EFFECT OF TERROIR ON THE QUALITY EVOLUTION OF CABERNET SAUVIGNON IN PENEDÈS A.O.C.

L'EFFET DU TERROIR SUR L'EVOLUTION DE LA QUALITE DU CABERNET SAUVIGNON DANS L'APPELLATION D'ORIGINE PENEDES.

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Key words: cabernet sauvignon, harvest quality, Penedès A.O.C., soil cartography, terroir.

Mots clés: Cabernet sauvignon, qualité de la vendange, A.O.C. Penedès, Cartographie du sol, terroir.

ABSTRACT

Cabernet sauvignon has become a very common grapevine in the Penedès region (Spain) where this variety can be well adapted and produce high quality products. The vegetative growth and fruit composition will depend on the wide range of soils of the A.O.C. area. In this sense, soil cartography is one of the best tools to determine the viticulture potential of a region using soil mapping that quantify different terroirs presents in the area. The aim of this work is to evaluate the whole evolution quality, from beginning of growing season to final wine, comparing Cabernet sauvignon vineyards located in different types of soils. The study was conducted in 2000 – 2001 period in two Cabernet sauvignon vineyards grafted on 41B and SO4. Vines are 26 and 13 years old respectively and its trelling system was "cordon Royat". Each vineyard was composed by two vastly different types of soil which effect was compared: slate-schist deep stony soil vs. lime stone clay soil and silt deep deposit vs. a shallow silt soil limited with a petrocalcic layer. Comparison refers to mineral composition of vegetative parts, grape quality in maturity and quality of wine resulting. These soil units have been determinate using very detailed soil cartography based on FAO methodology.

Results indicate that Cabernet sauvignon on slate-schist deep stony soil shows a better level of mineral nutrients on vegetative parts compared to calcareous or silties soils. This type of soil has large porous space and depth, allows a large root growth and distribution and also the maintenance of a good sanitary condition in the root zone. The evolution of grape composition from the veraison to harvest suggest that slate-schist deep stony soil and shallow silt soil have a correlation with vigour, yield, berry weight and colour degree. Specific dynamics of soil water, varying holding capacity and available water in each phenologic stage can determinate the increase in quality in these soils. Otherwise, wines obtained of each terroir, using microvinifications, show important differences in aroma and structure. That indicates that the knowledge of distribution of terroir in large A.O.C. areas is essential to optimise plantations in terms of quality.

RESUME

Le Cabernet sauvignon est un cépage très répandu dans la région du Penedès (Espagne) où cette variété peut bien s'adapter et donne des produits de haute qualité. La croissance végétative et la composition du fruit dépendront de la mosaïque de sols disponibles dans l'Appellation. Dans ce sens, la cartographie du sol est un des meilleurs outils pour déterminer le potentiel viticole d'une région : son utilisation permet d'évaluer les différents terroirs présents dans une région. Le but de ce travail est d'évaluer l'évolution de la qualité dès le début de la saison de croissance jusqu'au vin final, en comparant des vignes de Cabernet sauvignon situées sur différents types de sols. L'étude a été réalisée pendant la période 2000-2001, sur deux parcelles de Cabernet Sauvignon greffé sur 41B et SO4, âgées de 26 et 13 ans respectivement. Les souches sont palissées et taillées en Cordon de Royat. Chaque parcelle est composée par deux types de sol très différenciés: sol profond avec du schiste sur un sol caillouteux argilo-calcaire, et un sol profond limoneux sur un sol limoneux peu profond limité par une couche pétrocalcique.

La comparaison se fait au niveau de la composition minérale des feuilles, de la qualité du raisin à maturité et des vins finis. Ces unités de sol ont été déterminées en utilisant une cartographie du sol très détaillée basée sur la méthodologie de la FAO.

Les résultats indiquent que le Cabernet Sauvignon sur le sol profond avec du schiste montre une meilleure nutrition minérale sur les parties végétatives que celles du Cabernet Sauvignon sur sols calcaires ou limoneux. Ce type de sol a une grande porosité et profondeur, ce qui permet une bonne croissance et distribution des racines et également un bon état sanitaire dans la zone des racines. L'évolution de la composition de raisin depuis la véraison jusqu'à la maturité suggère que les sols profonds du schiste et les sols peu profonds limoneux ont une corrélation avec la vigueur, le rendement, le poids de la baie et la couleur. La dynamique spécifique de l'eau dans le sol, la variation de la réserve hydrique utile à chaque stade phénologique peut déterminer l'amélioration de la qualité sur ces sols. D'autre part, les vins obtenus sur chaque terroir, après microvinifications, présentent des différences importantes dans l'arôme et la structure. Cela montre que la connaissance de la distribution du terroir dans de grandes régions d'Appellation d'Origine est essentielle pour optimiser les plantations en ce qui concerne la qualité.

