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On the composition and quality of *Q. robur* L. from different regions in South-West Europe (Fagales, Fagacea)

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Abstract: A comparative study of samples of *Q. robur* L. from France (Limousin), Spain (Basque Country) and Portugal (northern region) was carried out to estimate the variability in quality and composition of the heartwood of these species. Aside from their heterogeneity for reasons of differences in cultivar and growing environment conditions, the woods presented quite distinct characters. They are first and foremost better suited than *Q. petraea* to rapid growth, resulting in wood with very wide rings that are rich in phenolic extractibles and poor in aromatic compounds.

Key words: *Q. robur*, *Q. petraea*, geographical origin, grain, composition

INTRODUCTION

European oaks and particularly *Q. robur* and *Q. petraea* are widely used in cooperage (TARANSAUD, 1976). The heartwood of these species is graded according to its qualities and composition. The qualitative criteria used are related to the growing speed of the tree (VIVAS, 1995). Growing speed determines the width of the growth ring (POLGE and KELLER, 1973; FEUILLAT *et al.*, 1993). It is influenced by weather conditions, the nature of the soil, forestry conditions and the aptitudes of the trees (POLGE, 1973; NEPVEU, 1984; NEPVEU, 1991). The width of the growth rings, or «grain», then determines important properties such as porosity (FEUILLAT *et al.*, 1992) and chemical composition (VIVAS, 1995).

The price of wood in auctions organized by the ONF is constantly increasing, and the search for new supply sources presents a certain interest. It is therefore advisable to have good knowledge of the variability in the quality of woods of the same species from one production area to another. This article presents the first results of this approach.

MATERIAL AND METHODS

I – PLANT MATERIAL

The different wood samples came from: the Demptos cooperage (Limousin, France), CIFOR-INIA in Madrid (Spain, Basque Country) and the company Ferreira

[1]Office National des Forêts, a public organization for the management and operation of French forestry, responsible among other things for organizing the sale of batches of wood in auctions with reverse bidding.

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(Northern Portugal). Botanical identification was carried out on leaves from adult branches, picked in the first half of July.

II – DETERMINATION OF THE WIDTH OF THE RINGS (LC) AND THE TEXTURE OF THE WOOD (T)

Lc corresponds to the width of a growth ring in mm. It was measured using a measuring gauge with an accuracy level of ± 0.01 mm. The summer wood was generally measured in the same way (Be mm) and, by taking the difference (Lc – Be), the width of the springwood was obtained (Bp mm).

The texture is equal to the Be/Lc ratio; this is the index we used, without giving it a unit. The texture presents an interest essentially in the comparison between different samples.

III – MEASURING THE INFRADENSITY OF THE WOOD

The infradensity, or minimal theoretical density, was determined by the anhydrous weight Po to saturated volume Vs ratio. The determination method complies with the protocol presented by NEPVEU (1987). Briefly, the dimensions of the sample are measured very precisely, then Po is determined after 48 hrs at 102°C. Finally, the wood is saturated by being soaked in cold water for 24 hrs under slight nitrogen pressure, and Vs is estimated. ID is expressed in kg/m^3.

ID measurement on samples that had lost part of their hydrosoluble extract was carried out in the same way; except that, before the measurements, the wood was soaked in water at 80°C for 72 hrs, then dried slowly in a dry, aired place with an ambient temperature until it presented a constant temperature.

IV – METHODS FOR ANALYSING THE COMPOSITION OF THE WOOD

Determination of dry extract, estimation of total phenols and measurement by HPLC of ellagitannins have all been described by VIVAS *et al.* (1996). The *cis* and *trans* whisky-lactones are measured by GC from the diethyl-ether soluble fraction of the acetone-water extracts of wood, according to the MARSAL and SARRE method (1987). Eugenol is measured by GC according to the method described by CHATONNET (1991).

RESULTS AND DISCUSSION

We compared a sample of *Q. robur* from three forests: one French, one Spanish and one Portuguese. The sampling for the Basque Country and Portugal was reduced in scale, but the botanic origin was certain.

