Wines produced with 'Cabernet Sauvignon' grapes from the region of Bagé in the state of Rio Grande do Sul, Brazil

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Abstract – The objective of this work was to characterize 'Cabernet Sauvignon' wines made from grapes cultivated in the region of Bagé, RS, Brazil, during three crop seasons. A randomized complete block design was carried out with three treatments and three replicates. The evaluations were performed for the 2004, 2007, and 2008 growing seasons. 'Cabernet Sauvignon' wines of the 2004, 2008, and 2009 harvests differed for the following parameters: density, alcoholic content, total acidity, pH, reducing sugars, OD 420, 520, and 620, color intensity, total anthocyanins, total polyphenols, sodium, calcium, magnesium, manganese, copper, iron, rubidium, phosphorus, methanol, propanol, 2-methyl-l-propanol, 2, 3 - methyl-l-butanol, and sum of alcohols. 'Cabernet Sauvignon' has potential to be produced in the Bagé region, and to help it to become a wine growing region in Brazil.

Index terms: color stability, enology, grape production, physicochemical characters, potassium.

Vinhos produzidos com a uva 'Cabernet Sauvignon' da região de Bagé, no Rio Grande do Sul

Resumo – O objetivo deste trabalho foi caracterizar vinhos 'Cabernet Sauvignon' elaborados com uvas produzidas na região de Bagé, RS, durante três safras. Um delineamento experimental de blocos ao acaso foi realizado com três tratamentos e três repetições. As avaliações foram feitas para as safras de 2004, 2007 e 2008. Os vinhos 'Cabernet Sauvignon' das safras 2004, 2008 e 2009 diferiram quanto aos seguintes parâmetros: densidade, teor alcoólico, acidez total, pH, açúcares redutores, DO 420, 520 e 620, intensidade de cor, antocianinas totais, polifenóis totais, sódio, cálcio, magnésio, manganês, cobre, ferro, rubídio, fósforo, metanol, propanol, 2-methyl-l-propanol, 2,3 - methyl-l-butanol e soma de álcoois. 'Cabernet Sauvignon' tem potencial de ser produzida na região de Bagé e contribuir para que ela venha a se tornar um polo vinícola no Brasil.

Termos para indexação: estabilidade de cor, enologia, viticultura, características físico-químicas, potássio.

Introduction

'Cabernet Sauvignon' wine, either of varietal or assemblage origin (Jacobs et al., 2016), stands out among winegrowers. The range of cultivars from the genus *Vitis vinifera* (Zocche et al., 2016) allows the production and appreciation of these wines under Brazilian and worldwide conditions (Jayaprakasha et al., 2001). This genotype is from the Bordeaux region of France and, phenologically, its plants have late sprouting and maturity, with medium vigor and productivity (Rizzon & Miele, 2002). It is hevely dependent on edaphoclimatic conditions, and on the technology and management strategies used by winegrowers (Bail et al., 2008). Research carried out by Jackson (2008) showed that this genotype is the best known and most studied in Europe because it provides wines of superior potential and intense aromas, similar to blackcurrants, when produced under favorable edaphoclimatic conditions. However,

it has an herbaceous aroma when the environmental conditions are adverse (Falcão et al., 2008).

The terroir is intrinsic to the edaphoclimatic conditions of the growing environment – such as air and soil temperature, relative air humidity, photosynthetically active radiation, thermal amplitude, altitude, latitude, soil type, water and nutritional availability, and some biotic events inherent to the environment, where the same genotype tends to modify the characteristics of the produced wine (Fischer et al., 1999; Rizzon & Miele, 2002, 2003, 2004; González-Neves et al., 2004; Cosme et al., 2009; Parr et al., 2009; Tao et al., 2009). Crop management aspects of 'Cabernet Sauvignon' in Serra Gaúcha and Santana do Livramento regions influence the acidity and quality of the produced wine (Manfroi et al., 1997; Rizzon et al., 1998). Low temperatures affected grape pre-fermentation in the municipality of Dom Pedrito, in the state of Rio Grande do Sul (Pötter et al., 2010).

Studies on this genotype show its acclimatization and adaptation to the specific conditions of each growing environment, evidencing the conditions to which the genotype is subjected; therefore, changes regarding phenolic maturation were perceptible (Bertagnolli et al., 2007), as the wines showed a pronounced astringency, the presence of pyrazines, and a flavour considered herbaceous by sensory perception (Rizzon & Miele, 2002; Pötter et al., 2010).