INTRODUCTION

Cabernet sauvignon is a French grapevine, originally from Bordeaux that was introduced in Spain in 1862. In Catalonia, it has a good adaptation in the area of Penedès Appelation of Origin (A.O.C Penedès), with a total of 1119 hectares in 2000, which represent the 24% of red varieties planted in this area (Denomination Council of A.O.C. Penedès, 2002). Wines of Cabernet sauvignon grapes have a great quality when grown in appropriate soils. They are characterized by their dense tannins, good graduation, colour, intensity, structure and complex bouquet.

Achieving a high quality harvest, depends on different factors: mineral nutrition, dynamic soil water, etc (CHAMPAGNOL, 1997). The relationship between mineral content in plants, yield and quality are still not known very well (CHAMPAGNOL, 1990). Harvest is influenced by climatic conditions (microclimate), soil, traditional practices and technological factors. All these factors define the complex system of viticultural terroirs ([1]MORLAT, 2001).

Usually, the soil has an important influence on the quality of the grape, depending on the origin and mineral composition of the soil, field capacity, soil water, drainage, rooting depth and agronomic fertilization ([2]MORLAT, 2001, JACKSON, *et al.*. 1993). The most vigour

plants will be those located in rich soils, this create an imbalance between yield and vegetative growth with a decrease in the quality of the wine (DELAS, 2000). Moreover, low soil water content after veraison increases the content of sugar and anthocyanins in berries. Nevertheless, important hydric stress after veraison results in a must with poor organoleptic properties (SCIENZA, 1983).

The main objective of this study is to determine, in AOC Penedès, the influence of different soils on the maturity of Cabernet Sauvignon grapes and its effect on the quality of the wine.

MATERIALS AND METHODS

Experimental plots were chosen in two different areas from AOC Penedès.

Description of studied plots

Sivill vell

Situated within the Penedès basin, of Miocene origin, which is a tectonic depression with pre-coastal slopes to the North and Northwest, and coastal ones to the South and Southeast.. It is a reception and accumulation area of eroded materials from the bordering mountain range. Basically, there are calcareous soils with basic pH, with a moderate to large depth and a diversity of textures.

Climate of the area is typical mediterranean, warm summers and fresh winters: an annual average precipitation of 607 mm, an annual average minimum temperature of 8,8ºC, an annual average maximum temperature of 19,5ºC, and an annual average medium temperature of 14ºC (Region III – IV (WINKLER *et al.*, 1974)).

Sivill vell was planted in 1974, with clon 15 and grafted on 41B rootstock. The plant density is 2500 vines / hectare and the trelling system "cordon Royat".

Types of soil of this plot are:

Pc: Shallow and sandy loam soil, with a subsurface petrocalcic horizon at 60 cm. Xerochrept petrocalcic. SSS 1975,1994.

Dt: Deep soil made of fine terrigen deposits and clay loam textures. Xerochrept calcixerollic. SSS 1975, 1994.

St. Elies

Situated in an area that borders the Penedès depression and the pre-seaboard Catalan mountain range. Tertiary and Quaternary material predominate in this area. Nevertheless there is a small amount of land resting on a substratum of Palaeozoic origin with slate and quartzite. This area has different soils: from calcareous with medium and shallow textures and different depths, to slate soils with stones and moderate to low depths.

It is a mediterranean climate with a continental tendency: an annual average precipitation of 600 mm, an annual average minimum temperature of 4,7ºC, an annual average maximum temperature of 26,6ºC, and an annual average medium temperature of 15,2ºC (Region III – IV (WINKLER *et al.*, 1974)).

St. Elies was planted in 1974 with clon 169 and grafted on SO4 rootstock. The plant density is 4350 vines / hectare and the trelling system "cordon Royat".

Types of soil of this plot are:

Sl: Shallow and stony slate, schistosity soil with a lithic contact at a 60 cm. Xerochrept tipic. SSS 1975, 1994.

Ls: Deep calcareous soil with loam textures. Xerochrept calcixerollic. SSS 1975, 1994.

Description of the methodology

The trial was carried out in four different soil type blocks with a random distribution (two blocks by plot), and each consisting of 25 vines (five continuous rows with five vines each one).

