DOI: https://doi.org/10.20870/oeno-one.2026.60.3.10048

OPEN ACCESS

ENOLOGY ORIGINAL RESEARCH ARTICLES

A large-scale check-all-that-apply (CATA) study of the sensory characteristics of white and red wines produced from fungus-resistant grape varieties in the South of France

Soline Caillé[1,*], Alain Samson[2], Olivier Geffroy[3], Stéphanie Roi[1], Christian Chervin[4], Valérie Olivier[5], Marc-Antoine Dolet[4,5], Caroline Paire[6], Foued Cheriet[6]

[1] SPO, Univ Montpellier, INRAE, Institut Agro, Montpellier, France
[2] INRAE, Unité expérimentale de Pech Rouge, 11430 Gruissan, France
[3] PPGV, Université de Toulouse, Ecole d'Ingénieurs de PURPAN, 75 voie du TOEC, 31076 Toulouse, France
[4] LRSV, Université de Toulouse, INP-AgroToulouse, CNRS, Avenue de l'Agrobiopôle, 31326 Auzeville-Tolosane, France
[5] AGIR, Université de Toulouse, Toulouse INP, PURPAN, INRAE, AGIR, Castanet-Tolosan, France
[6] MoISA, Université de Montpellier, Institut Agro Montpellier, 2 place Pierre Viala, 34000 Montpellier, France

Article number: 10048

*correspondence:
soline.caille@inrae.fr

Associate editor:
Sue Bastian

Received:
22 April 2026

Accepted:
28 July 2026

Published:
7 September 2026

This article is published under the **Creative Commons licence** (CC BY 4.0).

Use of all or part of the content of this article must mention the authors, the year of publication, the title, the name of the journal, the volume, the pages and the DOI in compliance with the information given above.

ABSTRACT

Fungus-resistant grape varieties (FRG) are increasingly recognised as a promising way to make the wine industry more resilient in the face of societal pressures and climate change, while also creating new market opportunities. However, sensory data on FRG wines, particularly those produced in southern France, is limited – the present study aimed to provide a sensory characterisation of these wines on a large scale. A total of 43 white and 33 red wines, made from FRG and *Vitis vinifera* varieties, were evaluated over two consecutive years by a trained panel using the Check-All-That-Apply (CATA) method. Panel performance was validated using replicate samples assessed across sub-sessions. The results highlighted a wide diversity of sensory profiles among FRG wines, which were comparable to those of *Vitis vinifera* wines, with no clear distinction between the two categories. White FRG wines exhibited particularly high variability, influenced by climate and vintage, whereas red wines showed more distinctive patterns. Some varieties, such as 'Vidoc', displayed a broader range of profiles, while others, including 'Artaban', showed more consistent profiles across sites and years. These findings provide the wine industry with practical insights, indicating that FRG varieties can be planted without risking the production of wines with atypical sensory profiles. Future research should build on these results by conducting detailed aroma compound analyses and hedonic evaluations with experts and consumers, with and without information disclosure regarding the resistant character. Additionally, FRG wines from other French vineyards should be investigated.

KEYWORDS: FRG, white wine, red wine, sensory characterisation

INTRODUCTION

Since grapevine domestication that occurred simultaneously in the Near East and the Caucasus region about 11,000 years ago (Dong *et al.*, 2023), varietal evolution through sexual reproduction has generally been the result of unintentional processes (Yobrégat, 2018). The introduction of phylloxera (*Daktulosphaira vitifoliae*) from America to Europe, first detected in France in 1863, led several breeders in the late 19th century and early 20th century to conduct directed interspecific crosses involving American *Vitis* species in order to develop rootstocks that could withstand this sap-feeding insect, which was destroying vineyards planted with *Vitis vinifera* (This *et al.*, 2024). This was followed by a period of variety breeding, resulting in the creation of "hybrid direct producers", known in French as HPD. Besides being resistant to phylloxera, enabling them to be planted on their own roots, these varieties also exhibited cross-resistance to downy mildew (DM) (*Plasmopara viticola*) and powdery mildew (PM) (*Erysiphe necator*), two other fungal diseases introduced from America during the same period (Töpfer *et al.*, 2011). In 1960, the area planted with HPD reached up to 400,000 hectares in France, representing 30 % of the national vineyard area (Reynier, 2011).

The restrictive regulatory framework that emerged after the Second World War considerably slowed down grape breeding initiatives in France, contributing to the removal of these varieties (Paire *et al.*, 2024; Torregrosa *et al.*, 2024).

The only French interspecific hybridisation programme conducted during the second half of the 20th century to develop fungus-resistant grape varieties (FRG), sometimes referred to as fungus-tolerant varieties, was led by Alain Bouquet, a researcher at the French National Research Institute for Agriculture, Food, and Environment (INRAE). The programme involved backcrossing *Vitis rotundifolia Michx* offspring with several *Vitis vinifera* Mediterranean cultivars (Paire *et al.*, 2024). Subsequently, in 2000, in response to growing societal pressure to reduce pesticide use, INRAE launched an ambitious breeding programme in Alsace named "RESDUR" to combine several resistance genes against DM and PM, and therefore to limit the risk of disease bypass (Schneider *et al.*, 2019).

The first four varieties obtained within the framework of this programme – 'Floreal', 'Voltis', 'Vidoc', and 'Artaban' – were registered in the French catalogue in 2018. Currently, French winegrowers can choose from a total of 40 tolerant or fully resistant varieties developed in Italy, Germany, or Switzerland by public or private breeders (www.plantgrape.fr).

These varieties, which enable limiting the number of spray applications targeting DM and PM, typically from 10 to 15 treatments to only 2 or 3, are becoming increasingly popular among winegrowers as illustrated by the 2,270 hectares of vines in France in 2023 (Torregrosa *et al.*, 2024). Interest in this approach is particularly pronounced in the south of France, specifically in the Occitanie region (Dolet *et al.*, 2024).

