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Characterization of 'Cabernet Sauvignon' wine made with grapes from Campanha– RS Region

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Campanha region in the state of Rio Grande do Sul (RS) has received attention on grape production specifically 'Cabernet Sauvignon', 'Merlot' and 'Tannat'. Due to the edafoclimatic peculiarities such as sandy soil, good thermal amplitude and sunshine, and low rainfall during the ripening period, it is supposed that the wine of this micro-region, in especially Bagé, might have particular typicity. However, as being a recent activity in the region, the results on grape ripening and wine quality are few. The objective of this work was to characterize Cabernet Sauvignon wines made with grapes from the Region of Campanha, state of Rio Grande do Sul – Brazil, specifically from the municipality of Bagé. As control parameters, it was also vinificated, grapes of the same cultivar from vineyards of Serra do Sudeste and Serra do Nordeste of the state of Rio Grande do Sul. The grape of each vineyard was harvested and submitted to microvinification. In one of the vineyards in 2007 (in the region of Bagé) was measured the late harvesting of grapes on wine quality. In general, the results of Bagé wines from the 2004 vintage pointed to good alcohol content and dry extract, but no efficiency on intensity and shade of color. This is probably due to the decrease of acidity during vinification reducing the stability of anthocyanic compounds. The over-ripeness of 'Carbenet Sauvignon' grapes during 2007 vintage is a positive alternative of both color and alcohol increment in the wines of Bagé/RS. There was no effect on total acidity whether compared to conventional harvesting or industrially recommended. The high levels of K detected might be one of the factors that contributed to the low total acidity, high pH and color.

Key words: *Vitis vinifera*, grape quality, color, ripening.

INTRODUCTION

Seeking to expand and differentiate the Brazilian vitiviniculture, the wine sector is investing in new potentially apt regions to produce grapes and wines of particular quality. From this context, the South Meso-Region of Rio Grande do Sul, specifically Região da Campanha where Bagé is located, has presented edafoclimatic potential to become an interesting Brazilian winery resort. This micro-region is situated on 31°S, having dry climate, good sunshine and thermal amplitude, and low rainfall right before harvesting. The average values of the main climate parameters are: minimum air temperature (annual average of 12,3°C) and maximum air temperature (annual average of 24,3°C) (Tonietto and Mandelli, 2003), annual rain precipitation of 1.388 mm, air relative humidity of 76% and sunshine of 2.372 h. In general, these conditions allow the development of enological ripening and provide quality to the grapes and wines (Miele and Miolo, 2003). 'Cabernet Sauvignon' is a late-ripening variety and, although, the variants as *terroir* and vinification conditions, the wines have good structure and a particular character. The wine is dark red, bodied and with a great persistent aroma. The young wine is a little hard, astringent, tannic and astringent. The ageing process is slow and demands a long time of storage (Souza, 2000).

Nevertheless, the wine is not just a variety result, but especially it is a complex of natural and human factors that determines the qualitative and quantitative potential of the cepagem, vineyard and region. The natural features (climate, soil, topographic exposition, etc.) are independent variables that affect the product quality and differentiation. The management does not have direct action on these processes, except rare exceptions; once chosen the region, they continue during the whole productive life of the vineyard, without possible rectification practices. It is evident that management interferences may occur as soil correction, irrigation, vineyard mulching, etc (Hidalgo, 1980; Mandelli, 2002). According to Martinez-Peláez (1994), the climate establishes or does not favor the eco-physiological conditions of the vine culture, whereas the mesoclimate determines the particularities in each region. He also points out that it is not possible to idealize that a country might develop a wine industry based on the rusticity of the specie or appeal to diverse genotypes. There must be an adjustment between ecosystem conditions of each region and their wine typicity as cited by Mandelli (2002). Diaz (1992), in commenting on the main relationships between environment and wine biochemicals characteristics, affirmed that the specificities of wine characteristics are determined by grape quality. Nevertheless, the grape quality at first depends upon the cultivar and then the environment where it is produced. The others aspects are accomplished by the management of grape production and the enologic process (Mandelli, 2002).

