



Australian Dry White Wines from cv. Verdelho Produced in the Queensland Granite Belt Region: Volatile and Sensory Characterisation

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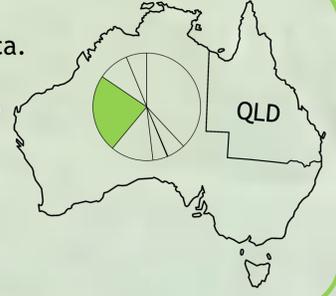
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Introduction

- Verdelho is a white grape vine which grows well in the Granite Belt region of the Australian state of Queensland, where it accounts for ca. 25 % of local wine production, and is used to make dry white wines.
- However, despite its use as one of the main grape varieties for Madeira wine production in Portugal, there is very little known about the aroma and sensory features of this variety as a dry white wine style.
- In this work, a complete volatile characterisation of Verdelho wines from the 2012 vintage produced in the Granite Belt region has been undertaken for the first time.
- Volatile compounds were isolated by Solid Phase Extraction (SPE) and quantified using Gas Chromatography-Mass Spectrometry (GC-MS) and a corresponding sensory characterisation of this distinctive wine style has been investigated using sensory descriptive analysis.



Materials & Methods

Samples: Eight commercial wines prepared using similar winemaking protocols (cold clarification, alcoholic fermentation and ageing in stainless steel) were analysed. **Volatile Extraction and GC/MS Analysis:** A solid-phase extraction (SPE) method with Lichrolut™ EN resin (Merck, Germany) was used for isolation of volatile compounds including free and bound monoterpenes. To hydrolyse the bound monoterpene fraction, wines were first treated with a commercial enzyme preparation based on pectinase and β-glucosidase derived from *Aspergillus niger* (OenoBioTech, France). GC-MS analysis was undertaken using an Agilent 6890N GC equipped with 5975 Mass Spectrometric Detector (Palo Alto, USA) and capillary column DB-WAX (J&W Science, USA). **Sensorial Analysis:** Five of the eight wines were subjected to descriptive sensory analysis techniques. 13 assessors (7 male and 6 female, aged 28 to 58) generated 22 sensory attributes by consensus (3 for appearance, 11 for aroma, and 8 for mouthfeel/palate). Wine samples were presented according to a balanced Latin square block design in coded wines glasses, with each sample evaluated by each panellist in triplicate. **Statistical Analysis:** GC-MS and sensory data were analysed using the XLSTAT Software package (Version 2013.2, France). Significant differences in mean concentrations of volatile compounds and sensory attributes were tested by one-way analysis of variance (ANOVA) followed by a post hoc comparison (Tukey's test at $p < 0.01$ for the volatile compounds, and at $p < 0.05$ for the sensory attributes).

Volatile Characterisation

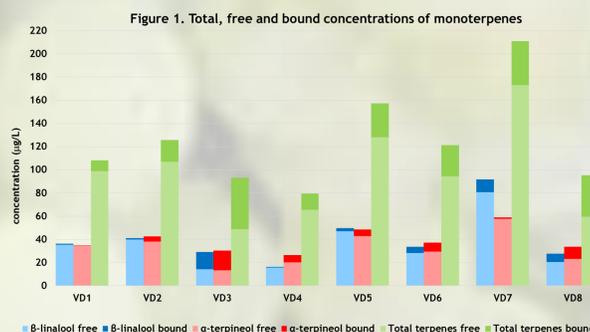
A total of fifty-six volatile compounds were identified and quantified, with concentrations ranging from 1 µg/L to more than 50,000 µg/L, with a selection of some of the most representative shown in Table 1.

Alcohols: *cis-3-hexenol* was present at levels above sensory detection thresholds, suggesting a role in the aroma, contributing 'green', 'grass' and 'leafy' notes.^{1,2,3,4} *3-methyl-1-butanol* was present at high odour activity values that can contribute to 'fusel', 'alcohol' aroma notes.⁵ *2-phenylethyl alcohol* and *2-methoxy-4-vinylphenol* also show OAV>1, which may contribute to pleasant 'rose-like' and 'spicy' aroma nuances in wine.¹

Esters: The ester group showed the most significant variability among the wine samples. *2-phenethyl acetate*, *ethyl decanoate*, *ethyl octanoate*, *ethyl hexanoate* and *isoamyl acetate* all showed high odour activity values, suggesting an active contribution to the sensory properties of these Verdelho wines. 2-phenylethyl acetate has been described as an enhancer for 'floral' and 'sweet-like' notes in young white wines, especially if associated with compounds with 'sweet' aroma such as isoamyl acetate.⁶

Acids: *hexanoic*, *octanoic* and *decanoic acid* detected at concentrations above their sensory threshold level with OAV>1, likely having an impact in the aroma. *isobutyric*, *butyric*, and *3-methylbutyric acid* also showed OAV>1, with concentrations that differed significantly between samples, which may lead to differences in their contribution to the 'cheese', 'fatty' notes in the wines aroma.^{7,8}

Monoterpenes: The total amount of measured free monoterpenes (59.4-173 µg/L) confirms Verdelho as a neutral variety.⁹ *β-linalool* and *α-terpineol* were the most abundant, with only the former showing significant differences between samples, and an OAV>1, showing a potential discriminatory sensory power, contributing to the 'floral' aroma of the wines.^{6,10} In these samples, the total monoterpene content were found predominantly in their free forms (Fig 1.)



