










Volatile and phenolic compounds in white wines produced at Campanha Gaúcha, Brazil

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ABSTRACT: The Campanha Gaúcha region has recently (2020) received an Indication of Provenance ('IP Campanha Gaúcha') for wines and sparkling wines. Scientific data and research developed during the last decades could provide the necessary information for this first characterization of the area. Nevertheless, there is a lack of detailed data about the composition of Campanha Gaúcha wines. In this study, five Campanha Gaúcha white wines of different grape varieties (Riesling, Gewürztraminer, Semillon, Sauvignon Blanc and Chardonnay) produced in the 2018 vintage were collected directly from the winery and followed analyses of several volatile and phenolic compounds. The 2018 vintage was rated among the best of the 3 preceding decades for this region. The results, originated from this excellent vintage, demonstrate the qualitative potential of the region for the wines elaborated with the grape varieties covered by this study. They are important records for the construction and enlargement of databases for future research and can also provide further scientific basis for more detailed definition of intra-regional and inter-regional differences and similarities regarding the characteristics of Campanha Gaúcha wines.

Key words: Campanha Gaúcha, wine, volatile compounds, phenolic compounds.

Compostos voláteis e fenólicos em vinhos brancos produzidos na Campanha Gaúcha, Brasil

RESUMO: A região da Campanha Gaúcha recebeu recentemente, em 2020, a Indicação de Procedência 'IP Campanha Gaúcha' para vinhos e espumantes. Dados científicos e pesquisas desenvolvidas nas últimas décadas puderam fornecer as informações necessárias para esta primeira caracterização da área. No entanto, faltam dados detalhados sobre a composição dos vinhos da Campanha Gaúcha. Neste estudo, vinhos de cinco variedades de uva branca (Riesling, Gewürztraminer, Semillon, Sauvignon Blanc e Chardonnay), produzidos na Campanha Gaúcha na safra 2018, foram coletados diretamente da vinícola e encaminhados para análises de vários compostos voláteis e fenólicos. Essa safra foi classificada entre as melhores das três décadas anteriores para esta região. Os resultados, oriundos dessa excelente safra, demonstram o potencial qualitativo da região para as castas abrangidas por este estudo. São registros importantes para a construção e ampliação de bancos de dados para pesquisas futuras e também podem fornecer embasamento científico para definição mais detalhada das diferenças e semelhanças intra e inter-regionais quanto às características dos vinhos da Campanha Gaúcha.

Palavras-chave: Campanha Gaúcha, vinho, compostos voláteis, compostos fenólicos.

INTRODUCTION

The Campanha Gaúcha region produces considerable amounts of grapes (*Vitis vinifera*) for the wine industry since the decade of 1980. It has recently (2020) received an Indication of Provenance ('IP Campanha Gaúcha') for wines and sparkling wines - a first step towards its characterization and recognition as an important wine producing area. This characterization relied mostly on scientific data and research (EMBRAPA, 2020). A fundamental aspect distinguishing wines from specific origins is their typical aroma (GONZAGA et al., 2020) that is determined by volatile compounds present at very low level (WATERHOUSE et al., 2016). Nevertheless, there is a lack of studies on the volatile composition of Campanha Gaúcha wines. The 2018 vintage

(2017-2018 growing season) produced grapes of high oenological quality and was rated among the best of the three preceding decades for this region (ALVES & TONIETTO, 2018). Some Campanha Gaúcha wines were recognized among the most representative Brazilian wines of this same year (2018) (ABE, 2018). The study provided a screening of volatile and phenolic compounds found in white wines produced at the Campanha Gaúcha region in the 2018 vintage.

This study covered wines of five varieties, Chardonnay, Gewürztraminer, Riesling Renano, Sauvignon Blanc e Semillon. The batches of these wines were produced in the 2018 vintage, adopting all the standard procedures for commercial production of wine grapes and wines in a commercial company (vineyard and winery) located in Santana do Livramento, Rio Grande do Sul State, South region

of Brazil. The vineyards presented sandy textured Alisol, gentle slopes with average altitude of 300m, and humid subtropical climate (Cfa), following the Köppen-Geiger climate classification system. One 750 mL glass bottle (sealed with cork) of each wine type was collected directly from the stainless-steel tanks of the winery in September 2018.

Volatile and phenolic compounds were evaluated following procedures identical to those described by KALTBACH et al. (2022). Values for alcohol content, pH, titrable acidity and soluble solids in the grapes used for wine production were provided by the industry from internal routine quality control protocols that meet the requirements of the Brazilian legislation (BRASIL, 2018).

