Effects of Temperature on Finished Wines

Sylvie Collas, Arnaud Descôtes
Technical & Environmental Department of the Comité Champagne

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Champagne producers use all means at their disposal to obtain a quality product, in the vineyard as well as in the cellar. However, once the bottles are loaded onto the lorry to be shipped out, it becomes harder for the producer to control the quality of the shipment through to the final consumer. Therefore it is important to know what influence the conditions of storage and transport might have. In numerous articles we have looked at the harmful consequences that light-strike (goût de lumière) can have, but what about temperature?

A study was conducted in Champagne in 2014 by eProvenance, a company offering services for monitoring and analysis of wine storage and transport conditions around the world. In 2016, the Comité Champagne organized a series of tests in order to determine the effects of exposure to cold and heat on the different components of Champagne.

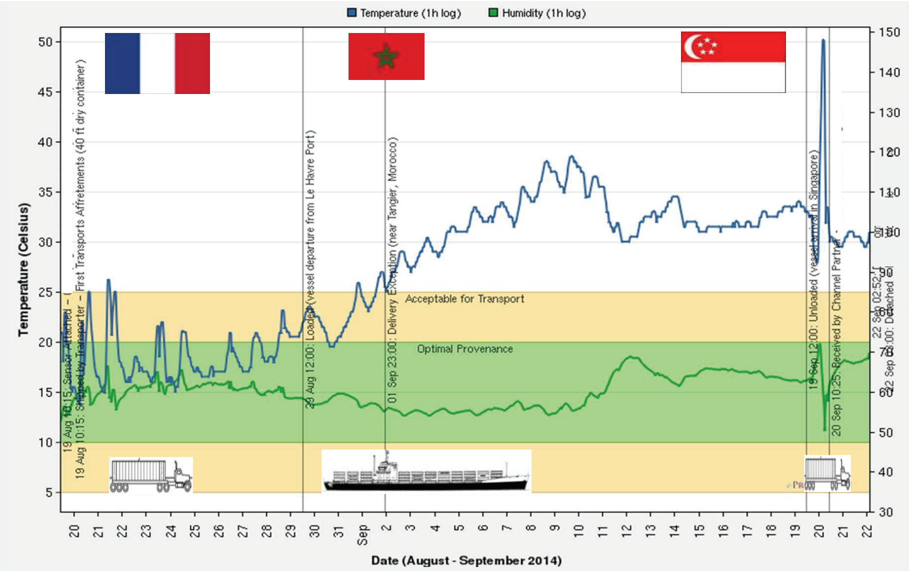
Experiment protocol

Two wines were used for this study: a non-vintage Brut blend and a Rosé. The temperature treatments applied consisted of storing the bottles in chambers at -4 °C, +30 °C and +45°C, as well as simulating a journey to Asia (figure 1b). This was based on data from eProvenance indicating day-night fluctuations between 14°C and 50°C, with 2 weeks at more than 30°C (figure 1a). The control sample was kept in cellars at +15°C. The length of exposure varied from 3, 7, 14 to 28 days for the isotherms and 34 days for the "Asia" simulation.

Effect on the closure

The closures used were micro-agglomerates without discs. The parameters were measured on three bottles to establish an average with the associated standard deviations.

Pressure, measured with LaserPro (see Le Vigneron Champenois, November 2015), appeared unaffected by the different treatments (figure 2). We can assume therefore that the CO_2 permeability of the closure does not change, even three months after exposure.



For the shipment, overall, we see an average of **27.1°C and 60.2% relative humidity**.

The shipment spent **497 hours (21 days) at over 25°C**:

- Sea transport occurred at between 25 and 38.5°C
- Temperature spike to 49.5°C on arrival in Singapore
- Storage at around 30°C in Singapore

Humidity remained within acceptable levels.

