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+ Corresponding author*:* debora.soares@uniarp.edu.br

Physicochemical and mineral characterization of Goethe grape must from Santa Catarina, Brazil: technological implications for processing

Eliezer Ferrais de Lara[1], Jorge Fernandes Filho[2,3], Débora Soares Souza Marins[1*]

[1]Universidade Alto Vale do Rio do Peixe
[2] Universidade Federal de São Carlos – Sorocaba
[3] Empresa de Pesquisa Agropecuária e Extensão Rural

Abstract. Goethe grape is a regionally important cultivar in southern Brazil, especially in Santa Catarina, where it is associated with the identity of the Vales da Uva Goethe. However, information on the basic composition of Goethe grape must is still limited when compared with Brazilian cultivars widely used for juice and wine processing. This study characterized the physicochemical and mineral profile of a Goethe grape must produced in Santa Catarina and discussed its technological suitability in relation to published data for processing grapes and grape juices. Grapes from the 2026 harvest were manually destemmed, deseeded, macerated and filtered. The must was analyzed in triplicate for pH, soluble solids, titratable acidity and mineral composition. Goethe must showed pH 3.83, 11.00 °Brix and titratable acidity of 0.375 g tartaric acid 100 mL^{-1}, resulting in a soluble solids/titratable acidity ratio of 29.33. In comparison with Brazilian processing cultivars such as BRS Carmem, BRS Cora, IAC 138-22 Máximo and Isabel Precoce, the Goethe must had lower soluble solids and lower titratable acidity, while its pH was higher than the range commonly reported for grape must intended for juice processing. Mineral analysis indicated high concentrations of phosphorus, nitrogen and potassium among the macronutrients, whereas iron and manganese were the most abundant micronutrients. The cationic profile, especially potassium, calcium and magnesium, reinforces the technological relevance of mineral characterization because these elements may affect acid-base balance, stability and processing behavior. The results indicate that Goethe grape must have regional and technological interest, but its use in agro-industrial derivatives requires harvest maturity standardization and broader studies involving different vineyards, seasons, phenolic composition and sensory evaluation.
Keywords: Vitis spp., titratable acidity, soluble solids, potassium, grape processing, regional cultivar.

Introduction

The physicochemical composition of grapes must be one of the main criteria used to define the technological suitability of grapes for juice, wine and other agro-industrial derivatives. Soluble solids are related to sugar accumulation and potential processing yield, whereas titratable acidity and pH influence microbial stability, sensory balance, color stability and the need for technological corrections during processing (Viana *et al.*, 2017; Tecchio *et al.*, 2022). Therefore, the joint interpretation of °Brix, acidity, pH and soluble solids/acidity ratio is more informative than the isolated evaluation of each variable.

In Brazil, processing grapes have been extensively studied, especially cultivars of Vitis labrusca and hybrids used for whole grape juice production. Studies with Bordô, Concord, Isabel, BRS Carmem, BRS Cora, Isabel Precoce and IAC 138-22 Máximo show that cultivar, rootstock, harvest conditions and extraction system significantly modify the final composition of grapes, musts and juices (Viana *et al.*, 2017; Bender *et al.*, 2020; Bender *et al.*, 2021; Tecchio *et al.*, 2022). Brazilian regulations also use soluble solids as a relevant quality parameter for grapes intended for juice processing, and Tecchio *et al.* (2022) reported that processing grapes should reach at least 14 °Brix according to national standards (Brasil, 2018).

Goethe grape has historical, territorial and economic relevance in Santa Catarina, mainly in the Vales da Uva Goethe, where the cultivar is associated with regional identity and geographical indication. Molecular analyses confirmed the identity of Goethe grape from Urussanga using microsatellite markers, and agronomic descriptions

have highlighted specific characteristics of Goethe and its clones in this region (Schuck *et al.*, 2010; Della Bruna *et al.*, 2016). Nevertheless, the scientific literature still provides limited data on Goethe must composition, especially when compared with the large amount of information available for Brazilian red and white processing cultivars.

