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Phenolic composition and physicochemical analysis of wines made with the Syrah grape under double pruning in the Brazilian high-altitude Cerrado

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Abstract. This study explores the growing potential of vitiviniculture in Brazil's Federal District, an emerging wine region marked by unique climatic conditions and innovative cultivation techniques. With the recent development of winter wine production using double pruning, this region demonstrates promising results, especially for the Syrah grape variety. The vines undergo two distinct annual cycles due to the absence of dormancy, typical in tropical viticulture. Physicochemical and phenolic composition of nine Syrah wine samples from the 2022 and 2023 harvests were analysed. Results showed significant year-to-year differences: 2022 wines had higher total phenolic compounds (76.68±10.42 mg/L) ($p=0.0221$) and cyanidin (19.19±1.32 mg/L) ($p=0.036$) levels, while 2023 samples had greater resveratrol (9.36±0.66 mg/L) ($p<0.0001$) and catechin (54.20±2.31 mg/L) ($p=0.0065$) contents. These variations may be attributed to environmental factors, as temperature fluctuations and rainfall disparities. Despite these differences, all wines exhibited a robust phenolic profile, indicating strong potential for the region's wines. The findings suggest the feasibility of a future designation of origin, highlighting the need for further studies.

1. Introduction

Wine has long been intertwined with the history of Western civilization, expanding into new territories over the centuries. Although viticulture in Brazil is relatively recent compared to traditional wine-producing countries, the country offers significant potential for grape cultivation. This is largely due to its diverse environmental conditions—particularly the variability in climate and soil across different regions [1].

In Brazil, this expansion is reflected in the emergence of new wine-producing areas that go beyond traditional viticultural zones. Innovations such as tropical viticulture and the unique production of winter wines have contributed to this development [2]. As a result, vitiviniculture holds growing socioeconomic importance in the country. According to the Brazilian Ministry of Agriculture and Livestock, the state of Rio Grande do Sul—located in southern Brazil—accounts for the largest area under grapevine cultivation, followed by the northeastern states of Pernambuco and Bahia [3]. Rio Grande do Sul is thus recognized as Brazil's principal vitivinicultural region. In this area, approximately 86% of grrape production comes from *Vitis labrusca L.* and its hybrids [4].

However, new regions such as the high-altitude Cerrado have gained recognition for their promising production potential and wine quality. Historically, viticulture in this semi-arid region was considered unfeasible, but the introduction of a technique known as winter viticulture has made it possible. This method relies on double pruning, where a formation prune is conducted after harvest—typically in September—and a production prune follows in February. This technique shifts the harvest season from summer to winter, a period characterized by hot days and cool nights, which favor optimal grape maturation. The approach is viable in areas where vines do not undergo endodormancy, and studies have shown that the Syrah variety is particularly well-suited to this cultivation method [5].

Over the past two decades, the quality of Brazilian wines has improved significantly. This progress is attributed to the introduction of new grape varieties, the adaptation of cultivars, clones, and rootstocks, as well as advancements in both agronomic practices and oenological techniques. Nonetheless, climate remains a major challenge. In the South and Southeast regions, grapes typically follow a single annual production cycle from August to February. Harvest occurs during the rainy summer months (December to March), increasing the risk of fungal diseases and grape rot [6,7]. In contrast, Brazil's tropical regions—particularly in the Northeast—experience higher temperatures and lower thermal amplitude during ripening, which can slow the accumulation of phenolic compounds. These compounds are crucial for grape color, structure, and wine stability [8].

Globally, wine is among the most widely consumed beverages. Its composition includes alcohols, sugars, acids, minerals, proteins, and various compounds such as organic acids, volatiles, and polyphenols. Among these, polyphenols are especially important, as they influence wine quality—affecting color, flavor, and mouthfeel—and also offer health benefits, including antioxidant and cardioprotective properties [9]. Therefore, understanding the physicochemical and phenolic composition of wine is essential for a comprehensive evaluation of its quality.

At the 45th OIV Congress, held in Dijon during the organization's centennial celebration, we presented the initial findings of this research [5]. The present article continues that work, with the aim of investigating the physicochemical and phenolic composition of Syrah wines from the 2022 and 2023 harvests. This study seeks to deepen our understanding of the impact of phenolic and technological ripening in grapes cultivated in Brazil's Federal District.