Although the region of Bagé has already produced and marketed 'Cabernet Sauvignon' grapes for more than ten years, studies reporting its oenological potential are still scarce.

The objective of this work was to characterize 'Cabernet Sauvignon' wines made from grapes grown in the region of Bagé, RS, Brazil, during three crop seasons (2004, 2007, and 2008), considering that this region has potential to be a wine producing center in the country.

Materials and Methods

The study was carried out in a vineyard established in 2000, with vines of the 'Cabernet Sauvignon' genotype, clone CS18A, grafted on 'Paulsen 1103', conducted in a single espalier, with 1.2 m spacing between plants, and 3.0 m between rows. The vines were pruned using a double spore cord, and the height of the canopy was approximately 1.20 m. For this study, grapes were collected from the same vineyard, located in Olhos D'Água, in the region of Bagé, in the Campanha Gaúcha (at 31º19'53"S, 54º06'25"W).

A randomized block design was carried out with three treatments and three replicates. Considered as treatments, the harvests of 2004, 2007, and 2008 were evaluated. The harvest stage and processes followed the common procedures for industrial purposes, with grapes between 20.1 and 21.1°Brix, 87 and 93 meq L^{-1} of titratable acidity (TA), pH between 3.43 and 3.59, and density between 1.0852 and 1.0901 g cm^{-3}, seed with a light brown color, and average yield for the three harvests of 2.5 kg of grapes per plant. The soil is characterized as a Planossolo Vértico (Santos et al., 2013) – Vertic Planosol. Soil analysis was performed at 0.40 m soil depth, whose samples showed pH 5.0 and 240 g kg^{-1} clay content, 12 g kg^{-1} organic matter, 3.5 mg dm^{-3} P, and 80 mg dm^{-3} K. The control of weeds, pest insects, and diseases was carried out according to the crop demand, allowing plants to be free from biotic stresses, thus, minimizing the environment influences on the experiment result (Zocche et al., 2016).

For this experiment, three microvinification processes were carried out in each harvest, which was considered as experimental unit, in order to carry out the statistical analyses. The experimental unit consisted of 20 L bottles, in which 17 kg of grapes were peeled off and crushed and, immediately after, 50 mg L SO_2 and 20 mg L of *Saccharomyces cereviseae* yeasts (Maurivin, AB Mauri, Camellia, NSW, Australia) were added. Maceration was carried out for six days at 20 to 25°C, with daily repression, and cap removal on the seventh day after the beginning of the process.

As soon as alcoholic fermentation finished, racking was performed, and the malolactic fermentation was monitored, which lasted, on average, four months. After that, the tartaric stabilization was performed in a cold chamber at 4ºC for ten days, and the wines were bottled. Physicochemical evaluations were performed eight months after the beginning of winemaking (Jacobs et al., 2016; Zocche et al., 2016). The evaluated characters were: density, alcoholic content, total and volatile acidity, pH, reducing sugars (Amerine & Ough, 1976), total polyphenols, anthocyanins, and color intensity (Ribéreau-Gayon & Stonestreet, 1965). The contents of Ca, Mg, Mn, Fe, Cu and Zn were obtained by atomic absorption analyses, whereas K, Na, Li, and Rb contents were obtained by flame

emission (Analytical..., 1976). Phosphorus content was determined by calorimetry using ammonium molybdate. The volatile compounds ethyl acetate, methanol, propanol-1, 2-methyl-l-propanol, 2,3 - methyl-l-butanol, and the sum of the higher alcohols were determined by gas chromatography, in an apparatus equipped with a flame ionization detector, and a Carbowax 600 stainless steel column of 3.2 m long and "1/8" internal diameter. The gas vector used was nitrogen with 30 mL min^{-1} flow of. The vaporizer was at 140°C, oven temperature was 98°C, and the detector was at 160°C. The wine sample (3 μL) was directly injected after receiving 10% volume of a solution of methyl-4-pentanol-2 at 1g L^{-1} as an internal standard (Bertrand, 1975).