In addition to classical physicochemical parameters, mineral composition is relevant for the characterization of grape matrices. Elements such as potassium, calcium, magnesium, phosphorus, iron, manganese, copper and zinc may contribute to nutritional value, acid-base equilibrium, oxidative reactions and product differentiation. In organic grape juices from southern Brazil, potassium was the predominant mineral and was followed by phosphorus, calcium and magnesium (Miele *et al.*, 2015). In Goethe rosé grape juice, mineral and phenolic composition were also associated with antioxidant properties (Dani *et al.*, 2009). Thus, mineral profiling may support the technological interpretation of Goethe grape must and contribute to its scientific and regional valorization.

The objective of this study was to characterize the physicochemical and mineral profile of a Goethe grape must produced in Santa Catarina, Brazil, and to compare the results descriptively with published data for processing grapes and grape juices.

Materials and Methods

Sample preparation

The study was conducted with a Goethe grape sample processed in Caçador, Santa Catarina, Brazil, during the 2026 harvest. The sample was identified as Goethe according to the laboratory batch record. Grapes were manually selected, seeds were removed, and berries were macerated until the liquid fraction was obtained. The material was filtered, and the resulting must was immediately used for physicochemical analyses.

Physicochemical analyses

The hydrogen potential was determined by the electrometric method using a calibrated pH meter, previously adjusted with buffer solutions at pH 4.00 and 7.00. Soluble solids were measured by refractometry and expressed as °Brix. Titratable acidity was determined by neutralization titration with 0.1 mol L^{-1} sodium hydroxide and phenolphthalein as indicator, and the results were expressed as g tartaric acid 100 mL^{-1}, according to analytical principles recommended for grapes and derived products (AOAC International, 2019). The soluble solids/titratable acidity ratio was calculated by dividing the °Brix value by titratable acidity.

Mineral composition

Mineral composition was determined in triplicate for nitrogen, phosphorus, magnesium, potassium, calcium, copper, zinc, iron and manganese. Macronutrients were expressed as g kg^{-1} and micronutrients as mg kg^{-1}, according to the units reported in the analytical dataset. Because the present work focuses on technological characterization, mineral data were interpreted comparatively and descriptively rather than as direct dietary intake values.

Statistical analysis

Results were expressed as mean ± standard deviation from three analytical replicates. Comparisons with literature data were descriptive because the studies differed in cultivar, region, harvest season, sample preparation and analytical conditions. No inferential statistical test was applied between the present results and values obtained from published studies.

Ethics statement

This study involved only a plant-derived food matrix and did not involve humans or animals. Therefore, ethics committee approval was not required.

Results and Discussion

The Goethe grape must show pH 3.83 ± 0.06, soluble solids of 11.00 ± 0.00 °Brix and titratable acidity of 0.375 ± 0.000 g tartaric acid 100 mL^{-1} (Table 1). The soluble solids/titratable acidity ratio was 29.33. This profile indicates a must with low sugar concentration, low titratable acidity and relatively high pH when compared with Brazilian processing cultivars described in the literature.

Table 1. Physicochemical characteristics of Goethe grape must.

Variable	Analytical replicates	Result
pH	3.9; 3.8; 3.8	3.83 ± 0.06
Soluble solids	11; 11; 11	11.00 ± 0.00 °Brix
Titratable acidity	5.00; 5.00; 5.00 mL NaOH	0.375 ± 0.000 g tartaric acid 100 mL^{-1}
Soluble solids/titratable acidity ratio	calculated value	29.33

The °Brix value observed in Goethe must was below the values commonly reported for processing grapes. Tecchio *et al.* (2022) evaluated Brazilian cultivars for juice and wine production and reported mean soluble solids ranging from approximately 15.88 to 17.62 °Brix for BRS Carmem, BRS Cora, IAC 138-22 Máximo and Isabel Precoce. The authors also emphasized that all cultivars reached the minimum value of 14 °Brix required by Brazilian regulation for processing

grapes into juice (Brasil, 2018). In the present study, the Goethe must reached only 11.00 °Brix, suggesting that the sampled lot was harvested or processed under conditions that did not favor high sugar accumulation. This result does not invalidate the technological potential of Goethe grape, but it indicates that harvest maturity should be standardized before recommending the material for industrial processing.

