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Physicochemical parameters of juices made from different grape varieties in the 2019 and 2020 Harvests of Rio Grande do Sul

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Abstract. Analyzing the physicochemical parameters of grape juice is fundamental for understanding variations between different harvests and cultivars and their implications for the quality of the final product. With few up-to-date articles and studies available on the physicochemical parameters of grape juice, this study aimed to evaluate these parameters in grape juices produced from different varieties in the 2019 and 2020 harvests in Serra Gaúcha. The parameters analyzed included total acidity, density, Brix degree, sugar content, color intensity, anthocyanins, tannins, total polyphenol index, alcohol content, pH, and antioxidant activity, correlating with legislation. Values were expressed as means and standard deviations, and statistics were analyzed using analysis of variance (ANOVA) and Tukey's post-hoc test, with values considered significant when $p \leq 0.05$. Comparative analysis between juices made with different grape varieties revealed important differences in anthocyanin levels, tannins, total polyphenols, antioxidant activity, and color intensity for juices made exclusively with Bordeaux grapes. The comparative analysis between vintages showed statistical differences for anthocyanins, antioxidant activity, color intensity, and tannins.

1. Introduction

The history of winemaking in Rio Grande do Sul (RS) is deeply intertwined with the arrival of immigrants during the state's colonization period, starting with the Germans and later the Italians. While the Portuguese and Spanish had already introduced viticulture to RS, the Italian immigrants truly elevated its significance within the Gaucho landscape [1].

As described by Lavandoski, Tonini, and Barreto (2012) [2] and Manfio (2019) [1], Italian immigrants brought with them not only winemaking traditions but also the knowledge and passion for wine production. This transformed viticulture in RS into a daily activity and a cornerstone of the local economy. Influenced by cultural elements and the collective memory of Italian descendants, a strong identity developed around the production and commercialization of wines, encompassing various traditions and expressions within the context of viticulture. The Serra Gaúcha region stands out as a prominent area for both wine production and wine tourism [2].

Climatic factors play a crucial role in the quality of grapes and, consequently, their derived products [3]. Characteristics such as humidity, rainfall, and average annual temperature, unique to each region, directly influence the organoleptic properties [4]. Climate adversities and their constant changes in recent years have led to alterations in color, maturation, and physicochemical characteristics. To mitigate these effects, producers often resort to growth regulators to enhance grape quality [5].

As stipulated in Article 18 of Decree No. 6.871/2009, "juice" refers to an unfermented, unconcentrated (except in specific cases), and undiluted beverage. This beverage undergoes a treatment process to ensure its quality and preservation until consumption. Additionally, the legislation states that the juice should not contain substances foreign to the fruit or plant of origin, except those permitted by specific regulations [6].

Given its significant content of phenolic compounds, grape juice is consumed for its natural antioxidant properties [7-8]. The state of RS plays a vital role in Brazil's grape industry, contributing over 50% of the total harvest volume and approximately 90% of the national grape juice production. This underscores the importance of research to ensure the authenticity and genuine origin of these products.

The nutritional benefits of grape juice have spurred increased research interest. Consumers are becoming more aware of the health benefits associated with grape juice [8]. However, maintaining consistency and safety in grape juice production is essential to ensure that nutritional and flavor standards remain consistent over time. Rigorous monitoring of production processes and ingredient selection contributes to delivering grape juice that meets established criteria and provides consumers with a reliable and healthy product [9].

Silva (2010) [10] noted that chemical composition varies significantly among grape cultivars, with differences in phenolic profiles resulting in grapes with distinct flavors and colors. Therefore, characterizing different grape varieties is crucial. Given the limited research on the physicochemical parameters of grape juices, this study aimed to conduct a detailed analysis of these parameters in grape juices produced from various varieties in Serra Gaúcha/RS during 2020.

2. Material and methods

A total of 43 juice samples were included in this study: 17 from the 2019 harvest and 26 from the 2020 harvest. These were divided into four distinct categories: juices made exclusively with Bordô grapes (SB, n = 12), juices produced from Bordô and Isabel grapes (SBI, n = 13), juices made with blends of various grape varieties (SV, n = 16), and juices combining Bordô and Niagara grapes (SBN, n = 2). Data were obtained from a database containing physicochemical analyses of grape juices conducted by a specialized beverage testing laboratory in Serra Gaúcha/RS.

The physicochemical parameters analyzed included total acidity (meq/L), density (20/20°C), Brix, sugar content (g/100 mL), color intensity (ABS), anthocyanins (mg/L), tannins (g/L), total polyphenol index (ABS), alcohol content (% v/v), pH, and antioxidant activity using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method. Values were expressed as means and standard deviations. Statistical analysis was performed using analysis of variance (ANOVA) and Tukey's post-hoc test, considering values significant when $p \leq 0.05$, using the SPSS 25.0 statistical program for Windows.