Figure 1a. Temperature and relative humidity readings of a shipment from Champagne to Asia (Singapore) – Source: eProvenance

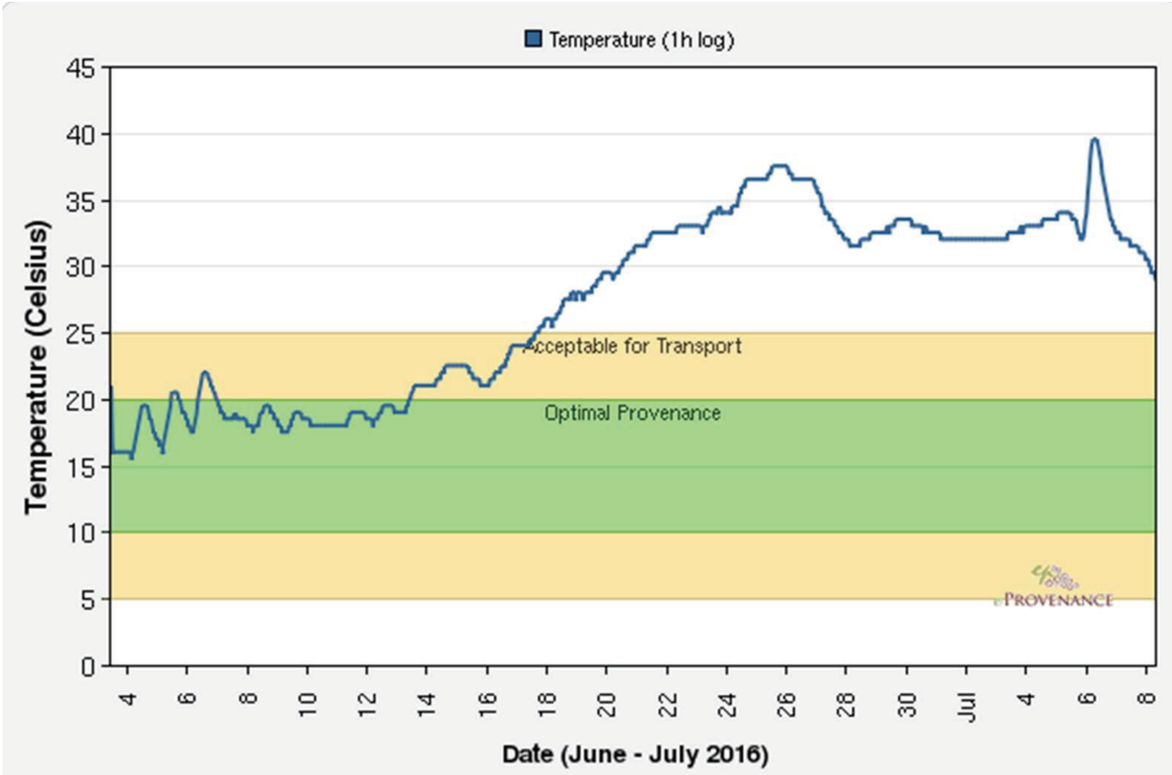


Figure 1b. Thermal profile applied to bottles to simulate an "Asia" shipment – Source: eProvenance