Low soluble solids may be associated with genotype, harvest anticipation, rainfall near harvest, vineyard conditions or sample preparation. In grape juices, processing can also reduce soluble solids depending on the extraction method. Bender *et al.* (2021) showed that the steam-juicer system reduced soluble solids when compared with enzymatic extraction, while Costa *et al.* (2019) also discussed that extraction technology may affect physicochemical traits in Bordô and Concord grape juices. Although the present material was a manually prepared must and not a heat-extracted juice, these studies reinforce that the composition measured in the final liquid fraction reflects both grape maturity and processing conditions.

Titratable acidity was also lower than that reported for many processing cultivars. Tecchio *et al.* (2022) found acidity values of 0.82% tartaric acid for Isabel Precoce, 0.97% for BRS Carmem, 1.17% for IAC 138-22 Máximo and 1.38% for BRS Cora. By comparison, Goethe must presented 0.375 g tartaric acid 100 mL^{-1}, a value below the acidity range considered adequate for the production of balanced grape beverages in the same study. This low acidity explains the high soluble solids/titratable acidity ratio despite the low °Brix value. Therefore, the ratio should not be interpreted as evidence of advanced maturity or high sweetness, but rather because of low acid concentration.

The pH value of Goethe must was higher than the values reported for the cultivars evaluated by Tecchio *et al.* (2022), which were close to 3.05-3.25. The same authors emphasized that pH is directly related to anthocyanin stability and color intensity in red grape beverages. A descriptive comparison between the Goethe grape must analyzed in the present study and published data for processing grapes and organic grape juices is presented in Table 2. Although Goethe is not a red cultivar, pH remains technologically relevant because higher pH may reduce microbiological stability, modify acid perception and increase the need for acidification or blending. Miele *et al.* (2015) reported pH values from 3.17 to 3.62 in organic grape juices, with a mean of 3.36, and characterized Goethe juice as having high Brix and residual sugars and low volatile acidity. The pH of the Goethe must evaluated here was above this range, reinforcing that this specific lot may require technological correction if used for juice, wine or fermented beverages.

Table 2. Descriptive comparison between Goethe grape must and published data for processing grapes and organic grape juices.

Material	Soluble solids (°Brix)	Titratable acidity	pH	Main interpretation	Reference
Goethe must	11.00	0.375 g tartaric acid 100 mL^{-1}	3.83	Low soluble solids, low acidity and high pH	Present study
BRS Carmem grape must	17.62	0.97% tartaric acid	3.25	Suitable sugar level and moderate acidity	Tecchio *et al.* (2022)
BRS Cora grape must	17.48	1.38% tartaric acid	3.09	High acidity and low pH	Tecchio *et al.* (2022)
IAC 138-22 Máximo grape must	15.88	1.17% tartaric acid	3.20	Intermediate soluble solids and acidity	Tecchio *et al.* (2022)
Isabel Precoce grape must	17.22	0.82% tartaric acid	3.20	High soluble solids and lower acidity among evaluated cultivars	Tecchio *et al.* (2022)
Organic grape juices	12.7-17.5	48-144 meq.L^{-1}	3.17-3.62	Broad variation due to cultivar and processing	Miele *et al.* (2015)

From a processing perspective, the physicochemical profile observed in Goethe must has two main implications. First, the low soluble solids may limit the yield and sensory intensity of products in which sweetness or sugar-derived fermentation potential is relevant. Second, the combination of low acidity and high pH may reduce freshness and stability. These characteristics suggest that Goethe grape must should be evaluated under different harvest dates and vineyards to determine whether the profile observed here represents the cultivar, the local crop

conditions or the specific lot. For industrial application, blending with more acidic cultivars, correction of acidity, or harvest postponement until higher soluble solids are achieved may be considered. Bender *et al.* (2020) showed that blending Isabel grape juice with other cultivars modified physicochemical and sensory properties, supporting the idea that cultivar combinations may improve the technological performance of regional raw materials.

The mineral profile of Goethe must is shown in Table 3. Phosphorus and nitrogen were numerically the highest macronutrients, followed by potassium, calcium and magnesium. Among cationic macronutrients, potassium predominated over calcium and magnesium. Among micronutrients, iron and manganese were the most abundant, followed by copper and zinc. This information is relevant because mineral composition may influence technological behavior, including pH buffering, oxidative reactions, tartrate equilibrium and the differentiation of grape-derived products.