The sensorial analysis was conducted after six months of wine bottling, by a panel of 11 trained wine tasters who legally committed to the research participation being aware of the ethical and scientific responsibility of the research. They have the ability to quantify the aromatic, gustatory, and visual descriptors in red wines. The evaluations were performed for three consecutive days, where each taster was considered as the experimental unit of each treatment, and the magnitude of evaluation comprised scores from zero to nine according to the perceived intensity. The used descriptors were: color intensity, purplish red intensity, aromatic intensity, red fruit, dried fruit, tobacco/ chocolate/tea, vegetable/herbaceous, volume of mouth, tannic sweetness, acidity, astringency, persistence, and overall evaluation.

Data were subjected to the normality test of Shapiro & Wilk (1965). The analysis of variance was performed at 5% probability, and the significant characters were analyzed by Tukey's test. The analyses were performed using the Genes statistical software (Cruz, 2013).

Results and Discussion

The analysis of variance showed significant differences between the 2004, 2007, and 2008 growing seasons for density, alcohol content, total acidity, pH, total sugars, L420, L520, L620, color intensity, polyphenols, anthocyanins, Na, Ca, Mg, Mn, Cu, Fe, Rb, P, ethyl acetate, methanol, propanol-1, 2-methyl-l-propanol, 2,3 - methyl-l-butanol, and sum of the higher alcohols. However, no differences were found for volatile acidity, dry extract, tannins, K, Zn, and acetaldehyde, which regardless of the harvest, tend to respond in a similar way in the conditions of Bagé region (Table 1).

The wine density was higher for harvests of 2004 and 2007 than that of 2008 (Table 2). These results agree with a study about wine production in Rio Grande do Sul (Rizzon & Miele, 2002).

Alcohol content was higher in the 2004 harvest. However, for all harvests, the contents were above 10.5%. The content of soluble solids of Bagé region allows of wine production with the minimum alcoholic content required by the national laws (≥7°GL), without

Table 1. Summary of the variance analysis of the evaluated characters.

Character	Mean squares Harvests	Coeficient of variation (%)
Density (20/20°C)	0.0001*	0.05
Alcoholic content (% v/v)	1.4222*	3.21
Total acidity (meq L^{-1})	272.3333*	0.94
Volatile acidity (meq L^{-1})	1.0278^{ns}	11.52
pH	0.0525*	1.92
Reducing sugars (g L^{-1})	2.0053*	3.50
Dry extract	15.2659^{ns}	6.17
OD 420	0.0688*	12.33
OD 520	0.0279*	19.08
OD 620	0.0094*	16.72
Color intensity (OD 420 + OD 520 + OD 620)	0.2680*	15.85
Tannins	0.0262^{ns}	5.32
Total anthocyanins (mg L^{-1})	131495.8107*	8.87
Total polyphenols (mg L^{-1})	7.6369*	0.92
Acetaldehyde	167.4071^{ns}	58.56
Ethyl acetate	539.6125*	12.09
Methanol	28807.8025*	16.71
Propanol	196.0715*	13.55
2-methyl-l-propanol	13921.4737*	8.71
2.3-methyl-1-butanol	185022.2195*	7.60
Sum of higher alcohols	29541.7344*	8.09
K	51582.9514^{ns}	7.87
Na	50.0200*	13.42
Ca	363.6487*	4.77
Mg	299.8685*	2.77
Mn	6.9922*	2.21
Cu	2.6924*	10.28
Fe	1.4366*	5.11
Zn	0.0084^{ns}	23.62
Rb	11.0461*	18.17
P	2203.0905*	3.25

*Significant at 5% probability. ^{ns}Nonsignificant. OD, optical density.

the need of must concentration or chaptalization (Zocche et al., 2016). Total acidity of the harvests responded differently, and this character was higher in the 2004 harvest; however, the wines showed relatively low values, between 51 and 69 meq L^{-1}, and pH values were close to 4.0.

The volatile acidity and dry extracts did not differ between harvests (Table 2). Relatively low values of total acidity and high pH values result in wines with stability problems during maturation, especially those related to color components, such as anthocyanins and their interactions with tannins (Jacobs et al., 2016). Singleton (1987) found that the oxidation rate of wines with pH 4.0 is nine times higher than wines with pH 3.0. The total acidity in the 2004 harvest was lower than the minimum limit stipulated by the Brazilian laws (55 meq L^{-1}), and a pH of 4,185 was obtained. In the subsequent growing seasons (2007 and 2008), the values were very close, but were higher than the 2004 harvest; thus, the characters indicating coloration (Table 3) showed, for two harvests, higher levels than that of 2004 for OD 420, 520, and 620, color intensity, anthocyanins, polyphenols, and a shade brick color.