I – VARIABILITY IN THE GROWING WIDTH OF THE RINGS (LC) AND THE TEXTURE (T) OF THE WOOD

The measurement results are shown in table 1. On average, it was noted that the Portuguese wood had the highest Lc and the Spanish wood the lowest. It would seem that for the samples analysed, the environment conditions and forestry techniques are

[2]The width of the rings (Lc) and the texture (T) are defined by BSOP (1949) and NF B50002 respectively

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more likely to express the characters of *Q. robur*; that is to say its capacity to grow quickly, resulting in coarse-grain wood.

The most surprising results came from the comparison of Spanish *Q. robur* with the two others for given ecological and forestry conditions: the peduncle oaks yielded wood whose studied characters were comparable to those of French and Spanish sessile oak (VIVAS, results unpublished). Only the texture of the wood was significantly lower (threshold significance of 1% compared with Limousin *Q. robur* and 5% compared with *Q. petraea* from the centre of France and the Basque Country). DERET-VARCIN (1983), in a comparative study of the qualities of *Q. robur*, *Q. petraea* and their hybrids from the same forest, did not note any significant difference as to the width of rings. These results suggest the influence of growing conditions, richness of soil and weather factors on the growing speeds and related characteristics of the wood (grain, texture).

Statistically, the populations constituted by these three samples of *Q. robur* are different at a threshold of 1% (France/Spain) and 1‰ (France/Portugal and Spain/Portugal).

II – VARIABILITY OF INFRADENSITY

The infradensity calculated for the different samples is presented in figure 1. It was noted that the wood from Portugal presented the highest ID (>800 kg/m3). However, the samples from Spain had IDs that were comparable to those of *Q. petraea* (VIVAS, results unpublished).

In practical terms, the woods with high IDs require particular attention in hooping operations. A longer wait is needed for the temperature in the staves to allow the wood to be sufficiently flexible to limit breakage when the hoops are tightened; the tightening operation must be performed in several stages, with fairly long waiting periods.

Table 1

Variability in growth rings of heartwood of *Q. robur* from France, Spain and Portugal

(x: average, x-: minimal value, x+: maximal value, x-/x+: heterogeneity, CV%: coefficient of variation)
(Lc: ring width in mm, T: texture, Nc: number of rings per cm, Bl: width of springwood in mm)

		Q. robur		
		Limousin (Fr.)	Basque Country (Sp.)	North of Portugal
Lc (mm)	x	4.5	1.36	7.5
	x-	2.72	0.99	4.7
	x+	6.53	1.54	9.3
	CV %	29	16	24
T = Bf / Lc	x	0.77	0.47	0.89
	x-	0.73	0.44	0.82
	x+	0.84	0.51	0.93
	CV %	23	14	19

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III – VARIABILITY IN THE COMPOSITION OF THE WOOD

The analysis results are shown in table 2. it can be observed that *Q. robur* from the Basque Country had the least dry extract, the fewest ellagitannins and the most aromatic compounds (eugenol and whisky-lactones).

For the samples from Portugal, it is also clear that over-rapid growth has led to a global depreciation in the quality of the wood. According to the traditional appreciation criteria, this results in:

-An accumulation of hydrosoluble substances, particularly ellagitannins, causing an increase in the hardness and astringency characters linked to these molecules when wines are matured in barrels. Technologically speaking, this wood should be dried in the open air

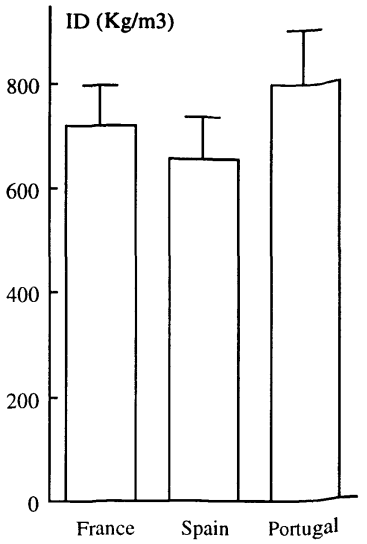

Figure 1 – Infradensity value (ID) of the samples of *Q. robur*

Table 2
Variability in the composition of wood samples of *Q. robur* from various regions

