HARVEST AND VINIFICATION MANAGEMENT DURING HEAT WAVES

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The summer 2003 heat wave had significant consequences both on the characteristics of the grapes to be vinified, and more generally, on the operation of wineries. In this paper, we summarize the main consequences heat waves can have on grapes and vinifications without attempting to present an exhaustive review. This work essentially refers to those "premature" regions, where an important part of the harvest had to be vinified under heat wave conditions in 2003.

Consequences of the heat wave on the organization of vinifications

The characteristics of 2003 harvests from vineyards in the Mediterranean and Rhone Valley

A dry and hot summer.

During the first part of the harvest (until August 25th), high day and night temperatures were prevalent. The soil water reserves, which were replete at the end of winter, diminished sharply in July and August, and reached a significant shortfall at the beginning of August, which was classified by the Climatological Association of the Herault as being 60 – 80% higher than the average deficit at this time in the Herault region. The temperatures were 4 – 5°C above usual averages, with low diel amplitudes and elevated daily minima.

Large variations in the vineyard

Even though vine health overall was very good, important differences regarding the quality potential were noticeable from veraison onwards.

The plots, which had not suffered water stress at this stage yet (i.e., the vast majority of the plots at the end of July) displayed indicators of a good quality potential: growth arrest, high leaf/grape ratio, small berries, moderate load, simultaneity of veraison, uniformity of cluster colour.

Certain plots (i.e., those located in areas with low water reserves, overloaded, or with insufficient root systems, especially in the case of young vines) already exhibited significant stress symptoms: leaf loss, greatly spread veraison, with an important proportion of miscoloured clusters.

The persistent drought and high temperatures during the first two weeks of August worsened this heterogeneity.

Abrupt ripening stops were observed on stressed plots leading even to halted growth of berries, which remained very small, and alarming leaf losses resulting in lignification difficulties and provoking in all instances significant concentrations, with very dry, sweet and acidic pulps.

The plots without problems at veraison were more or less affected by the persistence of the heat: Symptoms of water stress in some cases, "heat strokes" in others. In many cases, this evolution turned out to be reversible: The rainfalls of August 16th and 17th, as well as the subsequent sporadic rain periods together with the sharp temperature reduction (specifically the night temperatures at the end of August) sufficed to re-establish a normal physiological balance on many plots in September.

Extreme prematurity linked with grouping of maturities.

Indisputably, 2003 is the most premature vintage of the last 50 years. As an example, at equal sugar concentration, the plots of the ICV vineyard ("Observatoire du Millésime"*:* 25

plots with Merlot, Syrah, Chardonnay, Sauvignon, Grenache and Cabernet Sauvignon) were harvested 5 to 13 days earlier compared with the 1999-2002 average, and 14 to 24 days earlier than in 1999, which was the year with the latest harvest of this period.
The heat wave also caused a strong grouping of the maturities amongst varieties, which was even more marked than in 2001 (Figure 1).

