EFFECT OF ALTITUDE ON THE WINE-MAKING POTENTIAL OF LISTAN NEGRO AND RUBY CABERNET CULTIVARS IN THE SOUTH OF TENERIFE ISLAND

EFFET DE L'ALTITUDE SUR LE POTENTIEL DE VINIFICATION DES CÉPAGES DE LISTAN NEGRO ET DE RUBY CABERNET DANS LE SUD DE L'ÎLE DE TENERIFE

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Résumé : Une étude a été réalisée dans le sud de Tenerife, où l'on a suivi la maturation des variétés de raisin noir «Listan negro» et «Ruby Cabernet». Le Listan negro est la variété traditionnelle de cette île, alors que le Ruby Cabernet y a été introduit ces dernières années. Le vignoble s'étend depuis les zones basses, proches de la côte, jusqu'aux zones hautes, aux alentours de 1 500 mètres. Les différences climatiques qui se produisent en fonction des variations d'altitude sont à l'origine d'une vendange échelonnée ; les raisins de la zone haute tardent à mûrir.
Dans les zones basses, les contrastes de température ne sont pas très accusés entre l'été et l'hiver, le jour et la nuit - ce qui est le cas dans les zones hautes. Selon l'expérience de certaines caves de cette zone, la qualité des vins rouges obtenus semble dépendre, entre autres, de l'altitude du site d'origine des raisins. L'opinion générale est que le raisin venant des zones hautes est de meilleure qualité, bien que jusqu'ici aucune étude systématique n'ait été réalisée. Pour confirmer et quantifier l'influence de l'altitude sur la qualité du raisin dans cette zone, on a sélectionné deux parcelles à différentes altitudes - 280 et 520 m - sur lesquelles les deux variétés sont cultivées dans des conditions similaires, densité de plantation, système de conduite, etc. Depuis la véraison jusqu'aux vendanges, on a sélectionné des échantillons de trois groupes de 20 ceps, de chaque variété, sur chaque terrain. On a déterminé les paramètres conventionnels de maturation, acidité totale, pH et degré brix. Les teneurs en acide tartrique et malique ont été déterminées par méthode enzymatique et la teneur en composés phénoliques, «la maturité phénolique», ont été déterminés avec la méthode SAINT-CRICQ *et al*. (1998). Grâce à ces dosages, on a déterminé le potentiel total en anthocyanes, le potentiel en anthocyanes extractibles, l'indice de maturité des pépins et l'indice de maturité cellulaire en utilisant les relevés de température de quatre stations météorologiques de la zone, situées à des altitudes différentes. On a déterminé la variation journalière de température, selon l'altitude.
Les résultats obtenus indiquent une différence dans la composition des raisins, selon l'altitude. L'acide malique se maintient en plus grande quantité à plus haute altitude. La teneur en anthocyanes est nettement supérieure dans les zones hautes.
Le cépage Ruby Cabernet s'est montré le plus sensible aux changements d'altitude. Il contient plus d'anthocyanes et a une plus grande richesse phénolique que le Listán noir.

Abstract : In the south of the island of Tenerife (Valle de Güimar), a study was made of the composition of the grape and fundamentally in colour potential during the ripening of the red varieties Listán negro and Ruby Cabernet in two vineyards located at different heights above sea level. The conventional ripening parameters and total and extractable anthocyanin content have been determined in order to estimate all the main characteristic phenolic. Significant differences were detected between the varieties, along with a clear influence of vineyard altitude on accumulation of colour and phenolic substances in the grapes.

Key words: phenolic ripening, red grape, altitude, anthocyanin.

Mots clés : maturité phénolique, variétés de rouge, altitude, anthocyanes.

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INTRODUCTION

The Valle de Güímar grape and wine producing district is located towards the South of Tenerife (Canary Islands). The soils of the district are of volcanic origin and grapevine cultivation extends from areas near the coast up to very high altitudes, near 1 500 m a.s.l.

Rainfall is scarce, from 350 ml annually in the coastal areas to 550 ml nearer the summit. The sunshine is intense, with the highest number of hours on the island, due to the geographical position exposed from east to west, causing an early vintage (mid-July) in the lower areas, with some high sugar musts. The climatic differences according to height make for a staggered vintage in which the grapes from high areas are the latest to ripen (October).

