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Juices from 'Bordô' and 'BRS Cora' grapes grown in an organic production system in the Serra do Sudeste region

Abstract – The objective of this work was to evaluate the physicochemical composition of juices from the 'Bordô' and 'BRS Cora' grapes grown in an organic production system in the Serra do Sudeste region, in Southern Brazil, as well as to compare the cultivar results with data from other producing regions and with the requirements of the Brazilian regulation for whole grape juice. The used grapes came from a commercial vineyard, specifically from the 2016–2017, 2017–2018, and 2018–2019 production cycles. The juices were prepared by the steam drag method and evaluated for their physicochemical composition. The fruit showed suitable values for the parameters necessary for grape juice production. In general, the juices showed bioactive compounds contents similar to those obtained in other regions. The 'Bordô' juices evaluated in the three production cycles showed significant differences for several variables, which were attributed to the influence of weather on grape maturity. The juices of 'BRS Cora' showed high-consistency qualitative results even under the very distinct meteorological conditions of the three production cycles. The juices comply with the current Brazilian regulation for whole grape juice, except for soluble solids, which are severely lowered by the used extraction technique.

Index terms: *Vitis labrusca*, bioactive compounds, organic cultivation system, physicochemical composition.

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Sucos de uvas 'Bordô' e 'BRS Cora' cultivadas em sistema de produção orgânico na região da Serra do Sudeste

Resumo – O objetivo deste trabalho foi avaliar a composição físico-química de sucos de uvas 'Bordô' e 'BRS Cora' cultivadas em sistema de produção orgânico na região da Serra do Sudeste, no sul do Brasil, bem como comparar os resultados das cultivares com dados de outras regiões produtoras e com as exigências das leis brasileiras para suco de uva integral. As uvas utilizadas provieram de um vinhedo comercial, especificamente dos ciclos produtivos de 2016–2017, 2017–2018 e 2018–2019. Os sucos foram elaborados pelo método de arraste de vapor e avaliados quanto à sua composição físico-química. Os frutos mostraram níveis adequados dos parâmetros necessários para a produção de sucos. Em geral, os sucos apresentaram teores de compostos bioativos semelhantes aos encontrados em outras regiões produtoras. Os sucos de 'Bordô' das três safras avaliadas apresentaram diferenças significativas em vários dos parâmetros, as quais foram atribuídas à influência do clima sobre a maturação das uvas. Os sucos de 'BRS Cora' apresentaram resultados qualitativos de alta consistência, mesmo sob as tão distintas condições meteorológicas dos três ciclos produtivos. Os sucos atendem às regulações brasileiras vigentes para o suco de uva integral, exceto quanto aos valores de sólidos solúveis, que são severamente reduzidos pela técnica de extração utilizada.

Termos para indexação: *Vitis labrusca*, compostos bioativos, sistema de cultivo orgânico, composição físico-química.

Introduction

Factors such as the diversification of the grape variety matrix and the evolution of agro-industrial technologies for juice extraction have contributed to the improvement of the quality and expansion of grape juice in Brazil. Regions such as the southern half region of the state of Rio Grande do Sul (RS), where growing grapevines belonging to the *Vitis labrusca* group is not a traditional activity, have sought, through sustainable development, to change their production matrix (traditionally centered on sheep and cattle) to viticulture, carried out mainly by family farmers (Ritschel et al., 2018b). Currently, the grape production in Rio Grande do Sul is expanding beyond the most traditional producing regions. Between 1995 and 2013, the production that was more concentrated in the northeastern region of the state spread towards west and south, due to the high potential for grape production in these regions (Silva & Rodrigues, 2018). A large part of the grapes produced in the southern half are destined to the production of fine wine, with emphasis on the Campanha Gaúcha region which has been consolidating itself in this productive branch (Anzanello, 2012; Mello, 2018). However, with the increasing demand for grape juice in the Brazilian domestic market during recent years (Ritschel et al., 2018a), there is an opportunity to expand the areas planted with American and hybrid grape cultivars towards the southern half region of Rio Grande do Sul.

'Bordô' (*Vitis labrusca*) is one of the main grape cultivars used for juice production in Brazil (Mota et al., 2018). Very rustic and resistant to fungal diseases, its fruit have a high coloring matter (Ferri et al., 2017). Due to its great climatic adaptation, the 'BRS Cora' has been also an option for the diversification of the juice producing cultivars. 'BRS Cora' is a hybrid cultivar ('Muscat Belly A' x 'H. 65.9.14') developed by Embrapa. It has a raspberry flavor, great color intensity, and it is suitable for cuts with juices from other grapes that display color deficiency (Ritschel et al., 2018b).