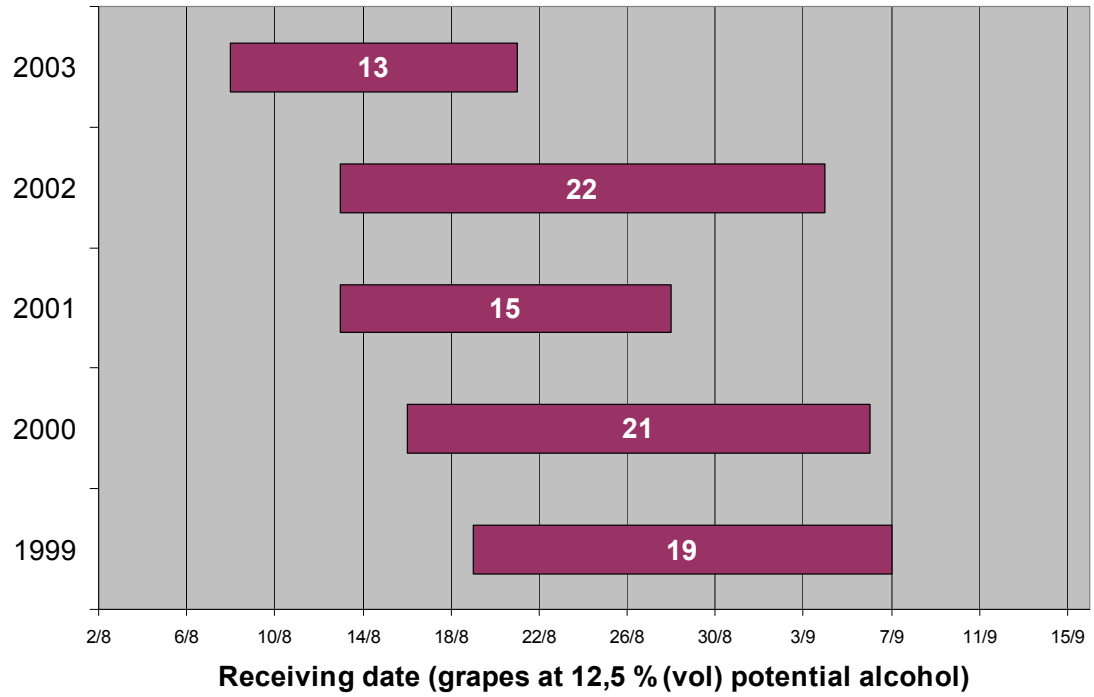


Figure 1: Start date, end date and total duration of grape deliveries from the ICV vineyard "Observatoire du Millésime" between 1999 and 2003 (18 plots with Syrah, Merlot, Chardonnay, Sauvignon, Grenache and Cabernet Sauvignon at equal stage of maturity:12-12,5 % vol.)

Frequently atypical compositions, which sometimes questioned the traditional segmentations.

The 2003 harvest was characterized by small berries with highly concentrated fruit pulp, which rapidly reached very high sugar levels: On August 18th, 2003, and in spite of the rain from the previous day, over 10 days of advance were recorded over the 2002 vintage, which already was premature!
However, at equivalent sugar levels, the berries displayed certain imbalances, particularly regarding anthocyanins. In the ICV vineyard, the anthocyanin contents were inferior compared with those measured in 2002: 14% lower for Syrah and 44% lower for Merlot.

Very early (before August 15th) the sensory characteristics of the berries revealed symptoms of stress: firm and difficult to pick berries, often with incomplete colouration in case of the reds, gelatinous fruit pulp, which would stick to the pips and skins and have a tendency to develop aromas of cooked or alcohol preserved fruit, whereas the skins remained hard, acidic and herbaceous.

The climate conditions also could question the hierarchy of enological potentials, as shown by the comparison of two Syrah plots, an AOC (appellation of controlled origin) plot located in

the Cotes du Rhone area (Estézargues), and a vin de pays (regional wine) plot in Montagnac (80 hl/ha yield).
While in 1999 the two plots had very different analytical profiles, with the Estézargues plot displaying more anthocyanins and a higher potential alcohol level, in 2003, the gaps clearly narrowed.

The potential alcohol level remained higher on the Estézargues plot, but the levels of anthocyanins were comparable on both plots, and the increased pH of the Estézargues Syrah reflected its unbalanced acid composition (table 1).

	Potential alcohol (% vol.)	Weight of 200 berries (g)	pH	Technical Maturity Index (Sugars/TA)	Potential Anthocyanins (pH 1, mg/l)	Total polyphenol index (TPI)
1999						
Estézargues	13,5	354	3,24	56	2008	44
Montagnac	12,4	372	3,24	51	1659	37
2003						
Estézargues	13,5	312	3,48	66	1430	50
Montagnac	12,8	331	3,32	59	1397	43

Table 1: Comparison of the berry composition at maturity on two plots in 1999 and 2003.

Practical consequences of the heat wave on the organisation of wineries and harvests

Review the selection criteria in the vineyard
In view of the rapidly evolving situation, in 2003, it was particularly important to make plot selection visits as close to the predicted harvest date as possible. It was equally crucial to adapt the selection criteria to the special qualities of the vintage: the estimation of the yield and the leaf/berry ratio alone did not allow to make effective selections. It was critical to consider criteria such as the sensitivity of the plot to water stress and the uniformity of the berry colouration in order to define the quality potential of the vines.