A Principal Component Analysis (PCA) was run with the results from chromatographic analyses. The numerous volatile compounds were plotted as active variables and phenolic compounds as supplementary variables. The analyses were run using R software (R CORE TEAM, 2020), the RStudio interface (R STUDIO TEAM, 2020), and the FactoMiner (LÊ et al., 2008) and FactoShiny packages (VAISSIE et al., 2020).

Musts presented the following characteristics, respectively for the varieties Riesling,

Gewürztraminer, Semillon, Sauvignon Blanc, Chardonnay: soluble solids ($^{\circ}$ Brix) - 19.8, 21.2, 18.4, 19.6, 21.4; pH - 3.3, 3.5, 3.3, 3.3, 3.7; total acidity (in g.L^{-1} of tartaric acid equivalents) - 5.7, 4.8, 5.8, 7.1, 5.1. Wines presented the following characteristics, respectively for the varieties Riesling, Gewürztraminer, Semillon, Sauvignon Blanc, Chardonnay: alcohol content (% by volume) - 11.5, 12.5, 11.4, 11.3, 12.3; pH - 3.4, 3.5, 3.4, 3.4, 3.8; total acidity (in g.L^{-1} of tartaric acid equivalents) - 6.0, 5.2, 5.3, 6.0, 5.2.

The concentrations of volatile (Tables 1 and 2) and phenolic (Table 3) compounds could provide a detailed characterization of these wines. The PCA (Figure 1) summarized more than 70% of the information regarding volatile compounds in the first two dimensions, what allows to graphically understand patterns and establish comparisons between the samples. The projections of the supplementary variables (phenolic compounds) were also sufficient to characterize the five wine samples. Only a few variables (Figure 1a) were poorly projected on these two axes (e.g. citronelol and methanol, isoamyl acetate, gallic acid, 3-methyl 1-butanol and 1 propanol). That means that the correlation of these variables with the others within the dataset is low.

Table 1 - Volatile compounds in the Campanha Gaúcha white wines - terpenes, alcohols, acids, aldehydes and volatile phenols.

Compound	Wine samples									
	Riesling		Gewurztraminer		Semillon		Sauvignon Blanc		Chardonnay	
	Mean ^a	RSD ^b	Mean ^a	RSD ^b	Mean ^a	RSD ^b	Mean ^a	RSD ^b	Mean ^a	RSD ^b
Citronelol	2.2	0.1	19.5	0.0	3.2	0.1	3.7	0.1	3.2	0.1
Linalol	49.8	0.0	46.2	0.0	5.5	0.0	7.2	0.0	8.2	0.0
Terpeniol	49.7	0.1	48.1	0.1	7.8	0.1	8.1	0.0	8.5	0.0
Nerol	3.0	0.0	6.2	0.2	3.1	0.4	0.0		3.0	0.1
Limonene	1.1	0.1	1.6	0.3	0.4	0.6	0.2	0.1	0.3	0.2
Geraniol	6.9	0.2	15.1	0.3	18.8	0.4	11.2	0.4	10.2	0.1
Metanol	37.1	0.5	32.6	0.3	35.5	0.2	27.7	0.1	40.0	0.1
1-propanol	25.9	0.1	30.2	0.1	43.5	0.1	21.3	0.2	38.5	0.0
1-butanol	24.3	0.1	23.4	0.1	16.5	0.1	25.1	0.2	30.9	0.1
2-metil 1-butanol	21.3	0.1	21.0	0.0	17.5	0.1	24.7	0.3	23.4	0.0
3-metil 1-butanol	149.7	0.1	138.2	0.0	118.9	0.1	157.3	0.1	128.5	0.0
1-hexanol	897.3	0.0	925.0	0.0	1283.5	0.0	1316.5	0.0	1172.9	0.0
Phenylethanol	9280.3	0.0	14078.3	0.0	14210.5	0.1	15149.0	0.1	10513.2	0.0
Isopentanoic acid	593.6	0.0	621.3	0.0	493.1	0.0	684.9	0.0	749.4	0.1
Hexanoic acid	4024.7	0.0	5966.5	0.0	9149.8	0.0	5319.4	0.0	5808.1	0.0
Octanoic acid	2150.2	0.0	6721.4	0.0	13029.1	0.1	6687.8	0.1	6823.8	0.0
Decanoic acid	36.9	0.1	1667.0	0.0	3620.9	0.2	1559.8	0.1	1485.3	0.0
Dodecanoic acid	17.1	0.1	68.3	0.0	107.6	0.2	63.0	0.2	42.0	0.2
Ethanal	89.6	0.1	81.6	0.2	50.4	0.3	60.9	0.2	91.4	0.1
Furfural	19.3	0.1	82.8	0.1	31.9	0.1	48.7	0.0	86.9	0.1
Benzaldehyde	6.2	0.3	12.6	0.2	5.5	0.3	10.6	0.0	14.4	0.0
5-methylfurfural	-		-		-		-		-	
Eugenol	-		-		-		-		-	

