An alternative approach to measuring dose rates for wood pieces

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Introduction

THE USE OF oak wood pieces is a practice by which it is possible to impart a given quantity of oak wood compounds to wines in order to obtain certain oenological results, such as enhancing woody flavours, increasing complexity, volume and structure. This operation enables winemakers to get the benefits of oak for low and medium range wines, which could not be aged in barrels because of the price barrier.

The impact of wood compounds obtained from alternatives not only depends on the type of products (size, grain size, etc), the origin of wood (French oak, American oak, etc), the toasting (light, medium, etc), but also on the quantity of wood which is put into contact with the wine. The quantity of oak (dose) may vary a lot according to the type of result required.

The way of calculating the wood dose differs between the various alternative products.

The dose is generally expressed in g/L for small wood pieces (powders, chips). This approach is commonly accepted and provides consistent results, whereby winemakers find a correlation between the oak intensity and the quantity (in grams) of oak they have used.

In contrast, for big wood pieces (staves) two types of wood measuring co-exist. One of them is using the g/L approach, while the other is the calculation of the area of wood in contact with wine as a percentage of the total volume of wine.

This latter approach is linked to the analogy with barrel ageing. Thus, winemakers frequently talk about the percentage of contact area of the new barrel (or of new wood) to express the dose of oak. Since the internal area of a 225L barrel is about 2m^3, 100% of a new barrel is equal to 0.0089m^2/L. In cellar practice, winemakers seldom use doses equivalent to 100% of a new barrel, but rather 30-50%.

What is the base of this type of calculation? The calculation, based on contact surface, reflects the hypothesis of proportionality of wood compounds migration according to the wine-wood contact area. The basis of this hypothesis is the very low penetration of wine into wood by its surface. In other words, independently of the wood thickness, the wine will always penetrate at the same (rather low) depth in wood and extracts the same quantity of wood extractives.

The experience we have with barrels shows that this is certainly true as far as barrel ageing is concerned.

It has been proven that there are

two phases in the extraction of wood compounds during wine ageing in barrels. The first phase corresponds to a progressive hydration of wood by wine (approximately four months), while the second phase is a stationary phase during which the depth of penetration remains constant. The speed of liquid penetration into wood is a limiting factor for the extraction of wood compounds (Kadim 1999). The depth of wine penetration into wood is about 2-4mm; there are various estimates of such penetration according to the methodology used. For example Feuillat (Feuillat *et al.*) estimated this layer by measuring the humidity, which was considered as a marker of penetration.

The extraction of wood compounds takes place in this thin, moistened area. It is known that the face exposed to wine is the least penetrable (the direction is perpendicular to the radial cut). This leads to a slow extraction of wood compounds during barrel ageing. Indeed Prida (Prida and Puech 2008) found that the quantity of whisky lactones in the moistened layers was still about 35-50% (in comparison to new oak) after two years of barrel use.

This means that the migratory flow of wood compounds can quite accurately be described by the law of mass transfer and this flow is directly proportional to the wine-wood contact surface.

Is it the same as far as staves are concerned? The use of staves involves their immersion into wine. Yet it is well known that wood permeability to liquids depends on the direction of penetration. It reaches its maximum in the longitudinal direction, which corresponds to the direction of the sap circulation in a living tree. In contrast, it is very low in the direction perpendicular to the radial cut (barrel stave cut) – the face exposed to wine when using barrels. Therefore the different stave surfaces (end, length, etc) immersed in wine are not equivalent in terms of penetration depth. When using staves of different geometry, we will lose the proportionality of extraction rate in relation to the contact area.

Let's look at an example, i.e., the comparison of a thin and a thick stave (twice as thick), both of equal lengths and widths. If we calculate the total surface of both staves, the values are similar, since the only difference comes from the surface of the stave extremities (the contact area will be slightly bigger with the thicker stave).

Figure 1. Stave of 18mm stave used for wine ageing and then cut lengthwise.

In order to calculate the percentage of extraction over the contact surface, the wine must penetrate into the whole surface of the stave at a similar low depth. Taking into consideration the anisotropy of wood, this is probably not the case. On the contrary, the wine will probably penetrate deeper into the wood in the longitudinal direction. The

simple observation of staves used for wine ageing then cut lengthwise shows that wine penetrates into the heart of wood (Figure 1).

