« Precision and homogeneity of barrels selected with OakScan®: two examples of selection adapted to different wine profiles or aging objectives »

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Introduction

The variability of oak heartwood, particularly with regard to its chemical composition (Snakkers *et al.* 2000, Doussot *et al.* 2002), is the initial challenge facing the cooper. Not only does this variability exist between two trees, but it is systematic within the same piece of timber, between the heart and the sapwood (Masson *et al.* 1995). Beginning in 2006, Radoux became interested in developing rapid and non-destructive measuring processes in order to better control its raw material at each stage of its transformation.

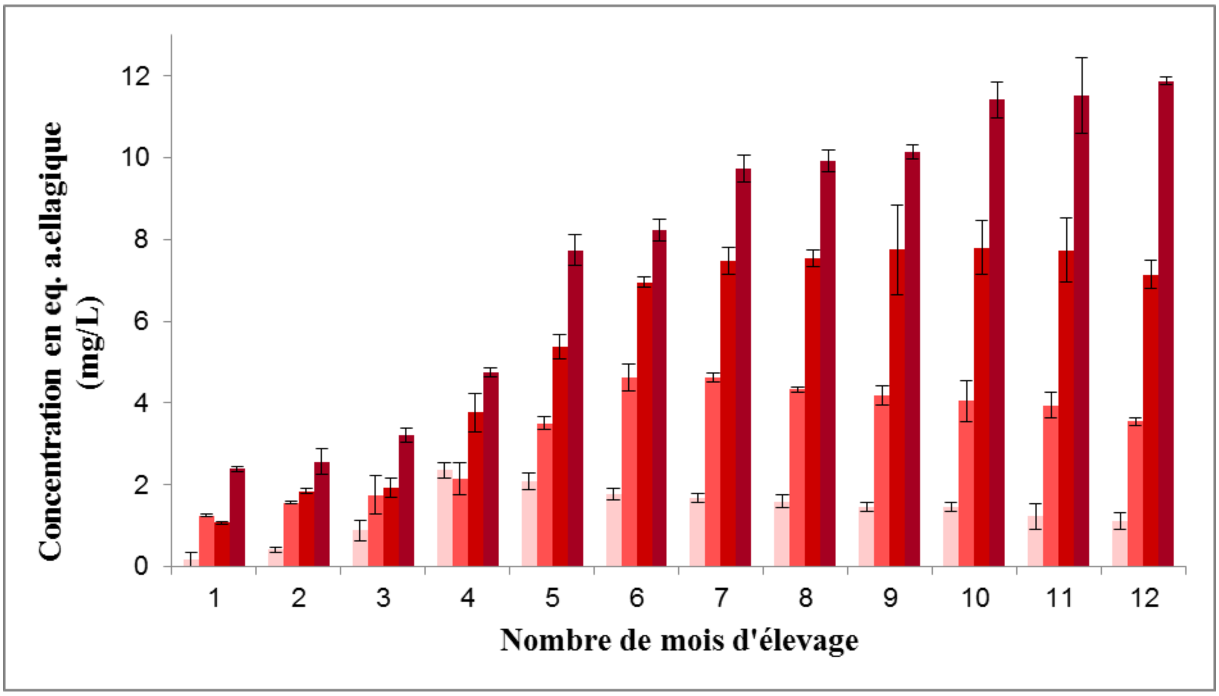
In 2009, Oakscan was the first tool within the cooperage industry able to instantly measure the quantity of polyphenols present in staves used to manufacture barrels (Giordanengo *et al.* 2009). Its use was then extended to the selection of oak for oenology. The polyphenols, the majority of which are composed of ellagitannins in the oak (hydrolysable tannins which release ellagic acid), have proved to have an important impact on the structure and color of wines (Quideau *et al.* 2005, Saucier *et al.* 2006), on their protection against oxidation (Vivas et Glorie 1996), and above all on the organoleptic perception of wines, particularly on the palate (Glabasnia et Hofman *et al.* 2010).