Several studies have been carried out aiming to characterize the wines of the main Brazilian wine-growing regions with focus on the Serra Gaúcha (Rizzon et al., 1998; Rizzon and Miele, 2001). In this region it has been verified that, regarding its edafoclimatic and management conditions, the main red wine varieties (Merlot, Cabernet Sauvignon, Cabernet Franc and Tannat) have provided wines with high acidity, good color and structure but incomplete phenolic ripening. Among the cited varieties, Merlot has been pointed out as the more equilibrated wine (Rizzon et al., 1998; Rizzon and Miele, 2004; Rizzon and Miele, 2003; Rizzon and Miele, 2002). Because of the lower rainfall and higher sunshine in the Region of the Campanha, it is believed that the grapes might acquire good ripening providing wines with intense color and adequate phenolic ripening. However, there may be difficulties as for acidity preservation. In spite of good thermal amplitude, there are some periods with excessively high night temperatures that results in wines with high pH levels. The objective of this work was to characterize Cabernet Sauvignon wines made with grapes from the Region of Campanha, State of Rio Grande do Sul – Brazil, specifically from the municipality of Bagé. As reference parameters it was also vinificated grapes from Santana do Livramento, Encruzilhada do Sul and Bento Gonçalves. Furthermore, the effect of late harvesting of grapes on wine quality was studied.

MATERIALS AND METHODS

The experiment was carried out with 'Cabernet Sauvignon' grapes cultivated at different vineyards situated at the Region of the Campanha (one at Santana do Livramento and two at Bagé – São Xico and Cerrito), Serra do Sudeste (one at Pinheiro Machado and one at Encruzilhada do Sul) and Serra Gaúcha (Vale dos Vinhedos, Bento Gonçalves). The vineyards were between four and eight years old. The vines were planted at 1.20 x 3.30 m and trained on simple trellis system. From each vineyard, three boxes of grapes weighing about 16 kg each were harvested. The grapes were harvested on 3rd March, 2004 with three microvinifications of three replications for each vineyard.

Microvinification

For each experimental unit, the grapes were crushed and the musts were acondicionated into 20 L glass flasks topped with a Müller valve. The must was enriched with 40 mg/L of sulphur dioxide and 15 mg/L of pre-active dry yeast. The must remained on

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Table 1. Basic physico-chemical characteristics of must of 'Cabernet Sauvignon' grape, 2004 vintage of the regions Bagé, Pinheiro Machado, Encruzilhada do Sul, Santana do Livramento and Bento Gonçalves.

Vineyard	°Brix	Total Acidity (meq/L)	pH
Bagé – São Xico	19.07	100	3.43
Bagé – TrêsCerros	20.1	77	3.45
Santana do Livramento	18.84	90	3.5
Pinheiro Machado	19.75	109	3.2
Encruzilhada do Sul	20.4	90	3.29
Bento Gonçalves	20.37	98	3.43

fermentation at 23 and 25°C. The fermentation time, in presence of skins and seeds, was of six days with daily pumping over. The first separation was done after the end of alcohol fermentation. The wines continued in flacks adapted with the same Müller valves until the end of malolactic fermentation. In the way, next the wines were separated and again it was added the sulphur dioxide (50 mg/L). The tartaric stabilization was done at temperature of 4°C for a period of ten days. After the tartaric stabilization was completed, the wines were bottled.

Wine physico-chemical analysis

The physico-chemical evaluations (density, alcohol concentration, total acidity, volatile acidity, pH, dry extract, reducing sugars, reduced dry extract, ashes, alkalinity of ashes) were done with conform methods described by Ribéreau-Gayon et al. (1976). The anthocyanins contents were determined by the method of Ribéreau-Gayon and Stonestreet (1965). The optical density (OD) at 420 nm, 520 nm and 620 nm and the total polyphenols were determined by spectrophotometry, previously calibrated by Rizzon and Miele (2002) with cuvests of 1 mm and 10 mm of optical path for color indexes and total polyphenols, respectively.

Statistical analysis

The data were submitted to analysis of variance and the comparison of means by Tukey test at 1% level of significance. The statistical analyses were performed by using Sanest program (Zonta and Machado, 1991).