Although studies conducted in north-eastern USA and Québec under cool climate conditions have shown that wines made from hybrid grape varieties obtained from interspecific crosses involving *Vitis vinifera* and other *Vitis* species can exhibit distinct olfactory profiles and contain significant concentrations of rotundone, monoterpenols, or methoxypyrazine (Homich *et al.*, 2017; Sleger *et al.*, 2015; Sun, 2011), or have a variable cis-3-hexenol to trans-2-hexenal ratio (Pedneault *et al.*, 2013), little is known about the sensory characteristics of wines made from new varieties obtained and grown in Europe, particularly under warmer conditions. However, a recent study by Dolet *et al*. (2026) in southern France demonstrated that professional panels found no notable differences in the sensory profiles or overall preference of wines made from FRD varieties compared to those made from traditional *Vitis vinifera* varieties. Although Paire *et al.* (2025a) investigated the use of 'Vidoc' and 'Artaban' in French Merlot red blends produced in the south of France, three studies on monovarietal wines were, to our knowledge, conducted in the alpine climates of Switzerland and the Italian province of South Tyrol (Blackford *et al.*, 2025; Duley *et al.*, 2025a; Duley *et al*., 2025b). Research carried out in Switzerland showed that white FRG wines exhibit distinct characteristics compared to traditional varieties, with some having higher alcohol content and varying acidity. Red FRG wines showed greater sensory differentiation, particularly in terms of spiciness and bouquet. They were also notably darker and more intense in colour due to their high phenol and anthocyanin content. In contrast, the Italian study reported little sensory distinctiveness between FRG and *Vitis vinifera* wines, with only the attributes "honey" and "pineapple" showing a significant difference.

The present study aimed to characterise the sensory profiles of a large range of commercial and experimental white and red wines produced in the south of France from FRG during two consecutive seasons using the check-all-that-apply (CATA) method. This increasingly popular and simple descriptive method, which was introduced in sensory science in 2007 (Adams *et al.*, 2007), has proved powerful enough to discriminate between samples (Valentin *et al.*, 2012). Some wines made from traditional *Vitis vinifera* varieties produced in the region under study were also included in the experimental design for comparative purposes.

MATERIALS AND METHODS

1. Wine samples

A total of 43 white wines (vintages 2018–2023) and 33 red wines (vintages 2020–2023) underwent sensory characterisation. Samples from FRG (single-varietal or blended) and *Vitis vinifera* (single-varietal) were evaluated for both types of wine. The study included both experimental and commercial wines mainly from the Occitanie and Nouvelle-Aquitaine regions in the south

of France (Tables 1 and 2). Using experimental wines ensured 100 % varietal purity, whereas commercial wines, despite varietal labelling, may contain up to 15 % other varieties. The detailed composition of commercial wines was confirmed by the winery when possible. Wines were classified into three geographical-climatic areas, namely the Mediterranean (Type 8), the Southwest basin (Type 7) and the Altered oceanic (Type 4) areas, according to the classification provided by Joly *et al.* (2010). The altered oceanic climate is mild with moderate rainfall, the southwest basin climate is warmer with rare frosts, and the Mediterranean climate has hot, dry summers and wet winters.

The *Vitis vinifera* grape varieties were selected for their prevalence in the study region and because they are among the most widely planted varieties in 2022, used to produce white and red wines within the Protected Geographical Indication (PGI) Pays d'Oc, which is the main designation for varietal wines in southern France (https://www.paysdoc-wines.com). The reference wines were selected to represent the commercial offering of each variety in the study region. They were produced by major wine companies that sell several million bottles of these wines each year.

This study was conducted over two years to capture the full diversity of profiles, as seasonality and *terroir* are the main factors influencing the composition of wine, particularly with regard to aroma compounds and sensory characteristics (van Leeuwen *et al.*, 2020).

The FRG wines used in this study were those produced in southern France identified in an earlier, comprehensive national study of the commercial FRG wine market in France (Paire *et al.*, 2025b). In addition to geographical origin, the selection was guided by two main criteria: maximising sample diversity and including emerging varieties, such as 'Floreal', 'Artaban', and 'Vidoc', whose cultivated area is beginning to expand in southern France (Dolet *et al.*, 2024). The selected wines were made from FRG varieties bred in several European countries such including France (*e.g.*, 'Floreal', 'Voltis', 'Artaban', 'Vidoc', Bouquet G14, Bouquet 3176), Germany ('Souvignier Gris', 'Muscaris', 'Cabernet blanc', 'Prior', 'Monarch', 'Cabernet Cortis'), Switzerland ('Sauvignac', 'Pinotin', 'Cabernet noir', 'Cabernet Jura'), and Italy ('Soreli', 'Sauvignon Kretos', 'Cabernet Volos', 'Merlot Khorus').

The oenological parameters of the wines were measured just before the sensory analysis was performed, in accordance with the reference methods of the International Organisation of Vine and Wine (OIV). The analysis was carried out once without replication (Tables S1 and S2).

2. Sensory analysis

Sensory analysis was conducted at INRAE UMR SPO in Montpellier, France, over two consecutive years: 2023 (year 1) and 2024 (year 2). The panel comprised 19 panellists in year 1 and 17 in year 2. Panel members were selected based on their sensory performance and interest, and then underwent training in the descriptive sensory analysis of wines (norm ISO 8586-2, 2008).

The wines were analysed using the Check-All-That-Apply (CATA) methodology (Meyners *et al*., 2013) and, more specifically, during the olfactory assessment with hierarchical CATA (Koening *et al*., 2023). The CATA principle is that panellists are given a list of predefined descriptors based on previous research and reviewed by project team members. They then selected all the descriptors that describe the sample to be tested. The set of descriptors used in this study is highly consistent with those identified by Garcia *et al*. 2022 in their previous research.

As for hierarchical CATA, this method allows for a more "natural" structure of attributes and reduces cognitive effort. It is a descriptive analysis method that enables the evaluation of a large number of samples. Prior to all tasting sessions each year, judges are trained to understand and consistently use the attributes, as well as to familiarise themself with the methodology. Standards were created by adding compounds to white or red wine to help the judges identify and remember the sensory attributes. A detailed list of the sensory attributes and related standards can be found in Table 3.

Wines were analysed over several sessions each year, with an average of 11 ± 1 white wines and 8 red wines tasted per session. The analyses were conducted in individual testing booths. Samples (30 ml) were served at room temperature (18 ± 1 °C) in black glasses to avoid potential visual influences during evaluation. The glasses were covered with a plastic cap and marked with random three-digit codes. The wines were presented in a monadic service according to William's Latin square design to balance the order of presentation and the carry-over effect (Macfie *et al.*, 1989). Fifty per cent of the wines were analysed in duplicate. For each sample, judges had to select the most relevant attributes from lists of 30 olfactory terms (classified hierarchically into 12 families) and 9 gustatory terms for white wines, and 29 olfactory terms (classified into 13 families) and 10 gustatory terms for red wines (Table 3).