3. Results and discussion

The average climatic conditions for the 2019 and 2020 harvests, along with the average relative humidity per year, are presented in Table 1. The physicochemical parameters of the 43 juice samples from 2019 and 2020 are shown in Tables 2 and 3. Some analyses, such as color intensity, showed statistical significance, being higher in SB compared to the others (p = 0.001). Similarly, anthocyanin values in SB were significantly higher than in the other juices (p = 0.001).

Table 1. Average high and low temperatures and relative humidity between the years 2019 and 2020.

Parameters	Years	
	2019	**2020**
Higher average temperature (ºC)	25,6	36,5
Lower average temperature (ºC)	17,1	14,5
Average relative humidity (%)	80,6	84,5

Source: Prepared by the author, 2024.

Canossa et al. (2017) reported an anthocyanin content of 124 mg/L, significantly lower than the 2004.08 ± 1259.57 mg/L found in the present study, and high color intensity (420 nm and 620 nm) in juices produced with Bordô grapes. In this context, the authors highlight that the grape variety influenced the color intensity of the juice, with Bordô grape juice exhibiting the highest intensity, correlated with the highest total anthocyanin content.

Furthermore, for grapes intended for juice production, high levels of coloring matter are essential. Color is crucial for consumer acceptance, as juices with low color intensity are less appealing. Additionally, grapes with low pigment content tend to be deficient in sugar and excessively acidic, making color a good indicator of the overall quality of the grape and juice [10].

According to Malacrida and Motta (2006) [11] and Monteiro (2002) [12], anthocyanins are plant pigments that impart blue, purple, and all shades of red. These compounds are water-soluble and highly unstable at high temperatures, widely used as natural colorants, and their intensity is evaluated by the absorption of light at specific wavelengths, reflecting the quantity and type of pigments present.

When evaluating tannin levels, the values for SB were 5.08 ± 1.02 (g/L), higher than that observed in SBN, which was 3.15 ± 0.45 (g/L) (p = 0.002). Regarding the total polyphenol index, SB showed 106.36 ± 17.66, higher than the 63.15 ± 9.05 observed for SBN (p = 0.003).

Tannins are phenolic compounds that contribute to astringency, flavor, color, and product stability. Polyphenols are important antioxidants that also influence color and flavor and offer health benefits to foods and beverages [13-14].

According to Kowal et al. (2023) [15] and Santos (2021) [16], the diversity in the results of the analyses can be attributed to different grape varieties, climatic conditions, soil, agricultural practices, and processing methods used by the industry. Consequently, the production technique of grape juices can vary in the extraction of compounds from the grape cascade, resulting in significant differences in the chemical composition of the juice, especially in components related to its color.

Changes in color, pH, and the environment can influence anthocyanin levels, as these substances can degrade under various conditions such as high temperatures, changes in the color of the medium, or exposure to light [17-18].

The pH results varied between 3.42 ± 0.15 and 3.25 ± 0.08, which partially agrees with the study by Barbosa (2023) [17], who found an average pH of 3.6. The pH of the juice is influenced by the genetic diversity of the grapes and the manufacturing process and is also relevant to the flavor of the final product [18].

In the present study, the antioxidant activity of all types of juice showed values very close to 100%. This finding is similar to a study conducted by Bassanesi, Andrade, and Salvador (2020) [19] on the antioxidant capacity of juices and nectars from grapes in Rio Grande do Sul, where the authors reported that the antioxidant activity in red grape juices ranged from 95.85% to 97.38%. These results corroborate the high antioxidant capacity observed in this study, especially for SB and SBI grapes.

Table 2. Results of the physicochemical parameters of juices made from different grape varieties.

Parameters	Bordeaux	Bordeaux and Isabel	Cut of various varieties	Bordeaux and Niagara
Total acidity (meq/L)	97,07 ± 9,75^{A}*	97,13 ± 8,45^{A}	101,33 ± 14,45^{A}	87,25 ± 5,85^{A}
Sugar (g/100mL)	14,67 ± 0,74^{A}	14,26 ± 1,12^{A}	14,63 ± 1,22^{A}	14,43 ± 0,38^{A}
Anthocyanins (mg/L)	2004,08 ± 1259,57^{B}	368,98 ± 300,37^{A}	477,14 ± 366,73^{A}	634,6 ± 303,8^{A}
AA (%)	97,58 ± 0,27^{B}	97,31 ± 0,59^{AB}	97,49 ± 0,53^{B}	96,42 ± 0,99^{A}
°Brix	16,03 ± 0,69^{A}	15,67 ± 1,04^{A}	15,92 ± 1,11^{A}	15,75 ± 0,35^{A}
Density (20/20°C)	1,0655 ± 0,0029^{A}	1,0639 ± 0,0045^{A}	1,0653 ± 0,0049^{A}	1,0643 ± 0,0016^{A}
AC (% v/v)	0,27 ± 0,10^{A}	0,37 ± 0,27^{A}	0,25 ± 0,07^{A}	0,16 ± 0,02^{A}
TPI (ABS)	106,36 ± 17,66^{B}	67,84 ± 17,73^{A}	66,23 ± 13,37^{A}	63,15 ± 9,05^{A}
Color intensity (ABS)	2,73 ± 1,03^{B}	1,42 ± 0,72^{AB}	1,47 ± 0,68^{AB}	1,17 ± 0,45^{A}
pH	3,42 ± 0,15^{A}	3,28 ± 0,09^{A}	3,26 ± 0,07^{A}	3,25 ± 0,08^{A}
Tannins (g/L)	5,08 ± 1,02^{B}	3,41 ± 0,89^{A}	3,33 ± 0,68^{A}	3,15 ± 0,45^{A}