RESULTS AND DISCUSSION

The mash showed very different results (Table 1) to the different regions, probably related to soil type and climatic conditions imposed by the altitude difference. But all followed the same line that increasing the total sugars, decreased acidity. They followed which is widespread in the literature which provides increased maturation of sugars, but the cannibalization of malic acid, there is a reduction in major or minor proportion of the total acidity. The wine density (Table 2) settled between 0.9973 and 0.9945, which is considered normal for dry red wines (Rizzon and Miele, 2002). The alcohol concentration of the wines varied from 10.7% to 12.39% (v/v) (Table 2) and there was not chaptalization. This indicates that with the improvement on vine culture, the grapes accumulated sufficient sugar levels to obtain the minimum alcohol contents required. This is backed up by Castro et al. (1991) who cited that a good phytotechnic management increases sugars levels. This aspect is important since, in general, there is still the need for corrections as for the addition of sugar as for the concentration or combination of methods (Manfroi et al., 2006). Comparing the alcohol contents and residual sugar of wines (Table 2) with the °Brix of the respective musts (Table 1) the relation is coherent with the yield estimated in the alcohol fermentation of red wines.

The total acidity varied significatively (Table 2). The higher concentrations were obtained in wines of Encruzilhada do Sul and Pinheiro Machado. This result is expected in these regions for having good thermal amplitude and nights of low temperatures during the grape ripening period. Nevertheless, the region of Serra Gaúcha is known for producing grapes with high total acidity (Rizzon and Miele, 2002; 2004; Manfroi et al., 2006 Therefore, the acidity of the wine was 55 mEq / L in the region of Bento Gonçalves, which is similar to the wine regions of Bagé and Santana do Livramento (48 and 56 mEq / L, respectively). Although, the musts had presented initial total acidity between 77 and 109 mEq/L (Table 1), there was a reduction in values to 51 and 66 mEq/L in the stabilized wine. The decrease of total acidity during the tartaric stabilization process is normal because of the precipitation of potassium acid tartrates and bitartrates (Rizzon et al., 1998; Manfroi et al., 2006). But, the exact causes of low total acidity were not demonstrated. A possible explanation for low acidity rates is the high potassium content found (Table 3) between 1263 and 1947.1 mg / L, which would favor a higher precipitation of potassium bitartrate decreasing, tartaric acid content influencing acidity. Potassium is the main nutrient required by the vine, being responsible for the proper development of the plant and fruit, also being required by the yeast during fermentation and interfering with the pH of the must and wine. It was observed that the higher potassium content (Table 3), the higher pH found in wine (Table 2). The pH is one of the most important variables in the equilibrium of wines and wine responsible for providing microbiological stability, color and sensory balance, directly interfering extractability and

Table 2. Classic analysis in Cabernet Sauvignon wines of the regions of Santana do Livramento, Bagé (São Xico and TrêsCerros), Encruzilhada do Sul, Pinheiro Machado and Bento Gonçalves, 2004.

Variable	Wine Grower Regions						General Average	VC%
	Santana do Livramento	São Xico (Bagé)	TrêsCerros (Bagé)	Encruzilhada do Sul	Pinheiro Machado	Bento Gonçalves		
Density (20/20°C)	0.9973 a*	0.9964^{ab}	0.9952^{bc}	0.9945^{c}	0.9951^{bc}	0.9954^{bc}	0.9956	0.03
Alcohol content (% v/v)	10.7^{a}	10.65^{a}	12.0^{a}	12.08^{a}	11.36^{a}	12.39^{a}	11.5	2.8
Total acidity (meq/L)	48.00^{b}	51.00^{b}	56.00^{b}	66.00^{a}	65.00^{a}	55.00^{b}	56.8	2.7
Volatile Acidity (meq/L)	10.5^{ab}	7.5^{b}	8.0^{b}	12.0^{a}	9.5^{ab}	11.5^{a}	9.3	5.9
pH	4.2^{a}	4.19^{a}	4.11^{a}	3.89^{b}	3.83^{b}	4.16^{a}	4.1	0.5
Dry Extract (g/L)	24.2^{ab}	22.94^{abc}	22.68^{bc}	20.82^{c}	21.60^{c}	24.98^{a}	22.9	1.8
Reductors sugars (g/L)	1.73^{cd}	1.33^{d}	1.95^{bc}	2.26^{ab}	2.46^{a}	1.76^{cd}	1.9	4.3
Reduced Dry Extract (g/L)	23.47^{a}	22.62^{ab}	21.74^{abc}	19.57^{c}	19.83^{bc}	24.22^{a}	21.9	2.5
Alcohol in weight / Reduced dry Extract	3.35^{c}	3.77^{bc}	4.42^{ab}	4.93^{a}	4.52^{ab}	4.09^{bc}	4.2	3.3
Ashes (g/L)	4.15^{a}	3.88^{ab}	3.75^{ab}	3.50^{ab}	2.93^{b}	4.13^{a}	3.7	4.8
Ashes Alkalinity (meq/L)	45.25^{a}	40.50^{b}	37.75^{b}	32.25^{c}	30.75^{c}	40.50^{b}	37.8	2