Data acquisition was assisted by FIZZ software (FIZZ network, v.2.518; Biosystème, Courtenon, France).

3. Statistical analysis

HCATA data were collected in a product-by-attribute table for each subject, with scores of 0 (absent) or 1 (present).

To incorporate the hierarchical structure, we first aggregated the selected descriptors, carrying over those chosen at the lowest level to the higher levels (descriptor, then family), as described by Koenig *et al.* (2023): if a judge selected a descriptor, the corresponding family was assigned a checkmark. When multiple terms were evaluated within the same family, that family was assigned a single checkmark.

TABLE 1. Description of the white wine samples used in the study (n = 43).

Wine code	Grape variety	Vintage	Geographical area	Wine type	Analysis year
Bq3159	Bouquet 3159-2-12	2022	Mediterranean	experimental	Year 1
Bq3159-Flo	Bouquet 3159-2-12 – 'Floreal'	2023	Mediterranean	experimental	Year 2
BqG5	Bouquet G5	2022	Mediterranean	experimental	Year 1
BqG5-BqG9	Bouquet G5 – Bouquet G9	2023	Mediterranean	experimental	Year 2
BqG9	Bouquet G9	2022	Mediterranean	commercial	Year 1
CabB	'Cabernet blanc'	2023	Mediterranean	experimental	Year 2
Chd_1[a]	'Chardonnay'	2022	Mediterranean	commercial	Year 1
Chd_1[b]	'Chardonnay'	2022	Mediterranean	commercial	Year 2
Fleu_1	'Fleurtai'	2022	Mediterranean	experimental	Year 1
Fleu_2	'Fleurtai'	2023	Mediterranean	experimental	Year 2
Flo_1	'Floreal'	2022	Mediterranean	experimental	Year 1
Flo_2	'Floreal'	2022	Mediterranean	experimental	Year 1
Flo_3	'Floreal'	2022	Mediterranean	commercial	Year 1
Flo_4	'Floreal'	2022	Mediterranean	commercial	Year 1
Flo_5	'Floreal'	2022	Mediterranean	commercial	Year 2
Flo_6	'Floreal'	2023	Mediterranean	commercial	Year 2
Flo_7	'Floreal'	2023	Southwest basin	commercial	Year 2
Flo_8	'Floreal'	2023	Southwest basin	experimental	Year 2
Flo_9	'Floreal'	2023	Southwest basin	experimental	Year 2
Ker	'Kersus'	2023	Mediterranean	experimental	Year 2
Mus	'Muscaris'	2023	Altered oceanic	commercial	Year 2
Mus-Flo-Sor	'Muscaris' – 'Floreal' – 'Soreli'	2022	Mediterranean	commercial	Year 2
Saph_1	'Saphira'	2022	Mediterranean	experimental	Year 1
Saph_2	'Saphira'	2023	Mediterranean	experimental	Year 2
Sau_1	'Sauvignon'	2022	Mediterranean	commercial	Year 1
Sau_2	'Sauvignon'	2022	Mediterranean	commercial	Year 2
Savc	'Sauvignac'	2020	Altered oceanic	commercial	Year 1
Savc-Musc	'Sauvignac' – 'Muscaris'	2023	Altered oceanic	commercial	Year 2
Sor_1[a]	'Soreli'	2022	Mediterranean	commercial	Year 1
Sor_1[b]	'Soreli'	2022	Mediterranean	commercial	Year 2
Sor-Fleu-Souv	'Soreli' – 'Fleurtai' – 'Souvignier gris'	2022	Mediterranean	commercial	Year 2
Souv_1	'Souvignier gris'	2022	Mediterranean	experimental	Year 1
Souv_2	'Souvignier gris'	2022	Mediterranean	commercial	Year 1
Souv_3	'Souvignier gris'	2022	Mediterranean	commercial	Year 1
Souv_4	'Souvignier gris'	2022	Mediterranean	commercial	Year 2
Souv_5	'Souvignier gris'	2023	Southwest basin	experimental	Year 2
Souv-Mus_1	'Souvignier gris' – 'Muscaris'	2022	Mediterranean	commercial	Year 1
Souv-Mus_2	'Souvignier gris' – 'Muscaris'	2023	Mediterranean	commercial	Year 2
Souv-Savc	'Souvignier gris' – 'Sauvignac'	2020	Altered oceanic	commercial	Year 1
Vio_1[a]	'Viognier'	2022	Mediterranean	commercial	Year 1
Vio_1[b]	'Viognier'	2022	Mediterranean	commercial	Year 2
Vol_1	'Voltis'	2022	Mediterranean	experimental	Year 1
Vol_2	'Voltis'	2018	Southwest basin	experimental	Year 2

Samples made from *Vitis vinifera* grapes are highlighted in grey. The types listed in "Geographical area" are numbered as in Joly *et al.*, 2010. Wines with the same superscript letter (ab,) are the same wine and vintage, but may be from different commercial batches and were evaluated in both years.

TABLE 2. Description of the red wine samples used in the study (n = 33).