Today this tool allows us to guarantee a defined and reproducible quantity of polyphenols, characterized by a Polyphenolic Index (IP) ranging from 0 to 100, in the selection of standard predefined wood categories or adaptable according to the requirements of the wine. As an example, the principal predefined selections in the tight grain oak are : the «low potential» selection or IP20, the «medium potential» selection or IP40 (which is the most abundant in the natural distribution of wood), and the «high potential» selection or IP60.

1 Choice and impact of OakScan selections on wines

From 2009 to 2012, Tonnellerie Radoux carried out research on ten trial sites, in collaboration with the ISVV of Bordeaux (CIFRE Thesis), which revealed how the selection of wood (barrels and staves) by OakScan impacted the organoleptic properties of wines aged in contact with this wood (Michel *et al.* , 2013). The quantities of ellagitannins remaining in the wine and capable of releasing ellagic acid after acid hydrolysis were examined over a period of time. A relationship was revealed between the extraction of ellagitannins from the wood by the wine and its molecular break down (hydrolysis, oxidation…) or complexation with other molecules present in this environment (Jourdes *et al.* 2011). Thus, during aging, the concentration of ellagitannins in the wine gradually increases to a maximum (a phase referred to as « taking on the flavor of the oak ») and then decreases more or less rapidly depending on the intensity of the reactions of molecular break down and complexation.

The difference of the initial concentration of ellagitannins in the wood, characterized by the variation of the Polyphenolic Index, was the dominating parameter on the evolution kinetics of the ellagitannins extracted by the wine. As demonstrated in the diagram below, the longer the wine had been aged in contact with wood rich in ellagitannins, the greater and more delayed the polyphenolic extraction was. Thus, the same red wine aged in barrels whose IP ranged between 20 and 70 showed a maximum concentration of ellagitannins in the wine between the 4th and 12th months. The concentration of remaining ellagitannins then began to drop, this occurring earlier with selections of the lower IP. These differences significantly modified the perception of the wines on the nose (fruit intensity, oak intensity, smoked/roasted notes) and on the palate (tannic perceptions, structure, fullness) at the various stages of aging (6-12-18-24 months). Therefore, the objective length of aging should be a primary consideration in the choice of the oak's IP.



Concentration of ellagitannin; number of months of aging

In the same way, the differences of the wines' IPT played a role in the extraction kinetics of the ellagitannins and their content in wines. Thus a wine whose IPT was high (IPT84) had a lower concentration of residual ellagitannins than a less rich wine (IPT77), especially through their integration into more complex structures which participate in the construction of the wine (Glabasnia *et al.* 2006, Stark *et al.* 2010). The aging of wine in contact with wood rich in ellagitannins (IP60) increased its fullness and persistence, however, the residual tannic perception cumulated with that of the original wine. The sensory profile of the initial wine, in addition to the chemical data on the richness and polyphenolic maturity, is essential in optimizing aging through the choice of the IP of the wood, thereby achieving a better ratio between gain in structure and tannic perception.

The differences in the « grain » of the wood (average width of age rings) also modified the chemical exchanges with the wine. The rate of extraction kinetics of ellagitannins and wood compounds proved to be affected by the size of the grain. With the same level of IP, the concentration of ellagitannin increased more slowly in contact with the tighter grain during the first months. However, during the second part of aging, when the transformation of ellagitannins is quicker than their extraction, the drop in concentration of residual ellagitannins is lower when the size of the grain increases: in other words, the integration of the tannins extracted from the wood seems greater with the tightest grains.

Finally, the toasting process significantly impacted the evolution kinetics in the concentration of ellagitannins in the wine. A lighter toast (such as Radoux Révélation) preserved the level of ellagitannins in the wood and increased the quantity of tannins extracted during aging ; a heavier toast broke down the ellagitannins and therefore lowered the level of enrichment of the wine, especially at the beginning of the aging process. The choice of the type of toast, depending on the intensity and aromatic profile that is being sought after, must be taken into account during initial selection of the IP of the wood.