*Means with the same letter in line are not significantly different by Tukey Test (α = 0.01).

Table 3. Analysis of phenolic compounds, tartaric acid and potassium in Cabernet Sauvignon wines of the regions of Santana do Livramento, Bagé (São Xico and TrêsCerros), Encruzilhada do Sul, Pinheiro Machado and Bento Gonçalves, 2004.

Variable	Wine Grower Regions						General Average	VC%
	Santana do Livramento	São Xico (Bagé)	TrêsCerros (Bagé)	Encruzilhada do Sul	Pinheiro Machado	Bento Gonçalves		
O.D. I 420	0.172^{c}	0.368^{ab}	0.323^{ab}	0.353^{ab}	0.396^{a}	0.233^{bc}	0.308	8.5
O.D. I 520	0.176^{c}	0.385^{abc}	0.390^{abc}	0.471^{ab}	0.612^{a}	0.268^{bc}	0.384	12.3
O.D. I 620	0.053^{c}	0.139^{ab}	0.115^{abc}	0.127^{ab}	0.143^{a}	0.074^{bc}	0.109	11.2
Color Intensity (O.D.420 + O.D.520 + O.D.620)	0.401^{c}	0.892^{ab}	0.828^{abc}	0.951^{ab}	1.153^{a}	0.575^{bc}	0.8	10.6
Color (O.D.420 / O.D.520)	0.979^{a}	0.958^{a}	0.828^{ab}	0.757^{bc}	0.647^{c}	0.868^{ab}	0.84	3.5
Tannin (g/L)	1.42^{c}	1.53^{c}	1.72^{bc}	2.68^{ab}	2.86^{a}	1.36^{c}	1.9	10.3
Totals Anthocyanins (g/L)	244.83^{c}	393.63^{b}	493.73^{ab}	567.45^{a}	568.42^{a}	438.44^{b}	451.1	4.1
Totals Polyphenols (g/L)	29.0^{d}	36.55^{bc}	38.65^{b}	45.8^{a}	48.05^{a}	31.55^{cd}	38.3	2.6
Tartaric Acid (g/L)	3.9^{a}	3.05^{a}	3.5^{a}	2.46^{a}	2.83^{a}	3.27^{a}	3.2	11
Proline (mg/L)	2168.25^{a}	1927.40^{a}	1893.10^{a}	442.75^{b}	905.55^{b}	1888.50^{a}	1537.6	5.5
Potassium (mg/L)	1925.7	1947.1	1894.7	1351.0	1263.0	1839.7	1703.5	11.9

*Means with the same letter in line are not significantly different by Tukey Test (α = 0.01).

stability of anthocyanins. These pigments are very important and are involved in color development and stabilization of wine (Pechamat et al., 2014). The high potassium concentration found may be related to soil conditions, fertilization and variety of the rootstock. Therefore, it is necessary to study and monitoring of the K levels in the soil of the vineyards, as well as monitoring the progress of this cation on the vine.