Wine code	Grape variety	Vintage	Geographical area	Wine type	Analysis year
Art_1	'Artaban'	2022	Mediterranean	experimental	Year 1
Art_2	'Artaban'	2022	Southwest basin	experimental	Year 2
Art_3	'Artaban'	2023	Mediterranean	experimental	Year 2
Art_4	'Artaban'	2023	Mediterranean	commercial	Year 2
Bq3176_1	Bouquet 3176-21-11	2022	Mediterranean	experimental	Year 1
Bq3176_2	Bouquet 3176-21-11	2022	Mediterranean	experimental	Year 1
Bq3176_3	Bouquet 3176-21-11	2023	Mediterranean	experimental	Year 2
Bq3328	Bouquet 3328-306	2022	Mediterranean	experimental	Year 1
BqG14_1	Bouquet G14	2022	Mediterranean	experimental	Year 1
BqG14_2	Bouquet G14	2023	Mediterranean	experimental	Year 2
CabCor	'Cabernet Cortis'	2022	Mediterranean	experimental	Year 1
CabJur_1[a]	'Cabernet Jura'	2020	Altered oceanic	commercial	Year 1
CabJur_1[b]	'Cabernet Jura'	2020	Altered oceanic	commercial	Year 2
CabN_1[a]	'Cabernet noir'	2022	Mediterranean	commercial	Year 1
CabN_1[b]	'Cabernet noir'	2022	Mediterranean	commercial	Year 2
CS	'Cabernet-Sauvignon	'2021	Mediterranean	commercial	Year 1
Gre	'Grenache'	2022	Mediterranean	commercial	Year 2
Mer_1	'Merlot'	2021	Mediterranean	commercial	Year 1
Mer_2	'Merlot'	2021	Mediterranean	commercial	Year 2
Merk_1	'Merlot Khorus'	2021	Mediterranean	commercial	Year 1
Merk_2	'Merlot Khorus'	2022	Mediterranean	commercial	Year 2
Mon_1	'Monarch'	2022	Mediterranean	experimental	Year 1
Mon_2	'Monarch'	2023	Mediterranean	experimental	Year 2
Pino_1	'Pinotin'	2022	Mediterranean	experimental	Year 1
Pino_2	'Pinotin'	2023	Mediterranean	experimental	Year 2
PN	'Pinot noir'	2022	Mediterranean	commercial	Year 2
Prior_1	'Prior'	2022	Mediterranean	experimental	Year 1
Prior_2	'Prior'	2022	Mediterranean	experimental	Year 1
Syr	'Syrah'	2021	Mediterranean	commercial	Year 1
Vid_1	'Vidoc'	2022	Mediterranean	experimental	Year 1
Vid_2	'Vidoc'	2022	Southwest basin	experimental	Year 2
Vid_3	'Vidoc'	2023	Mediterranean	experimental	Year 2
Vid-Art	'Vidoc' – 'Artaban'	2022	Mediterranean	commercial	Year 2

Samples made from *Vitis vinifera* grapes are highlighted in grey. Wines with the same superscript letter (a or b) are the same wine and vintage, but may be from different commercial batches and were evaluated in both years.

TABLE 3. List of descriptors and standard solutions used for the sensory analysis and training sessions, respectively.

White wines			Red wines		
Olfactory family	Olfactory descriptors	Standards	Olfactory family	Olfactory descriptors	Standards
F_Fruity	citrus exotic fruit white fruit cooked fruit muscat	grapefruit and lemon zest exotic fruit mix fruit in syrup apricot jam muscat wine	F_Fruity	red berries blackcurrant	red fruit juice blackcurrant juice red fruit jam
F_Floral	white flowers rose	linalol rose water	F_Floral	violet	α-ionone
F_Vegetable	blackcurrant bud fresh grass undergrowth	fresh grass humus	F_Vegetable	sweet pepper fresh grass undergrowth	2-isobutyl-3-methoxypyrazine green pepper fresh grass humus
F_Spicy	pepper	black pepper clove	F_Spicy	pepper liquorice	black pepper liquorice concentrate clove
F_Empyreumatic	burnt smoked caramel	toasted bread smoky aroma liquid caramel	F_Empyreumatic	burnt smoked caramel	toasted bread smoky aroma liquid caramel
F_Pastry	vanilla baking spices honey biscuit	vanilla powder baking spices all-flower honey madeleines	F_Pastry	vanilla baking spices brioche	vanilla powder baking spices brioche
F_Alcohol	alcohol cherry	absolute ethanol kirsh	F_Alcohol	alcohol cherry	absolute ethanol kirsh
F_Lactic	butter	melted butter condensed milk	F_Lactic	butter	melted butter condensed milk
F_Mineral	flint dust	flint pentachloroanisol	F_Mineral	flint dust	flint pentachloroanisol
F_Chemical	amyl solvent	isoamyl acetate banana candy nail polish remover	F_Chemical	amyl solvent	isoamyl acetate banana candy nail polish remover
F_Oxidised	sweet wine prune nut	Rivesalte natural sweet wine prune juice walnut kernels	F_Oxidised	sweet wine prune nut	Rivesalte natural sweet wine prune juice walnut kernels
F_Reduced	sulphur boiled vegetables	sulphur vegetables for soup	F_Reduced	sulphur boiled vegetables	sulphur vegetables for soup
Gustatory descriptor		Standards	F_Animal	leather	4-ethylphenol
Acidity		tartaric acid	Gustatory descriptor		Standards
Alcohol		absolute ethanol	Acidity		tartaric acid
Bitterness		caffeine	Alcohol		absolute ethanol
Aqueous		water	Bitterness		caffeine
Aromatic			Aqueous		water
Fat		cellulose gum	Aromatic		
Sweetness		rectified concentrated must	Fat		cellulose gum
Short			Sweetness		rectified concentrated must
Long			Short		
			Long		
			Astringency		grape tannin extracts

The letter F before the descriptor indicates that it refers to an olfactory family.

The obtained binary data were analysed using XLSTAT 2022 software (Lumivero, Paris, France). Before processing the results, we ensured the panel's performance by analysing the average reproducibility index (Ri), which was calculated to assess each judge's individual performance.

$$R_i = \frac{1}{n} \times \sum 2 \times \frac{Des_{rep}}{Des_{rep1} + Des_{Rep2}} \quad \text{(Equation 1)}$$

Des_{rep} is the number of terms used by the judge for each replicate.

Des_{rep1} and Des_{rep2} are the total numbers of terms used by the judge for the first and second replicates, respectively.

n is the number of samples duplicated.

This parameter, which ranges from 0 to 1, was used in previous studies (Campo *et al.*, 2008).

To identify significant differences between wines for each attribute, a Cochran's Q test was performed. Descriptors that were significant at the 5 % level in at least one of the two evaluation years were selected.

Multiple Factor Analysis (MFA) was performed on the contingency table by separating the significant olfactory and gustatory descriptors into two tables and adding the year of analysis as a supplementary variable to investigate its effect on the sensory results.

RESULTS AND DISCUSSION

1. Panel performance, discriminating attributes, and impact of the year of analysis

In this study, the reproducibility index (Ri) had a maximum value of 0.90, indicating 90 % consistency in common terms between two replicates for a given judge, and a minimum value of 0.42. The median Ri values were 0.69 and 0.68 for white wines in years 1 and 2, respectively, and 0.70 and 0.65 for red wines in the same periods. These results can be considered robust, as they are superior to those reported in the reference study (Campo *et al*., 2008). Overall, the jury's performance exhibited notable homogeneity, with slightly higher reproducibility observed in year 1 and for red wines (Table S3).

