

The quality of oak wood and its use for the vinification and ageing of wine

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Summary : Oak wood has been used for many centuries for vinification, transporting, ageing and storing of wine. Knowledge of the quality of the wood and the mechanisms associated with the vinification and ageing of wine having profited to a large extent through research. The author therefore presents a review of recent acquisitions in the different domains relating to cooperage and oenology. A short reminder about the structure of oak wood and the methods of maintaining and exploiting forests, constitutes the first part of the article. Thereafter, a synthesised study of the mechanisms involved in vinification and ageing of dry white wines and the phenomena of oxidoreduction of red wines in barrels, is considered.

Key words : *Quercus robur*, *Quercus petraea*, forest management, vinification, ageing, dry white wines, red wines.

INTRODUCTION

Wood is the material which was used to replace the different storage recipients and for ancient transporting of wine (TARANSAUD, 1976 ; REMY, 1991). Since then, oak forests, which are the providers of coopers, have been managed and maintained (LACROIX, 1993). The quality of the oak wood has been coded and only that which is in species susceptible to improving the quality of the wine (POLGE, 1973 ; DERET-VARCIN, 1983).

With great rapidity, *Quercus robur* (syn. pedunculate oak) and *Quercus petraea* (syn. sessile oak) are imposed as the principal species adapted to the ageing of wine.

... of the wine develops and becomes more complex (BOIDRON and *al.*, 1988) ; the wood releases into the wine numerous specific substances or substances formed during the toasting of the barrels (VIVAS and *al.*, 1991). Then, the porous material of which the wood is made allows the wine to undergo simultaneous processes called « low oxidation condition » (VIVAS and GLORIES, 1993). The wine, when removed from the cask, is totally modified ; the barrel is thus not a simple improver which merely gives to the wine a woody aroma.

THE QUALITY OF OAK WOOD AND FRENCH FOREST MANAGEMENT

The bulk of the oak forests used for cooperage are found in the Centre France. The pedunculate oak and the sessile oak represent respectively 19 % and 14 % of the total bulk of planted forests. 65 % of forests are public and managed by the O.N.F. (Office National des Forêts) : 29 % belong to private estate and 71 % is communal forest. Private forests represent 35 % of the total forest area.

In France, natural or spontaneous forest does not exist (LACROIX, 1993). Forests have always been an environment used by man for gathering, as a source of energy, as a source of construction material, as a place of grazing for domestic animals and finally as a source of oxygen.

Silvicultural management of the French forest areas requires two modes of area treatment :

The coppice under plantation

This practice came about in order to assure man's essential needs ; in other words the provision of a source of energy, construction material, charcoal as well as for the production of food for their herds. Under these circumstances, perpetuation of the forest was assured by the reserves, in the coppice, of essentially precious essence twigs, generally from the oak and the beech trees. The twigs provided by the coppice have the inconvenience of often being on top of cut stumps which ultimately produce defective trees. The periodic cutting of the coppice places the trunks of the trees in full light allowing the development of bumps and low branches which decrease the quality of the tree trunks as a whole.

In the practice of plantation, perpetuation is assured by the sowing of this precious essence which comes from an existing tree in the plantation. Throughout its life, planting is done with saplings which are all of the same age. Under these conditions the trunks of the trees remain sheltered from light. This leads to the obtention of clean trunks which have developed neatly, this enables them to be used for products of high technological quality.

The trees are felled after 180 to 250 years to make place for young seedlings. This regeneration takes 15 years and costs 15,000 to 20,000F/ha.

The term « merrain » is no longer used today except to designate wood destined for the cooper. Only sessile and pedunculate oaks make merrains suitable for the ageing of wines and brandies. These oaks present the following characteristics : good mechanical properties, essential for the resistance of the barrels ; ease of debit by splitting ; ease of curving and bending ; good thermal insulation and low porosity which favour the phenomenon of oxygen penetration.

The log of merrain quality should be between 1.05 m and 1.10 m or even a multiple of this dimension (length of staves = 1.05 m). The merrain wood should correspond with the very severe selection conditions :

- straight grained wood,
- absent of knots or scattered burrs,
- little sapwood,
- tight rings.

The value of an uncut merrain varies according to quality from 900 to 2200 F/m². The volume of oak wood used by coopers is approximately 10 % of the annual oak wood crop.