Monitor the maturity controls.
The very high variation encountered in the vineyard was reproduced on the cluster level. This resulted in the need for carrying out ripening control samplings more carefully in order to improve the evaluation of the actual maturity impaired by the high dissimilarity. Only samplings, which closely reflected the variation of the clusters and plots, as well as the sufficient frequency of these samplings (twice weekly) allowed to ensure an adequate assessment of the actual maturity of the plots.

Anticipate rapid ripening accelerations.
Especially at the beginning of harvest time, sufficient sampling frequencies were crucial to anticipate the sometimes very rapid advances in technical maturity, and to avoid having to reap the entire harvest at potential alcohol levels superior to 13.5%, particularly in the case of white grapes.

Organize the harvest considering the high temperatures.
In 2003, it was essential to consider the high day and night temperatures for the management of grape deliveries. In the first part of the harvest time, only picking before 10 a.m. ensured grape temperatures below 25°C. During the month of August, temperatures of up to 40°C could be measured on grapes that were delivered later during the day.

The reception of warm to very warm grapes has two types of detrimental consequences for wineries:

1) the grapes become more delicate, the risk of oxidation increases, as well as the refrigeration and anti-oxidant requirements needed to preserve the grape qualities (especially for whites)

2) a more difficult and costly control of maceration temperatures and alcoholic fermentations in terms of refrigeration needs.

Manage the refrigeration capacity in the winery.
The temperature control was an essential part of vinifications under heat wave conditions. The absence of effective cooling during the nights and the vatting of relatively warm grapes increased the refrigeration needs of wineries. The appropriate management of the cooling capacities and the identification of priorities were crucial for well controlled vinifications.

Practical consequences of the variation among grapes

Separate the different grape types to apply tailored vinification strategies
The strong variation among grapes required winemakers to apply specific vinification and control strategies for each tank. In 2003 more than in any year before, the simultaneous presence of balanced and ripe grapes and those affected by concentration phenomena or maturity arrests in the same winery, led to proscribe systematic corrective steps. Furthermore, it was essential for wineries to dispose of means allowing the individual treatment of the diverse grape categories in order to ensure their optimum valorization.

Perform acid additions, which were often necessary, on a case by case basis.
Even though the pH of grapes generally was higher than in previous years, under no circumstances acid additions were to be carried out systematically and massively. The benefit of tartrate additions had to be determined under consideration of the sensory properties and analytical profile of each tank. The significant risk of causing aggressive notes inherent to excessive acid additions inevitably required considerable caution regarding this procedure.

Determine the required duration of macerations by sensory and chemical analyses.
Likewise, the management of maceration lengths could not be based on general ideas and assumptions about this vintage. In fact, only a precise sensory and chemical test of each tank could allow to optimize the expression of the polyphenolic potential, which, depending on the grape type, was very heterogeneous even within a single variety. Occasionally, for a given plot, this potential appeared to be very different from previous vintages.

Closely check the alcoholic and malolactic fermentations, which were often difficult.
The management of both alcoholic and malolactic fermentations was also complicated by the considerable variation of the grape material. Especially for grapes delivered at the beginning of the harvesting period, winemakers had to face important temperature rises during alcoholic fermentations, rises, which were the cause of fermentations problems, even where the grapes did not have excessive potential alcohol levels. On the other hand, very concentrated grapes with a potential alcohol level exceeding 13.5% required the implementation of all the recommendations provided for the proper management of alcoholic fermentations (refer to the 13 key points for the management of alcoholic fermentations, ICV document).

The high percentage of wines with low malic acid contents (< 1 g/l) and elevated potential alcohol levels significantly complicated the onset of malolactic fermentation. However, for other grapes, malolactic fermentations could be fast, and spontaneous occurrences could

even be observed during macerations. Again, the strong variations required precise analytical controls of tanks.

Some key points for the valorization of concentrated grapes with elevated production costs

The key points were defined within the framework of procedures for a winery, whose objective it was to ensure the continuing production of a wine with a fresh-fruity style (even fresh jam) and round mouthfeel, in spite of the harvest condition (high proportion of withered and shrivelled berries). They are partly based on results obtained during different studies, which were carried out at the experimental ICV winery.