In the lower areas, the contrasts between summer and winter or between day and night are not so marked, unlike in the high areas, where the winters are cold and summers hot, and at night the temperature drops considerably. The vine as a fruit tree is known to need a certain number of hours of coolness or a difference in temperature between day and night to produce quality fruit (KLIEWER, 1970; CRIPPEN and MORRISON, 1986).

The predominant red variety is Listán negro, though in the last few years some other foreign varieties like Ruby Cabernet have been introduced. According to the experience of some wine-producers in this area, the quality of the red-wines obtained seems to be in function of the altitude at which the grapes are grown. A widespread opinion is that the red grapes grown at high altitudes are of better quality.

The object of the present study has been to confirm and quantify this, in order to establish the most suitable areas for grape cultivation destined for red wine production in the South of the island. In this way a difference was detected between mountain and lowland red grapes, as regards their capacity to store pigments and phenolic substances in general.

EVOLUTION OF THE DIFFERENT COMPONENTS OF THE GRAPE DURING RIPENING.

Veraison, the onset of ripening, marks the beginning of colour changes and sugar accumulation, abrupt transformations take place during this stage of ripening process (STOEV and ZANKOV, 1958).

Glucose and fructose represent 99 or more of the carbohydrates in *Vitis vinifera* (KLIEWER, 1967). At veraison there is twice as much of the first as of the second, while they are present in practically the same proportion when the grapes are ripe, a mean of 0.92 (HRAZDINA *et al.*, 1984). However, in warm climates some authors have pointed out that the sugar content increases continually, without reaching a stable value at any moment of the ripening process (MAUJEAN *et al.*, 1983; ROBREDO, 1993).

The acidity of the grape and the resulting juice is as important in wine-production as the quantity of sugars. It can vary according to the variety, climate and year, i.e. 3 to 10 g/l expressed as sulfuric acid and sometimes more, according to the degree of ripeness. This results in a pH normally between 3 and 3.6, influencing microbial activity and wine flavor (BOULTON, 1996).

The acidity of the mature grape is due mainly to tartaric, malic and citric acids. The proportion of other acids is relatively low, but they are numerous: ascorbic, caffeic, alpha-ketoglutaric, fumaric, galacturonic, glyceric, glycolic, oxalic, pyruvic, etc. (BOULTON, 1996).

The titrable acidity during ripening decreases exponentially (MARECA, 1983; MARTINEZ *et al.*, 1985), due mainly to the breakdown of malic acid and diverse dilution, salification and transformation processes, aided by the high temperatures (RUFFNER, 1982; KANELLIS and ROUBELAKIS-ANGELAKIS, 1993). Malic acid is the main acid contributing to reduced acidity (McCARTHY *et al.*, 1983; ROSEMARY *et al.,* 1993), and temperature is the main environmental factor that affects its development and concentration in the ripe grape, being degraded with temperature in cell respiration. The longer and warmer the summer, the lower will be the malic acid concentration. The clusters most exposed to sunlight and therefore reaching higher temperatures are less rich in malic acid (SMART, 1982; KLIEWER and LIEDER, 1986; WOLF *et al.*, 1986).

The grape cluster is very rich in phenolic compounds located both in the stalk and the fruit, most especially in the seeds and skin.

Most of the phenolic compounds in the grape are monomers; polymers are formed later, in the wine, by the joining of these monomers. The development of polymers and changes in their composition are of great technological importance in wine conservation and aging. The changes in colour and flavor in aged red wines are due mainly to polymerization and oxidation phenomena.

The anthocyans that appear in the grape are combined with sugars, mainly glucose and these sugars can be combined in turn with acetic, cumaric, caffeic and

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other organic acids. These combinations receive the generic name of anthocyanins. The fundamental property of the anthocyans and their combinations is their contribution towards the red and red-violet colours of wine.

The different grape varieties possess a range of anthocyanic compounds, as they do not have identical genetic material, nor are they grown in the same environment or conditions. The influence of genetics is decisive, and in itself the analysis of these and of the percentage of acylated anthocyanic pigments allows the identification and classification of varieties (ANDERSON *et al*., 1970).