^aMean concentration, in mg.L^{-1} . ^bRelative standard deviation, in percentage. - Undetected.

Table 2 - Volatile compounds in the Campanha Gaúcha white wines – esters.

Compound	Wine samples									
	---Riesling---		Gewurztraminer		---Semillon---		Sauvignon Blanc		---Chardonnay---	
	Mean ^a	RSD ^b	Mean ^a	RSD ^b	Mean ^a	RSD ^b	Mean ^a	RSD ^b	Mean ^a	RSD ^b
Ethyl acetate	56.8	0.1	61.4	0.3	52.2	0.1	88.2	0.3	78.1	0.1
Ethyl butanoate	332.3	0.0	523.6	0.1	720.8	0.2	416.7	0.0	594.6	0.0
Ethyl hexanoate	346.9	0.0	877.7	0.2	1209.4	0.4	644.0	0.1	1009.2	0.1
Ethyl heptanoate	0.4	0.1	0.9	0.2	0.7	0.4	1.2	0.1	0.8	0.1
Ethyl octanoate	238.7	0.1	1860.0	0.3	1850.9	0.5	1328.2	0.1	1602.6	0.1
Ethyl nonanoate	0.2	0.3	1.1	0.2	1.8	0.3	1.2	0.1	0.8	0.1
Ethyl decanoate	6.9	0.2	766.5	0.2	1177.8	0.3	497.8	0.2	468.8	0.0
Ethyl dodecanoate	3.8	0.3	24.3	0.1	153.3	0.2	23.6	0.1	22.8	0.0
Ethyl-2-furoate	27.2	0.0	20.6	0.1	24.2	0.1	18.4	0.0	11.6	0.1
Ethyl benzoate	0.3	0.1	0.7	0.1	0.6	0.1	0.8	0.1	0.5	0.1
Ethyl-2-methyl-butyrate	3.6	0.1	3.2	0.1	2.7	0.6	3.5	0.1	4.4	0.1
Isoamyl acetate	1737.9	0.0	3000.9	0.1	2308.2	0.3	1855.4	0.0	646.0	0.1
Isoamyl butyrate	2.8	0.0	3.0	0.2	2.5	0.2	2.8	0.1	3.5	0.2
Isoamyl hexanoate	0.7	0.1	3.0	0.3	3.2	0.5	2.4	0.2	3.0	0.1
Isoamyl octanoate	1.9	0.1	11.9	0.3	18.4	0.2	10.0	0.1	6.9	0.0
Hexyl acetate	43.6	0.1	43.8	0.2	185.1	0.4	31.6	0.1	2.8	0.1
Diethyl succinate	817.3	0.0	652.2	0.0	573.7	0.0	575.3	0.0	774.4	0.0
Methyl hexanoate	-		-		-		-		-	
Methyl octanoate	0.4	0.1	1.0	0.3	0.9	0.4	0.8	0.2	1.0	0.1

^aMean concentration, in mg.L⁻¹. ^bRelative standard deviation, in percentage. - Undetected.

To the best of the authors' knowledge, no such detailed data about the composition of Campanha Gaúcha white wines exists in the literature. Additionally, the fact that they were originated from an excellent vintage implies that they represent well the qualitative potential of the region for these grape varieties. Therefore, these results constituted a valuable database for future research.

Furthermore, the establishment of more specific and delimited geographic indications such as Designations of Origin within the current Indication of Provenance Campanha Gaúcha can be eventually desirable in the future. The data obtained in this research can provide further scientific basis for more detailed definition of intra-regional and inter-regional differences and similarities regarding the characteristics of Campanha Gaúcha wines.

Table 3 - Phenolic compounds in the Campanha Gaúcha white wines.