In this case, the quantity of extracted wood compounds will be much higher with a thick stave than with a thin one. If total penetration is considered, a thick stave will produce twice as many extracted compounds as a thin stave because the mass of a thick stave is double that of a thin stave.

In the current study, we are trying to answer the question about the penetration rate of wine into a stave and its interaction with wood. If it is low, the extraction should be proportional to the surface, whereas if it is high, the extraction should be proportional to the mass of wood.

Figure 2. Balance of wood extractives.

Equipment and methods

Staves of 7mm and 18mm (Seguin Moreau, Cognac, France) were used in the study. Both types were made of French oak with medium toasting.

These staves were macerated in wine (Domaine de Chiroulet, Vin de Pays des Côtes de Gascogne, Tannat, 2011 vintage) separately (two individual tanks) for 7mm and 18mm, the doses being 10g/L of stave in both cases (two staves/hectoliter for 18mm and five staves/hectoliter for 7mm). The staves were immersed in wine in April and removed in November, therefore a total contact time of seven months.

Pieces of 4cm were sawn off each stave, the samples were mixed together and ground down to a 0.5mm powder. This procedure was required in order to obtain an average sample and reduce the effects of a possible toasting heterogeneity.

The wood powder was soaked by shaking (300 tours/min.) by the model wine solution (12%v/v pH3.5) during 24 hours. The extracts were analysed by HP-SPME-GC-MS according to the Carrillo method (Carrillo *et al.* 2006) for main compounds arisen from wood toasting: furfural, furfuryl alcohol, 5-methyl-furfural, guaiacol, and vanillin.

After wine maceration (seven months), the staves were removed from the wine. A 4cm long piece was sawn from the central part of each stave. This time, we did not use the extremities since there might have been too many compounds because of the lengthwise penetration of wine into the wood. This way we avoided the artifact risk of the trial.

The wood pieces were ground down, extracted and analyzed following the method described above. Finally the wines obtained during trials were also analysed using the same protocol.

Results

We reviewed the compounds distributed between the liquid (wine) and the solid phases (wood after maceration) and compared them with the quantity of wood compounds before maceration. Given the absence of furfuryl alcohol in wood and its appearing in wine through the reduction mechanism for furfural, we defined the total furfural as a sum of furfural and furfuryl alcohol. Its concentration was compared with furfural amount in wood.

The balance of compounds shows us that the sum of compounds after maceration (wine and wood) is lower than their initial amount in wood before maceration. This fact could be explained by the transformation of such compounds in the wine medium and corresponds to the conclusions made by Spillman (Spillman *et al.* 1997, Spillman *et al.* 1998) about the evolution of furfural and vanillin, and also to the phenomena reported by Nonier (Nonier *et al.* 2006), which pointed out the interaction between wood aldehydes and wine phenolics.

The amount of wood extractives (after extraction) in wine, in wood and losses due to transformation are shown in Figure 2 (example of a 7mm stave). All amounts were expressed in percentage of initial concentration in wood before maceration.

One can see that the rate of loss of compounds in the wine medium is spectacular, except for guaiacol, which seems to be stable. The furfural, 5-methyl-furfural are very affected (loss of about 90%) by the wine medium, while there is just 50% of loss for vanillin.

If we only focus on the extraction of wood compounds (Figure 3), one can observe that the 7mm staves contain less than 5% of the initial concentration of wood compounds, while the 18mm staves contain 2-20% of the initial concentration depending of the analysed molecule.

This study shows that during maceration of staves in wine, the wood loses a significant proportion of its extractives. If we consider the amount of wood extractives leached by wine (difference between extractives in wood before and after maceration), we find approximately the same amounts for 7mm and 18mm staves taken at an identical dose (10g/L), a small discrepancy arising only from a slight difference between extraction rates for these two types of staves (Figure 4).

On the other hand, if we consider the dose of staves in percentage of surface (example of thin and thick staves), we have almost 2.5 times as much equivalent barrel surface for the 7mm stave than with the 18mm. This means that a winemaker who takes into consideration the contact area would in practical terms use a dose of 2.1 staves (7mm) to reach the result obtained with two staves of 18mm in terms of wood extraction, and must have made a mistake with the doses. This leads to a very important error as far as oak extraction and oenological results are concerned.

