

Comparative proximate and phenolic characterization of winemaking sediments



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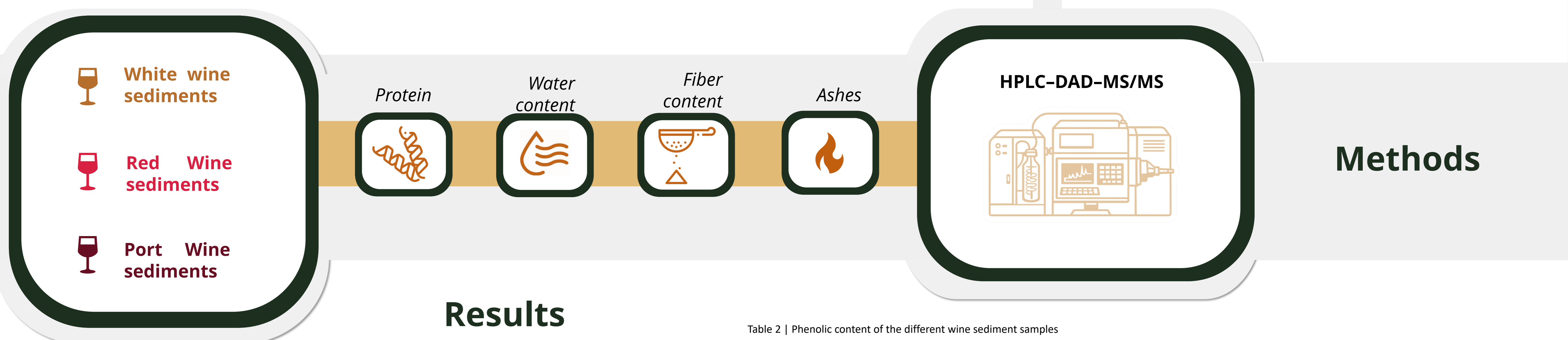
PORTO

Introduction

The wine industry generates a wide range of solid residues throughout vinification, many of which remain underexploited despite their potential as sources of bioactive compounds. While byproducts such as pomace and conventional lees have been widely studied, less attention has been given to specific sediment fractions collected at defined stages of the process. In particular, sediments recovered after fermentation and prior to bottling represent a distinct and poorly characterised matrix. Unlike primary lees or pomace, these materials result from prolonged settling and transformation processes, potentially leading to unique compositional profiles shaped by fermentation dynamics, microbial activity, and chemical ageing. These sediments are expected to concentrate structural nutrients (e.g. proteins, fibres, minerals) alongside a diverse range of polyphenols, including phenolic acids, flavonoids, and stilbenes, compounds associated with antioxidant and health-promoting properties. However, their nutritional composition and phenolic signature remain largely unexplored, limiting their integration into valorisation strategies.

Objectives

- Characterise nutritional composition
- Profile phenolic compounds (HPLC-DAD-MS/MS).
- Compare sediment from different sources
- Identify relevance for functional applications



Results

Table 1 | Phenolic content of the different wine sediment samples

	Moisture content (%)		Ash (% dw)		Protein (% dw)	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
White Wine Sediments	67.7	0.0	12.7	0.3	27.3	0.3
Red Wine Sediments	49.3	1.9	24.2	0.6	14.7	0.8
Port Wine Sediments	59.1	0.5	13.3	1.1	14.2	1.0

Table 2 | Phenolic content of the different wine sediment samples

	m/z [M-H] ⁻	Fragments	Compound	[concentration] (µg/L)	Standard deviation
White Wine Sediments	616	484,16 / 272,13 / 148,92	2-S-glutathionylcftaric acid	0.172	0.000
	149	134.93	tartaric acid		
	311	178,98 (100) / 148,92 / 134,89	caftaric acid	0.044	0.000
	865	422,35 / 295,09 / 162,98 (100) / 148,93 / 118,90	procyanidin trimer	0.077	0.000
	325	193,03 (100) / 133,92	feraric acid	0.069	0.000
Red Wine Sediments	301	150.95	quercetin	0.044	0.000
	616	484,24 / 272,15 / 148,92	2-S-glutathionylcftaric acid	0.552	0.000
	311	179 (100) / 148,90 / 134,93	caftaric acid	0.169	0.000
	655	637,36 / 329,20	malvidin 3-G-caffeoyl-glucoside	0.031	0.000
	317	178,97 / 150,97 / 136,95	myricetin	0.722	0.000
Port Wine Sediments	301	150.85	quercetin	0.069	0.000
	865	559,21 / 515,34 / 353,18 (100)	procyanidin trimer	0.594	0.001
	655	637,41 / 329,21	malvidin 3-G-caffeoyl-glucoside	0.040	0.033
	655	329.19	malvidin 3-G-caffeoyl-glucoside	0.164	0.000
	317	178,90 / 150,94 / 136,97	myricetin	0.343	0.000
301	150.95	quercetin	0.060	0.000	
285	279.95	kaempferol	0.434	0.000	