Origin of wood	Sample variability	Dry extract (mg/g)	Total ellagitannins (mg/g)	Eugenol (µg/g)	Whisky-lactones (µg/g)
France (Limousin)	Average (x)	109	62.5	1.1	5.5
	Minimal value (x-)	99.7	30.5	0	2
	Maximal value (x+)	118	87.6	2.4	13
	Heterogeneity (x-/x+)	0.84	0.34	-	0.15
	C.V %	5.4	24	52	56
Spain (Basque Country)	Average (x)	92	58	2.1	34
	Minimal value (x-)	59	24	0.32	16
	Maximal value (x+)	98	72	4.6	52
	Heterogeneity (x-/x+)	0.6	0.33	0.07	0.3
	C.V %	22	28	42	28
Portugal (North of the country)	Average (x)	134	96	0.32	2.5
	Minimal value (x-)	72	74	0	1.1
	Maximal value (x+)	162	152	0.43	4.6
	Heterogeneity (x-/x+)	0.44	0.48	-	0.23
	C.V %	19	25	29	17

[3]Hooping is the operation which gives the staves their final shape.
[4]Eugenol and whisky-lactones are the principal odorant molecules in fresh European oak: they have odours of cloves and coconut respectively.

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longer than other woods (>3 years' drying) and regularly sprayed with water, in order to eliminate a great quantity of extractibles;

-Relatively low levels of aromatic compounds. This wood cannot give lightly woody notes to wines. In technological terms, this wood must undergo strong heating so as to develop aromatic substances from the thermal degradation of the lignins;

-Finally, it should be noted that when the growth of *Q. robur* is sufficiently slow, the wood has both a tight grain and qualitative characters that are comparable to those of *Q. petraea* (VIVAS, 1995).

CONCLUSION

The results collected for the same species of tree (*Q. robur*) from different countries show the influence of environment conditions on the characteristics of the woods and their qualities. The distribution of *Q. robur* from these countries, for the samples analysed and the parameters studied, is represented in figure 2. The average position of the samples of French *Q. petraea* is also detailed for comparison.

It would thus seem that in the same way as vines, the notion of terroir can be applied to oaks. Environment conditions combined with adapted forestry methods have a decisive influence on the quality of the heartwood, and consequently on its market value.

This sort of methodological approach should be envisaged in the framework of a more detailed study on the terroir effect on the orientation of the typical characters of the oak species used in cooperage.

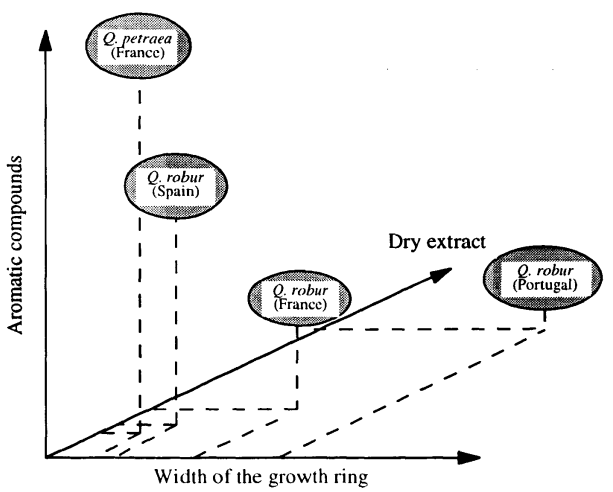

Figure 2 - Distribution of studied samples *Q. robur* in comparison with average population of French *Q. petraea*

Criteria : width of the growth ring, hydrosoluble dry extract and aromatic compounds (eugenol, whisky-lactones)

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