Determinations in each block were:

- Initial soil characteristics: soil profile, physical environment (geology, geomorfology, etc) and parameters from different depths (0-30 cm and 30-60 cm).
- Petiolar analysis at the veraison: petiol samples were taken from the first opposite cluster in each vine shoot (DELAS, 2000).
- Grapes maturation: up to a total of two groups by vine, one from each vine shoot. Groups were composed by 3 to 5 berries taken from the first cluster (middle of the vine shoot) alternating upper and lower levels (CARBONNEAU A., et al 1991).
- Microvinification: The harvest in Sivill vell took place on the 26/09/01 and in St. Elies on the 21/09/01, with good sanitary conditions in both plots. In every case there was a maceration at low temperature for three days. Fermentation took place for seven days in Sivill vell´s samples and eight days in St. Elies´ samples.
- Sensory analysis of wines elaborated from four different types of soils. The taste trial was performed by five tasters. Four wines were characterized by their sensory properties: colour, flavour and taste.

Analysis carried out in four different types of soils are summarized in Table 1.

Analitical type	Temporarity	Determinations
Soil analysis	Initial characterization	Description soil profile and physical environment. Texture, pH, conductivity, organic matter, P, K, Mg, total carbonates, active carbonate and cation exchange capacity.
Petiol analysis	Veraison	N, P, K, Mg, Ca, B, Fe, Cu, Zn and Mn.
Grape maturation analysis	Two times weekly	Weight of 100 berries, pH, total acidity, must density and °Brix.
Microvinification	After harvest	pH, total acidity, °Brix, Fermentation kinetic, colour intensity.
Sensory analysis	After vinification	Colour, flavour and taste (sensory panel)

Table 1. Parameters and Analysis.

RESULTS AND DISCUSSION

Plot soils of the Sivill vell are moderatelly basic, with no salinity problems and high content of organic matter (Table 2). The main difference between this two soil types is the rooting depth, because the root growth and distribution in the Pc soil is limited by the horizontal petrocalcic stratus. The sandy loam texture, the presence of coarse fragments and the depth limitation in Pc soil results in a lower water hold ing capacity, and a faster drainage than in the Dt soil (clay, deep and less stony). Therefore, Pc soils will bear an hydric stress in the warm season before than the Dt soil does, specially in xeric climate-soils as is the case of the Penedès region. Additionally, the Pc soil has a carbonate increasement at a depth of 30-60 cm, that will result in a chlorosis power index higher than in the Dt soil (Table2).

Results in the mineral petiolar composition are not discriminatory enough. There are differences in the potassium concentration, with higher levels in the Pc soil (Table 3). The ratio K/Mg is in the upper limit in the Pc soil and in the lower limit in the Dt ones. This can result in a less acidic must in the Pc soil and more acidic in the Dt soil (DELAS, 2000).

St. Elies soils are basic and have no salinity problems. Organic matter in the calcareous soil (Ls) is moderate and low in the slate soil (Sl) (Table 2). Talking about physical and hydrological properties, the Sl soil has the sandiest texture and wealth of stones. This will result in the Sl soil, a lower water holding capacity and a faster drainage than the Ls soil will have. Moreover, the low rooting depth in the Sl soil, will have a similar effect than in the Pc soil of the Sivill vell plot. The Pc soil of the Sivill vell plot and Sl soil of St. Elies are likely to suffer an hydric stress in dry seasons. This stress can favor the maturation process due to the vegetative growth stop, which will have a good translocation of precursors and sugars to the berry (CHAMPAGNOL 1997, DELAS 2000).

Obviously, there are no carbonates developed over schistosy or slate soil (Ls), contrary to the calcareous soil (Sl). But in this case, the presence of carbonates does not imply an iron chlorosis (Table 2).

The petiolar mineral composition (Table 3) in the Sl soil and Pc soil show a high potassium content . Meanwhile, the Ls soil shows lower values: the ratio K/Mg is very low; this could be the reason of the higher acidity of the must obtained from berries coming from this soil.

The evaluation of clusters maturation in each plot gave different results in each soil type. In Sivill vell, the Brix grade of grapes coming from the Pc soil is always two degrees higher until the harvest than in grapes coming from the Dt soil (figure 1). On the other hand, there are no differences in the harvest yield, as the production in the Pc soil is 3,2 Kg/vine and in the Dt soil is 2,9 Kg/vine.