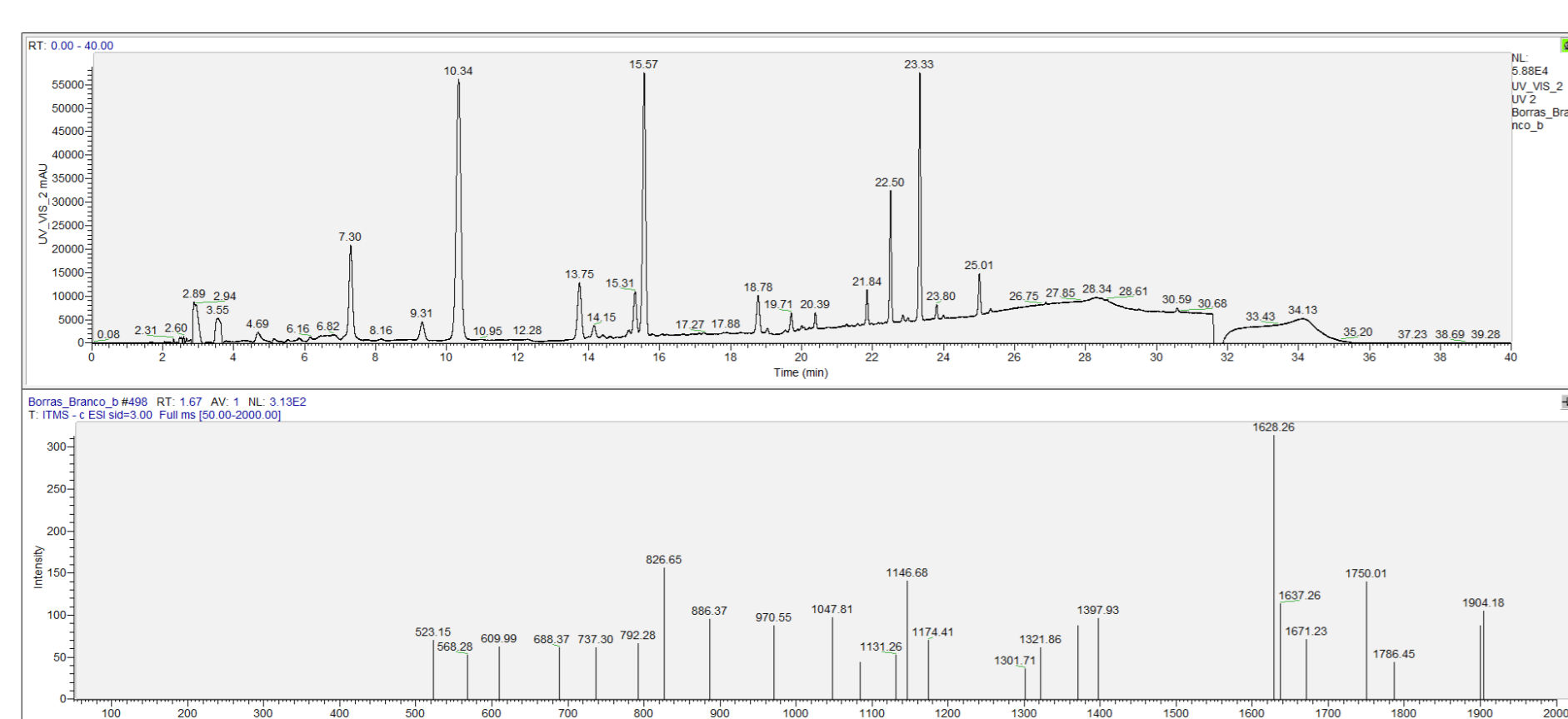


Figure 1 | White Wine Sediments HPLC-DAD-MS/MS chromatogram

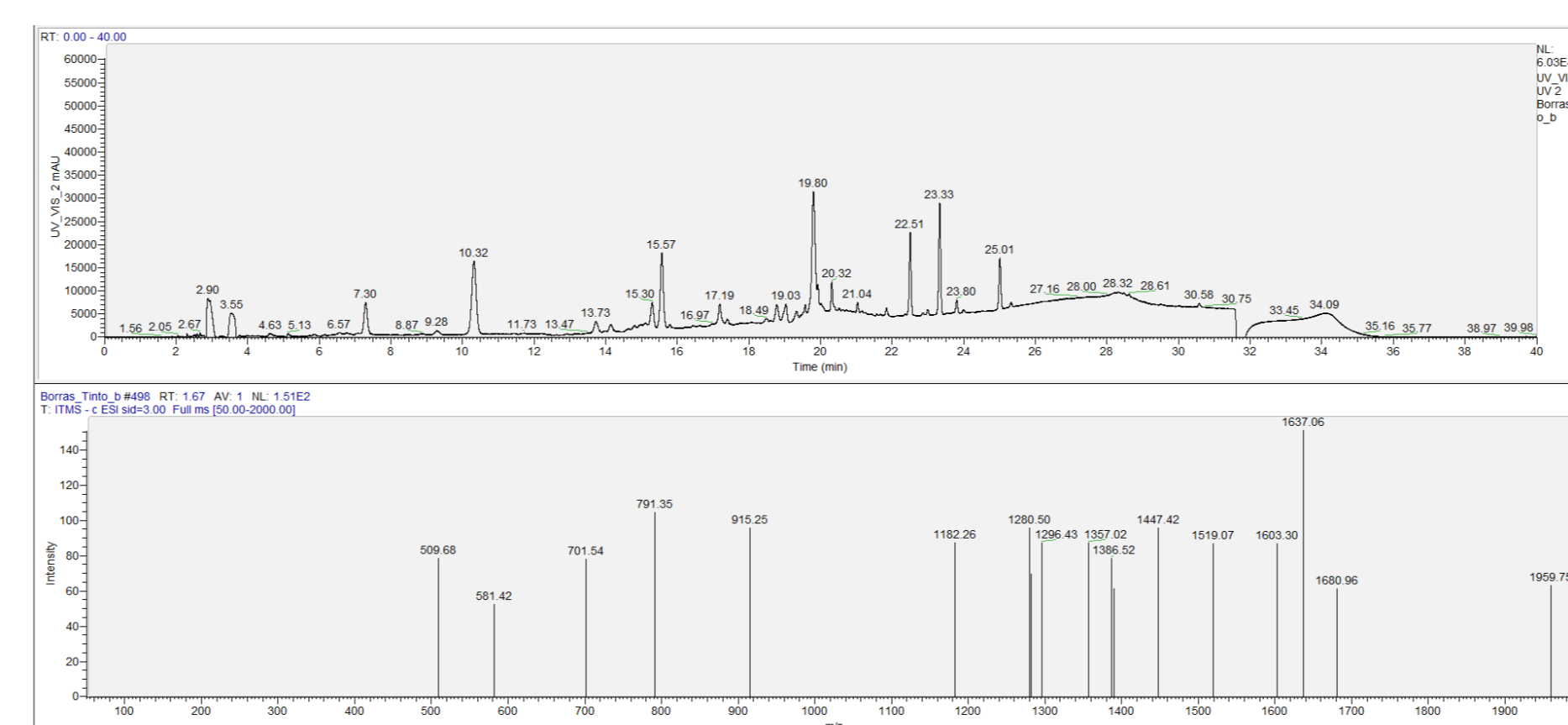


Figure 2 | Red Wine Sediments HPLC-DAD-MS/MS chromatogram

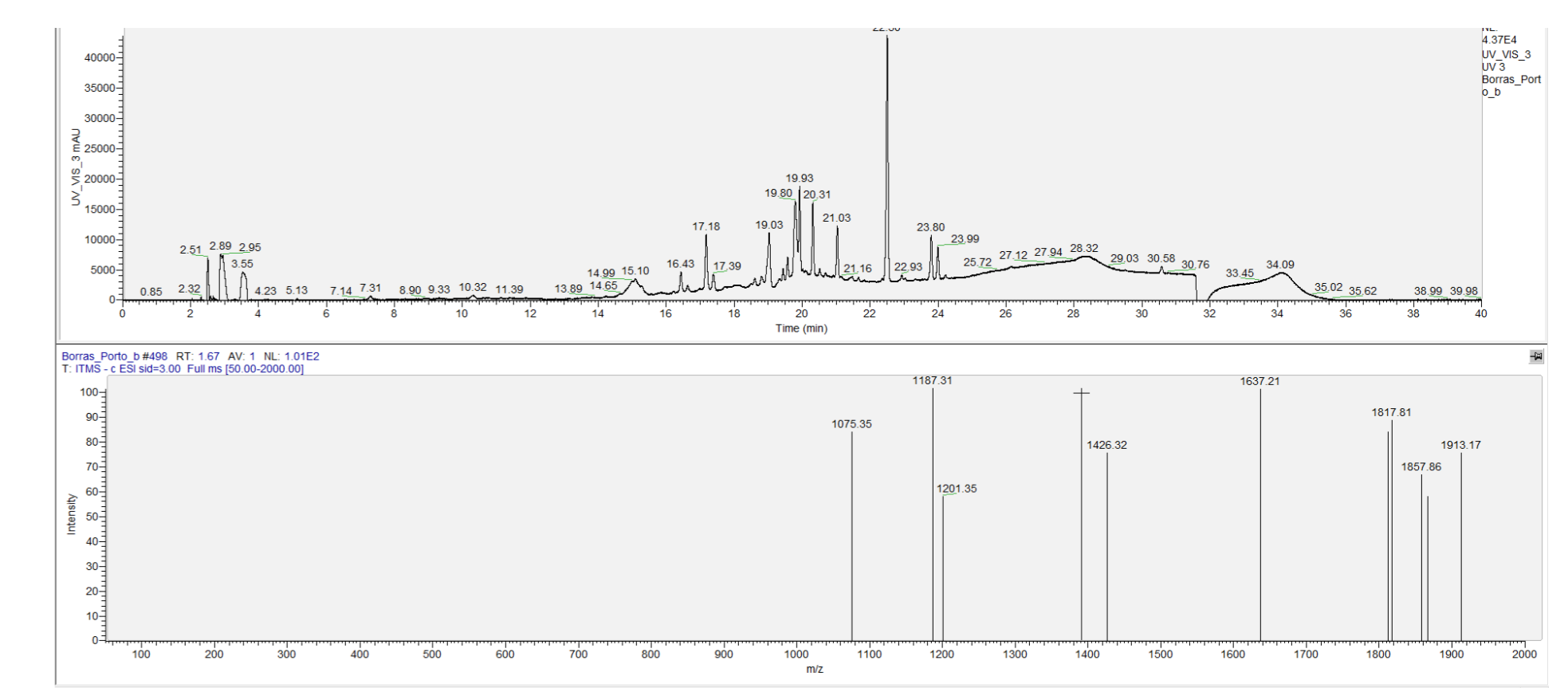


Figure 3 | Port Wine Sediments HPLC-DAD-MS/MS chromatogram

Conclusions

This study demonstrates that winery sediments collected prior to bottling constitute a distinct and previously underexplored matrix with significant potential for valorisation. Clear compositional differences were observed across sediment types, reflecting the influence of wine type and processing conditions. In particular, red wine sediments were characterised by higher mineral content, whereas white wine sediments showed increased levels of protein and fibre, with port wine sediments displaying intermediate characteristics. All sediment types exhibited a rich and diverse phenolic composition, including phenolic acids, flavonoids, proanthocyanidins, and stilbenes such as resveratrol and its derivatives. Importantly, both qualitative and quantitative differences in phenolic profiles were identified, highlighting the strong impact of vinification processes on the resulting chemical composition. The simultaneous presence of structural nutrients and bioactive phenolic compounds underscores the multifunctional nature of these materials. Overall, the findings support the potential of pre-bottling winery sediments as sustainable sources of food-relevant proteins and functional ingredients, contributing to the development of high-added-value applications within circular bioeconomy frameworks.

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