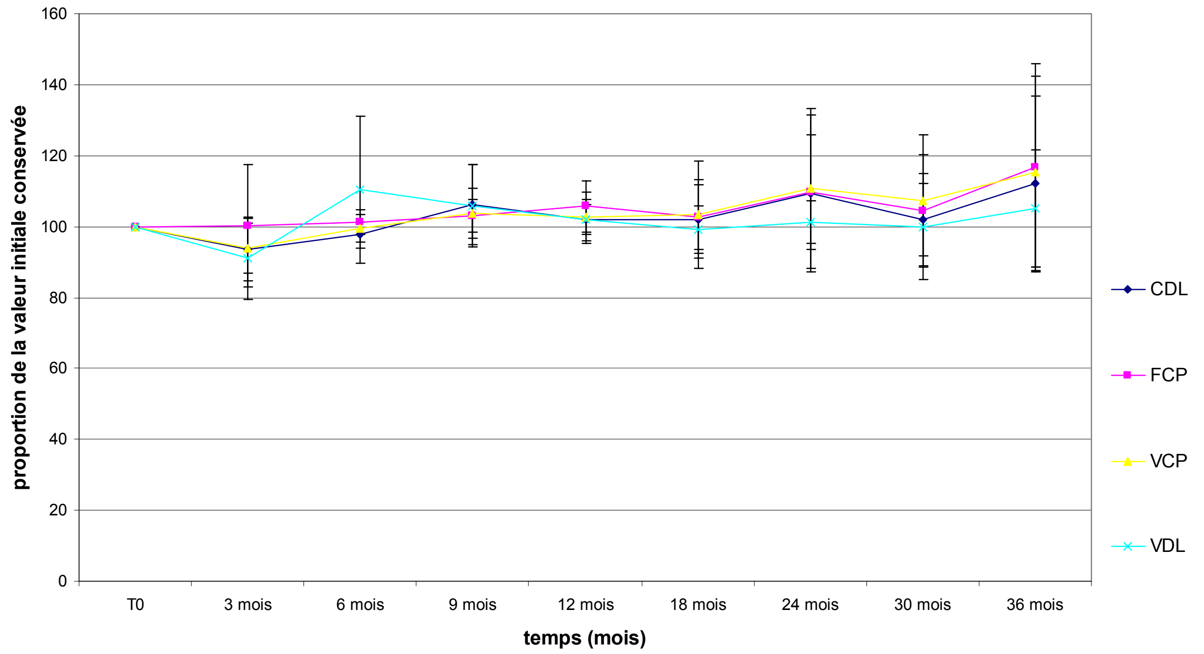

Figure 3: Evolution of the colour intensity (% of initial value) for all wines over 36 months of storage. (Inter Rhone Results)

X-axis: Time (months)
Left Y-axis: Percentage of initial value remaining

The storage conditions had no significant effect on any of the wines and at any of the stages, and showed only a very slight evolution over time. On the other hand, by differentiating the rosé wine from the 4 red wines, a difference between these two wine types could be seen. The colour intensity of the rosé wine increased during storage, while the colour intensity of the red wines did not change.

With regards to the hue, a continuous increase could be observed for all treatments and wines (Figure 4).