2. Material and Methods

2.1. Samples

For this study, commercially available wines made from the Syrah grape variety were selected, comprising six samples from the 2023 vintage and three samples from the 2022 vintage.

2.2. Analysis

The analysis were carried out during 2024 and 2025, at the Oenological Reference Laboratory (LAREN/SEAPI) of the State Secretariat of Agriculture of Rio Grande do Sul, located in Caxias do Sul, Brazil.

2.2.1. Alcoholic strength

The alcoholic strength was determined by distilling the wine, followed by measuring the alcohol content of the resulting distillate. The procedure followed the reference method OIV-MA-AS312-01A, as outlined in the 2024 Compendium of International Methods of Wine and Must Analysis of the OIV [10].

2.2.2. Total acidity

The total acidity was determined by potentiometric titration, in accordance with the OIV-MA-AS313-01 method [10].

2.2.3. Volatile acidity

The volatile acidity was determined by distillation followed by titration, in accordance with the OIV-MA-AS313-02:R2015 method [10].

2.2.4. Total Dry extract

Total dry extract was determined using an adapted version of Method OIV-MA-AS2-03A [10].

2.2.5. Density

The density was determined according to the OIV-MA-AS2-01 method [10].

2.2.6. Chlorides

The chlorides content was determined by potentiometric analysis, following the OIV-MA-AS321-02 method [10].

2.2.7. Total phenolic compounds

The total phenolic compounds were analyzed by direct absorbance measurement at 280 nm using a Prove 600 Spectroquant spectrophotometer (Merck Millipore), following the methodology described by [11].

2.2.8. Resveratrol

The trans-resveratrol content was determined by High Performance Liquid Chromatografy (HPLC), with diode array detector, following [12].

2.2.9. Catechin and Epicatechin

The catechin and epicathechin concentrations were determined by High performance liquid Chromatografy (HPLC), with diode array detector, following the method of [13] adapted.

2.2.10. Antocyanins

The concentrations of cyanidin, delphinidin and malvidin-3-O-glucoside were determined by High performance liquid Chromatografy (HPLC), with diode array detector, following the method OIV-MA-AS315-11 - HPLC - Determination of nine major Anthocyanins in red and rosé wines [10].

2.3. Statistical analysis

For evaluating the results, we used the GraphPad Prism version 10.0. The years were compared by t student test and the different samples were compared by ANOVA, pos hoc test. We considered the statistical difference p<0.05.

3. Results and discussion

Regarding the physicochemical composition (Figure 1) no statistical significant differences were observed between the 2022 and 2023 vintages in terms of alcoholic strength, total acidity, dry extract, density, or chloride levels. However, a significant difference was found analyzing the volatile acidity: wines from the 2023 harvest showed higher values (9.19 ± 0.345 meq/L) compared to those from 2022 (6.16 ± 0.350 meq/L), with p < 0.001. Volatile acidity in wine comes from acetic acid and related compounds, either in their free form or combined as salts [10]. Pluviometric conditions, as well as other climatic conditions, can cause this difference between years. The volatile acidity content of both vintages is considered satisfactory for the quality of the wines, being below the maximum limit established by the OIV at the Maximum acceptable limits of various substances contained in wine (OIV-MA-C1-01) - 20 meq/L [10]. Overall, the acidity levels are exceptional, a quality likely attributed to the region's significant thermal amplitude. Situated at an altitude of around 1,000 meters above sea level, this area experiences daily temperature swings of up to 20°C, which play a crucial role in preserving the wine's vibrant acidity. It is worth noting that, while the alcohol content did not vary significantly between the two vintages studied, the overall average was considerably higher than that typically observed in other Brazilian wine regions, such as the South. According to the database of the Secretary of Agriculture of the State of Rio Grande do Sul (SEAPI), the average alcohol of 2022 and 2023 vintages, for red *Vitis vitinifera* wines, was 10.69 % v/v. The mean alcohol levels in the samples of this study reached 13.88 ± 0.91% v/v, with values ranging from 12.38% to 15.44% v/v. These figures reflect a high degree of technological ripeness in the grapes, indicative of favorable growing conditions and effective vineyard management.