Cochran's Q tests revealed significant differences ($p < 0.05$) for 15–21 olfactory attributes in white wines and 9–14 in red wines (Table S4), depending on the year, representing 25 % to 50 % of the descriptors. Notably, 11 olfactory descriptors consistently distinguished white wines across both years, compared to just 6 for red wines. In contrast, gustatory attributes were more variable, with 60 % to 100 % of descriptors showing significant differences between wines.

The sensory analysis revealed a greater number of significant differences in the gustatory profile than in the olfactory profile. This is consistent with practice, since the gustatory dimension typically involves fewer descriptors. In contrast, olfactory evaluation is often subject to descriptor overlap whereby multiple attributes describe a similar sensation. However, specific panel training helps to reduce this effect, which is consistent with the findings of Seinforin *et al*. (2023). Their analysis of recognition rates indeed demonstrated higher overall performance for olfaction than for taste, supporting the conclusion that the sense of smell is more effective than taste for the identification of grape varieties. Furthermore, more significant differences were identified among white wines than red wines. This may be due to the larger sample size of the white wine set, which potentially introduced greater sensory diversity. The most significant descriptors enabled clear characterisation of the wines using common terminology such as *fruity*, *floral*, c*hemical*, and defects such as *reduced* and *animal*. Interestingly, the *mineral* descriptor reached statistical significance, despite the poorly defined nature of this attribute (Parr *et al*., 2018). The sensory descriptors used to describe wines show a strong alignment with the terminology previously established by Koenig *et al*. (2023).

In both MFA analyses, the "year of analysis" was included in a supplementary table. The results revealed no significant effect of the year of analysis, as evidenced by the very low RV coefficients (0.12 for white wines and 0.06 for red wines). This confirms that the wines' sensory profiles are consistent across the two years of analysis, enabling reliable comparisons to be made between them (Table S5).

2. White wines analysis

Figure 1 shows the MFA results for the white wines, with the PC1 and PC2 axes accounting for 40.51 % of the total variance.

MFA reveals two primary sensory dimensions that distinguish the wines. Axis 1 captures the contrast between wines characterised by reduction (*boiled vegetable, reduced,* and *sulphur*) and *acidity*, which are positioned on the negative side, and those characterised by *aromatic intensity* and *sweetness*, which are located on the positive side. This axis reflects a key opposition in the sensory profiles, with wines distributed along it based on their balance of these contrasting attributes.

Axis 2 introduces a secondary differentiation, opposing wines characterised by *alcohol* intensity, *pastry* and *empyreumatic* descriptors (*biscuit, caramel, empyreumatic*) to wines described as *aqueous*, *short* and *fruity* descriptors (*blackcurrant, exotic fruit*). Together, these two axes provide a comprehensive framework for understanding the sensory diversity and complexity of the wines studied, which may be attributed to the grape variety or the winemaking process.

Figure 1 illustrates the variety of sensory profiles that can be produced from a single FRG cultivar. In this case, the 'Floreal' cultivar was used to produce 9 wines from various regions in the south of France. Some of these wines (Flo_8 and Flo_9) are associated with *fruity* and *aqueous* perceptions, while others (Flo_2 and Flo_3) are associated with *sweetness* perception. One wine (Flo_1) is associated with *boiled vegetables* and *reduced* aromas. It is worth

noting that the nine 'Floreal' wines tested here had alcohol percentages ranging from 10.6 % to 14.8 % (Table S1), demonstrating the wide range of grape maturities used in these 'Floreal' wines.

The impact of climate was particularly noticeable for 'Floreal', with Flo_7, Flo_8, and Flo_9 exhibiting similar sensory profiles due to being produced under the Southwest basin climate, as reflected by their close proximity in the MFA. Compared with the warmer Mediterranean climate, which accounted for the majority of the samples (34 out of 43 wines), wines produced under the cooler conditions of the Southwest basin were perceived as more *aqueous* by the panel. This effect may be due to familiarity, as participants recruited in Montpellier were probably more accustomed to the fuller-bodied wines typically produced locally in the Mediterranean region. The climate effect was less pronounced for Souv_5, which was produced in the Southwest basin and exhibited similar characteristics to Souv_2, Souv_3, and the Souv-Mus_1 and Souv-Mus_2 blend, all of which were produced under warmer Mediterranean conditions. The close proximity of Flo_2, Flo_3, and Flo_6, all of which were produced under the Mediterranean climate from different vintages, shows that the season had a more limited impact on sensory profiles than the varietal effect.

The sensory profiles of the eight blended wines revealed the distinct influence of their parent varietals. Blend Bq3159_Flo has a profile that is closely aligned with pure 'Floreal' wines of the Mediterranean type. Blends incorporating Muscat-scented varieties, such as G5 and 'Muscaris', are characterised by prominent Muscat notes (*floral, rose, and white fruit*), but these notes are less intense than in pure wines. Conversely, the 'Sauvignac' – 'Muscaris' blend is more strongly characterised by the 'Sauvignac' profile. Similarly, other blends containing 'Sauvignac' resemble pure wines made from this grape variety more closely. In contrast, 'Souvignier gris' appears to contribute no distinct sensory characteristics when used in blends, with wines containing this variety tending to align more closely with the aromatic and structural profiles of the other associated grape varieties.

For wines made from *Vitis vinifera* varieties, the central position of the sample on the MFA and the limited distance between samples of the same variety suggest less distinctive and pronounced profiles and lower diversity. However, this observation is based on a small sample size, and more wines are needed to draw firm conclusions. The samples analysed primarily serve as reference standards and may not fully represent the broader diversity of commercial wines currently available. As expected, the Chd_1 and Chd_2 samples were described as *buttery*, a term frequently used to characterise 'Chardonnay' wines (Bartowsky & Henschke, 2004). Surprisingly, 'Sauvignon' wines (*i.e.*, Sau_1 and Sau_2) did not exhibit intense *fruity* or *exotic fruit* notes or *aromatic* character, despite this variety's potential to produce wines with high levels of varietal thiols. This may be due to the warm and dry climatic conditions experienced in their region of production (Mediterranean climate), which did not favour the biosynthesis of thiol precursors (Roland *et al.*, 2011). Similarly, 'Viognier' wines, namely Vio_1 and Vio_2, were not perceived by the panel as having an intense *white fruit* aroma. This attribute, together with *stone fruit,* is often used to describe these wines, and its intensity is related to the concentrations of linalool, geraniol and nerol (Siebert *et al.*, 2018). Nevertheless, a more detailed study of the aroma composition of the wines in question would be valuable to build on the present work.