Three stages are to be distinguished in anthocyan accumulation in ripening: a first stage of rapid build-up in the skins, a second slower phase and finally a third stage of reduction when the grapes begin to be over-ripe (GLORY and AGUSTIN, 1994, GONZALEZ-SAN JOSÉ *et al*., 1990).

SAINT-CRICQ *et al*. (1998), established an analytic procedure for determining the anthocyan content in grapes, based on measurement of decolourization with bisulfite at two different pH: 3.2 and 1. At pH 3.2, the extractable anthocyans would be liberated from the skin cells under standard conditions, while at pH 1 all the anthocyans will be liberated. The constitution of the membrane of these cells, i.e. their state of degradation at ripeness and therefore the greater or lesser ease of liberation or extraction, seems to be the origin of the differences in anthocyan concentrations between varieties, while climatic and soil conditions determine the number of molecules biosynthesized inside the skin cells.

In general, total phenolics in the grapes increases during ripening, then falls during the over-ripe phase. Several studies show a close dependence of the polyphenols fraction on temperature during ripening, in that a fall in the concentrations of these compounds occurs with a rise in ripening temperature (KLIEWER, 1970; BUTTROSE *et al*., 1971; PIRIE and MULLINS, 1980; TOMANA *et al*., 1979; CRIPPEN and MORRISON, 1986).

The grape tends to develop stronger colouration when the daytime temperature is between 15 and 25 ºC and at night between 10 and 20 ºC. At higher temperatures (e.g. at 35-37 ºC by day and 32 ºC at night), biosynthesis can be seriously affected, and in some varieties is totally inhibited. Under good conditions, from two to three times more anthocyans can be synthesized. The high temperatures inhibit the accumulation of sugars in the grape, thus triggering the limiting effect of anthocyan synthesis. A decrease of 10 ºC during the day under conditions of high illumination provides an increase in colouration of 40 % (KLIEWER, 1970).

The formation pathway of the phenolic compounds competes with the growth of the plant, consequently any action to invigorate the plant will hinder anthocyan synthesis. In addition, as the phenolic compounds are synthesized from the hexoses, this is favored by a maximum accumulation of sugars in the grape. On fertile land with a suitable water regime, increased planting density may reduce the vigor of vine growth and thus allow higher crop quality, providing more colour. On the contrary, in less fertile soils under threat of drought, the high densities do not lead to any improvement in quality or colour, despite providing the lowest productions per vine (ARCHER and STRAUSS, 1991).

Another important factor is the vine water status, which can be determined by means of leaf water potential. Early mild water deficits throughout the growth period it seems to have beneficial effect on the phenolic content of berries (CHONÉ, 2001). Concentration of berry anthocyanins and phenolics decrease with increase in water application, mainly due to an increase in berry weight (GINESTAR *et al*., 1998).

Phenolic ripeness in no way substitutes the so-called technological ripeness obtained from the sugars/acidity ratio in the grape - the fundamental parameter used in the field, since it is quick to perform and its value helps to decide the harvesting date. However, the phenolic ripeness also allows one access to other information of use in wine production, and so it supplements the technological ripeness data.

It should be emphasized that the methods for determining phenols in grapes are not always comparable with the extraction techniques used. The same results are not obtained when extracting in aqueous or aqueous/alcoholic media, with or without shaking, or with long or short macerations. Also the form of expressing the results for the phenolic components, in g/100 g or in g/kg of grapes could lead to non-concordant results. The first reflects the variations in concentration in the grapes, independently of their weight, while the second includes the variations in the weight of the grapes.

EFFECT OF ALTITUDE

Normally, temperature regime is affected by altitude of the site, type of top soil and sun insolation (JACQUET and MORLAT, 1997; BERTAMINI *et al*., 1999). In a trial carried out in the Douro valley, Portugal (MATEUS, 2001), low altitude it seems to be an important factor favoring the biosynthesis of some phenol

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Table I - Mean values of ºBrix during ripening. Duncan test (significances at p< 0.05).