Compound	Wine samples									
	---Riesling---		Gewurztraminer		---Semillon---		Sauvignon Blanc		--Chardonnay--	
	Mean ^a	RSD ^b	Mean ^a	RSD ^b	Mean ^a	RSD ^b	Mean ^a	RSD ^b	Mean ^a	RSD ^b
Gallic acid	1135.8	0.0	1002.1	0.1	1472.3	0.0	1193.9	0.1	1418.0	0.0
Catechin	8374.2	0.0	5122.4	0.0	7325.7	0.0	6345.6	0.1	5417.1	0.0
Epicatechin	1051.7	0.0	1147.5	0.0	941.1	0.1	964.4	0.1	703.9	0.0
Caffeic acid	7554.0	0.0	4469.2	0.0	3475.9	0.0	5415.1	0.0	9830.2	0.0
trans-p-Coumaric acid	1373.4	0.1	916.9	0.0	300.6	0.0	968.3	0.0	1370.4	0.0
Sinapic acid	1130.5	0.1	1246.3	0.0	285.3	0.1	520.5	0.0	534.9	0.0

^aMean concentration, in mg.L⁻¹. ^bRelative standard deviation, in percentage. - Undetected.

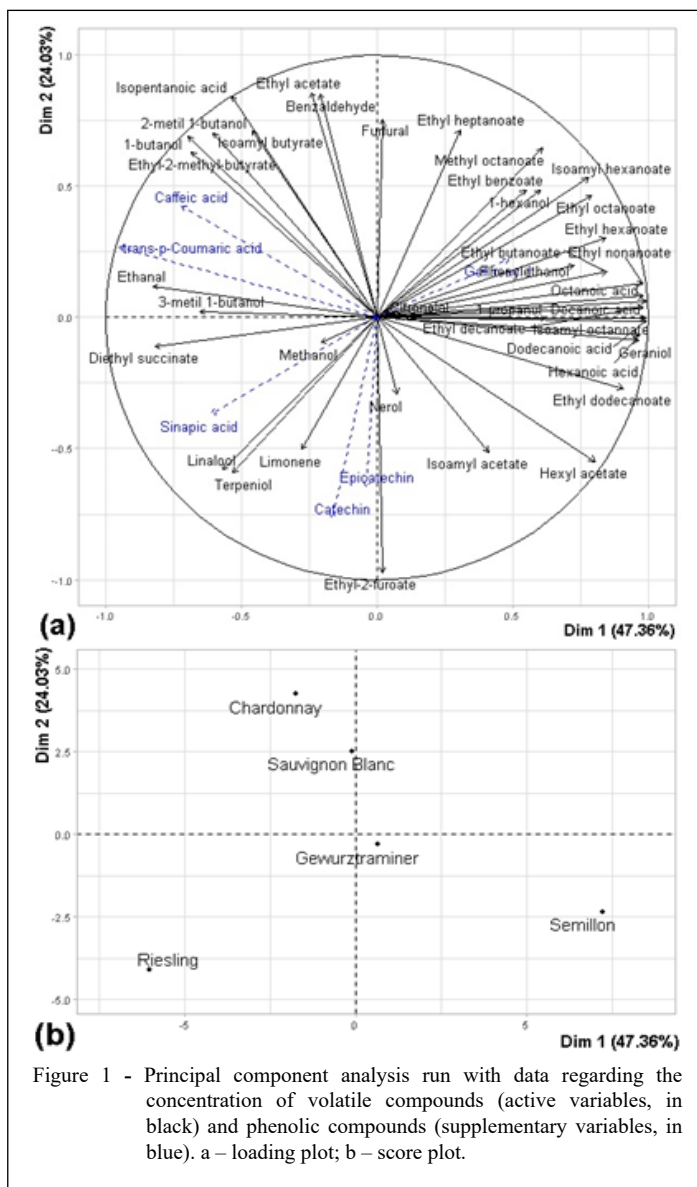


Figure 1 - Principal component analysis run with data regarding the concentration of volatile compounds (active variables, in black) and phenolic compounds (supplementary variables, in blue). a – loading plot; b – score plot.

DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interests.

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AUTHORS' CONTRIBUTIONS

SBAK, PLPKL, VBC and FGH. RW, FGV and SVAMW. Data acquisition: SBAK and CMGS. WG, LBC and

BJRF. Design of methodology and data analysis: CMGS and JAC. WG, CMGO and OGF. SBAK, PLPKL, VBC and SBAK, PLPKL, VBC and GB, WG and RW prepared the draft of the manuscript. All authors critically revised the manuscript and approved of the final version.

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