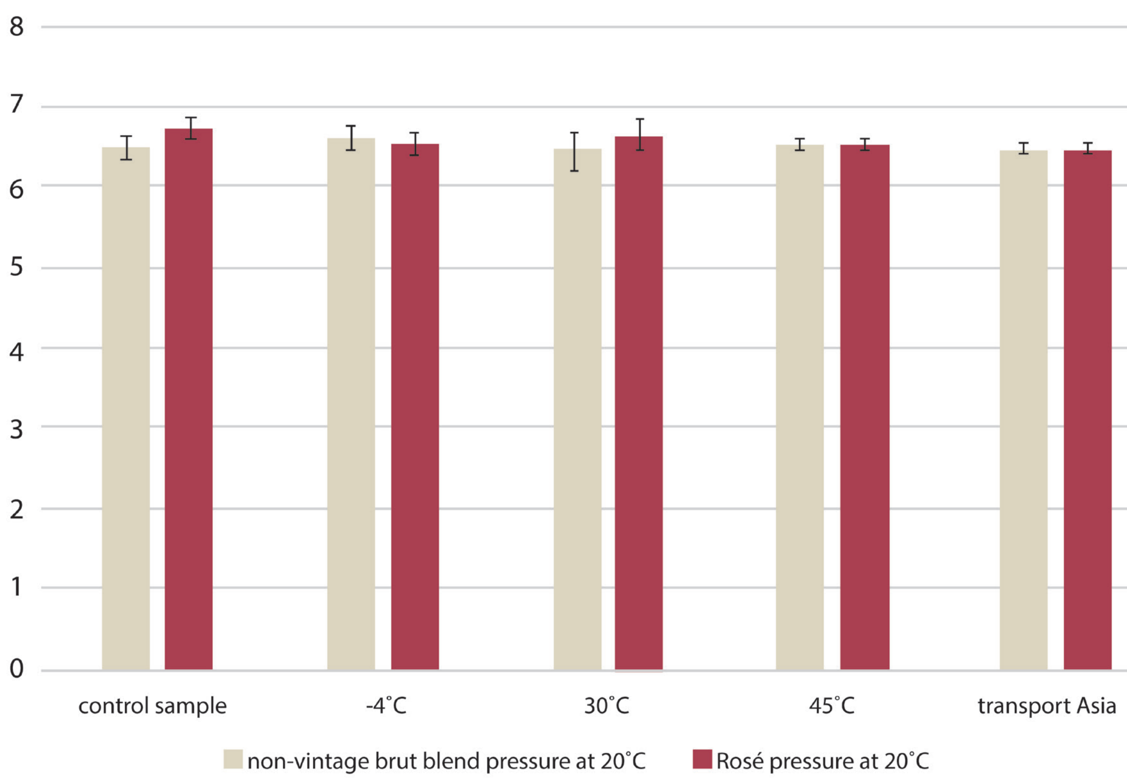


Figure 2. Pressure in bars (at 20 °C) measured in bottles having undergone temperature treatments for 1 month. – Source: eProvenance

Extraction force, measured with a torque meter (see Le Vigneron Champenois, July 2016) shows considerable variation for the batch stored at 45°C (figure 3). The uncorking force is 20% less for the blend and 40% less for the Rosé. Nevertheless, the readings remain within acceptable levels, with a tendency to be a bit low for the Rosé. This result appears not to change over time.

Visual examination of the closures after opening allows us to compare how well they regain their shape. While the batch stored at 30°C remains only slightly affected, the wine exposed to 45°C temperatures shows a certain amount of pegging, which becomes more apparent as the treatment time increases (photo 1).

Effect on wine colour

The L*a*b* coordinates of the different samples were analyzed. This technique uses 3 dimensional space (figure 4). Two axes (a and b) determine the chromaticity, corresponding to colours on the visible light spectrum: axis "a" goes from green to red and axis "b" from blue to yellow. The third axis "L" defines the brightness or clarity.

For the blended wine stored at 30°C and 45°C, a slight reduction on the a* register and an increase on the b* register can be observed, while the brightness L* remains stable (figure 5). There is therefore a shift in colour towards **"greeny-yellow"**, with a more marked alteration for the higher temperature (45°C).

With the Rosé wine we can also see a slight drop of the a* and an increase of the b* coordinates, especially when exposed to 45°C. Once again, the clarity L* does not vary. Exposure to heat therefore causes a less red tint, moving towards **"orangey-yellow"** (figure 6).

The simulation of transport to Asia showed results equivalent to the 30°C isotherm, while the colour of the wine stored at -4°C did not change.