Table 3. Mineral composition of Goethe grape must**.**

Element	Unit	Mean value	Standard deviation
nitrogen	g kg^{-1}	21.93	1.18
phosphorus	g kg^{-1}	33.00	1.04
magnesium	g kg^{-1}	1.93	0.50
potassium	g kg^{-1}	14.60	1.66
calcium	g kg^{-1}	5.00	0.60
copper	mg kg^{-1}	52.07	0.86
zinc	mg kg^{-1}	5.97	0.06
iron	mg kg^{-1}	113.77	2.53
manganese	mg kg^{-1}	54.40	1.84

The relatively high potassium concentration is technologically important because potassium may reduce free acidity through salt formation and may contribute to pH increase in grape musts and wines. This interpretation is compatible with the observed combination of high pH and low titratable acidity. In grape juices, Miele *et al.* (2015) reported potassium as the predominant mineral, with concentrations ranging from 895 to 2792 mg L^{-1}, followed by phosphorus, calcium and magnesium. Although the units and analytical basis of the present study differ from those of juice studies, the predominance of potassium among cationic macronutrients agrees with the general mineral behavior of grape-derived products. Dani *et al.* (2009) also reported relevant concentrations of potassium, calcium, magnesium and iron in Goethe rosé grape juice, supporting the importance of mineral characterization for this cultivar.

Iron and manganese were the most abundant micronutrients in the Goethe must analyzed. These elements are relevant because they may participate in redox reactions and enzyme-related processes, and their concentrations may reflect soil characteristics, vineyard management and contact with processing materials. Copper was also detected and should be monitored in future studies because copper-based products are commonly used in viticulture and may contribute to residue accumulation in grapes and derived products. Miele *et al.* (2015) highlighted copper as an element of concern in organic grape juices because of the frequent use of Bordeaux mixture in vineyards, although mean concentrations in their survey were generally low. In the present study, the copper value should be interpreted according to the analytical basis of the dataset and not directly compared with mg L^{-1} juice standards without unit conversion and method harmonization.

The comparison with published studies indicates that Goethe must may be better understood as a regional raw material requiring specific technological management rather than as a direct substitute for standard processing cultivars. Its main limitation in the sampled lot was not mineral composition, but the physicochemical balance represented by low °Brix, low titratable acidity and high pH. Conversely, the mineral profile provides a useful chemical descriptor for future studies on origin, vineyard management and processing aptitude. When combined with phenolic, volatile, organic acid and sugar profiling, mineral characterization may contribute to building a more complete technological identity for Goethe grape and its derivatives.

This study has limitations that should be considered. The work was based on one Goethe grape lot, and the comparison with other cultivars relied on literature data obtained under different environmental and methodological conditions. Therefore, the results should be interpreted as an initial characterization rather than a definitive compositional standard for Goethe grape. Future research should include multiple vineyards, harvest dates, seasons and clones, as well as phenolic compounds, organic acids, individual sugars, volatile compounds, antioxidant activity and sensory acceptance. Such studies would clarify whether the profile observed here is recurrent in Goethe musts from Santa Catarina and would support technological recommendations for juices, wines and innovative regional products.

Conclusion

Goethe grape must from Santa Catarina showed 11.00 °Brix, pH 3.83 and titratable acidity of 0.375 g tartaric acid 100 mL^{-1}, resulting in a high soluble solids/titratable acidity ratio mainly caused by low acidity. Compared with Brazilian processing cultivars reported in the literature, the sample had lower soluble solids and acidity and higher pH, indicating the need for harvest maturity standardization and possible technological adjustments before industrial application. Mineral

characterization revealed high concentrations of phosphorus, nitrogen and potassium among macronutrients and predominance of iron and manganese among micronutrients. The cationic mineral profile, especially potassium, calcium and magnesium, reinforces the importance of mineral analysis for interpreting acid-base behavior and processing aptitude. The results position Goethe must as a promising regional matrix, but further studies with more samples, seasons and complementary bioactive analyses are required to consolidate its technological use.

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Conflict of Interest

The author declares no conflict of interest.

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