Measuring the tartaric acid in the wines, the final concentration between 2.46 g/L (Encruzilhada do Sul) and 3.9 g/L (Santana do Livramento) is considerated satisfactory (Rizzon et al., 1998; RizzonandMiele, 2001) to maintain the total acidity of red wines. But, this is not found in this work, because even with good contents of tartaric acid there was detection of high pHs up to 4.2 (Santana do Livramento). Contrary to expection, the wines with the highest final concentration of tartaric acid showed high pH (Santana do Livramento) and the lowest ones showed low pH (Pinheiro Machado and Encruzilhada do Sul). The apparent cause of high levels of pH in wines of Santana do Livramento may be associated with the higher concentrations of K, which would result in higher proportion of soluble tartaric salts in the wine. It also has generated a higher precipitation of

acids tartrate during fermentation and tartaric stabilization. Regarding volatile acidity it may be affirmed that the fermentation and wine treatments of Bagé were conducted adequately (values between 7.5 and 8.0 mEq/L). To the other wines the volatile acidity also settled under 20 mEq/L, which level is recognized as the maximum value by Brazilian legislation. Nevertheless, the values between 10.5 and 12 mEq/L found in the wines of Encruzilhada do Sul, Bento Gonçalves and Santana do Livramento are an indication of alert because they mean a tendency to wines alterations.

The wines pH variations had opposite behavior to the total acidity, which is normal (Manfroi et al., 2006). In other words, the wines from regions of lower total acidity showed high pH levels. In general, red wines from the classics regions of Brazilian wine-growing are situated at pHs between 3.3 to 3.8. In this aspect, the wines of the studied vineyards require assessments to avoid increase in pH. It is proved that the inductor causes of high pH also cause low total acidity, excess potassium, high night temperature and/or interaction of these factors. Nevertheless, these hypotheses need to be proved. All the musts (Table 1) showed pH values in the recommended range, but the stabilized wine had higher values of pH. This pH increasing is coherent with the reduction of total acidity observed as transforming musts (Table 1) into stabilized wine (Table 2). The reduction of the total acidity was in average 40%. The average dry extract settled above 20 g/L, indicating that the particular year allowed the soluble solids and sugar accumulation, which resulted in wines of good structure on these components. From the total of dry weight more than 90% is reduced dry extract (dry extract-residual sugars), which was expected for dry red wine. The relation of alcohol (mass)/reduced dry extract always set below 5.20 that it is the maximum limit permitted by Brazilian legislation for a great wine equilibrium.

Concerning ashes concentration, normally the encountered value corresponds approximately to 10% of the dry extract (Manfroi et al., 2006). This contribution was in average 17% of the total dry extract in these wines, indicating that the mineral matter significantly participated of the total dry extract. In analyzing the ashes alkalinity the wines of lower total acidity and higher pH also showed higher values of this variable, suggesting that there is an effective formation of salts in these wines probably with K for being the main cation of wines (Rizzon et al., 1998). Assessing the indicator variables of yellow (OD 420), red (OD 520) and violet (OD 620) color, it was verified that the wines from São Xico (Bagé-RS) and Santana do Livramento had higher relation OD 420/OD 520 close to 1.0, value commonly observed in older wines (Ribéreau-Gayon and Stonestreet, 1965; Manfroi et al., 2006). As all wines were vinificated in the same date and process the color differences must be due to grapes origin. It is provable that the higher OD_{420} alterations (yellow color indicator) are due to the low total acidity and high pH of these wines. It is widely known that the acidity and pH strongly affect the anthocyanins stability in wines (Boulton, 1980a; Boulton, 1980b; Champagnol, 1988,1986; Rizzon et al., 1998). This affirmation is confirmed by the higher contents of anthocyanins and total phenol compounds found in the wines of higher acidity and lower pH (Encruzilhada do Sul and Pinheiro Machado). Sims and Morris (1985) had already proved that high pH permits the formation of “tostada” color (brown) in wine. The shade “tostada” or “brick” color is the result of increasing yellow color together with violet and red colors. In fact, wines from regions with high pH levels also presented lower indexes of color intensity (OD 420 + OD 520 + OD 620) and higher proportional participations of OD 420.