The production of grapes under the organic cultivation system has increased worldwide. This is mainly due to the growing number of consumers who consider organic products safer and healthier than those from the conventional agriculture, since organic products are not subjected to the use of pesticides and chemical fertilizers in their cultivation (Cosme et al., 2018). The demand for organic juices is a reality (Flores, 2018). Some studies report that the concentration of phenolic constituents in juices of grapes cultivated in the organic system is significantly higher than that of grape juices from the conventional system (Toaldo et al., 2015). However, for the Campanha Gaúcha region under study, there is neither available literature on the subject, nor a report on the region producers cultivating the same cultivars in a conventional way; thus, a comparison of results on the matter should be performed. It is also known that the botanical and geographic grape origins significantly influence the antioxidant activity and the phenolic composition of juices. Thus, comparisons with conventional juices from other regions are not suitable (Granato et al., 2016).

The objective of this work was to evaluate the physicochemical composition of juices from the 'Bordô' and 'BRS Cora' grapes grown in an organic production system in the Serra do Sudeste region, in Southern Brazil, as well as to compare the cultivar results with data from other producing regions and with the requirements of the Brazilian regulation for whole grape juice.

Materials and Methods

The experiment was carried out during the 2016/2017, 2017/2018, and 2018/2019 production cycles, using grapes of the 'Bordô' and 'BRS Cora' obtained from a commercial producer, with certification for organic production, located in the municipality of Caçapava do Sul (30.34º S, 53.28º W, at about 450 m altitude), in the state of Rio grande do Sul, Brazil. The climate of the region is Cfa type, according to Köpen-Geiger's climate classification (Alvares et al., 2013). The harvest dates followed the producer's calendar, taking place on January 26, 23, and 29 of 2017, 2018, and 2019, respectively.

Grapes were harvested manually and placed in sanitized plastic boxes for transport to the laboratory. They were then selected and destemmed manually. A sample of the grapes was collected for analysis of soluble solids content before preparing the juices.

The juices were extracted using the steam distillation method, using a steam juicer with capacity for 20 kg of grapes. Destemmed berries were deposited in the perforated container, which was fitted in the external compartment and then coupled over the water tank. The whole set was placed on a gas stove. About 20 min after heating begun, the juice started to flow through the outlet tube. The bottling process was carried out hot, at temperatures of about 85ºC, in previously sanitized 1.0 L glass bottles. The bottles were left at room temperature to cool down and were subsequently stored in a cold room at 5°C until analysis.

To analyze the soluble solids (SS) content of grapes, expressed in °Brix, a number of berries were pressed from different portions of the bunch of different bunches, the wort was filtered, and the reading was performed in a digital refractometer PAL 1 (Atago and CO., Fukuy, Japan). Juice SS content was determined with a digital bench refractometer with automatic temperature compensation (Quimis Aparelhos Científicos, Diadema, SP, Brazil).

The following parameters were analyzed in the juices, according to Bender et al. (2021): total acidity (TA, mEq L^{-1}); pH reducing sugars (g L^{-1}); total anthocyanins (ANT, mg of cyanidin-equivalent 3-glycoside L^{-1} juice); total polyphenols (TP), in (mg of catechin-equivalent L^{-1}); antioxidant capacity (AC), in Trolox (µmol L^{-1} TEAC mL^{-1}). Juice color was determined by the model CM-5 colorimeter (Konica Minolta, Tokyo, Japan), recording the coordinates L*, a*, and b*. The parameter L* represents the luminosity of the sample, and the values of a* and b* were used in the calculation of the intensity (chroma) and hue (°Hue) of the color, obtained by the following equations: $C^* = [(a^*)^2+(b^*)^2]^{1/4}$ and $°Hue = \arctan b^*/a^*$, respectively. Total polyphenols, total anthocyanins, antioxidant capacity, and color parameters could not be analyzed in the samples from the 2018/2019 production cycle.

Monthly meteorological data were collected for the following parameters: rainfall (R, mm); global solar radiation (GR, W m^{-2}); effective insolation (EI, hours), counting the hours when radiation was greater than 120 W m^{-2} (Tiba, 2000; WMO, 2003); maximum (Tmax, ºC) and minimum (Tmin, ºC) temperatures; and relative humidity (RH, %). All data were collected in December and January, which corresponds to the final months of maturation and harvest for all cultivars in the production cycles under study. Data were obtained from the automatic meteorological stations of the national institute of meteorology (Inmet, 2020). In addition, the rainfall accumulated during the 5, 10, 15, and 20 days before the grape harvesting (dbh) were calculated. The heliopluviometric index of maturation (HI) was calculated using the methodology proposed by Westphalen (1977).