Although 'Cabernet Sauvignon' is not one of the richest grapes in anthocyanins, in comparison with grapes such as 'Alicante Bouchet' or 'Tannat', in several wine regions near the study area it was able to produce wines with good coloration (Pötter et al., 2010; Jacobs et al., 2016). Complementary oenological practices are usually associated with the use of pectolytic enzymes, thermovinification, the use of modular temperatures, fermentative pre-maceration at low temperatures (Zocche et al., 2016), correction of acidity, the use of oenological tannins, micro-oxygenation, other resources in the search for greater extraction of color and structure components, and stabilization during wine maturation process (Fernández-Zurbano et al., 1999; Carvalho & Curvelo-Garcia, 2000; Pérez-Lamela et al., 2007; Daudt & Fogaça, 2008; Chinnici et al., 2009; Pötter et al., 2010).

When evaluating wines produced with 'Cabernet Sauvignon' grapes in Bagé region, it was evidenced that, without using complementary oenological processes, the obtained product is unsatisfactory as for coloration and total polyphenol concentrations (Jacobs et al., 2016). The values observed in these wines were lower than those obtained in a research carried out in Rio Grande do Sul (Rizzon & Miele, 2002). According to González-Neves et al. (2004), the year of 2007 showed a wetter period during grape maturation, and even producing grapes with good content of soluble solids (above 20˚Brix), the color characteristics were lower.

As to the wine mineral composition, the 2008 harvest showed a higher concentration of sodium, magnesium, and rubidium. However, calcium showed a greater magnitude in 2007, and manganese, copper,

Table 2. Physicochemical composition of 'Cabernet Sauvignon' wines produced with grapes from the region of Bagé, RS, Brazil, in the 2004, 2007, and 2008 growing seasons[(1)].

Harvest	Density (20/20°C)	Alcoholic content (% v/v)	Total acidity (meq L^{-1})	Volatile acidity (meq L^{-1})	pH	Reducing sugars (g L^{-1})	Dry extract
2004	0.996a	11.926a	51.000c	7.500a	4.185a	1.325c	22.940a
2007	0.995a	10.833b	69.333a	8.000a	3.926b	2.960a	27.360a
2008	0.985b	10.655b	64.666b	8.666a	4.006ab	2.123b	24.367a

[(1)]Means followed by equal letters, lowercase in the columns, do not differ by the Tukey's test, at 5% probability.

Table 3. Means of physicochemical composition of 'Cabernet Sauvignon' wines produced with grapes from the region of Bagé, RS, Brazil, in the 2004, 2007, and 2008 growing seasons[(1)].

Harvest	OD 420	OD 520	OD 620	Color intensity	Tannins	Total anthocyanins (mg L^{-1})	Total polyphenols (mg L^{-1})
2004	0.368a	0.384a	0.139a	0.892a	1.530a	393.630a	36.550a
2007	0.068c	0.192b	0.033b	0.294c	1.688a	323.72b	33.400c
2008	0.253b	0.306ab	0.053b	0.614b	1.522a	1.140c	34.533a

[(1)]Means followed by equal letters, lowercase in the columns, do not differ by the Tukey's test, at 5% probability. OD, optical density.

iron, and phosphorus were relevant in the 2004 harvest (Table 4). An important aspect to be highlighted is the wine mineral constitution behavior between harvests, with outstanding alterations between grapes of plants of 4 and 8 years. Considering this, the oenological potential improvement of grapes occurs as the age of the vineyard advances and sanitary conditions are enhanced (Rizzon et al., 2008). The excess of K may cause a reduction of total acidity, an increase of pH, anthocyanin destabilizations, and an intensification of purplish and yellowish colors (Daudt & Fogaça, 2008).

Research by Pötter et al. (2010) with 'Cabernet Sauvignon' grapes, in Dom Pedrito, RS, resulted in wines with pH below 3.6, but with high total polyphenols and coloration. High pH values and low total acidity tend to increase K uptake dynamics, culminating in the excessive precipitation of K bitartrate during winemaking (Daudt & Fogaça, 2008). Since studies are scarce to prove this dynamic, attention should be redoubled to the vineyard intrinsic type of soil, as K absorption by 'Cabernet Sauvignon' genotype is modified. In a comparison of wines produced with the same genotype, K concentrations were different, even under the same climatic indexes in Campanha Gaúcha region (Bagé and Dom Pedrito, RS) (Jacobs et al., 2016).