For grapes with a high percentage of withered and shrivelled berries the main technical objectives are:

- Extract the colour from the skins and the compounds conferring body to the wine (polysaccharides) from the ripe pulp, and stabilize them. These compounds are sufficiently soluble in aqueous or weak alcoholic solutions.
- Avoid extraction of hard and dry tannins (common in stressed and later withered berries). Avoid production of ethereal aromas, which intensify the cooked character of the berries.
- Ensure a smooth and complete fermentation, while avoiding sulphur (rubber odours) and vegetal aromas.

Favour the extraction of colour and compounds conferring body while avoiding extraction of hard and dry tannins

The essential technical methods to achieve these objectives are:

Early and extensive enzyme additions.

The early use of an extraction enzyme (with strong polygalacturonase activity) at grape reception is important. The amounts usually applied should be doubled and the enzyme solution distributed evenly over the grapes. In 2003, the increase of the enzyme additions had a clear effect on the extraction kinetics of polyphenols, as demonstrated by the experiments of our R&D department (Figure 2). This year, a sufficient enzyme addition to grapes with very gelatinous pulps was essential in order to reduce the need for harsh mechanical extractions and to rapidly structure the mid-palate mouthfeel with tannic intensity and body.

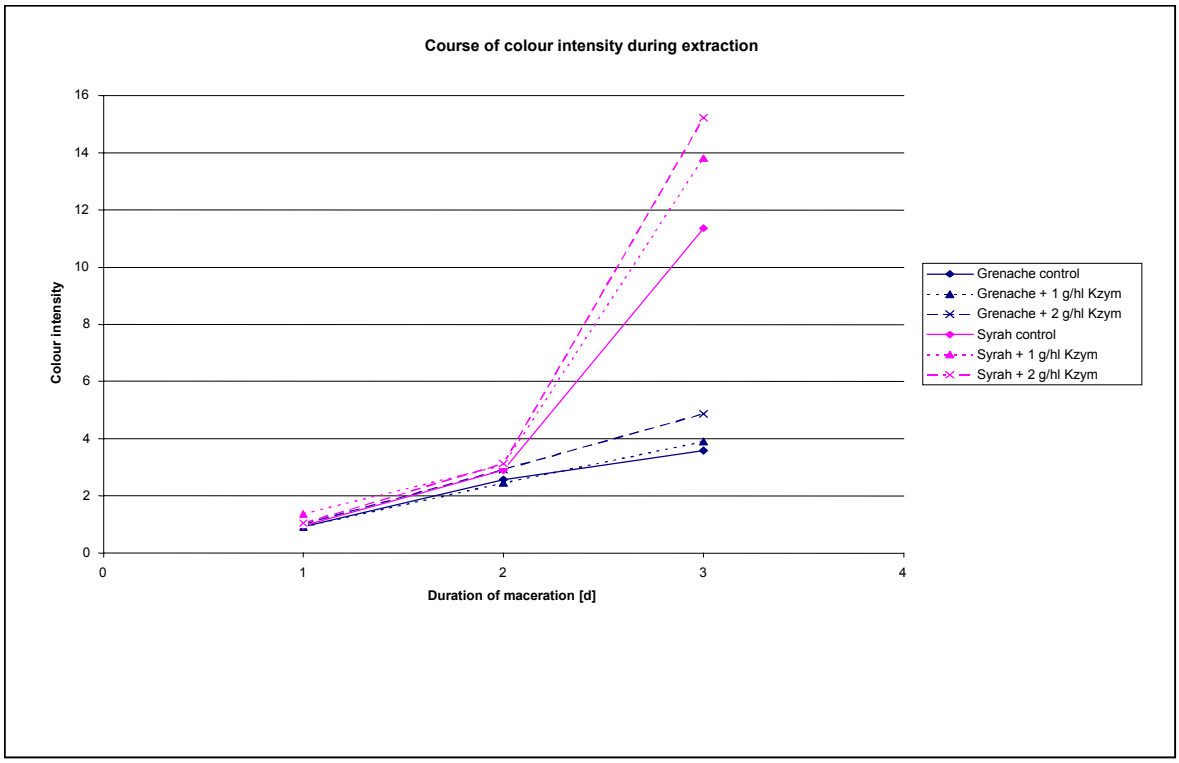


Figure 2: *Effect of enzyme additions on the course of polyphenol extraction from withered berries of the 2003 vintage.*