The experimental design was unifactorial, and the production cycle was the treatment factor. A completely randomized design was carried out for each grape cultivar with four replicates. The experimental unit is represented by a 1.0 L juice bottle.

Data relating to normality were analyzed by Shapiro Wilk test, heteroscedasticity according to Hartley test, and residues independence using graphic analysis. The results were subjected to the analysis of variance, and those showing significant differences had their means compared by Tukey's test, at 5% probability. Statistical analysis were run with the software Rbio (Bhering, 2017).

Results and Discussion

The juice of 'Bordô' grapes showed mean SS values varying from 9.9 to 13.1 °Brix; and juices from the 2017–2018 and 2018–2019 cycles showed higher values than that of the 2016–2017 cycle (Figure 1 A). Soluble solids in 'BRS Cora' juices ranged from 11.5 to 12.1 ºBrix and showed no differences for any of the evaluated cycles (Figure 1 B). According to the Brazilian regulatory instruction (Instrução Normativa n°14, de 8 de fevereiro de 2018), whole grape juices should have 14 ºBrix as minimum SS content (Brasil, 2018). Therefore, none of the juices produced in the present study complied with the current regulation. Nonetheless, before the juice extraction, grapes (or must) showed values from 12.0 to 15.7 °Brix in 'Bordô' grapes (Figure 1 A), and from 14.1 to 15.5 °Brix in 'BRS Cora' grapes (Figure 1 B), in the three production cycles. These results can be explained by the extraction method used, which invariably incorporates water into the juice through the condensation of water vapor during extraction. Eventually, higher SS values could have been obtained if grapes were harvested later. Nevertheless, the producer's calendar, which is determined by crop season intrinsic conditions, and the feasibility of operations under commercial production standards, was the criterion followed in this research.

The juice physicochemical parameters are largely influenced by juice elaboration conditions (Bender et al., 2018). Among such conditions we considered the following as important ones: the steam distillation extraction method, which employs a steam juicer; the form of heating; and the temperature of water and grapes. Another study has already observed that different amounts of water were incorporated into the juice, when different heating sources were coupled to steam juicers at industrial scale (Marcon et al., 2016);

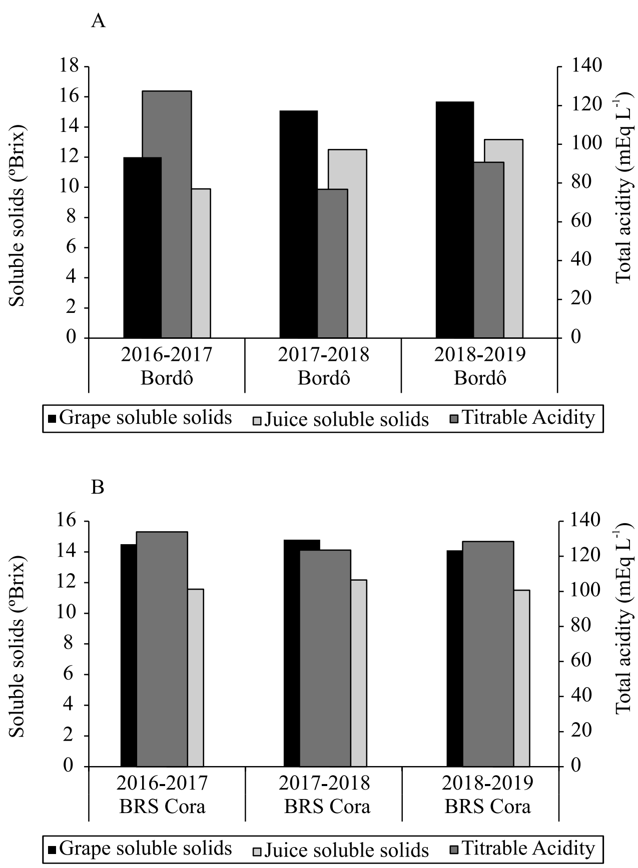

Figure 1. Mean values of the soluble solids content in grapes and grape juices, and titratable acidity in juices produced from 'Bordô' (A) and 'BRS Cora' (B) grapes, in the 2016–2017, 2017–2018, and 2018–2019 production cycles, in the Serra do Sudeste region, in Southern Brazil. Means followed by the equal letters, in the columns, do not differ by Tukey's test, at 5% probability. ^{ns}Nonsignificant.

these authors also report a reduction of up to 3.8 ºBrix, when comparing the SS content in grapes and their juices.