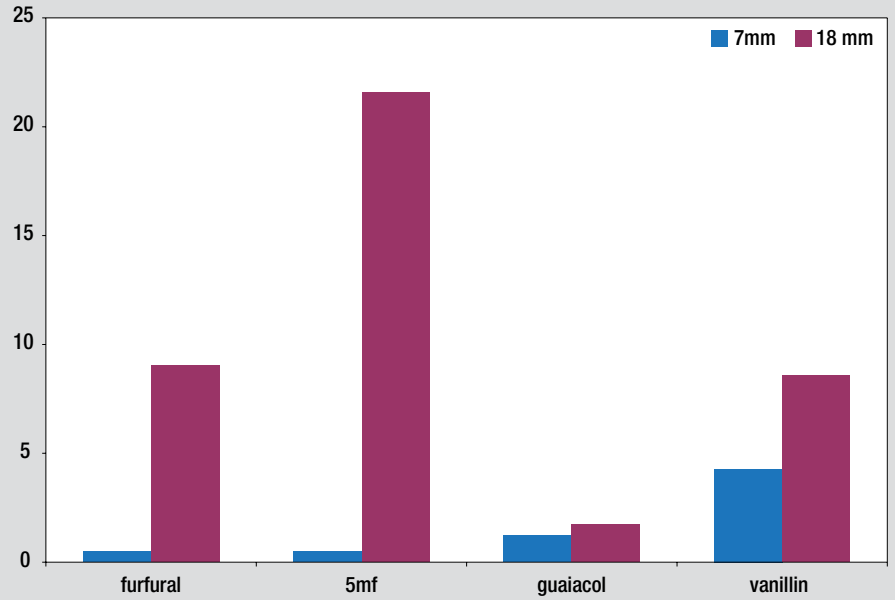

Figure 3. Percentage of extractives in wood.

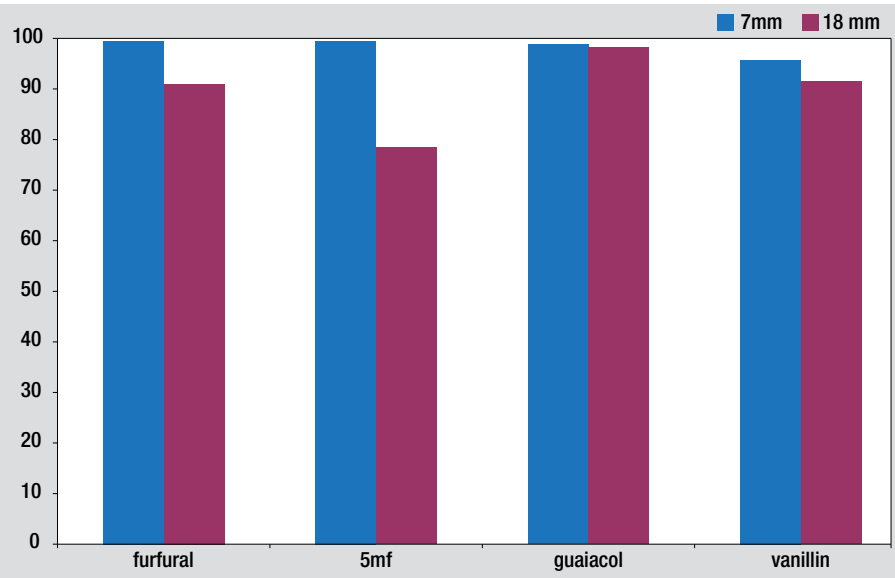

Figure 4. Percentage of extractives leached in wine.

Conclusions

This trial shows that the way of expressing the wood dose for staves in g/L is closer to reality in oenological terms than that expressed in terms of contact surface. This result is conditioned by the phenomenon of a very deep penetration of wine inside the stave (in all three directions: radial, tangential and longitudinal) and consequently by a significant extraction of wood compounds (80-95%) during the stave maceration; this phenomenon is different to those observed when using barrels.

The use of surface area still makes sense if the winemaker always works with the same type of stave. For example, by doubling the number of staves per hectolitre, he or she also doubles the surface area.

However this approach is no longer accurate if the winemaker uses different types of staves and in particular staves of different thickness. In this case the use of the g/L approach is essential and enables the winemaker to avoid making errors of dosage and therefore oenological mistakes. GW

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