In the future, the private estate and communal public forests will experience a considerable expansion (240,000 ha of estate forest in 1990, 470,000 ha in 100 years ; 88,000 ha of communal forest in 1990, 470,000 in 100 years). The resource of merrain is thus guaranteed in the long run. In the near future, the O.N.F. envisages the creation of labelled merrain oak guaranteeing its origin, much like the A.O.C. labelling currently used for quality wines.

THE FERMENTATION AND AGEING OF DRY WHITE WINES IN OAK CASKS

The dry white wines which are suitable for keeping are fermented and aged in oak casks ; the age of the cask bears great importance on woodiness and the intensity of the much sought after oxidation reactions. After having been abandoned momentarily for neutral and more easily maintainable recipients (concrete, stainless-steel, plastic), we have reverted to the use of wood for all quality white wines. The originality of the ageing of white wines in barrels as apposed to red wines resides in the intervention of yeasts and their interaction with the wood itself.

The yeasts possess a wall made up of glucidic colloid, essentially glucanes and mannoproteins (LLAUBERES and *al.*, 1987 ; LLABUBERES, 1988). The parietal constituents and especially the mannoproteins are released during the alcoholic fermentation, and intensifies during the period of ageing on lees. The restoration of the lees in suspension, using the « batonnage » technique, favors the enrichment of the wine with yeast colloids. These constituents are capable of combining the phenol compounds of the wine and the wood ; besides a wine aged in a barrel is not as rich in polyphenols as the same wine aged in a stainless-steel tank. During ageing, the yellow colour of the wine diminishes and the gustatory impact of the tannins of the wood is limited (DUBOURDIEU, 1992). The wine appears clearer and less astringent.

Ageing on lees allows the limitation of the oxidoreduction phenomenon. The keeping and ageing of a wine in a tank which contains these lees, provokes a drop in oxidoreduction potential quickly followed by the appearance of reduced odours responsible for the depreciation of the wine. The wine is enriched with sulphide compounds (H_2S , ethanethiol, methanethiol, ethyl and methyl-sulphures) ; their perception threshold is relatively low in the order of $\mu g/l$ (LAVIGNE and *al.*, 1992, LAVIGNE and *al.*, 1993). Conversely, a wine aged in a new cask can be kept for several months on lees, these enable the impact of oxidation reactions to be limited ; the lees in this regard are a source of reducing capacity (VIVAS and GLORIES, 1995). The « batonnage » enables the oxidoreduction potential to be homogenised throughout the entire profile of the barrel. Finally, it is advisable to note the prolonged use of a cask limits the oxidation reactions and increases the risk of the appearance of an olfactive reduction character.

Wood is susceptible to giving a wine particular aromatic hints (VIVAS and *al.*, 1991) : whisky-lactones (smell of coconut), vanilla aldehyde

(smell of vanilla) and eugenol (the smell of cloves). These odour molecules present in reasonable quantities are detected by the tasters. On the other hand, if they are excessive, the wine appears rougher and marked too much by the woody character (BOIDRON and *al.*, 1988). The woody aroma of a wine fermented and aged in a barrel is inferior to that of a wine barreled after alcoholic fermentation ; in this case, the first type is preferred (DUBOURDIEU, 1992). This observation is essentially associated with the cell wall capacity of the yeasts and their glucidic colloids to fix certain aromatic molecules. What is more, the reductive activity of the yeast during the fermentation enables the transformation of vanilla aldehyde, fragrant, to vanilla alcohol, scentless (MARSAL, 1988). Finally, for the same reasons, the wines which have been aged on total lees are preferred to those wines aged on thin lees. (DUBOURDIEU, 1992).

Recently it was observed, that during alcoholic fermentation, the variable aroma of the Sauvignon increased, this suggests the intervention of yeast preceding the discovery of the aroma of vines. Henceforth, it seems that the prolonged maintenance of the wine on yeast biomass in autolysis (lees) may also reinforce the character of vines in the overall aroma of the wine (DARRIET, pers. comm.).

AGEING OF RED WINES IN OAK BARRELS

The ageing of red wines in oak barrels is generally sought after as it gives the wine woody hints, sometimes grilled or smoked which suit our great wines. But over and above the aromatisation, the wood has constituent capacity to deeply modify the composition and quality of the wine. Most of these modifications brought about by the barrel are associated with the phenomenon of oxidoreduction.