	min (µg/L)	max (µg/L)	mean (µg/L)	SD (µg/L)	OTH (µg/L)	OAV (µg/L)	
ALCOHOLS	1-Hexanol*	782	2141	1224	421	4080	0.3
	cis-3-Hexenol*	37	127	70	27	40	1.8
	2-Methyl-1-propanol	9358	34518	19024	7846	40000	0.5
	1-Butanol*	516	1544	863	291	150000	0.0
	3-Methyl-1-butanol	89991	143277	113240	15543	30000	3.8
	3-(Methylthio)-1-propanol	73	191	132	34	500	0.3
	Benzyl alcohol*	30	266	117	85	200000	0.0
	2-Phenylethyl alcohol	8110	16206	10662	2537	10000	1.1
	2-Methoxy-4-vinylphenol*	13	224	68	59	40	1.7
	ESTERS	Ethyl hexanoate*	921	2077	1478	336	14
Ethyl lactate*		4200	11964	7870	2562	154000	0.1
Ethyl octanoate*		1022	2513	1695	472	240	7.1
Ethyl-3-hydroxy-butanoate*		163	462	308	80	20000	0.0
Ethyl decanoate*		284	725	537	147	200	2.7
Diethyl succinate*		267	1115	658	273	200000	0.0
Diethyl malate*		352	1767	1158	424	10000	0.1
Isoamyl acetate*		2411	11534	7228	2608	30	241
Hexyl acetate*		70	387	260	87	670	0.4
2-Phenylethyl acetate*		138	1017	428	255	250	1.7
ACIDS	Propanoic acid*	935	2040	1367	348	8100	0.2
	Isobutyric acid*	1609	3769	2766	633	2300	1.2
	Butyric acid*	1264	2508	1870	345	400	4.7
	3-Methylbutyric acid*	283	973	670	212	250	2.7
	Hexanoic acid	4389	6814	5448	742	420	13
	Octanoic Acid	5940	9297	7427	1012	2200	3.4
	n-Decanoic acid	2087	3635	2747	495	1400	2.0
	Dodecanoic acid	53	118	88	21	6100	0.0
	Phenylacetic acid*	10	221	55	59	1000	0.1
	TERPENES	β-Linalool (free)*	13	83	34	22	15
α-Terpineol (free)		13	59	32	14	250	0.1
β-Citronellol (free)		3	10	7	2	100	0.1

Table 1 - Volatile concentrations, Odour Thresholds (OTH) and Odour Active Value (OAV) in Granite Belt Verdelho wines. * indicates significant differences according to ANOVA results ($p < 0.01$).

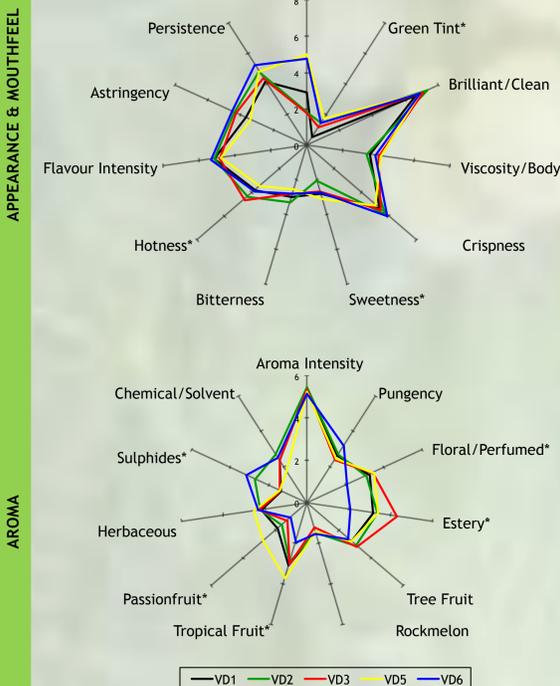
Sensory Characterisation

Verdelho wines from the Granite Belt region were characterised by a 'brilliant/clean' appearance and 'flavour intensity', in which 'crispness' and 'persistence' were dominant descriptors. Aroma was characterised as intense, with 'tree-fruit' and 'pungency' as dominant descriptors, together with 'herbaceous' and 'rockmelon' notes.

VD2 showed a high level of the 'floral/perfumed' attribute, likely due to higher levels of potent odorants such as 2-phenylethyl alcohol and 2-phenylethyl acetate (data not shown). VD3 showed the largest 'estery' flavour attribute, supported by high levels of isoamyl acetate, ethyl-3-hydroxybutanoate, and diethyl malate (data not shown) contributing to 'banana', 'fruity', 'grape-like', 'apple skin like', 'sugar' and 'sweet' aromas.^{1,5,11} VD2 and VD3 also showed high scores for 'hotness', which may be linked to the higher value of alcohol contents for these samples. High scores for 'floral/perfumed' and 'tropical fruit' attributes were found for VD3 and VD5, with the latter being characterised by the highest values of medium chain fatty acid ethyl esters. VD5 also showed the most 'golden' colour, 'tropical fruit' and 'passionfruit' aromas, together with the highest 'sweetness' and lowest 'hot' attributes. VD6 was characterised by the highest level of the 'sulphides' note, together with a high level of the 'golden' appearance.

Conclusions

In this work, the combination of SPE techniques with GC-MS, together with descriptive sensory analysis has successfully allowed a complete analysis of the volatile compounds and sensory characterisation for the Verdelho wines produced in the Granite Belt region of the Australian state of Queensland for the first time, revealing their complex chemical profile and rich aromatic composition.



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