Overall, the lack of clear clustering between *Vitis vinifera* and FRG across the extensive wine sample examined in our study does not corroborate the hypothesis of FRG distinctiveness. This finding is consistent with previous research (Duley *et al.*, 2025a).

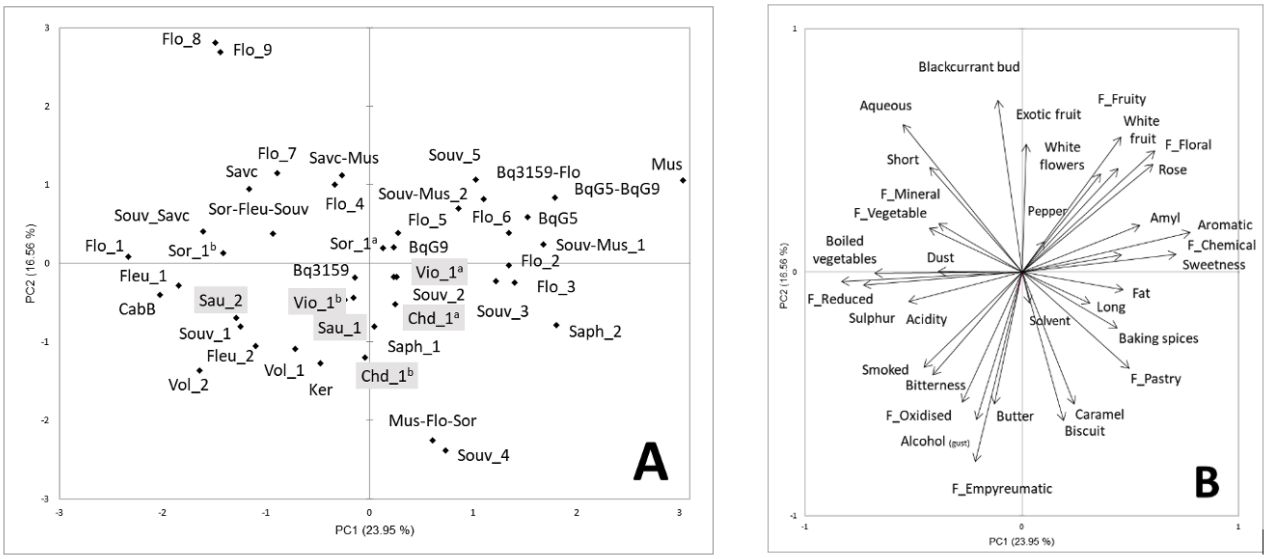


FIGURE 1. Multiple Factor Analysis (MFA) of white wines.

Score plot (A) showing the positioning of individual wine samples and loadings plot (B) showing sensory descriptors. The analysis was based on significant CATA attributes from two consecutive vintages (Year 1: n = 19 panellists; Year 2: n = 17 panellists).
Samples made from *Vitis vinifera* grapes are highlighted in grey. The acronyms are explained in Table 1.

3. Red wines analysis

For the red wines' MFA (Figure 2), the PC1 and PC2 axes accounted for 36.62 % of the total variance.

Axis 1 clearly distinguishes between wines characterised by *acidity* and *aqueous* attributes and those defined by *sweetness* and aromatic descriptors (*amyl, aromatic, floral, violet*). In contrast, axis 2 is primarily explained by descriptors from chemical families (*chemical, amyl*), and reduced attributes (*reduced, sulphur, boiled vegetable*), which further refine the differentiation of the wines' sensory profiles. This axis highlights the influence of chemical nuances and reduction-related characteristics in defining the complexity of red wines, a factor that can be attributed to either the grape variety or the winemaking process.

Similar to the observations made for the white wines, the FRG red wines showed considerable variability in their sensory profiles, with some exhibiting spicy (*e.g.*, Vid_1), *fruity*, *oxidised* and *acid* (*e.g.*, Merlk1, Vid_22, Art_2), *reduced* and *bitter* (*e.g.*, Bq3176_1, CabJur_2, Bd3328), or *amyl, aromatic* and *floral* (*e.g.*, CabCor, Bq3176_2) characteristics.

Within the FRG varieties represented by the largest number of replicates, 'Artaban' and 'Vidoc' are of particular interest. 'Vidoc' samples showed clear differences in sensory expression, as indicated by their scattered positions on the MFA plot. Specifically, Vid_1 is perceived as having a higher *alcohol* intensity than the other samples. However, it should be noted that the alcohol percentage does not differ between Vid_1 and Vid_3 (both 14.22 %). Vid_2 is characterised by higher *acidity* and lower *sweetness*, consistent with the analytical data, particularly the pH levels and total acidity measurements for this wine. Additionally, Vid_2 is less *spicy*. In contrast, Vid_3 differs in its aromatic profile, which is described as more *amyl*. In contrast, the 'Artaban' wines were more homogeneous despite originating from different vintages and climatic conditions. The latter wines were generally described as *fruity* and tended to show lower viscosity and persistence, which is consistent with their negative association with *fat* and *long* attributes. The oenological parameters of the 'Artaban' wines are relatively uniform (Table S2). However, the Art_2 sample showed slight variations, most notably in its acidic profile (pH and total acidity), indicating a marginal differentiation.

A comparable degree of homogeneity was also observed for 'Pinotin'. Conversely, some FRG red wines exhibited greater variability than 'Vidoc', particularly the Bouquet varieties (*e.g.*, Bq3176_1, Bq3176_2, BqG14_1, and BqG14_2). As these wines were produced under experimental conditions, it is possible that the vintage effect had a greater influence on the results than the varietal characteristics themselves.

Regarding red wines made from *Vitis vinifera*, all samples were distributed along PC2 and exhibited greater variability in sensory profiles compared to the white wines. This can be attributed to the greater diversity of grape varieties used, including those traditionally planted in Bordeaux ('Merlot' and 'Cabernet-Sauvignon'), the Mediterranean ('Grenache' and 'Syrah'), and Burgundy ('Pinot noir'). As previously noted, this principal component primarily captures differences in olfactory characteristics rather than taste or mouthfeel perception. Notably, the 'Syrah' sample (Syr) did not exhibit the highest intensity of *sulphur* or *reduced* aromas despite this variety's known tendency to develop such notes (Geffroy *et al.*, 2020). Similarly, 'Pinot noir' wines exhibited only weak *cherry* notes, despite this being a descriptor frequently used to describe wines made from this variety (Aubry *et al.*, 1999).