This research was developed on a wide scale resulting today in a database of 40 trial sites where a great number of barrel making parameters (grain, Polyphenolic Index, barrel volume, toast), those of the wine (IPT, level of alcohol, PH, total acidity, phenolic maturity, residual sugar etc..), and the conditions in which it has been prepared (Malolactic fermentation with or without contact with wood, use of lees, date of placement in barrels, temperature of cellar, control of oxygen etc…) have an impact on the evolution kinetics of the extracted ellagitannins and their influence on quality. An individualized approach based on monitoring the level of residual ellagitannins in wine helps us to integrate all the parameters which have an impact during aging and to be as precise as possible in analyzing the capacity of the wine to assimilate this extraction and in the recommendations we put forward with regard to the appropriate OakScan selections.

2 Example of selection of Polyphenolic Index to produce two different wine profiles

Two selections of wood for a Transport 27mm barrel were examined on a 100% Cabernet Sauvignon wine (Chile, Colchagua, 2010), the initial oenological analyses of which were as follows :

IPT	TAV (% EtOH)	SR-5 (g/l)	ph	AT (gH2SO4/l)	AV (gH2SO4/l)	Amal (g/l)	Alac (g/l)
89	15.53	4.6	3.73	3.61	0.45	0.02	1.00

All the French oak used was selected using the OakScan process, and underwent the same toasting process (Red Wine Medium Classic). The characteristics of the oak selection were as follows :

Description	Average Polyphenolic Index (OakScan measurements)	Selection of grain
Low Potential / IP20	IP 20 +/-5	Tight avg 2mm)
High Potential / IP50	IP 50 +/-6	Tight (avg 2mm)

An additional modality aged in STAINLESS STEEL barrels of the same shape and size was used as a Reference. It was placed in the same area of the cellar and followed the same aging process.

The tasting was conducted with a series of three wines tasted blind. Ten tasters completed a sensory analysis form marking the intensity perceived by descriptors on the nose and palate on a scale from 1 to 7: 1/none – 2/very weak – 3/weak – 4/average – 5/fairly strong – 6/strong – 7/very strong. A specific scale of texture was proposed: 1/weak – 2/hollow – 3/smooth – 4/velvety – 5/slight astringency – 6/tannic – 7/ excess.

2-1 Analysis of sensory data

The data for each descriptor were analyzed using variance analysis (Fisher Test). In this way, the descriptors used for each series are those which present at least one significant difference between the modalities used (threshold at 5%). Then, an analysis of the averages (Student-Newman-Keuls Test, threshold at 5% and 10%) helped group and classify the modalities: here the modalities belonging to the same statistical group, that is, not significantly different, are allocated to the same group identified by the letters A, B or C.

Average marks out of 7 and results of the Newman-Keuls test at 5% at 14 months aging

Descriptors	REFERENCE	LP IP20	HP IP50	F calc.	Proba.	F. Judge
intensity fruit	5,00	4,38	4,50	1,62	0,2338	
intensity wood	2,38 B	3,88 A	3,88 A	6,63	0,0094	
	Very low	average	average		**	
coconut	1,13 B	2,50 A	2,38 A	4,20	0,0373	
	none	Very low	Very low		*	
vanilla	1,38 B	3,38 A	2,63 B	5,44	0,0178	
	none	low	Very low		*	
spices	2,13 B	3,13 A	3,38 A	3,13	0,0754	
	Very low	low	low			
smoked-roasted	1,50 C	2,38 B	3,50 A	12,17	0,0009	
	none	Very low	low		***	
fruit on palate	5,00	4,38	4,88	1,37	0,2852	
roundness	4,13	4,00	4,25	0,27	0,7653	**
fullness	4,75 B	4,38 B	5,50 A	6,78	0,0087	**
	average	average	Fairly strong		**	
bitterness	3,00 A	1,50 B	1,88 AB	4,20	0,0373	*
	average	none	Very low		*	
texture	2,63 B	4,25 A	4,00 A	5,02	0,0227	*
	smooth	velvety	velvety		*	
persistence	5,25	4,88	5,13	0,51	0,6140	**