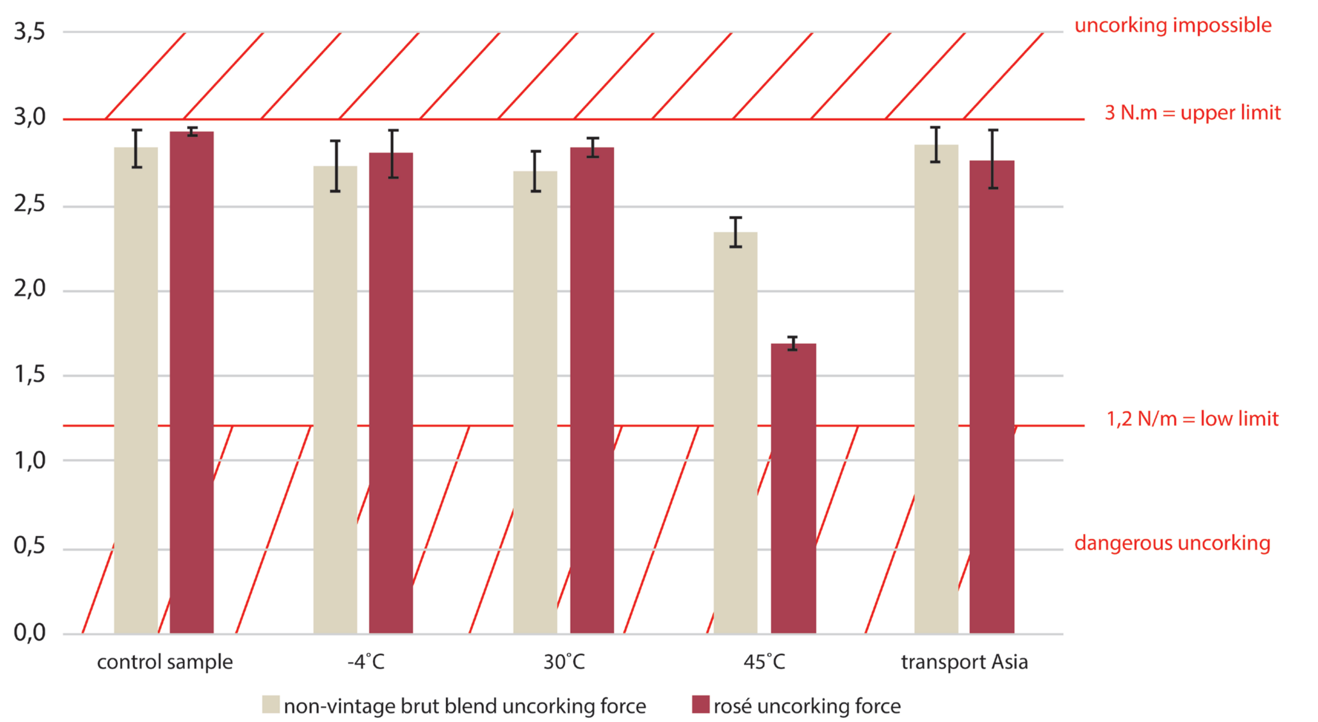


Figure 3. Uncorking force, measured in N.m, on bottles subjected to the different temperature treatments for 1 month.

Photo 1. Appearance of closures after opening, from bottles subjected to treatment at 45°C (for between 3 and 28 days) and those from the simulated "transport to Asia"

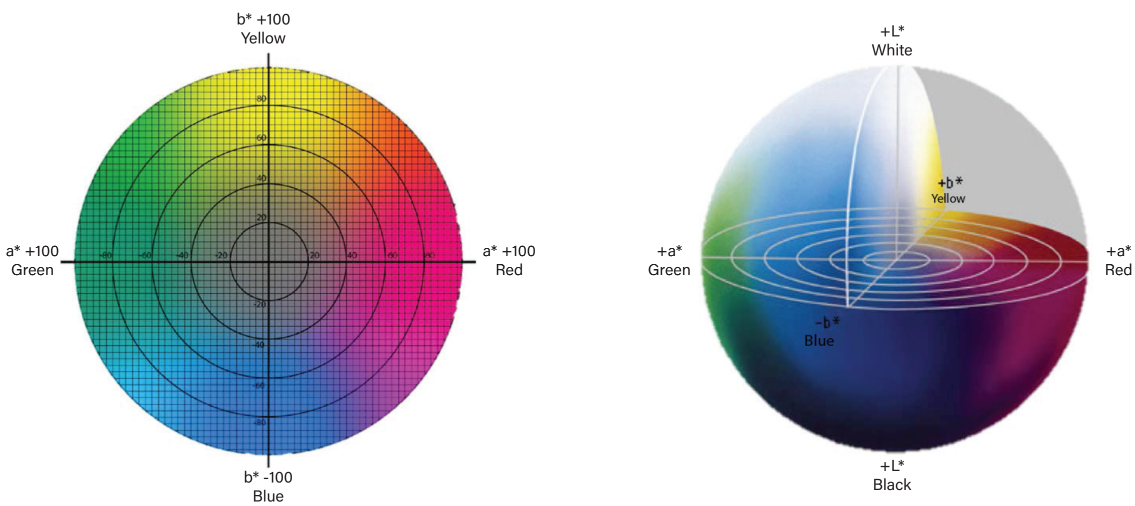


*Figure 4. Visuals of L*a*b* coordinates for calculating colorimetric variance between 2 samples (model developed by the CIE).*