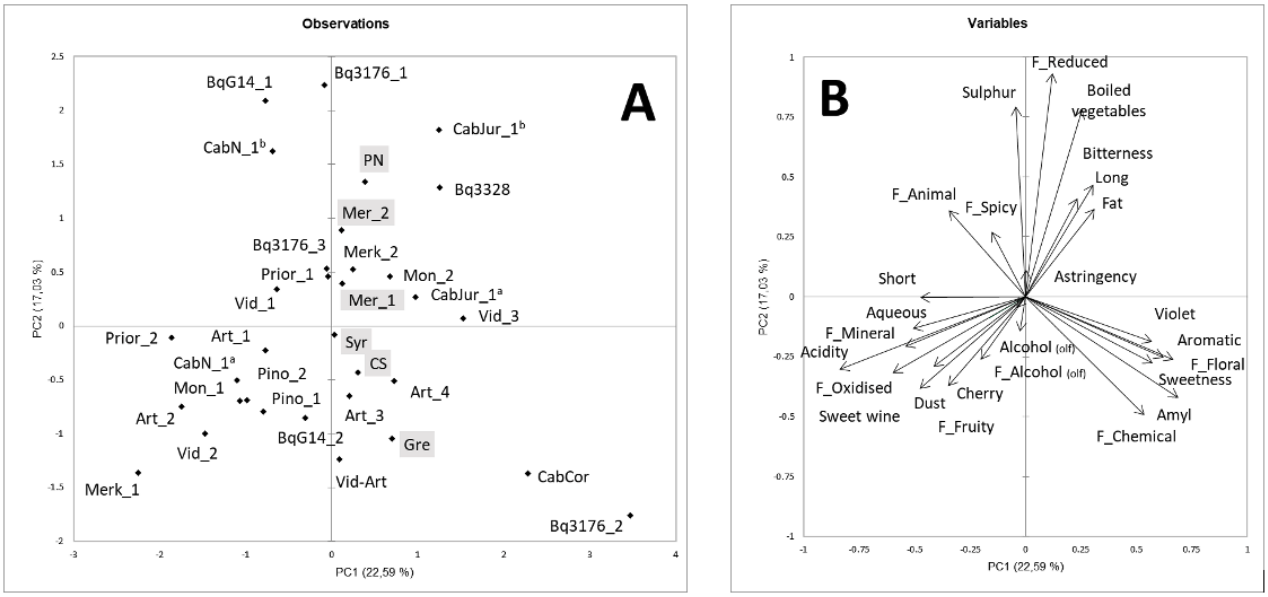


FIGURE 2. Multiple Factor Analysis (MFA) of red wines.

Score plot (A) showing the positioning of individual wine samples and loadings plot (B) showing sensory descriptors. The analysis was based on significant CATA attributes from two consecutive vintages (Year 1: n = 19 panellists; Year 2: n = 17 panellists).

Samples made from *Vitis vinifera* grapes are highlighted in grey. The acronyms are explained in Table 2.

'Cabernet Volos', 'Cabernet noir', 'Cabernet Jura', and 'Merlot Khorus' exhibited sensory profiles that were notably different to those of 'Cabernet-Sauvignon' and 'Merlot', respectively (Figure 2). The breeders named these FRG to indicate their *Vitis vinifera* parentage. However, our results suggest that there is no sensory resemblance between wines made from the parental varieties and their FRG derivatives, which could potentially mislead consumers. This issue requires the attention of regulatory authorities, particularly given the ongoing discussions at the OIV concerning varietal nomenclature (Resolution OIV-VITI 609-2019). According to the current protocol for naming a new variety, proposed names must avoid the use of names that may lead to possible confusion with the names of other existing varieties, particularly those that are already commercially established. Nevertheless, these findings should be interpreted with relative caution, given that our experimental design included only one wine produced from each of 'Merlot' and 'Cabernet-Sauvignon'.

4. Discussion

Despite the absence of a year effect in the analysis and the robust performance of our panel, it should be noted that the MFA representation of the wines (Figures 1 and 2) explains a maximum of 40 % of the total variability in the data for both colour categories. This relatively low percentage is due to the large number of variables included in the model (35 for white wines and 26 for red wines). As only statistically significant descriptors were selected for these analyses, these results highlight a high degree of sensory variability in the perception of the wines studied.

Statistically significant correlations were observed between sensory attributes and oenological parameters for both white and red wines. Specifically, the perception of *alcohol* was positively correlated with its actual content (r = 0.62 and r = 0.54), while perceived acidity showed significant correlations with measured pH levels (r = –0.64 and r = –0.62) and total acidity (r = 0.79 and r = 0.42). These alignments between chemical analyses and sensory data demonstrate the trained panel's ability to evaluate these wine attributes accurately.

The study reveals distinct sensory dynamics between white and red fungus-resistant grape (FRG) wines. White FRG wines exhibited high variability, which was significantly driven by vintage and climate. Certain varieties, such as 'Floreal', showed a wide range of profiles, from *boiled vegetables* to *fruity* notes, depending on their origin. In contrast, red FRG wines, such as 'Artaban', displayed more consistent sensory patterns, regardless of production context. Furthermore, the sensory panel identified a higher number of significant olfactory descriptors for white wines (11) than for red wines (6), which is likely due to the larger sample size and the greater aromatic diversity found among white varieties.

Furthermore, analyses of white and red wines revealed no significant overall sensory differences between new and traditional grape varieties. This finding is consistent with recent research (Duley *et al*., 2025b). This suggests that the aromatic and gustatory potential of the new varieties is comparable to that of traditional varieties and is mainly influenced by factors such as grape ripeness, winemaking practices, soil and climate conditions rather than genetic origin alone.

As a complementary study, it would be interesting to investigate the differences between FRG and *Vitis vinifera* wines, with respect to their content of key grape-derived aroma compounds such as terpenes (monoterpenols and rotundone), C13-norisoprenoids, varietal thiols, and alkylmethoxypyrazines (Robinson *et al.*, 2014). Similarly, it would be valuable to evaluate the appreciation of the large set of wines studied by both experts and consumers (Borello *et al.,* 2024), either with or without disclosing information about the fungus-resistant characteristics, in line with the approach adopted by Dolet *et al.* (2026).