* significant at 5 % ** significant at 1 % *** significant at 0,1 % ! test not carried out

The differences between the wines aged in wood and those aged in the reference stainless steel containers are significant for seven different descriptors on the nose and palate. Overall, the modalities aged in wood are logically more marked by the oak descriptors on the nose. On the palate, the perception of bitterness on the Reference is significantly softened by the aging in wood, particularly with the IP20 selection, and the gain in texture turns a « smooth » wine into a « velvety » one.

For the two modalities aged in wood, three descriptors significantly discriminate the potential of woods tested at a threshold of 5%:

- Vanilla: the low potential (IP20) are significantly more marked by vanilla than the high potential (IP50), at a threshold of 5% without judge's effect;
- Smoked/roasted: the high potential are significantly more marked than the low potential, at a threshold of 0.1% without judge's effect;

- Fullness on the palate: the high potential are significantly fuller than the low potential at threshold of 1%, but with a very marked judge's effect.

A differentiated structuring effect became clearly apparent with the varying polyphenolic wood indexes at 14 months of aging. We stress that this structuring effect did not give rise to any difference in the expression of the fruit either on the nose or on the palate (without judge's effect), in spite of a more vanilla profile for the selection IP20, and a more roasted profile for the selection IP50. In the same way, there is no significant difference on the persistence (strong judge's effect), with a wine initially rich on the palate and long on the finish.

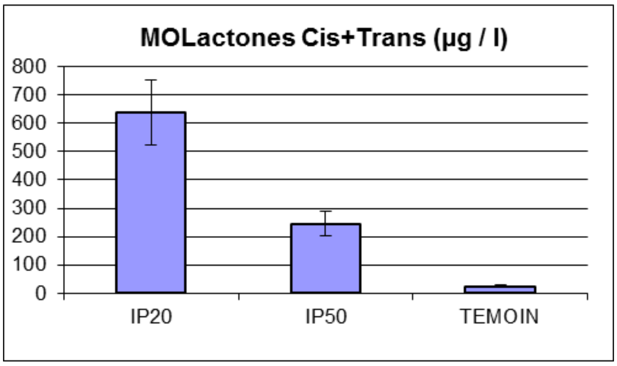
2-2 Analyses of chemical data

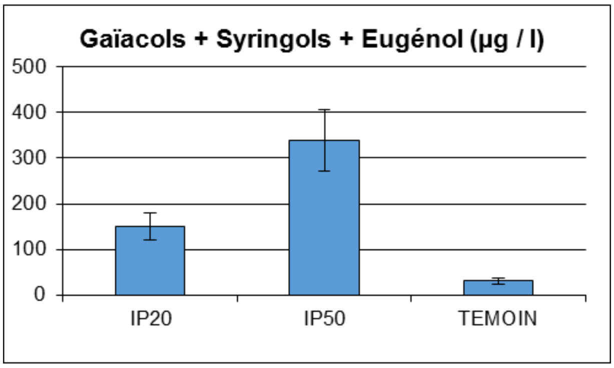
Samples of wines at 14 months of aging show slight oenological differences between the modalities aged in wood and those aged in stainless steel containers:

Noms	CO2 (mg/L)	TAV (% EtOH)	GF-5 (g/L)	SR-5 (g/L)	pH	AT (gH_2SO_4/L)	AV (gH2SO4/L)	AMal (g/L)	ALac (g/L)
002-Inox	428	15.58	2.1	4.5	3.73	3.60	0.45	0	0.96
002-BP	113	15.78	0.8	3.6	3.71	3.81	0.60	0.14	0.94
002-HP	124	15.67	0.9	3.6	3.70	3.79	0.57	0.13	0.92