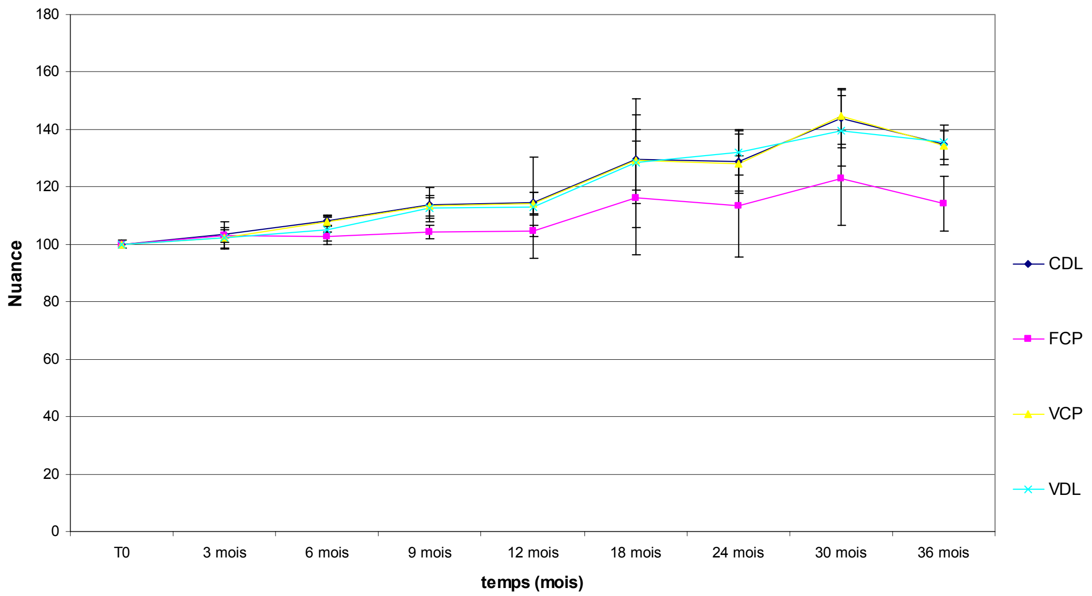

Figure 4: Evolution of the hue (% of initial value) for all wines over 36 months of storage. (Inter Rhone Results)

X-axis: Time (months)
Left Y-axis: Hue

The hue increased steadily and reached 135% of the initial value under the CDL, VDL and VCP conditions, and 115% under the FCP conditions. Thus, this increase was not as pronounced in the case of the favourable storage conditions, i.e. FCP.

Therefore, the decrease in anthocyanins was probably due to reactions that formed yellow pigments. The FCP storage method was best suited to limit the development of this yellow hue by conserving a larger proportion of anthocyanins.

The analyses of the tristimulus values, red hue (a) and yellow hue (b) by chromametry confirmed the colour intensity and shade results. The red hue decreased in red wines and remained stable in the rosé wine, while the yellow hue increased in all the cases. Thus, the increase in colour intensity in the rosé wine was due to the increase of the yellow hue. The hue increased systematically in all the wines.

The environmental conditions had no significant effect on the TPI, whether for rosé or red wines. This parameter basically remained stable during the 36 months of the trial. Thus, the results are not shown. The same is true with regards to other parameters such as the percentage of alcohol, the total acidity, the pH, the sugars and the heat test.

An increase in volatile acidity levels could not be detected, which indirectly shows that no microbial growth occurred.

Organoleptic parameters

The wines were tasted at different stages. Considering the amount of data obtained, we decided to limit the presentation to the results obtained at the T+6 months stage corresponding to a short storage period, and to those obtained at the T+36 months stage, which represent an average storage period. At the beginning of the trial, the wines were tasted in order to ensure that they had no specific defects and to develop an appropriate vocabulary for the future tasting.

Depending on the tasting stages, the storage conditions producing the best wines were not always the same.

Figure 5 presents the tasting results at the T+6 months stage.

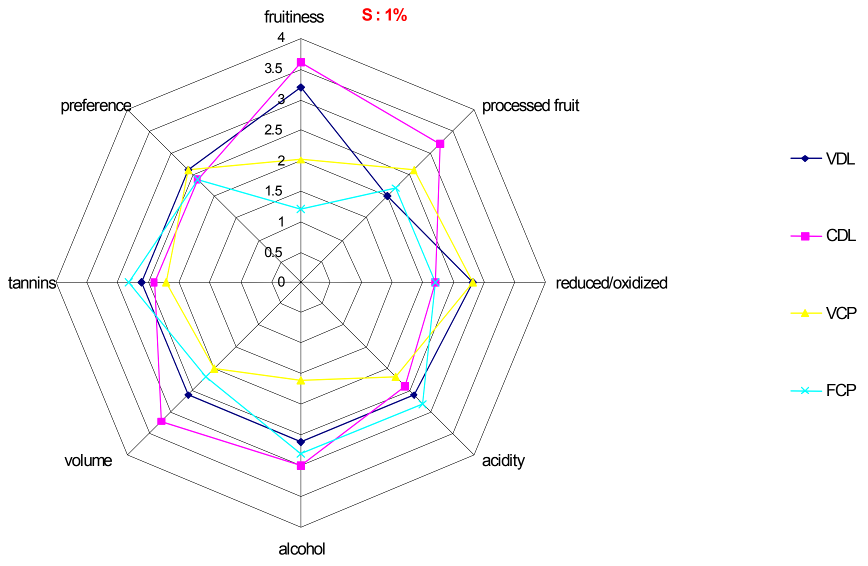

Figure 5: Effect of storage method on wine attributes obtained by sensory analysis. Data points show averages of rankings obtained for all five wines at the T+6 months stage. (Inter Rhone Results)

At this stage, a single organoleptic attribute, i.e. fruitiness, allowed differentiation of the treatments. Ironically, the storage conditions including upright storage of wines exposed to light allowed best preservation of wine fruitiness. On the other hand, no significant difference could be observed with regards to the other tasting parameters, specifically concerning the wine preference.