Valeurs moyennes du degré Brix au cours de la maturation. Test de Duncan (significatif à p< 0.05)

Sampling	Ruby cabernet	Listán negro
1	11.50 a	10.59 a
2	13.28 a	12.77 a
3	15.50 a	13.21 b
4	15.99 a	15.13 a
5	18.05 a	16.70 b
6	19.40 a	17.53 b
7	20.84 a	18.37 b
8	21.94 a	19.07 b

compounds like (+) catechin, (-) epicatechin, procyanidin dimers, etc.

In relation to the sugar content, soluble solid level on must decreased with increasing altitude of cultivation (CVETKOVIC, 1999; STEFANINI *et al.*, 1993; BERTAMINI *et al.*, 1999). However there is a positive relationship between titrable acidity, malic acid content and altitude (BERTAMINI *et al.*, 1999 ; FALCETTI, 1990). In relation to wine quality, IACONO *et al.*, pointed out that quality of Chardonnay in the Trentino area was affected by altitude. High altitude gave wines more «body» and complex aroma.

MATERIALS AND METHODS

Two plots of vineyard at 280 (V1) and 520 m a.s.l. (V2) were selected as representantive of the area. The two varieties under study, Listán negro (a native Canary Island strain) and Ruby cabernet, were present in each plot, with a similar age (ten years), same training system: double card back-support, same orientation (East-West) and the same growing practices and planting density. Vine spacing was1.70 m between rows and 1.35 m within the row (4 360 plants/ha). All vines are planted on their own root-stock. Plants are cultivated on terracing, and both vineyard not differed by their soil, volcanic sand (lapilli) covered of volcanic gravel. The depth of the soil was 2.5 m and the depth of the top (volcanic gravel) was of 30 cm. The average of annual rainfall during this experience was 350 mm, drip irrigation was applied (150 mm) during winter (November to January).

In order to establish the homogeneity of sampling, three blocks of 20 vines were selected at each vineyard and 10 grapes taken from each plant, reaching a total of 200 per block. A weekly sample was taken over a period of two years (1998 and 1999), beginning at each veraison and ending at the harvest about 8 weeks later. Ripening begins towards mid-July in this area. The data for 1998 are less complete due to the harvest being brought foward in one of the vineyards. Grape yield (kg/vine) was determined at the harvest.

I - ANALYSIS

The grape samples were crushed to obtain a homogeneous mash. Part of this was filtered and centrifuged. The following parameters were determined in triplicate on the clean juice so obtained: total acidity expressed as g/l tartaric acid, pH and ºBrix by CEE regulation 2676/90.

The tartaric and malic acid content was determined by enzymatic spectrometric analysis (B.W. Zoecklein) using an Echo Enosys robot. The rest of the mash was submitted to the NSC analytic procedure for the anthocyan and total phenol content.

II - TEMPERATURE DATA

Mean daily temperature was taken at 4 meteorological stations at 280, 340, 565 and 700 m a.s.l., covering the sampled vineyard area, and simple regression analysis applied with the SPSS statistical package in order to obtain a possible relationship between temperature variation and altitude in this zone.

III - STATISTICAL STUDY

Analysis of variance (ANOVA) was carried out using Duncan's test to establish the significant differences between the grape varieties and between altitude levels. A correlation study and linear regression by SPSS were also performed.

RESULTS AND DISCUSSION

In general, the results for both years were in agreement leading to similar conclusions. The data shown in the tables (I to VIII) and figures (1 to 6) are those for 1999. Applying linear regression analysis to these mean daily temperature data showed linear behavior with $R^2 = 0.95$. The average drop in temperature was 0.62 ºC per 100 m of altitude.

I - GRAPE YIELD

In this trial, there were not significant differences in production between varieties and locations. The mean value of grape yield was 4.12 kg/vine.

II - º BRIX RELATED TO PH AND TITRABLE ACID

The variety Ruby Cabernet ripened earlier. Its soluble solid content was significantly higher than Listán Negro from half-way through the ripening process up to harvesting (table I). On average, Ruby Cabernet (RC) was ten days ahead of the native variety.