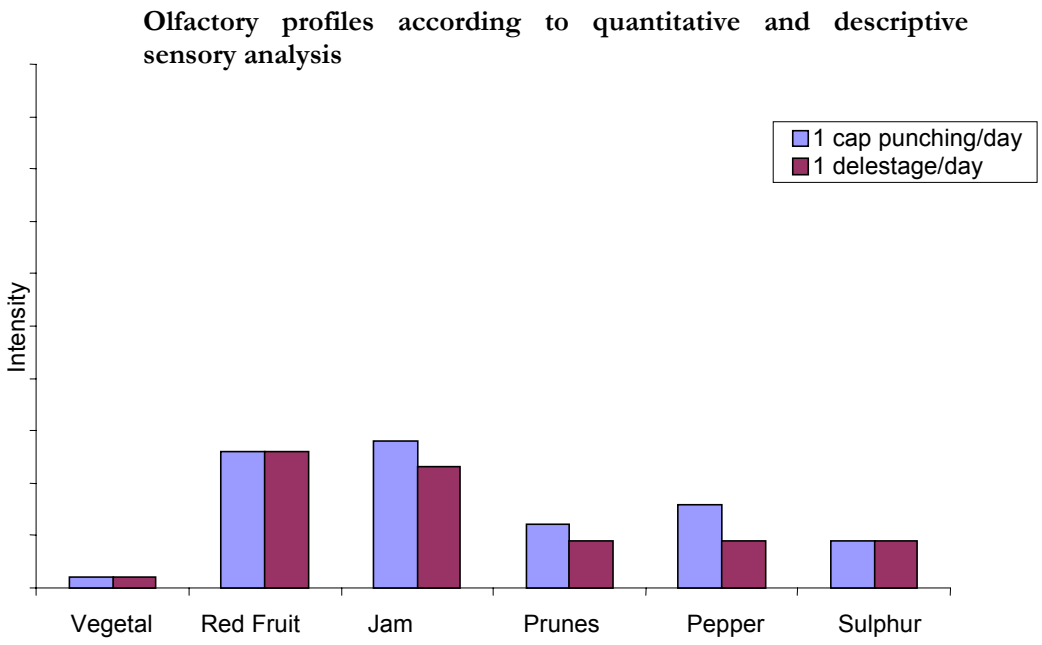
Destem and crush to facilitate gentle juice extraction.

Destemming and crushing were two crucial steps in 2003, especially to facilitate the rapid juice extraction from very small berries with thick skin and very gelatinous pulp.

Favour a gentle cap management by applying “delestage” (n.b. ICV maceration method) from the first days of maceration onwards.

Applied as soon as the cap has formed, aerated “delestage” encourages gentle extractions early on. During the next 3 to 4 days, the repetition of this method has to be scheduled according to the colour extraction rate, the tannic structure desired, and the constraints of the temperature management.

In comparison with pumping over, the “delestage” allows for a better and earlier extraction of the pulp constituents, which are responsible for a stable body (the most water-soluble polysaccharides, Figure 3). Accordingly, this allows to better stabilize the taste and aroma impressions of the fruity characters, and to avoid (or at least delay) the development of jam / burning / drying qualities, which are the direct consequence of harsh extraction methods applied to such grapes.



Carrying out delestage from tank filling onwards favoured a softer olfactory style, and allowed to increase the volume and tannic intensity, thus conferring more intensity to the wine.