The evolution of Brix grade of grapes coming from the Sl soil is an average of four degrees higher than the one of grapes coming from the Ls soil (figure 2). Nevertheless, there is a big difference between the yield of both soil types, as the production in the Sl soil is 2,2 Kg/vine and in the Ls soil is 0,3 Kg/vine.

Wines elaborated with grapes coming from the Sivill vell plot are different in alcohol grade and colour intensity depending on the type of soil. As shown in table 4 , berries from Pc soil gave an alcohol grade of 13,4° and a colour intensity of 9,16; meanwhile grapes coming from the Dt soil gave 11,5° and 7,4 respectively. These results in the case of Pc soil, in a wine with more colour intensity, structure and flavour intensity, compared to the wine coming from the Dt soil, which is lighter, acid and with lesser colour, as shown by sensory analysis (Table 5).

Products elaborated in the St. Elies plot have a high colour intensity. Nevertheless, the alcohol graduation in the wine elaborated from the Sl soil type,(14,1°) is higher than in the Ls soil (13,4°) (Table 4). The wine coming from the Sl soil has more potential, structure and body than the wine coming from the Ls soil, as shown by sensory analysis (Table 5).

CONCLUSION

The present study strengthens the theory that the dynamic of soil water and physical soil properties influence on the quality of the wine. Preliminary observations suggest that the potential degree of Cabernet sauvignon berries, in the AOC Penedès, is high in a shallow and drained soil. The plant, in this type of soil, can bear an hydric stress in the dry season in a xeric pedology-climate, regardless of the geologic region. Different soils, depending on their original composition and physical properties, could be a discriminatory parameter in organoleptic characteristics of the wine. Chemical parameters of the soil and the plant (petiol) are not good indicators to predict the potential quality of the harvest. These results suggest that the study of the soil, in the context of the terroir concept, will have to be oriented towards the study and characterization of its physical and structural properties, which will define the dynamic of water in the soil and its availability to the vine.

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Tables and figures

Table 2. Analitical characterization of soils studied.

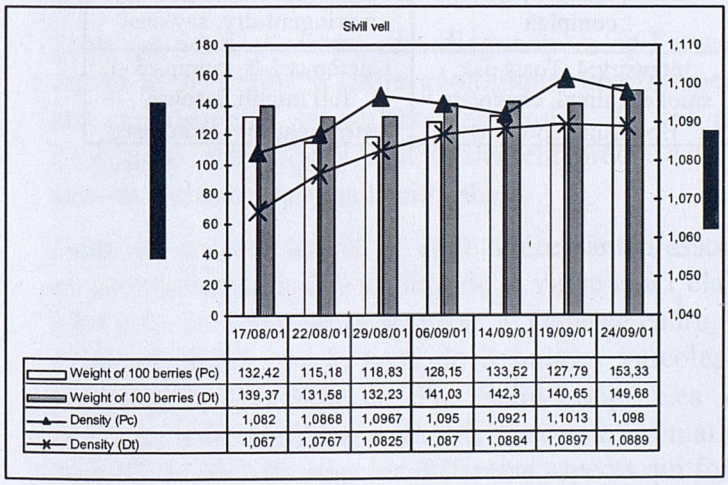
	SIVILL VELL				ST. ELIES			
DETERMINATION	**Pc (30cm)**	**Pc (30-60cm)**	**Dt (30cm)**	**Dt (30-60cm)**	**Sl (30cm)**	**Sl (30-60cm)**	**Ls (30cm)**	**Ls (30-60cm)**
% clay	14,5	25,8	32,0	31,5	21,5	11,7	13,5	23,1
% silt	33,1	36,5	40,8	42,4	27,0	34,6	40,9	31,2
% fine sand	35,5	24,1	19,9	18,8	34,2	31,3	29,7	25,8
% coarse sand	16,9	13,6	7,3	7,2	17,3	22,4	15,9	19,8
Texture classification	Sandy loam	Loam	Clay loam	Clay loam	Sandy clay loam	Sandy loam	Loam	Loam
Conductivity (dS/m)	0,12	0,15	0,18	0,14	0,10	0,10	0,11	0,11
pH H_2O	8,31	8,46	8,37	8,42	8,48	8,52	8,37	8,54
pH KCl	7,64	7,79	7,63	7,64	7,68	7,66	7,41	7,43
Organic matter (%)	1,74	2,25	2,64	2,26	0,82	0,71	1,42	1,21
P ppm	17,77	20,42	19,41	12,47	7,74	2,40	5,54	4,17
meq K /100 g soil	0,47	1,05	1,56	0,91	0,14	0,08	0,09	0,13
meq Mg/100 g soil	0,88	1,00	1,54	1,40	1,26	1,23	1,31	1,27
CEC[1] (meq/100g)	9,91	12,80	16,31	16,22	5,29	4,95	9,71	9,68
Fe ppm	267	62	112	131	228	225	305	325
% Active carbonates	1,52	14,15	11,38	9,89	1,31	0,88	3,95	3,76
CPI[2]	0,21	37,20	9,08	5,79	0,25	0,17	0,43	0,36
% Totals Carbonates	1,60	35,07	28,38	24,71	0,44	0,40	13,32	12,21
*WHC[3] (mm)	77		254		64		207	
*Drainage	fast		moderate		fast		moderate	
*Depth (cm)	60		> 150		60		> 150	
*Coarse fragments (%)	10		< 2		20		< 2	
* Origin material	Terrigen detritic over petrocalcic		Fine terrigen detritic		Slate and schistosity		Calcareous	