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Table II - Mean values of pH of varieties during ripening. Duncan test (significances at p< 0.05).

pH au cours de la maturation. Test de Duncan (significatif à p< 0.05)

Sampling	Ruby cabernet	Listán negro
1	2.83 a	2.96 a
2	3.00 a	3.11 a
3	3.10 b	3.28 a
4	3.27 b	3.47 a
5	3.47 b	3.63 a
6	3.57 b	3.74 a
7	3.67 b	3.81 a
8	3.75b	3.88a

Table III - Mean values of pH during ripening at different heights. Duncan test (significances at p< 0.05).

Comparaison du pH moyen à différentes altitudes. Test de Duncan (significatif à p < 0.05).

Sampling	pH vineyard 1 280 m	pH vineyard 2 520 m
1	2.84 b	2.97 a
2	2.99 b	3.13 a
3	3.11 b	3.27 a
4	3.33 b	3.42 a
5	3.51 b	3.60 a
6	3.63 a	3.69 a
7	3.72 a	3.76 a
8	3.78 a	3.78 a

Table IV - Mean values of total acidity of varieties expressed as g/l of tartaric acid during ripening. Duncan test (significances at p< 0.05).

Comparaison de l'acidité totale (g/l acide tartrique) au cours de la maturation. Test de Duncan (significatif à p< 0.05).

Sampling	Ruby cabernet	Listán negro
1	26.50 a	21.68 b
2	18.86 a	15.96 b
3	13.62 a	11.03 b
4	10.24 a	6.79 b
5	8.03 a	5.65 b
6	6.50 a	5.31 b
7	6.32 a	4.35 b
8	5.51 a	4.77 b

Comparing vineyards, the differences in ºBrix were not significant between different heights at the start of ripening, but towards the end of the process the grapes at higher altitudes ripened earlier.

Applying analysis of variance (ANOVA) to the pH values on each sampling date to compare varieties and differences in height, the results shown in tables II and III are obtained. Significant differences are seen between varieties and locations. The lowest pH values are those of RC. On comparing the two vineyards the grapes at higher altitudes have higher pH values on the same dates, only near harvesting were their pH values similar. This is anomalous in that the pH values for the same variety were higher in a cooler zone, in contrast to other studies (SMART, 1982; KLIEWER, 1970; WOLF, 1986) where at higher temperatures there was greater degradation of malic acid and therefore a decrease in total acidity and higher pH. This prompted us to compare varieties and locations on the basis of ºBrix (figure 1), instead of dates.

This shows, as with ANOVA, that RC has the lower pH. However, both have lower pH at higher altitudes, especially RC.

The titrable acid values (tables IV and V) confirm the pH results. RC has the highest total acid values with significant differences. Between locations on the same dates there were no significant differences due to altitude (table V). However, the comparison at equal degrees Brix revealed greater titrable acidity from plants situated higher up. In figure 2, these data are shown for RC and LN. As with pH, RC was more sensitive to the climatic changes deriving from higher altitude in this zone, increasing its total acidity more than LN.

The low acidity values in the zone, especially from LN, require correction of must acidity. The high pH above 3.5 and the total acidity under 6 g/l, are usual in warmer zones (ZOECKLIN *et al*., 1994.)

From the above graphs, linear behavior can be deduced between ºBrix, pH and titrable acidity, such that a progressive increase in pH and a decrease in titrable acidity accompanies ripening. Applying a bivariate correlation study to the data, a high Pearson correlation coefficient 0.871** (significant to a level of 0.01) was obtained between pH and degrees Brix. Applying linear regression an R^2= 0.759 was arrived at for the equation:

pH = 2.82 + 0.0825º. These values improved on applying this statistical treatment to each variety and altitude separately, resulting in correlation coefficients around 0.99, and R^2 = 0.97.