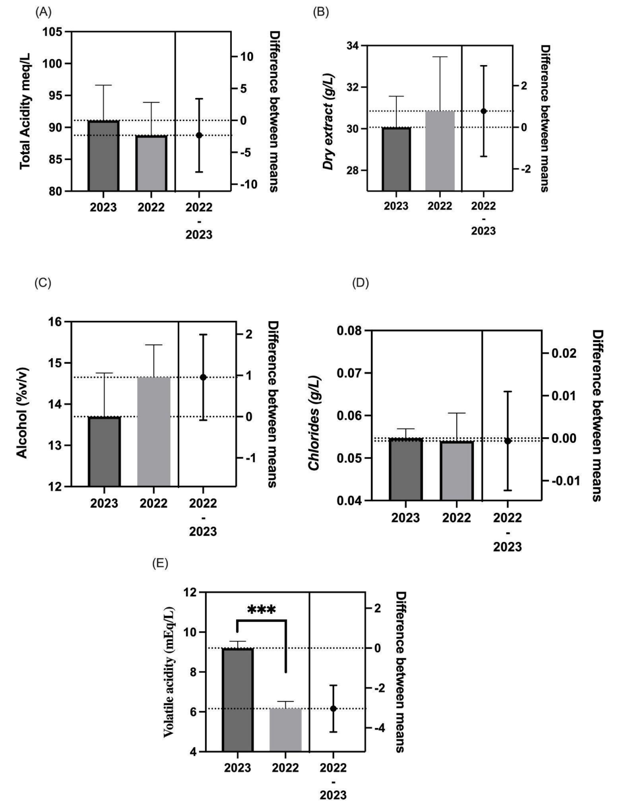

Figure 1. Total Acidity, Dry Extract, Alcohol, Chlorides and Volatile Acidity in Syrah wines from 2022 and 2023 harvests.

Significant differences were observed in the total phenolic content (TPC) between the two years analyzed (Figure 2), with wines from the 2022 harvest exhibiting higher levels (76.68±10.42 mg/L) compared to those from 2023 (67.05±5.89 mg/L, p=0.0221). These values are expressive when compared to international regions recognized by the Syrah production, as Australia, with some studies that report average TPC of 54 mg/L [14], and South Africa, with a study reporting an average of 50.94 mg/L [15].

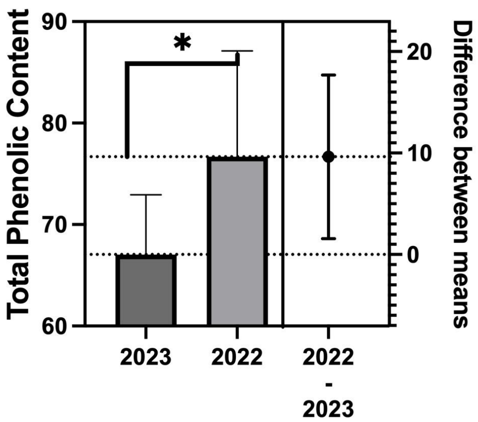

Figure 2. Total Phenolic Compounds in Syrah wines from different harvest, 2022 and 2023.

Wines made from grapes picked in the winter—when water is scarce and temperatures fluctuate significantly—generally have a higher alcohol level, more concentrated phenolic compounds, and deeper color than wines produced from grapes harvested in the summer [16].

Although in our study there were no differences in elaboration methods, influences at the grape maturation, such as the sugar level at the fermentation beginning, could explain these results.

Polyphenols are very important components of wine, especially in red wines. They are responsible for its sensory properties—particularly astringency, color, and bitter taste, and they also play a role in its aging potential [17]. The results of resveratrol, catechin, epicatechin, delphinidin, malvidin-3-O-glucoside and cyanidin, can be seen in Figure 3. In wine, the flavonoid subgroup of polyphenolic compounds includes flavonols, flavanonols, anthocyanins, flavan-3-ols, flavanones, and flavones. Non-flavonoid compounds, on the other hand, comprise hydroxycinnamic acids, hydroxybenzoic acids, and stilbenes. Stilbenes are molecules widely distributed throughout the plant kingdom. Although their concentration in wine is lower compared to other polyphenols, they have been extensively studied due to their biological properties and potential therapeutic effects [18]. The resveratrol levels were higher in the wine from the 2023 harvest (9.36±0.66 mg/L) compared to the ones from 2022 (4.77±10.36 mg/L, p<0.0001). The resveratrol is synthesized by plants in response to adverse growing conditions, such as mechanical injury, bacterial or fungal attacks, and exposure to ultraviolet radiation. Its occurrence is influenced by several factors, including grape variety, environmental conditions (such as climate, soil, and region), and winemaking practices [19, 20]. In the case of this study, differences in rainfall and insulation between the two years could explain these findings, however the storage influence on the resveratrol content can also be considered. The wines from the 2022 vintage were analyzed in 2024, having one more year of aging compared to those from the 2023 vintage. According to [21] who studied the loss of trans-resveratrol during storage and aging of red wines, freshly bottled wines may not show the same loss rate of resveratrol as that observed in aged wines as their residual enzymatic activity may change over time. In genuine wines from Rio Grande do Sul, from the 2020 to 2023 vintages, [22] found average values of 3.66 mg/L for the Merlot variety.