Source: Prepared by the author, 2024. AA: Antioxidant activity; AC:Alcohol content; TPI: Total polyphenol index *Values followed by different uppercase letters on the same line are statistically different ($p \leq 0.05$).

Table 3. Comparison between grape juice samples by harvest.

Parameters	Average of the juices from 2019 (n=17)	Average of the juices from 2020 (n=26)	p-value*
Total acidity (meq/L)	103,55 ± 14,09	94,73 ± 8,16	0,144
Sugar (g/100mL)	13,66 ± 0,55	15,08 ± 0,92	0,057
Anthocyanins (mg/L)	247,98 ± 197,07	1289,75 ± 1109,50	0,001
Antioxidant activity (%)	97,21 ± 0,78	97,54 ± 0,32	0,003
°Brix	15,09 ± 0,57	16,37 ± 0,84	0,183
Density (20/20°C)	1,0615 ± 0,0024	1,0671 ± 0,0037	0,122
Alcohol content (% v/v)	0,31 ± 0,19	0,27 ± 0,16	0,193
Total polyphenol index (ABS)	65,65 ± 18,62	85,70 ± 23,60	0,111
Color intensity (ABS)	1,17 ± 0,47	2,20 ± 1,03	0,000
pH	3,29 ± 0,16	3,33 ± 0,09	0,241
Tannins (g/L)	3,11 ± 0,58	4,30 ± 1,18	0,002

Source: Prepared by the author, 2024. *Values were significantly different by the T-test when $p \leq 0.05$.

According to current legislation, specifically Normative Instruction No. 14 of February 8, 2018, from the Ministry of Agriculture, Livestock, and Supply [6], grape juices are required to meet certain minimum and maximum physicochemical parameters, including a Brix degree of at least 14.0, a total acidity of at least 55 mEq/L, and a maximum alcohol content of 5% v/v [6].

However, the quality of grape juice is intrinsically linked to the quality of the grapes used in its production. Adhering to the standards required by the Ministry of Agriculture, Livestock, and Supply (MAPA) is essential for ensuring product quality. Consequently, grape juice can also contribute positively to the diet. The demand for grape juice consumption has been progressively increasing, driven by consumers' ongoing search for a healthy diet [20, 8, 21].

Studies by Almeida, Ribeiro, and Costa (2022) [21] indicate that grape juice consumption is associated with various benefits in the prevention of chronic diseases, including the inhibition of platelet aggregation, reduction of low-density lipoprotein (LDL) oxidation, improved cardiovascular health, and enhanced neurocognitive function. Additionally, the benefits related to chronic disease prevention are associated with the presence of antioxidant compounds in grape juice, which can neutralize free radicals. At adequate concentrations, these antioxidants can slow the oxidation of substances, providing protection to biological systems and preventing damage that may lead to serious diseases.

Therefore, according to Pontes et al. (2010) [7] and Junges (2023) [8], grape juice is consumed for its significant amount of phenolic compounds, which provide natural antioxidant substances. However, ensuring the consistency and safety of the product is crucial for maintaining uniform nutritional and flavor standards over time. Rigorous monitoring of production processes and careful selection of ingredients contribute to delivering grape juice that meets established criteria, providing a reliable and healthy experience for consumers [9].

In this context, the results obtained confirm that the analyzed samples comply with MAPA standards, demonstrating consistency and similarity regardless of the grape varieties used in juice production. This highlights the excellent quality of grape juices produced by the industry, regardless of the year or grape variety used, ensuring the quality and safety of the final product. Additionally, the study confirms the presence of significant concentrations of anthocyanins, within the limits established by MAPA, and other beneficial components such as antioxidants and phenolic compounds, which contribute to reducing the risk of cardiovascular diseases and inhibiting platelet aggregation. Thus, the study offers good options for consumers, promoting more informed and healthy food choices.

4. Conclusions

Juices produced exclusively with Bordô grapes exhibit higher indices of color intensity, anthocyanins, antioxidant activity, total polyphenols, and tannins compared to juices made with Isabel, Niagara, or a blend of different varieties, presenting a potential for market differentiation.

In the 2020 harvest, juices showed higher values for anthocyanins, antioxidant activity, color intensity, and tannins.

The results of this research confirm that all analyzed samples comply with the identity and quality standards established by MAPA.

Antioxidant activity, as measured by the DPPH radical scavenging capacity, was close to 100% in all samples evaluated.

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6. References

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