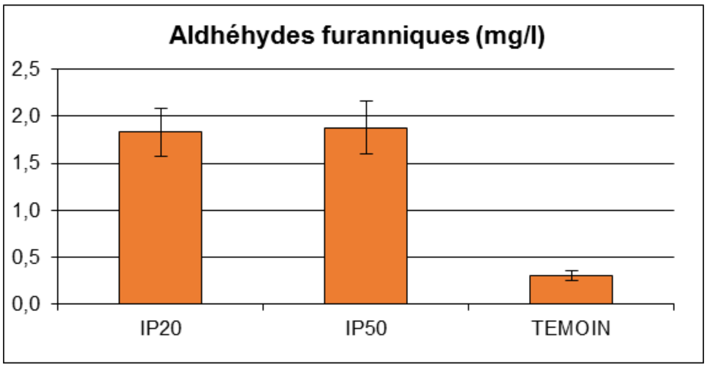
Noms = Names

As far as the aromatic compounds are concerned, the following analyses present the main aromatic molecules resulting from the toasting of the oak, the unit being indicated on each graph:



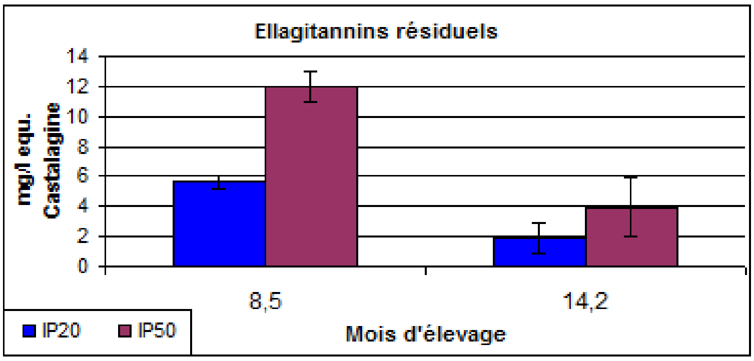


Temoin=reference; Guaiacols, no accent in Eugenol



Furanic aldehydes

As far are the ellagitannins are concerned, the analyses after acid hydrolysis are expressed in mg/l equivalent Castalagin.



Residual Ellagitannins; Castalagin; Months of aging

The chemical analyses confirm the two sensory profiles perceived during tasting: an OakScan IP20 modality rich in Cis/Trans MOLactones, low in smoked/roasted markers and which has taken on very few ellagitannins; and an OakScan IP50 modality lower in MOLactones and richer in smoked/roasted markers, having taken on more ellagitannins. A strong drop in residual ellagitannins at the end of aging can be noted, particularly in the case of the modality IP50, which confirms good integration of oak tannins after 14 months of contact.

3 Example of adapting the Polyphenolic Index to the length of aging

Three selections of wood for a Burgundy 228L barrel were examined on a Syrah/Grenache wine (France, South of Rhône Valley, 2012) whose initial oenological analyses were as follows:

IPT	TAV (% EtOH)	SR-5 (g/l)	ph	AT (gH2SO4/l)	AV (gH2SO4/l)	AMal (g/l)	ALac (g/l)
73	15.07	3.1	3.79	2.87	0.66	0	1.16

All the French oak used was selected with the OakScan process and underwent the same toasting process (Red Wine Evolution Medium with toasted heads). The characteristics of the wood selection were as follows:

Description	Average Polyphenolic Index (OakScan measurements)	Selection of Grain
IP30 Evo TM	IP30 +/- 4	Tight (avg 2mm)
IP40 Evo TM	IP41 +/- 6	Tight (avg 2mm)
IP50 Evo TM	IP49 +/- 4	Tight (avg 2mm)

The tasting was conducted with a series of three wines tasted blind at 11 and 15 months of aging. Ten tasters completed a sensory analysis form marking the intensity perceived by descriptors on the nose and palate on a scale from 1 to 7: 1/none – 2/very weak – 3/weak – 4/average – 5/fairly strong – 6/strong – 7/very strong. A specific scale of texture was proposed: 1/weak - 2/hollow – 3/smooth – 4/velvety – 5/slight astringency – 6/tannic – 7/ excess.