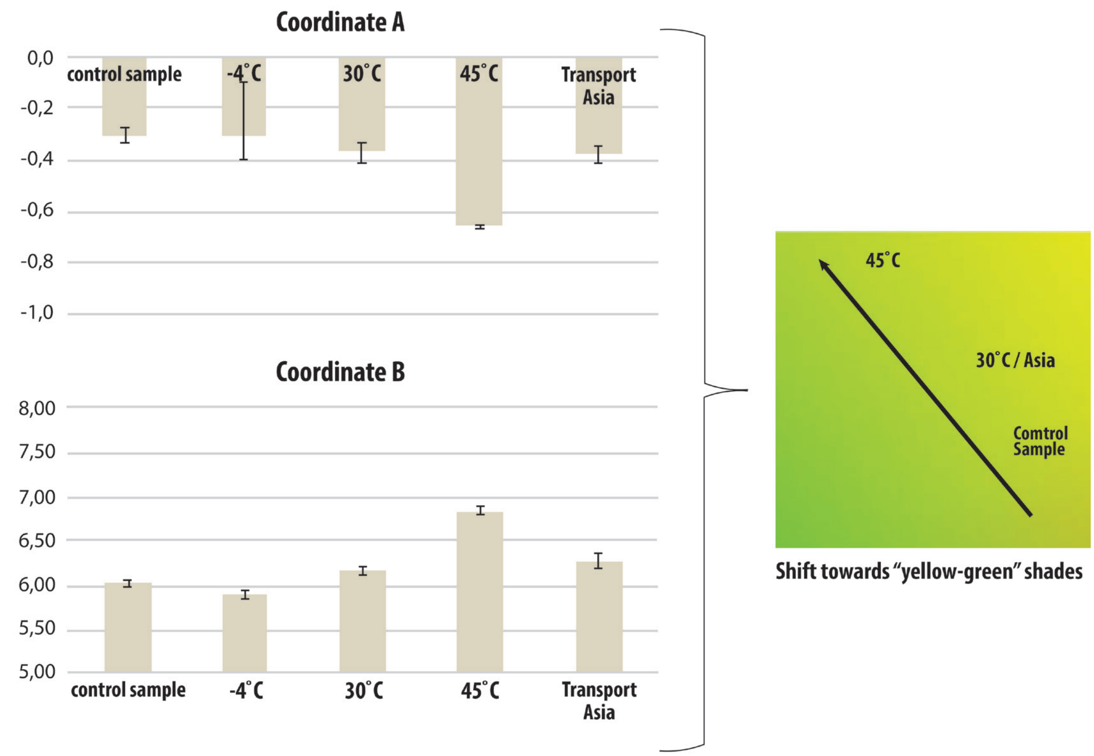


Figure 5. a and b* colorimetric coordinates of Brut non-vintage exposed to different temperatures for 1 month.*