According to Leeuwen et al. (2004), K contents in grapes depend on the soil type and on the genotype used. In wines produced from grapes cultivated in Bagé, the K contents varied from 1,694 to 1,947 mg L^{-1}. According to Rizzon & Miele (2002), K levels reached 1,426 mg L^{-1} in the average of six harvests for 'Cabernet Sauvignon' in the Serra Gaúcha region, also in the state of Rio Grande do Sul, Brazil. Some aspects may affect K uptake in 'Cabernet Sauvignon' vineyards, in the region of Bagé, such as low relative humidity in the maturation period, great evapotranspiration, mass flow through xylem vessels, and vineyard composed of grafted plants on 'Paulsen' rootstock, which shows an abundant and deep radicular system, with a greater capacity to absorb water and nutrients (Zocche et al., 2016).

As to volatile compounds of the wines, the 2007 and 2008 harvests were superior for methanol and propanol contents, whereas the 2004 harvest showed greater values for 2-methyl-l-propanol, 2,3 - methyl-l-butanol, and for the sum of higher alcohols (Table 5). The volatile compounds remained within the normal standards for fine red wines. According to Rizzon & Miele (2002), the presence of high concentrations of amylic alcohols (2-methyl-l-propanol, 2,3 - methyl-l-butanol) is characteristic of wines of this genotype, thus favoring herbaceous aroma often detected in them.

The higher alcohols were especially elevated in the first harvest, reflecting wines with a shortage of

Table 4. Means of mineral composition of 'Cabernet Sauvignon' wines produced with grapes from the region of Bagé, RS, Brazil, in the 2004, 2007, and 2008 growing seasons[(1)].

Harvest	K	Na	Ca	Mg	Mn	Cu	Fe	Zn	Rb	P
2004	1947.1a	12.9b	68.55b	84.90b	5.00a	1.50a	2.20a	0.40a	4.20b	166.83a
2007	1694.2a	10.75b	79.71a	87.23b	4.14b	0.22c	1.16b	0.29a	5.51ab	136.15b
2008	1880.8a	18.65a	57.69c	103.26a	2.03c	0.50b	0.88c	0.37a	7.97a	112.80c

[(1)]Means followed by lowercase letters, in the columns, do not differ by the Tukey's test, at 5% probability.

Table 5. Means of volatile compounds of 'Cabernet Sauvignon' wines produced with grapes from the region of Bagé, RS, Brazil, in the 2004, 2007, and 2008 growing seasons[(1)].

Harvest	Acetaldehyde	Ethyl acetate	Methanol	Propanol	2-methyl-l-propanol	2.3-Methyl-1-butanol	Sum of higher alcohols
2004	8.25a	60.15a	31.85b	17.90b	132.25a	4454.40a	604.60a
2007	23.16a	83.40a	219.67a	28.20ab	42.73b	252.83b	413.07b
2008	16.43a	60.19a	1744.25a	33.84a	56.65b	104.544c	463.80b

[(1)]Means followed by lowercase letters, in the columns, do not differ by the Tukey's test, at 5% probability.

refined aromas. Methanol and acetaldehyde at low concentrations indicate that the grapes were harvested in a good phytosanitary state, whose vinification process was also well conducted.

According to the sensorial analysis, the wines produced with 'Cabernet Sauvignon' from the 2008 harvest reached average scores below 5 for color intensity, red fruit aromas, volume in the mouth, and persistence; these scores are considered below standards for attributes usually considered as positive for red wine, indicating the low quality of these wines (Figure 1). The panel results agreed with those obtained by the analytical data, and indicate that the wines do not show a good concentration of color and structure components, which reflected in the sensorial evaluation. Therefore, there is a need for complementary studies to characterize the maturation evolution of this genotype in this environment, with practices to elucidate the nutrient absorption dynamics and their mobility to the fruit.