Among the 'Bordô' juices, those produced in the 2016–2017 cycle showed the highest average values for TA (Figure 1 A). Regarding this same parameter, 'BRS Cora' juices (Figure 1 B) were statistically equal for all production cycles. During the maturation process, SS levels increase and organic acids decrease (Kurt et al., 2017). Therefore, considering that the lowest values for SS also occurred in 'Bordô' juices in the 2016–2017 cycle, we can infer that the grapes were harvested early, before reaching their ideal ripeness. Invariably, it is worth mentioning that all juices obtained in the present study fit within the Brazilian regulation threshold, which requires a minimum of 55 mEq L^{-1} TA (Brasil, 2018).

The results regarding reducing sugars followed the trend of the SS results. 'Bordô' juices from 2017–2018 and 2018–2019 showed higher average values of reducing sugars, 117.04 and 120.07 g L^{-1}, respectively, and they were statistically non-different from each other (Figure 2 A). 'BRS Cora' juices, contained 104.0, 110.6, and 99.5 g L^{-1} of reducing sugars in the 2016–2017, 2017–2018, and 2018–2019 cycles, respectively, and they were statistically equal (Figure 2 B). This result was expected because the two variables are related, as sugar is the main component in the SS content (Rizzon & Link, 2006).

Among all meteorological analyzed data, those that showed the greatest variability between the production cycles were rainfall and maturity heliopluviometric index, and the latter was mostly determined by rainfall. The other parameters showed similar values (Table 1). A large volume of precipitation occurred in the months December and January of the 2018–2019 cycle in the city of Caçapava do Sul. This would contradict the results found in the present study, since the highest SS values and reducing sugars were found in this cycle, and they did not differ from those of the previous cycle (2017–2018), when there was almost no precipitation (Table 1). It is well-known that when rainy periods occur during the stage of grape maturation, the accumulation of sugars is negatively affected (Regina et al., 2010). However, when analyzing the precipitation accumulated at 10 days before the grape harvest in each cycle, it can be noted that the largest volume of rain occurred in the 2016–2017 cycle (Figure 3). In the 2018–2019 cycle, there were a lower precipitation volume, up to 10 days before harvest, resulting in grapes with good sugar levels, even when high precipitation values were accumulated during the grape maturation months. Thus, it can be noted that the number of dry days before harvest can influence the grape quality in rainy production cycles. Humid years, which were dry and sunny only at the end of the maturation period, still produced satisfactory qualitative results (Van Leeuwen & Darriet, 2016). In January 2019, Tmax and Tmin were higher, and RH lower than in 2017 (Table 1), which contributed to the SS increase. At the end of the maturation period, the SS accumulation is probably less a result of photosynthesis than a consequence of the concentration caused by evaporative loss (Keller, 2010).

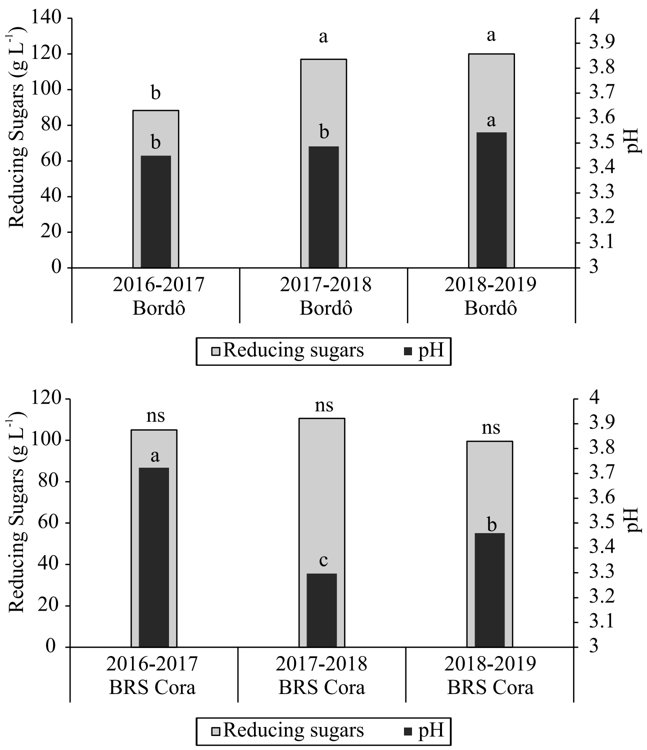

Figure 2. Mean values of reducing sugars and pH found in juices produced from 'Bordô' (A) and 'BRS Cora' (B) grapes, in the 2016–2017, 2017–2018, and 2018–2019 production cycles, in the Serra do Sudeste region, in Southern Brazil. Means followed by equal letters, in the columns, do not differ by Tukey's test, at 5% probability. [ns]Nonsignificant.