The correlation coefficient between titrable acidity and ºBrix for all the data was inverse at –0.820**. If total acidity is correlated with pH, the coefficient is –0.926** and applying linear regression: R^2 = 0.857 for the equation pH = 3.865 - 0.04517 AT. As with pH, these values improved on relating the date for each variety and vineyard, arriving at coefficients around 0.95 and R^2 around 0.90. Such high coefficients bet-

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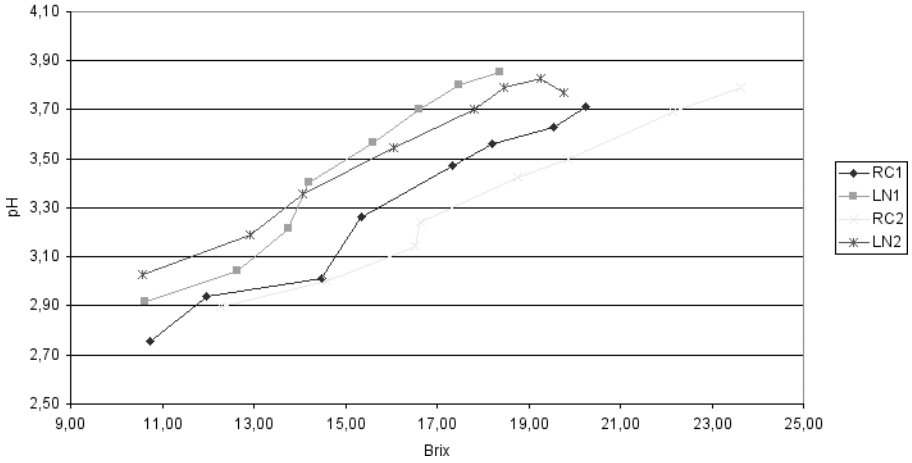


Fig. 1 - pH vs. ºBrix.

Évolution du pH au cours de la maturation.

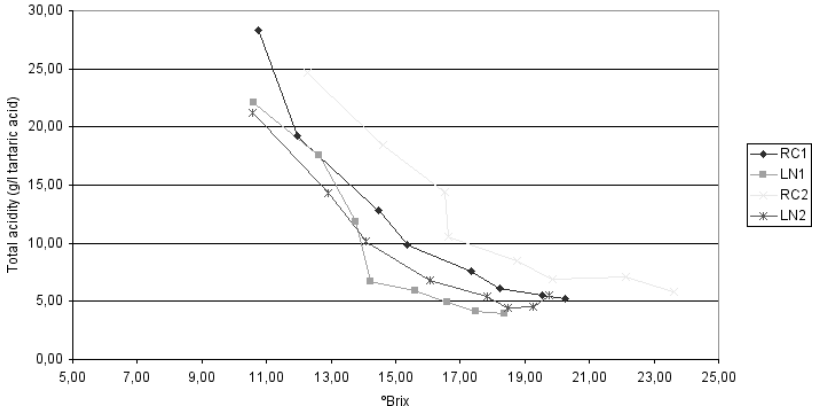


Fig. 2 - Total acidity vs. °Brix

Évolution de l'acidité totale au cours de la maturation.

ween total acidity and pH in musts contrast with the lower ones of 0.567 quoted in other work (BOULTON, 1980).

III - MALIC AND TARTARIC ACID CONTENT.

Figure 3 shows the changes in malic acid content in the two varieties. This acid accumulates in a significantly greater quantity at the higher altitude (at lower temperature). As remarked earlier, malic acid degrades more on increasing temperature in a cellular respiration process (SMART, 1982; KLIEWER, 1986; WOLF, 1986).

RC was more sensitive to climatic variations in this zone than LN. Its malic acid content was higher than LN.

A progressive lowering of malic acid content was observed to accompany the ripening of the grapes. The coefficient between malic acid content and Brix was -0.743**. This behavior was not repeated in the tartaric acid content, which dropped during the initial stage of ripening, later remaining more or less stable or descending slightly until harvesting, such that no linear or curve relationship was detectable between variations in tartaric acid content and ºBrix.

No significant differences were found in tartaric acid between varieties within the same vineyard. There were differences between the altitudes, more tartaric (6·5g/l near harvest time) building up at lower altitudes than higher up (4·5 g/l).