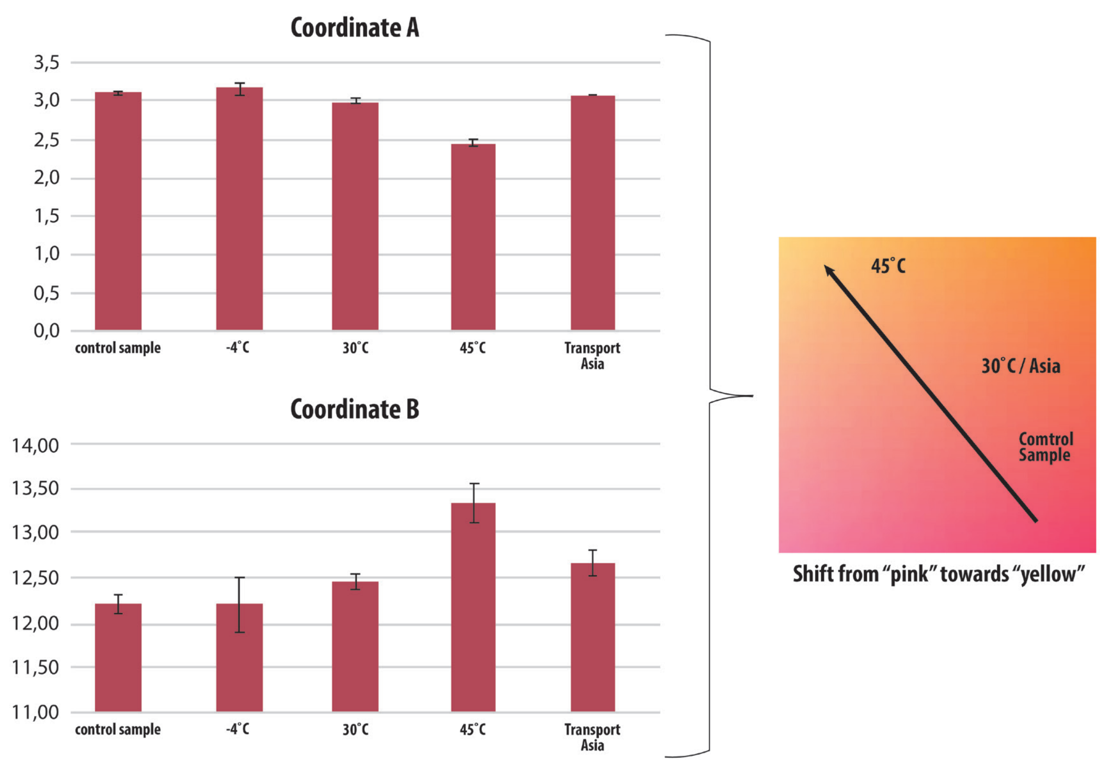


Figure 6. a and b* colorimetric coordinates of Rosé exposed to different temperatures for 1 month.*

Effects on the Organoleptic Profile of the Wine

Tasting Results

The tastings were held as triangular tests between the control sample stored in cellars at 15°C and the exposed batch. Bottles were first tasted one week after the treatment, then a second time 2 months later. Results compiled in table 1.

For wines in cold storage (-4°C), the panel did not detect any significant difference, either for the blend or for the Rosé.

For the blended wine, a sensorial difference is immediately apparent in the batch stored at 30°C for 14 days. Two months after exposure, the effect of temperature is felt from the 7-day batch onwards. However, the impact is most clear on the wine stored at a constant 45°C: the tasters noticed differences after only 3 days at this heat.

The Rosé Champagne seemed to be a little less sensitive and showed sensorial degradation after 7 days at 45°C.

The consequences of the "transport to Asia" simulation were noticed 2 months after the treatment for both wines.

An additional trial was undertaken to determine the impact of temperature variation: the samples were subjected to alternating temperatures of 15°C and 30°C for 7, 14 and 28 days. Only the batch of Brut non-vintage blend treated for 28 days stood out significantly from the control sample, roughly equivalent to the batch stored at 30°C for 14 days. One can assume therefore that **the effect of temperatures of 30°C and above is cumulative, whatever fluctuations may occur.**

The affected wines lose their fruitiness which is replaced by a reductive profile (sulfur, cooked vegetables, rubber), with the appearance of additional empyreumatic notes (toast, coffee).

Temperature	Duration	1 week after treatment	2 months after treatment
-4˚C	3 d	NS	NS
	7 d	NS	NS
	14 d	NS	NS
	28 d	NS	NS
30˚C	3 d	NS	NS
	7 d	NS	S
	14 d	S (r)	S (r,e)
	28 d	S (r,e)	S (r)
45˚C	3 d	S (r)	NS
	7 d	S (r)	S (r)
	14 d	S (r)	S (r)
	28 d	S (r,e)	S (r,e)
Transport Asia	34 d	NS	S (r,e)

Brut Non-vintage Blend

Temperature	Duration	1 week after treatment	2 months after treatment
-4˚C	3 d	NS	NS
	7 d	NS	NS
	14 d	S	NS
	28 d	NS	NS
30˚C	3 d	NS	NS
	7 d	NS	NS
	14 d	S (r)	NS
	28 d	S (r,e)	NS
45˚C	3 d	S (r)	S (r)
	7 d	S (r, e)	S (r, e)
	14 d	S (r, e)	S (r, e)
	28 d	S (r,e)	S (r,e)
Transport Asia	34 d	NS	S (r)

Rosé Wine

Table 1. Results of the triangular tastings, 1 week then 2 months after heat/cold exposure (Comité Champagne tasting panel). S: significant difference NS: insignificant difference (descriptor, r: reductive, e: empyreumatic).