Besides nutritional and managements aspects, the climatologic conditions also influence the syntheses and amount of grapes pigments (Leeuwen et al., 2004; Jones and Davis, 2000). As an example, Buttrose et al. (1971) verified that high temperatures affect positively increasing pigmentation in bagas of ‘Cabernet Sauvignon’, but not necessarily in ripen vineyards. Tabares et al. (2002) found high concentrations of phenols compounds in vineyards situated in higher altitudes. The grapes of ‘Cabernet Sauvignon’ grown in high-altitude climates showed remarkable and particular characteristics of the complete phenol maturation (Rosier, 2007). These factors could also have influenced the wine color intensity in this experiment. For example, the wines from Pinheiro Machado and Encruzilhada do Sul, situated at average altitude of 200 to 600 m, presented higher color intensity, whereas, Bagé and Bento Gonçalves are situated at 100 to 200 m (Miele and Miolo, 2003). However, the wine of Bento Gonçalves, produced at an altitude of approximately 600 m, does not respond in the same way. Higher levels of proline might be an indicator of vineyard ripening whether combined to good alcohols contents and adequate acidity levels. The amount of proline in wines is a genetic characteristic of the vine, thus, it is strongly influenced by climate conditions, nitrogen fertilizing and sanity degree of the grape (Bisson, 1991; Sponholz, 1991; Rizzon et al., 1993). Cultivar is one of the most important factors that interfere on proline content (Kliewer, 1969, 1970; Sponholz, 1991). Cabernet Sauvignon, Cabernet Franc and Merlot wines show elevated contents of proline in relation to Vitis Labrusca and hybrids (Bisson, 1991; Sponholz, 1991; Rizzon et al., 1993). According to Rizzon et al. (1993), the wines of ‘Cabernet Sauvignon’ present more elevated contents of proline than ‘Cabernet Franc’ and ‘Merlot’. The regions of Santana do Livramento and Bento Gonçalves showed proline contents articulated with vineyard age. But, Santana do Livramento did not reach adequate levels of alcohol, total acidity and pH. Regions of Bagé, the wines had high proline contents but with pH above 4, low total acidity and medium alcohol content. The problem is the the measurement year; the vineyards are four years old and are in their second year of production. Contrary to previous situations, the vineyards of Pinheiro Machado

and Encruzilhada, also with four years implantation, had inferior values of proline, good alcohol content, suitable acidity and low pH in the wines compared to other vineyard, supposing it to be vineyards of high enologic potential and in evolution phase, due to the lower proline contents.

According to Leeuwen et al. (2004), the climate influence was superior at most of wine parameters, followed by soil and cultivar. Therefore, it could be affirmed that for the typification of 'Cabernet Sauvignon' in the different assessed regions, it is only possible after years of repetition of the same experiment carried out in the 2004 vintage. Regarding ashes alkalinity (Table 2), the four regions that surpassed the technical limits (Santana do Livramento, Bagé- São Xico, Bagé-TrêsCerros and Bento Gonçalves) varied from 25 to 35 mEq/L. They are the same regions that showed pHs above 4, demonstrating a strong correlation between the two factors. This is coherent, since potassium is responsible for more than 40% of the ashes composition, reinforcing the hypotheses of the big influence of this cation on both wine pH and ashes alkalinity. It is also observed (Table 1) that the ashes amounts are high whether compared to the amounts encountered by Rizzon and Miele (2002), even that there is no technical limits for this variable. Comparing the wine ashes contents of the different regions, Pinheiro Machado that showed inferior ashes amounts to other regions had also lower pH. Normally, in wines of ripen grapes, the dry extract and alcohol content show a directly proportional relation, but it was not observed (Table 2). Only Bento Gonçalves satisfied this relation. The others regions showed a high amount of dry extract and low alcohol content (Santana do Livramento and Bagé – São Xico) or an opposite situation, low dry extract and high alcohols contents (Bagé – Três Cerros, Pinheiro Machado and Encruzilhada). The exact causes were not clarified but it is likely that excessive salt precipitation during cold stabilization has resulted in the reduction of dry extract. The reduced sugars levels (Table 2) demonstrate that all wines underwent adequate and complete alcohol fermentation. In Santana do Livramento and Bagé - São Xico, the values of alcohol in weight/reduced dry extract ratio were inversely proportional to alcohol content.

Conclusion

The wines Campanha Region of the State of Rio Grande do Sul, have a good structure. However, depending on the vintage, there might be decrease of total acidity and increase of pH, and consequently, problems on color stability during ageing.

Conflict of Interests

The authors have not declared any conflict of interests.

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