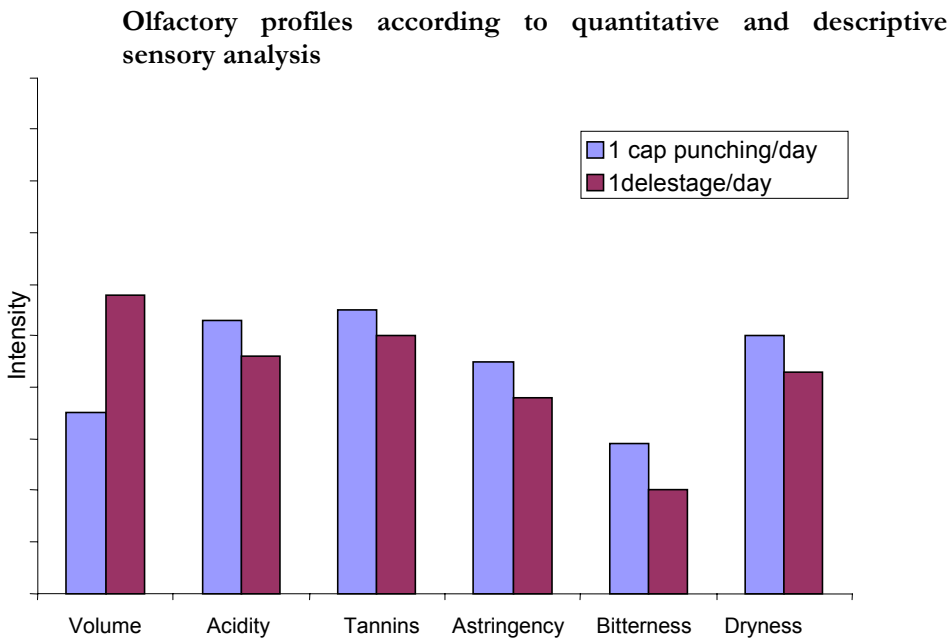


Figure 3: Effect of cap management technique on the organoleptic profile of wines with a 5 day maceration duration. Syrah 300501.

Experimental results 2002. Experimental winery of the ICV R&D department.

Extend the maceration length moderately.
The total duration of the maceration has to be determined according to results of tastings. For a wine with the objectives set above, and with the grapes available, the duration of the maceration generally was 4 to 6 days.

Manage the maceration temperatures.
Keep the temperature between 20 and 23°C in order to delay ethanol extraction as long as possible while allowing a good implementation of the selected yeast (thus avoiding the development of the indigenous flora). The temperature control is also a key element in the management of alcoholic fermentations.

Manage the risks of development of sulphur aromas.

Add oxygen moderately and regularly from the beginning of the maceration.
During maceration, these addition can be achieved by the aerated delestage technique.

If the must does not reveal significant sulphur aromas during maceration, a delestage without heavy aeration may retain fresher fruit aromas. In this case, a “semi-dose” of oxygen can be added with a sparger to the liquid phase of the tank.

Rapidly remove the plant particles.
After draining, the plant particles in the must have to be removed rapidly before they undergo an alcoholic maceration. The lengthy “maceration” of these particles in the wine after devatting can have the same effect as a prolongation of the maceration under the cap. Attaining the end of alcoholic fermentation without these plant particles is essential to prevent the rubber and cooked odours. This is part of the good practices of wineries, which regularly work with this type of grapes, such as in the South of Italy, Argentina, or California.

The blending of the different press wines has to be carried out considering their chemical and sensory profiles.

Prolongate oxygen addition after devatting.
It is important to add oxygen moderately and regularly to the liquid phase during the alcoholic fermentation. The rationale of oxygen additions is to avoid the development of sulphur odours. These risks were very high in 2003. The sulphur odours of rubber-type intensify the perception of cooked and jam aromas. The sulphur compounds equally increase the drying and burning sensations in the finish. Oxygen additions by aeration or by spargers have to be managed considering the fragility of the product (realize air exposure tests).

Regularly carry out yeast stirrings.
The objective of yeast stirrings also consists in limiting the risk of sulphur aroma apparitions, as well as favouring a smooth end of fermentation and the early liberation of mannoproteins, which will help to coat the burning aromas in the finish. The advantage of this technique is greater if the yeast strains selected are strong producers of mannoproteins.

Conclusions

Because of the heat wave, two types of difficulties were encountered in wineries in 2003: difficulties which were applicable to all the grapes, and those, which were specific for the grapes having suffered from concentration phenomena or maturation arrests. These difficulties led to the revision of the general winery organization (selection criteria retained, harvest management, setting priorities for utilization of refrigeration capacities), as well as to the management of vinifications on a case by case basis under consideration of the chemical and sensory analysis.

Unfortunately, not all consequences of these particular conditions have been revealed, so far. In fact, a considerable sensitivity of the wines with regards to their microbiological

stability has to be expected. Actually, several conditions, which are favourable to the development of spoilage microorganisms, coincided in 2003. Thus, it is crucial to stay vigilant and to extend the vinifications by a careful ageing process, which integrates the recommendations given to avoid microbiological spoilage.