Where do these compounds come from?

These "reduced" or "empyreumatic" aromas are characteristic of sulfur compounds (table 2).
J. Marais[4] has already demonstrated on Chenin Blanc, Colombard and Riesling varieties that temperature increase (from 20°C upwards) brings about a reduced perception of fruit aromas and an appearance of mature notes. This phenomenon increases with time and correlates with the appearance of **dimethyl sulfide (DMS), which smells of asparagus**. Other authors (5,6) have established that this molecule was released during storage of wine from a pool of precursors, essentially represented by S-methylmethionine (SMM), derived from a sulfur-containing amino acid, methionine.

In 1994, Park et al.[7] observed that, in wines characterized as reduced, DMS is widely present, but also ethanethiol (EtSH), in white wines made from Pinot Noir, and to a lesser extent (47% of cases) methanethiol (MeSH).

Compounds	Descriptors	Perception Threshold
Compounds characteristic of a "reduced" profile		In Wine
Hydrogen sulfide (H2S)	Rotten egg, sulfur	0,8 µg/L (a)
Methanethiol (MeSH)	Stagnant water, cabbage	0,3 µg/L (a)
Ethanethiol (EtSH)	Onion, cooking gas	0,1 µg/L (a)
Methionol (3-methyl-thio-1-propanol)	Cooked cabbage, cauliflower, garlic, rubber	1 200 µg/L (a)
Methional (3-methyl-thio-1-propanal)	Boiled potatoes, leeks	0,5 µg/L (b)
Dimethyl sulfide (DMS)	Quince, asparagus	22-60 µg/L (a)
Dimethyl disulfide (DMDS)	Cooked cabbage, Brussels sprout, onion	2,5 µg/L
Carbon disulfide (CS2)	Rubber, cabbage	110 µg/L
Compounds characteristic of an "empyreumatic" profile		In a typical solution
Ethyl 2-sulfanylpropionate (E2SP)	Toasty aromas	< 300 ng/L (c)
Ethyl 3-sulfanylpropionate (E3SP)	Toasty aromas, grilled meat	200 ng/L (d)
Ethyl 2-sulfanylethanoate	Toasty aromas	
Methyl 3-sulfanylpropionate	Toasty aromas	

(a) according to IFV Val de Loire (b) Escudero et al.[10] (c) Blanchard et al.[14] (d) Kolor et al.[15]

Table 2. Sulfur compounds which can give reduced aromas and empyreumatic notes in wines.

Franco-Luesma et al.[8] also observe that the anoxic storage of various wines at 25°C for 1 year generates an increase in the content of free H2S, MeSH and DMS, equivalent to a treatment at 50°C for 3 weeks without oxygen[9].

DMS mixed with MeSH could thus explain the "cooked vegetables" descriptors detected by our panel. Indeed, the combination of DMS, MeSH and hexanol leads to the formation of a "vegetable and cabbage" type odour, different from the individual characteristics of each of the compounds[10].

The defects detected can also be caused by other molecules, notably methional, characterized by "soup" aromas (boiled potato, cooked leek). This comes from the oxidation of wine[11], either by a degradation of methionine in the presence of dicarbonyl compounds (O-quinone), or by the chemical peroxidation of methionol produced during fermentation. Since methional has a much lower detection threshold than methionol (2,400 times less), a very small amount is sufficient for it to be detected.

Lastly, two thioesters, 2-sulfanylpropionate (E2SP) and 3-sulfanylpropionate (E3SP), with a toasted odour, are known to define the empyreumatic character of old Champagne wines[12]. The formation of these molecules is explained by an esterification between acetic acid and corresponding alcohols, themselves resulting from reactions with sulfur-containing amino acids[13].

Conclusion

Other classic physico-chemical parameters did not vary in our tests: temperature does not therefore modify pH, acidity, or SO2 content.

From an organoleptic point of view, wine is not sensitive to the cold, but genuine faults can appear very quickly in white wines stored at or above 30°C, and in Rosé wines stored at higher temperatures.