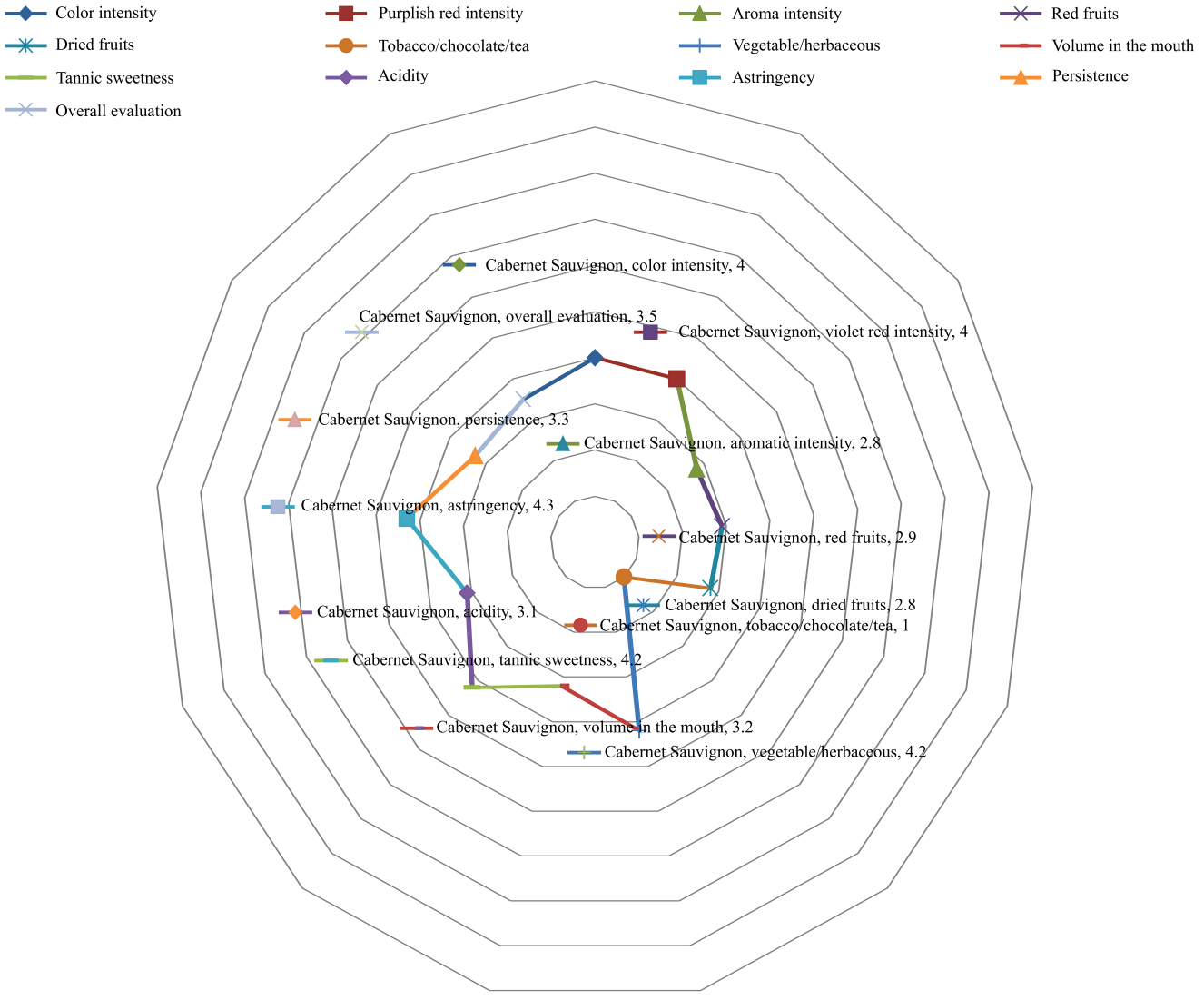

Figure 1. Sensorial analysis of 'Cabernet Sauvignon' wines made with grapes produced in the region of Bagé, RS, Brazil, in the 2008 harvest.

Conclusions

1. 'Cabernet Sauvignon' wines produced with grapes from the region of Bagé, in the state of Rio Grande do Sul, Brazil, differ between the studied crop seasons.

2. Density, alcoholic content, total acidity, pH, reducing sugars, OD 420, 520 and 620, color intensity, total anthocyanins, total polyphenols, sodium, calcium, magnesium, manganese, copper, iron, rubidium, phosphorus, methanol , propanol, 2-methyl-l-propanol, 2,3 - methyl-l-butanol, and the sum of alcohols, show variations over the 2004, 2008, and 2009 crop seasons.

3. 'Cabernet Sauvignon' has potential to be produced in Bagé, and to help it to become a wine producing region in Brazil.

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