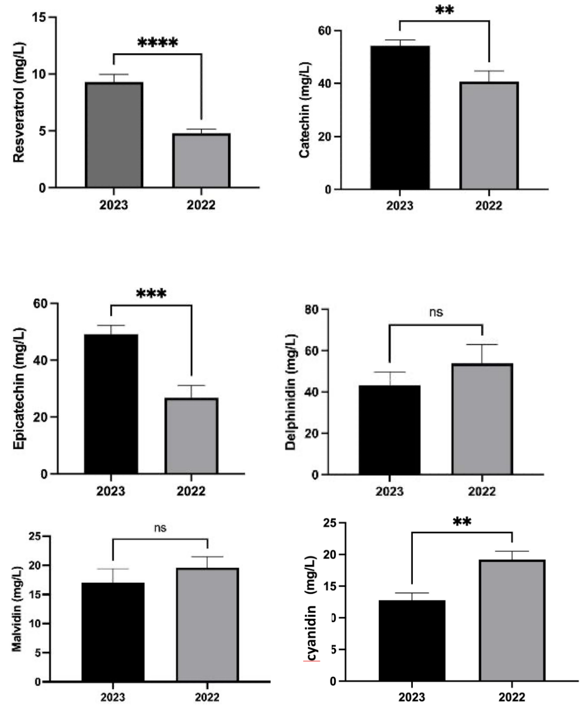

Figure 3. Resveratrol, catechin, epicatehin, cyanidin, delphinidin and malvidin-3-O-glucoside in Syrah wines from different harvest, 2022 and 2023.

Catechin levels were greater in 2023 (54.20±2.31 mg/L) than in 2022 (40.69±4.07 mg/L, p=0.0065). In Chilean Carménère wine, [23] found 25.2 mg/L, while in South African Syrah wines, [14] reported concentrations of up to 19.18 mg/L. Likewise, epicatechin levels were also higher in the 2023 vintage (49.18±11.13 mg/L), when compared to the 2022 vintage (26.76± 10.81 mg/L), but no statistical differences were observed. Catechin and epicatechin procyanidins are the main monomeric 3-flavonols found in grapes and wines [17].

Anthocyanins are natural pigments responsible for a wide range of colors in the plant kingdom and represent an important qualitative and quantitative component in grapes. The main anthocyanins include delphinidin, cyanidin, malvidin, petunidin and peonidin. Their concentration is influenced by species, grape variety, and various climatic and environmental factors [16]. In this study, cyanidin levels were lower in 2023 (12.78±1.14 mg/L) compared to 2022 (19.19±1.32 mg/L, p=0.036). Several factors may account for the observed differences between harvests, including the thermal range in the region (approximately 1,000 meters above sea level), with daily temperature variations of up to 20°C. Additionally, the rainfall variation. Delphinidin and malvidin-3-O-glucoside were also analysed in this study, with no statistical differences between harvests.

4. Conclusions

In recent years, vineyards have been established across various regions of the country, including several non-traditional areas. These emerging wine regions are producing wines that exhibit impressive quality and distinctive typicality A diverse range of viticultural techniques and grape cultivars are being introduced, though the full impact of these innovations remains to be seen. In our results we observed differences in volatile acidity, total polyphenols content, resveratrol, catechin and cyanidin levels. These factors could be explained by the maturation levels of these two harvests due to climate conditions. Additional studies, with more samples and vintages, will be conducted to investigate intra-regional variability and the impact of distinct cultivars on the phenolic profile of the High Altitute Cerrado region. Nonetheless, preliminary findings indicate a notably rich phenolic composition, underscoring the significant potential for establishing a designation of origin. However, this will require more comprehensive analyses and detailed characterization of the Syrah wines produced in the region.

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