3-1 Analysis of sensory data

The data for each descriptor were analyzed using variance analysis (Fisher Test). In this way, the descriptors used for each series are those which present at least one significant difference between the modalities used (threshold at 5%). Then, an analysis of the averages (Student-Newman-Keuls Test, threshold at 5% and 10%) helped group and classify the modalities: here the modalities belonging to the same statistical group, i.e. not significantly different, are allocated to the same group identified by the letters A, B or C.

Average marks out of 7 and results of Newman-Keuls Test at 5% at 15 months of aging

Descriptors	IP30 EVO TM	IP40 EVO TM	IP50 EVO TM	F calc.	Proba.	F. Judge
intensity fruit	5,00 B	4,40 C	5,40 A	12,67	0,0033	***
	Fairly strong	average	Fairly strong		**	
intensity wood	3,80	3,60	4,40	3,06	0,1031	**
coconut	3,20	3,00	3,20	0,21	0,8145	
vanilla	3,20	3,00	3,40	0,55	0,5997	
spices	3,80	3,80	4,20	1,45	0,2892	**
Smoked-roasted	3,40	3,40	4,40	2,86	0,1158	
Fruit on palate	4,60	4,60	4,40	0,17	0,8493	**
roundness	4,60	4,20	4,00	2,15	0,1785	**
fullness	4,20	4,40	4,40	0,17	0,8493	*
bitterness	2,00 B	2,80 A	3,00 A	3,50	0,0809	**
	Very low	Low	low			
texture	3,00 B	3,30 AB	4,00 A	4,42	0,0509	
	Smooth	Smooth	velvety			
persistence	4,60	4,20	4,60	0,62	0,5642	

* significant at 5 % ** significant at 1 % *** significant at 0.1 % ! test not carried out

Three descriptors significantly discriminate the modalities tested at 15 months of aging:

- Intensity of fruit: on the nose, the intensity of the fruit varies according to the richness of the wood (IP50>IP30>IP40) at the risk threshold of 1%, but with a strong judge's effect.
- Bitterness: the modality IP30 seems to be slightly less bitter than the others at a threshold of 10%, but with a strong judge's effect.
- Texture: the modality IP30, marked « smooth », is significantly less astringent than the modality IP50, marked « velvety », the modality IP40 not being discriminated at a threshold of 10% and without judge's effect.

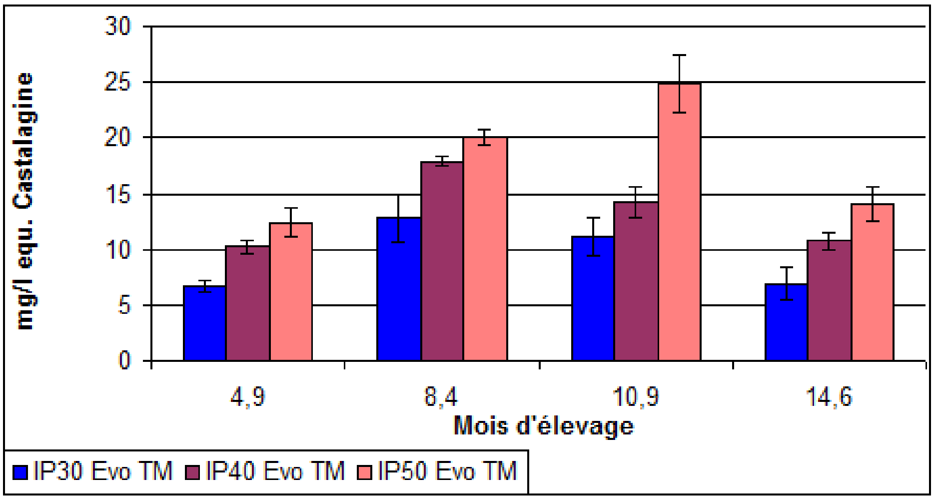
For the perception on the nose, the selection IP50 (with the highest level of ellagitannins) shows a significant capacity to protect the expression of the fruit in spite of a slightly higher aromatic contribution of oak (cf intensity of wood and smoked/roasted at the limit of being significant at 10%), but not enough to be significantly different. Since the addition of ellagitannins brings about an increase in the consumption of the wine's oxygen (Michel *et al,* 2013), we can assume with IP50 there is a more efficient buffer effect of oxidation reduction than with the other modalities which have a lower level of ellagitannins, especially on varietals sensitive to oxidation.