1. Cation exchange capacity
2. Chlorosis Power Index
3. Water Holding Capacity
* Referenced at all profile

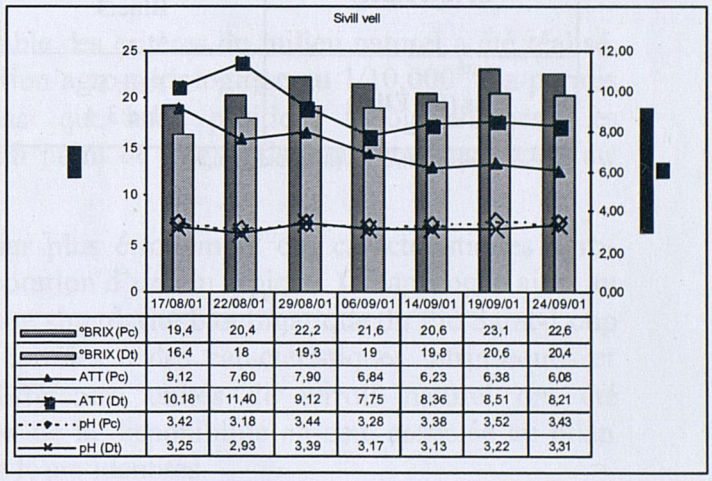
Table 3. Mineral composition in grapevine petioles for each type of soil (Results are expressed on a dry weight basis)

	N %	P %	Ca %	Mg %	K %	K/Mg	B ppm	Fe ppm	Cu ppm	Zn ppm	Mn ppm
Sivill vell : Pc	0,43	0,07	3,44	0,38	3,91	10,20	31	523	12,2	27,5	18,51
Sivill vell: Dt	0,49	0,10	3,73	0,79	1,64	2,07	37	1271	34,5	36,1	81,70
St.Elies: Sl	0,57	0,06	2,60	1,01	3,20	3,16	28	530	11,6	47,4	13,68
St.Elies: Ls	0,43	0,07	3,30	1,11	1,33	1,20	35	188	10,1	45,8	19,70

Figure 1. Evolution of parameters of grapes maturation in the Sivill vell plot

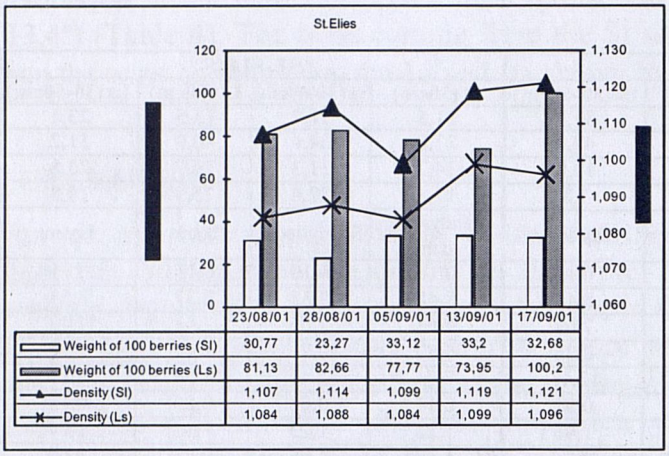


	17/08/01	22/08/01	29/08/01	06/09/01	14/09/01	19/09/01	24/09/01
Weight of 100 berries (Pc)	132,42	115,18	118,83	128,15	133,52	127,79	153,33
Weight of 100 berries (Dt)	139,37	131,58	132,23	141,03	142,3	140,65	149,68
Density (Pc)	1,082	1,0868	1,0967	1,095	1,0921	1,1013	1,098
Density (Dt)	1,067	1,0767	1,0825	1,087	1,0884	1,0897	1,0889