This is why attention must be paid to the conditions of wine transport and storage. Shipping in refrigerated containers can be a solution, but temperatures must be maintained throughout the journey. On this point, eProvenance has recorded cases where the cooling system has been disconnected during certain journeys. Where delivery is effected using several modes of transport (for example, transshipment) temperature may also vary during cargo transfer.

In sea shipments, the position of the container in the hold has an impact on temperature changes[16]: the top containers will experience more temperature fluctuations. In the centre of the ship, away from the outer walls, the inertia will be greater.

It is also important to check the storage conditions after unloading (waiting on docks in full sun, for example).

Just like with light-strike, raising the awareness of intermediaries and distributors is therefore essential to allow wine to reach the consumer just as it left the cellars and to avoid disappointment and complaints due to factors external to the product itself.

Our thanks to Simon Merah, Sandrine Lapie and Michel Valade who carried out this work. We are also grateful to Champagne houses Cattier and Thienot for providing us with the wines needed for the experiment.

References & Bibliography

(1) eProvenance's sensor technology records temperature and humidity associated with geolocation to determine transport and storage conditions. Based on data collected between 2010 and 2016, eProvenance has shown that, of their monitored shipments, 15% to the United States, 30% to Japan and 90% to China are subject to temperatures above 25 ° C.

(2) Determination of gases by non-invasive methods. Le Vigneron Champenois, November 2015, p. 64-79.

(3) Torquemeter for measuring unblocking force. Le Vigneron Champenois, July-August 2016, p. 58-68.

(4) Effect of storage and temperature of the formation of dimethyl sulphide and on white wine quality, Marais J. Vitis (1979), n ° 18, p. 254-260.

(5) Identification of S-methylmethionine in Petit Manseng grapes as dimethyl sulphide precursor in wine. Loscos N., et al. (2008) Analytica Chimica Acta. 621 (1), p. 24-29.

(6) Ability of Possible DMS Precursors To Release DMS during Wine Aging and in the Conditions of Heat-Alkaline Treatment. Ségurel M.A., et al. (2005). Journal of Agricultural and Food Chemistry. 53 (7), p. 2637-2645.

(7) Incidence of volatile sulfur-compounds in California wines. A preliminary survey. Park S. K., Boulton R. B., Bartra E., Noble A. C. (1994). American Journal of Enology and Viticulture, 45 (3), p. 341-344.

(8) Formation and Release of H2S, Methanethiol, and Dimethylsulfide during the Anoxic Storage of Wines at Room Temperature. Franco-Luesma E., Ferreira V. (2016) J. Agric. Food Chem. 64 (32), p. 6317-6326.

(9) Reductive off-odors in wines: Formation and release of H2S and 2 Methanethiol during the accelerated anoxic storage of wines. Franco-Luesma E., Ferreira V. (2015). November 2015 Food Chemistry 199.

(10) Quality and aromatic sensory descriptors (mainly fresh and dry fruit character) of Spanish red wines can be predicted from their aroma-active chemical composition. San-Juan F., Ferreira V., Cacho J., Escudero A. (2011). Journal of Agricultural and Food Chemistry, 59 (14), p. 7916-7924.

(11) Isolation and identification of odorants generated in wine during its oxidation: A gas chromatography-olfactometric study. Escudero A., Cacho J., Ferreira V. (2000). European Food Research and Technology, 211 (2), p. 105-110.

(12) Role of certain volatile thiols in the bouquet of aged Champagne wines. Tominaga T., Guimberteau G., Dubourdieu D. (2003). Journal of Agricultural and Food Chemistry, 51, p. 1016-1020.

(13) Contribution to the study of volatile sulfur compounds in red wines. Anocibar-Beloqui A. (1998). Thesis at the University of Bordeaux.

(14) Reactivity of 3-mercaptohexanol in red wine: Impact of oxygen, phenolic fractions, and sulfur dioxide. Blanchard L., Darriet P., Dubourdieu D. (2004). American Journal of Enology and Viticulture, 55 (2), p. 115-120.

(15) Identification of an important new flavor compound in Concord grape: ethyl-3-mercaptopropionate. Kolor M. G. (1983). Journal of Agricultural and Food Chemistry 31 (5), p. 1125-1127.

(16) Storage and transport of wine: research and practice. Simon Nordestgaard, Australian Wine Research Institute - Oenoforum 2018.