As far as perception on the palate is concerned, a tannic residue is more marked with the richer IP40 and IP50 selections, but the bitterness remains « low » and the wines are judged positively as « velvety ». At 15 months of aging, the comments differentiate the wine aged in IP30 as "tight" compared to the "dense and voluptuous" wine aged in IP40, and the wine aged in IP50 which was described as "more massive". Aging time is significant since at 11 months of age, the wine from IP30 had been described as having an "open nose" and being "fresh and balanced" on the palate compared to the IP50 which at that time was described as "very rich" and "hard".

3-2 Analyses of chemical data

The analyses of Ellagitannins after acid hydrolysis are expressed in mg/l equivalent Castalagin:

		Months of aging			
		4.9	8.4	10.9	14.6
Modalities	IP30 Evo TM	6.7	12.8	11.2	6.9
	IP40 Evo TM	10.2	17.9	14.2	10.7
	IP50 Evo TM	12.4	20.1	24.9	14.1



Castalagin; Months of aging

We can see that the modality in IP50 is still « taking on oak » at 11 months of aging, whereas the modalities in IP30 and IP40 have entered the phase in which the concentration of residual ellagitannins drops between the 8th and 11th month of aging.

For an aging objective of 10 to 12 months, the best choice would seem to be the IP30 and IP40 OakScan selections with an earlier and more marked constructive phase and the prospect of good fruit expression and tannin integration beginning as early as 10 months with the IP30. However, at 15 months, the IP50 OakScan selection shows a good protection of the fruit, a return to an aromatic balance and an optimum ratio between gain of texture and tannic perception. The qualities of the wine from the IP50 modality lead us to believe that a longer aging period (16, even 18 months) could optimize it even further.

Conclusion

The analysis of residual ellagitannins at various stages of wine aging helps us to understand the kinetics of integration of oak polyphenols and its impact on the final result on the wine's nose and palate. The results show a process with a peak ellagitannin concentration corresponding to the conclusion of the « taking on the flavor of the oak » phase (the moment when the wine begins to combine the wood tannins faster than it extracts them) and then a gradual drop corresponding to the start of the constructive phase of wood tannin integration and a gradual return to the fruit on the palate, gain in fullness and volume, and maximum depreciation of the tannic perception. The experience of numerous examinations of the analyses carried out on wines coming from the world's main wine producing regions shows that the ideal is to find an oak selection with a turning point which is around halfway through the aging process (maximum two-thirds) to allow for a sufficiently long and marked « constructive » phase in order to obtain optimal gains on the palate with a final richness in residual ellagitannins which is not too strong.

In addition to controlling the grain of the oak and the toasting process in barrel making, it is also essential that the level of polyphenols in the wood be measured systematically in order to achieve the precision which affects every organoleptic dimension of wine. Tools that help control this process, such as OakScan, developed by Tonnellerie Radoux, guarantee this precision and its homogeneity from one vintage to the next.