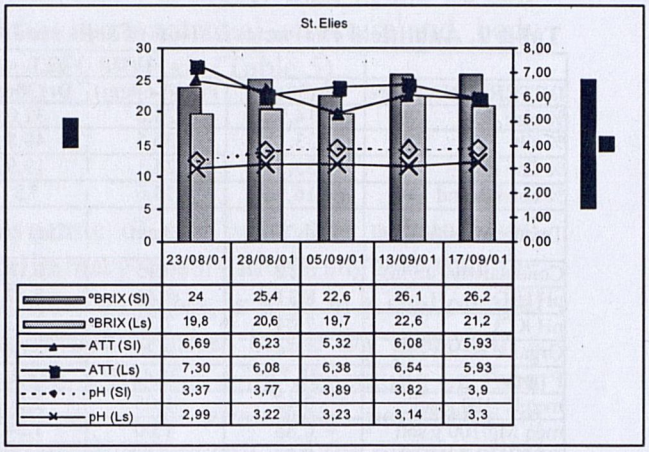


	17/08/01	22/08/01	29/08/01	06/09/01	14/09/01	19/09/01	24/09/01
°BRIX (Pc)	19,4	20,4	22,2	21,6	20,6	23,1	22,6
°BRIX (Dt)	16,4	18	19,3	19	19,8	20,6	20,4
ATT (Pc)	9,12	7,60	7,90	6,84	6,23	6,38	6,08
ATT (Dt)	10,18	11,40	9,12	7,75	8,36	8,51	8,21
pH (Pc)	3,42	3,18	3,44	3,28	3,38	3,52	3,43
pH (Dt)	3,25	2,93	3,39	3,17	3,13	3,22	3,31

Figure 2. Evolution of parameters of grapes maturation in the St. Elies plot



	23/08/01	28/08/01	05/09/01	13/09/01	17/09/01
Weight of 100 berries (Sl)	30,77	23,27	33,12	33,2	32,68
Weight of 100 berries (Ls)	81,13	82,66	77,77	73,95	100,2
Density (Sl)	1,107	1,114	1,099	1,119	1,121
Density (Ls)	1,084	1,088	1,084	1,099	1,096



	23/08/01	28/08/01	05/09/01	13/09/01	17/09/01
°BRIX (Sl)	24	25,4	22,6	26,1	26,2
°BRIX (Ls)	19,8	20,6	19,7	22,6	21,2
ATT (Sl)	6,69	6,23	5,32	6,08	5,93
ATT (Ls)	7,30	6,08	6,38	6,54	5,93
pH (Sl)	3,37	3,77	3,89	3,82	3,9
pH (Ls)	2,99	3,22	3,23	3,14	3,3

Table 4. Characterization of microvinification

	Sivill vell Pc	Sivill vell Dt	St. Elies Sl	St. Elies Ls
Initial analysis				
Alcohol grade	13,9	12,1	13,9	13,1
Total acidity(gH_2T/l)	3,04	3,8	3,19	3,04
pH	3,46	3,93	3,58	3,61
Final analysis				
Grau alcohòlic	13,4	11,55	14,1	13,4
Total acidity(gH_2T/l)	5,32	8,05	6,23	6,99
pH	3,87	3,66	3,52	3,54
Colour intensity	9,16	7,40	19,48	18,28

Table 5. Quality parameters from sensory panel

Soil type	Colour[1]	Flavour[1]	Taste[1]
Pc (Sivill vell)	Red: 4 Blue:3	Intensity: 3. Close, young, lactic, blackberry jam, vegetative, oak:2	Unctuous:1, tannins 2-3, structured and complex
Dt (Sivill vell)	Red: 3 Blue:2	Intensity: 2-3. Close, fruity, dry vine shoot, cherry jam	Unctuous:2, tannins:2-3, dry, acid, weak, syrah style.
Sl (St. Elies)	Red: 4-5 Blue:3	Intensity:4. Toast oak, sweet, fruity, vanilla , complex	Unctuous:2-3, tannins:3-4, full mouth:3, fruit, body, astringent-dry, sawdust
Ls (St. Elies)	Red: 5 Blue:3-4	Intensity:4. Toast oak, smoke, animal, chocolate, ripe fruit , soothing	Unctuous:2-3, tannins:3-4, full mouth:3, toast, astringent-dry, structured

1. Punctuation between 1 (low) and 5 (high)