Thus, at an early tasting stage, the storage conditions favouring a rapid evolution of the wine were not those that led to the most poorly judged wines.

Figure 6 shows the tasting results at T+36 months stage.

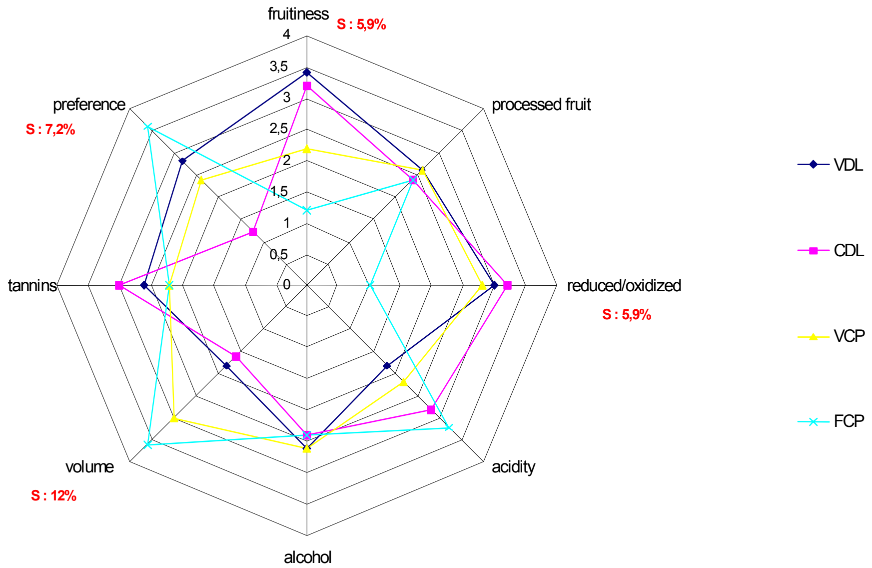

Figure 6: Effect of storage method on wine attributes obtained by sensory analysis. Data points show averages of rankings obtained for all five wines at the T+36 months stage. (Inter Rhone Results)

At T+36 months stage, more differences were found between the treatments. The wines stored under FCP conditions were always perceived as being the least fruity (significance level of 5.9%), least oxidized (significance level of 5.9%), and as having the highest mouthfeel rating. Finally, the wines stored under FCP conditions were the most preferred (significance level of 7.2%). In contrast, wines stored under CDL conditions were the least preferred.

Thus, it appears that the effect of the storage conditions on wines was stronger, the later the wines were consumed.

From the T+18 months stage onwards, the FCP conditions allowed to obtain the highest preference ratings for all wines tested.

Upon evaluating the physiochemical results, we could observe that from this stage onwards, the levels of free SO_2 decreased considerably in the 5 wines tested. Thus, the wine depreciation could be explained mainly by the free SO_2 decrease under the most unfavourable conditions.

Conclusions

This study allowed confirmation that various storage conditions affected the analytical and sensory parameters of wines differently.

A considerable decrease of the free SO_2 levels could be observed regardless of the storage conditions and the initial values. This decrease was less marked under the favourable FCP conditions.

The anthocyanin concentrations decreased strongly across all storage methods. This decrease was not linked to a decrease of the colour intensity or of the TPI, which excludes any degradation or precipitation. They react with other wine compounds to form other molecules. As a result of these reactions, the yellow colour of the wines increased, with an intensification of the hue and the yellow colour. These evolutions were certainly less pronounced under ideal storage conditions (FCP).

After storage durations characteristic for wines intended for fast turnover, the storage conditions had little influence on wine preference ratings, even though some conditions accelerated wine ageing. On the other hand, after periods of average to long storage, the conditions could harm wine quality. The FCP conditions always produced the least oxidized and most preferred wines, from the T+18 months stage onwards.

The levels of free SO_2 decreased strongly during storage and seemed to determine wine quality. Based on this observation, it is crucial that winemakers adapt the addition of SO_2 at bottling to the estimated consumption date and the selected distribution channels.

Temperature plays a very important role for wine conservation on an analytical as well as sensory level. Only those storage conditions combining the best environmental factors (bottle stored horizontally in dim light, low and stable temperature) will produce wines best conserved from an analytical point of view, and the most preferred from a sensory perspective.

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