I V - ANTHOCYANINS

The method established by SAINT-CRICQ *et al.* (1998) permits anthocyan content to be determined for two different extraction conditions: at pH 3.2, which is near that of the grapes and allows the easily extracted anthocyans (ApH 3.2) to be determined; and at pH 1, which degrades the skin cells and favors the extraction of all the anthocyans (ApH 1). The relative difference between these two values: «cell extractibility» EA, represents the capacity of the grape to release anthocyans during the ripening process.

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Tables VI and VII and figures 4 and 5 represent the extractible and total anthocyan contents and their variation throught the process. The anthocyan content of RC was three times higher than LN, and generally higher with altitude, by significant differences. RC was more sensitive than LN to altitude changes. The anthocyan content increased progressively in the first stage of ripening and tends to stabilize or decrease slightly around 19 ºBrix in the higher vineyard and about 17 ºBrix in the lower one in which temperatures are higher towards harvesting time. The anthocyan values found in this warm zone for LN are lower than those found in other studies for Merlot and Tempranillo (SAINT-CRICQ *et al*., 1998).

The extractibility (EA) generally diminished from veraison to picking although not without irregular varia-

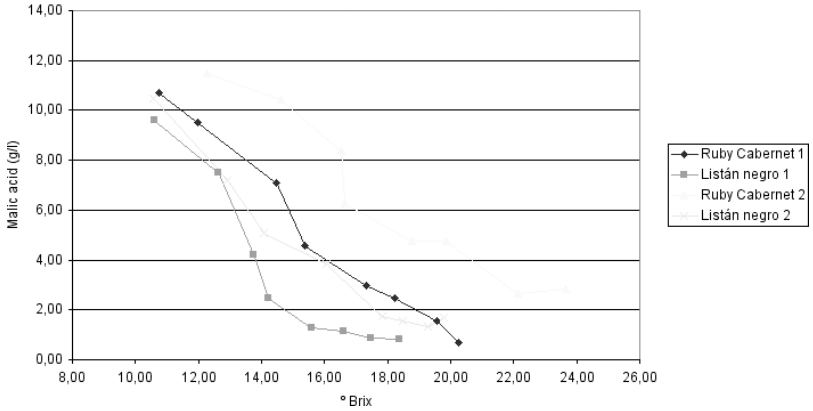


Fig. 3 - Malic acid vs °Brix

Évolution de l'acide malique au cours de la maturation

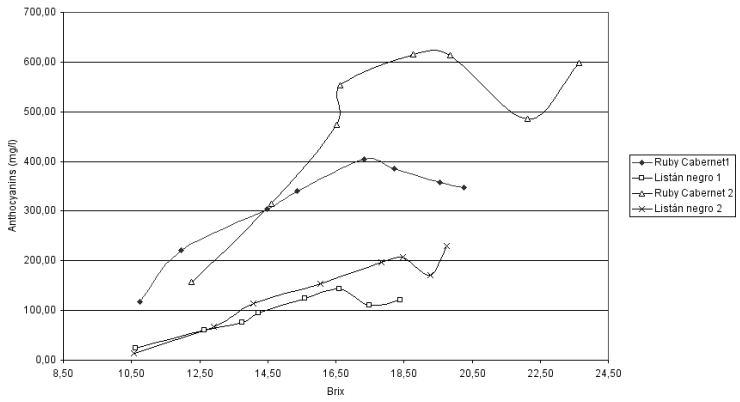


Fig. 4 - Anthocyanins at pH 3,2

Anthocyanes extractibles à pH 3,2

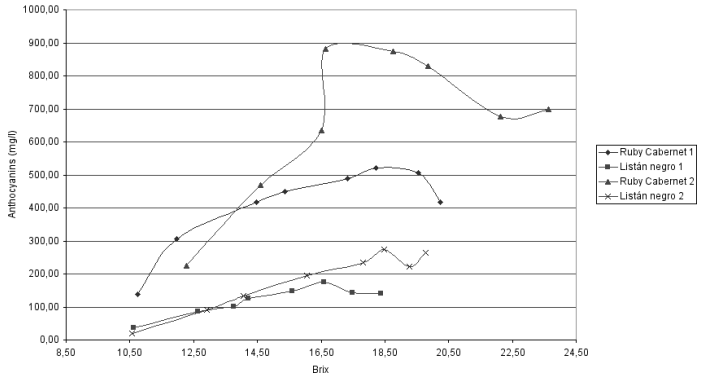


Fig. 5 - Anthocyanins at pH 1

Anthocyanes extractibles à pH 1

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tions. At harvest, it varied from 13 to 17, low values compared with Merlot and Tempranillo.