The ideal pH to obtain a quality grape juice is between 3.1 and 3.3 (Iniciando…, 2004). 'BRS Cora' juice produced in the 2017-2018 cycle met this quality requirement (Figure 2 B). Studies report an increase of the pH values of grapes, when there is increased availability of water to plants at the time of maturation (Miguel Filho et al., 2020). This may help to explain why 'BRS Cora' juice had a high pH in the 2016–2017 and 2018–2019 cycles (Figure 2 B). The same trend can also be observed for 'Bordô' juices, except for the 2016–2017 cycle (Figure 2 A).

Phenolic compounds impact on the color, astringency, and structure of grape juices. Among the phenolics, the most important groups are anthocyanins, tannins, and phenolic acids (Rizzon & Link, 2006). Some studies suggest that juices produced from grapes grown in organic production systems have very similar qualitative characteristics with juices from grapes grown in conventional systems; however, the organic grape juices tend to have higher levels of bioactive compounds (Granato et al., 2016). 'Bordô' grape juices from the 2017–2018 cycle had the highest average values of phenolic compounds, anthocyanins, and antioxidant capacity, in comparison with those from its

Table 1. Rainfall, global radiation (GR), effective insolation (EI), maximum temperature (T max) and minimum temperature (T min), relative humidity (RH), and maturity heliopluviometric index (HI) in December and January, in the 2016–2017, 2017–2018, and 2018–2019 production cycles, in the Serra do Sudeste region, in Southern Brazil (Inmet, 2020).

Production cycle	Month	Rainfall (mm)	GR ($W\ m^{-2}$)	EI (hour)	T max (°C)	T min (°C)	RH (%)	HI (months)
2016–2017	December	154.80	760,033.80	394.00	27.19	17.20	73.48	2.55
	January	137.20	715,165.30	396.00	27.23	18.53	83.46	2.89
2017–2018	December	23.20	810,272.00	399.00	28.38	17.30	70.04	17.20
	January	66.80	746,378.70	391.00	28.37	18.16	72.13	5.85
2018–2019	December	190.40	769,175.70	387.00	26.41	16.66	72.54	2.03
	January	301.40	641,197.40	381.00	27.62	19.66	81.00	1.26

previous cycle (Table 2). The best weather conditions, combined with the harvest at the appropriate maturation point, directly influenced this result. The levels of total polyphenols and anthocyanins (235–2,509 g L^{-1} and 7,320–8,230 μmol L^{-1} TEAC mL^{-1}, respectively) were within the range of those found in 'Bordô' juices produced in Santa Catarina by artisanal producers (Burin et al., 2010). The antioxidant activity correlates well with the content of polyphenols (Silva et al., 2016), as it could also be noted in the present study.

'BRS Cora' juices showed no statistical differences for any of the parameters related to the concentration of bioactive compounds, in any of the production cycles under study (Table 2). This result, together with the other parameters already discussed, shows the qualitative consistency of 'BRS Cora' juice produced in Caçapava do Sul. This cultivar seems to be less affected by the different weather conditions in the different production cycles. This result is in accordance with the purposes and applications for this cultivar which was developed to have the capacity to adapt to a wide range of climates (Ritschel et al., 2018b). Furthermore, 'BRS Cora' can improve the phenolic profile and antioxidant potential in blends with juices from other varieties or cultivars, being potentially a functional food (Silva et al., 2016). The TP values found in the present study are within the range of those found in 'BRS Cora' juices produced in different regions of Brazil (1,944–2,216 g L^{-1}) (Lima et al., 2014; Silva et al., 2016, 2019a). While the AC values are higher than those found in juices produced in São Paulo (2,500 μmol L^{-1} TEAC mL^{-1}) (Silva et al., 2016).