The barrel is a porous recipient, which allows the continual flow of traces of oxygen (VIVAS and GLORIES, 1993 ; MOUTOUNET and *al.*, 1994). The exchange occurs jointly through the bung hole, the joints of the staves making up the cask, and through the staves themselves. The dissolved oxygen content in the new cask is approximately 0.3 to 0.5 mg/l ; the corresponding oxidoreduction potential varies between 250 mV and 350 mV. The prolonged utilisation of the casks provokes a progressive blocking of the wood wall and a simultaneous diminution of dissolved oxygen content and oxidoreduction potential. The oxymetric profiles found in the casks having contained 3 to 5 wines show that ageing approaches the conditions of conservation of wines kept in tanks (oxygen < 0.1 mg/l - oxidoreduction potential < 200 mV).

It is necessary to point out that topping up provides approximately 1 mg/l of oxygen in the first 20 centimetres of wine ; racking allows the dissolving of 2.5 to 5 mg/l of oxygen (VIVAS and GLORIES, 1994 ; VIVAS and GLORIES, 1995).

The oxidation in casks, called « low oxidation condition », provokes a slow evolution of the wine. Whilst ageing in barrels we observe : a decarbonation of the wine (loss of CO₂) ; a spontaneous clarification associated with the flocculation of numerous deposits in suspension in the turbid wine at the end of alcoholic and malolactic fermentation, as well as the progressive loss of colloidal colouring compound ; a tartaric stabilisation of the wine by precipitation of the tartaric acid with potassium. What is more, the phenol compounds undergo profound modifications : the tannin-anthocyanin combinations stabilise the colour of the wine ; the condensation of the tannins among themselves, by the intermediation of ethanal, assures a softening of the wine ; the colour of the wine develops into a mauve-red and it appears to be darker. The proportion of tannins and anthocyanins should be balanced so as not to lead to reactions of oxidative degradation. The disparition of anthocyanins provokes a diminution of the red colour, and to the contrary the partial degradation of the tannins strengthens the yellow colour of the wine ; in consequence the wine becomes tawny in an untimely manner. In order to avoid this the tannins/anthocyanins molar links should be around 2 (1.5 to 2 g/l of tannins and 500 mg/l of anthocyanins). Free sulfite should not block the reactions of « low oxidation », and therefore must be maintained at 20 to 25 mg/l.

The wood, especially when new, gives to the wine a number of compounds which advantageously complete the effect of the « low oxidation condition ». In addition to the pool of aromas conjured up for vinification and ageing of dry white wines in casks, the wood transmits ellagitannins (hydrolysable tannins specific to oak wood and chestnut) to the wine. These phenol compounds are much more easily oxidised than the majority of the natural constituents of the wine, they therefore consume the dissolved oxygen first and protect the other compounds of the wine. They play a further role, because they possess an oxidising capability owing to their molecular structure, these wood tannins can therefore regulate the oxidation reactions of the wines and direct them towards a slow development of the phenol compounds. In this case, the reactions of oxidative degradation are decidedly slowed (VIVAS and GLORIES, 1993). Thus, the repeated violent oxidation in airtight tanks cannot yield the same result. The polysaccharides coming from the wall of the barrel progressively becomes soluble in the wine ; they give the wine a « rich » sensation and significantly diminish the astringency of the tannins.

CONCLUSION

Oak wood and wine are products which evolve simultaneously. Œnology started as a completely separate science, further more the past progress of œnology, both past and present, is the result of applied research combined with basic research.

Cooperage, through the impetus of coopers like DEMPTOS progressively became a well thought-out technique whilst at the same time tending towards becoming sciences of wood and cooperage. As in the case of wine, we hope to experience spectacular progress from now to the end of the 20th century. But we can already see the part of recent progress by the improvement in the quality of barrels and in the better thought-out combination of oak and wine.

The most spectacular progress can be summarise in three points :

- The improvement in knowledge regarding the structural and analytic qualities of oak destined to be used for making barrels ;
- The knowledge and reasoning about the ageing of white wines in casks, especially the relation between the lees and the wine and the aromas of the wood ;
- The understanding and interpretation of the ways of transformation of phenol compounds during ageing, as well as the definition of « low oxidation condition » in red wines.

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