V - TOTAL PHENOLS AND SEED-RIPENING

Table VIII shows the total phenols values for the grapes at harvest. Grapes from the lower vineyard (independently of variety) showed a decrease in total phenols from veraison to ripeness, while the value for the higher vineyards rose slightly. RC had the higher phenol content. Therefore, the negative influence of high temperatures during the ripening period is seen in the total phenols content and the poor adaptation of LN to that climatic zone.

The phenolic ripening value of the seeds, Mp, decreased from veraison to harvesting, the final values are shown in table VIII and as with the rest of the parameters, a clear influence of variety and altitude is seen. The best (i.e. lower) values are those of RC and the higher altitude.

Table V - Mean values of total acidity expressed as g/l tartaric acid at different heights. Duncan test (significances at $p< 0.05$).

Comparaison de l'acidité totale moyenne (g/l acide tartrique) à différentes altitudes.

Sampling	Vineyard 1 280 m	Vineyard 2 520 m
1	25.22 a	22.96 a
2	18.41 a	16.41 a
3	12.37 a	12.28 a
4	8.31 a	8.72 a
5	6.74 a	6.94 a
6	5.54 a	5.68 a
7	4.88 b	5.79 a
8	4.58 b	5.70 a

Table VI - Extractable anthocyanins at pH 3.20 (mg/kg). Duncan test (significances at p< 0.05).

Potentiel des anthocyanes extractibles à pH 3.2 (mg/kg). Test de Duncan (significatif à p< 0.05).

Sampling	Ruby Cabernet		Listán negro	
	Vineyard 1	Vineyard 2	Vineyard 1	Vineyard 2
1	223 a	300 a	47 b	26 b
2	420 b	598 a	116 c	128 c
3	579 b	901 a	144 c	218 c
4	648 b	1051 a	179 d	294 c
5	769 b	1169 a	237 d	374 c
6	731 b	1166 a	274 d	393 c
7	680 b	923 a	212 d	326 c
8	661 b	1136 a	230 d	436 c

Table VII - Total anthocyanins at pH 1.0 (mg/kg). Duncan test (significances at p< 0.05).

Potentiel total en anthocyanes à pH 1.0 (mg/Kg). Test de Duncan (significatif à p< 0.05).

Sampling	Ruby cabernet		Listán negro	
Sampling	Vineyard 1	Vineyard 2	Vineyard 1	
1	265 b	426 a	70 c	37 c
2	583 b	889 a	163 c	173 c
3	791 b	1207 a	190 c	256 c
4	853 b	1677 a	238 c	368 c
5	927 b	1662 a	283 d	448 c
6	992 b	1578 a	335 d	523 c
7	963 b	1284 a	270 d	420 c
8	795 b	1329 a	267 d	504 c

CONCLUSION

For this warm wine-producing zone on the south slopes of Tenerife a clear effect of temperature on red grape quality is demonstrated. The vines growing at a higher altitude are richer in phenolic compounds, desirable for red wine production. The high temperatures in the lower zones inhibit the synthesis of phenolics and give rise to a lower malic acid content in the grapes. However, in order to get a definitive demonstration, it could be necessary a complementary study about the vine water status including leaf water potential measures.

The variety RC appears more ideally suited to the area than LN. The differences due to variety and climatic conditions produce different levels of both extractible and total anthocyans. The variety RC was shown to be more sensitive to climatic variations.

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Table VIII - Total phenols expressed as gallic acid equivalents (GAE) (g/kg) and phenolic maturation of seeds (Mp) at harvest.

Phénols totaux et maturité tannique. Indice de maturité des pépins (Mp).

	Ruby Cabernet 1	Listán negro 1	Ruby Cabernet 2	Listán negro 2
Total phenols	1.109	0.827	1.422	0.933
Mp	45.5	74.6	27.0	57.2

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