Juice color is directly linked to its phenolic composition and antioxidant capacity (Granato et al., 2016). The two cultivars under study had high content of coloring matter (Table 2). Intensely colored juices are preferred by consumers (Bender et al., 2020). The 'Bordô' cultivar has spread throughout Brazil mainly due to this characteristic (Ferri et al., 2017). 'BRS Cora' is recommended to obtain intensely colored grape juice or to improve juices with deficient color (Silva

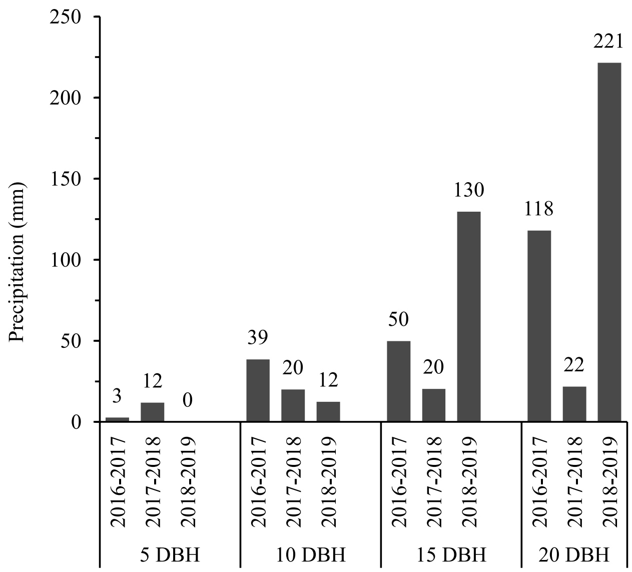

Figure 3. Precipitation (mm) at 5, 10, 15, and 20 days before harvest (DBH) of 'Bordô' and 'BRS Cora' grapes in the 2016–2017, 2017–2018, and 2018–2019 production cycles, in the Serra do Sudeste region, in Southern Brazil (Inmet, 2020).

Table 2. Average values of total polyphenols (TP, gallic acid-equivalent mg L^{-1}), anthocyanins (ANT, mg of malvidin 3-glycoside L^{-1} equivalent), antioxidant capacity (AC, in Trolox (μmol L^{-1} TEAC mL^{-1}); and color parameters: luminosity (L*), hue (°Hue), and color saturation (C*) found in juices produced with 'Bordô' and 'BRS Cora' grapes, in the 2016–2017 and 2017–2018 production cycles, in the Serra do Sudeste region, in Southern Brazil[(1)].

Juice	Cycle	TP	ANT	AC	L*	°Hue	C*
'Bordô'	2016–2017	1,502.20b	83.81b	2,805.00b	40.32a	352.43a	63.50a
'Bordô'	2017–2018	2,290.07a	189.10a	7,348.33a	15.38b	2.52b	47.08b
CV (%)		17.07	17.00	18.39	14.27	13.72	9.01
'BRS Cora'	2016–2017	2,168.87[ns]	126.87[ns]	7,920.00[ns]	33.73a	8.64[ns]	54.24[ns]
'BRS Cora'	2017–2018	1,969.13	131.39	8,388.33	21.19b	11.38	51.24
CV (%)		5.52	4.47	8.35	15.57	23.75	10.81

[(1)]Means followed by equal letters, in the columns, do not differ by Tukey's test, at 5% probability. [ns]Nonsignificant. CV, coefficient of variation.

et al., 2016, 2019b). 'Bordô' and 'BRS Cora' juices of the 2017–2018 cycle showed a lower value for L*. This parameter, which varies from white (L* = 100) to black (L* = 0), shows that the lower the value, the darker the sample (Wrolstad et al., 2005; Bender et al., 2020). From the °Hue values, it can be noted that 'Bordô' juices tend to red-blue shades because they have values close to 360°, while 'BRS Cora' juices tend to red (°Hue varying between 8.64 and 11.38) (Table 2). The C* value, which represents the intensity or the saturation of the color, showed no significant difference for 'BRS Cora' juices in the three cycles, but it was higher in 'Bordô' juices of the 2016–2017 cycle, indicating its intensity of reddish-purple pigments (Wrolstad et al., 2005).

Conclusions

1. 'BRS Cora' juices show consistent physicochemical composition in crop seasons under various weather conditions.
2. The physicochemical composition of juices produced from 'Bordô' and 'BRS Cora' grapes grown in organic production system in the Serra do Sudeste region, in Southern Brazil, is similar to those obtained in other regions.
3. 'Bordô' and 'BRS Cora' juices comply with the current Brazilian regulation for whole grape juice, except for the values of soluble solids, which are severely lowered by the extraction technique (steam juicer) employed.

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