Although this study involved a large sample of wines and constitutes, to our knowledge, the largest-scale research project on FRG sensory profiles to date, it is important to note that such profiling is still in its early years in France. There are currently limited quantities of FRG wines on the market as the cultivation of these varieties has only recently resumed (Dolet *et al*., 2024). These authors have demonstrated that Occitanie (in the south of France) leads the way in France in terms of areas planted with FRGs. For representativeness and logistical reasons, the majority of the wines tested in this study were sampled in this region. However, it would be interesting to extend this sensory characterisation to FRG wines from other French regions. Furthermore, including a broader range of vintages would account for interannual climate variability. The present study focused primarily on the 2022 and 2023 vintages for white wines and the 2021, 2022, and 2023 vintages for reds. Analysing additional years would provide a more comprehensive and diverse overview of the sensory potential of these cultivars.

CONCLUSION

To our knowledge, this is the first study of its kind to characterise the sensory profiles of a large set of FRG wines produced in southern France using a robust CATA approach.

A wide diversity of sensory profiles was observed, comparable to those of traditional *Vitis vinifera* wines. This is because both types of wine can produce a wide range of sensory profiles depending on *terroir* effects (van Leeuwen *et al*., 2020; Duley *et al*., 2025a).

White FRG wines exhibited high variability, influenced by climate and vintage conditions, whereas some red wines showed more consistent patterns across sites and seasons, such as 'Artaban'.

These findings offer valuable insights to the wine industry, indicating that growers can cultivate FRG varieties without worrying about producing wines with overly atypical characteristics. Integrating FRG varieties into production

through blending should enable the industry to maintain high sensory standards and product quality while reducing chemical inputs.

Future work should complement these findings by conducting detailed analyses of key aroma compounds, as well as hedonic evaluations with both experts and consumers, performed with and without disclosure of the wines' fungus-resistant characteristics. Extending the study to FRG wines produced in other French vineyards will also be important to understand consumer acceptance of these wines better.

ACKNOWLEDGEMENTS

The authors would like to thank the Occitanie Region for funding the Ressenti project through the Défi Clé Vinid'Occ, notably covering half of the doctoral thesis grants for Caroline Paire and Marc-Antoine Dolet. They would also like to acknowledge Vignobles Foncalieu and Grands Chais de France for their additional funding, and Eric Serrano, IFV, for providing experimental wines made from fungus-resistant varieties for use in the project. They are also grateful to the panellists who participated in the study.

REFERENCES

Adams, J., Williams, A., Lancaster, B. & Foley, M. (2007). Advantages and uses of check-all-that-apply response compared to traditional scaling of attributes for salty snacks. *In: 7th Pangborn Sensory Science Symposium*. Pp. 12–418. August 16th 2007, Minneapolis, MN, USA

Aubry, V., Schlich, P., Issanchou, S., & Etiévant, P. (1999). Comparison of wine discrimination with orthonasal and retronasal profilings. Application to Burgundy Pinot Noir wines. *Food Quality and Preference*, 10(4-5), 253-259. https://doi.org/10.1016/S0950-3293(99)00021-X

Bartowsky, E. J., & Henschke, P. A. (2004). The 'buttery'attribute of wine—diacetyl—desirability, spoilage and beyond. *International journal of food microbiology*, *96*(3), 235-252. https://doi.org/10.1016/j.ijfoodmicro.2004.05.013

Blackford, M., Guggenbühl-Gasser, B., Inderbitzin, J., Wiederkehr, M., Fuchsmann, P., Bieri, S., & Mackie-Haas, K. (2025). Consumer preferences in wine: traditional vs fungus-resistant varieties in Switzerland. *OENO One*, 59(3). https://doi.org/10.20870/oeno-one.2025.59.3.9239

Borrello, M., Vecchio, R**.,** Barisan L., Franceschi, D., Pomarici, E., Galletto, L. (2024). Is wine perception influenced by sustainability information? Insights from a consumer experiment with fungus resistant grape and organic wines. FOOD RESEARCH INTERNATIONAL, Volume 190, https://doi.org/10.1016/j.foodres.2024.114580

Campo, E., Do, B. V., Ferreira, V., & Valentin, D. (2008). Aroma properties of young Spanish monovarietal white wines: A study using sorting task, list of terms and frequency of citation. *Australian Journal of Grape and Wine Research*, 14(2), 104–115. https://doi.org/10.1111/j.1755-0238.2008.00010.x

Dolet, M. A., Paire, C., Cheriet, F., Geffroy, O., Le Fur, Y., Hannin, H., ... & Chervin, C. (2024). Resumption of the planting of grapevine varieties in France, referred to as "disease-resistant". *IVES Technical Reviews, vine and wine*. https://doi.org/10.20870/IVES-TR.2024.8261

Dolet, M. A., Maza, E., Geffroy, O., Le Fur, Y., Paire, C., Cheriet, F., … Chervin, C. (2026). Receptiveness of the wine industry to fungus-resistant grape varieties in the south of France. OENO one, 60(1). https://doi.org/10.20870/oeno-one.2026.60.1.9456

Dong, Y., Duan, S., Xia, Q., Liang, Z., Dong, X., Margaryan, K., ... & Chen, W. (2023). Dual domestications and origin of traits in grapevine evolution. *Science*, 379(6635), 892-901. https://doi.org/10.1126/science.add8655

Duley, G., Ceci, A. T., Longo, E., Darnal, A., & Boselli, E. (2025a). Are white wines from disease-resistant hybrid grapes comparable to *Vitis vinifera*? A chemical and sensory analysis from South Tyrol. *OENO One*, 59(2). https://doi.org/10.20870/oeno-one.2025.59.2.9203

Duley, G., Ceci, A.T., Longo, E., Darnal, A., Martín-García, B., Boselli, E. (2025b). Chemical and sensory properties of South Tyrol red wines from disease-resistant and *Vitis vinifera* cultivars. npj Science of Food 9, 69. https://doi.org/10.1038/s41538-025-00412-z

Garcia, L., Perrin, C., Nolleau, N., Godet, T., Farines, V., Garcia, F., Caillé, S., & Saucier, C. (2022). Impact of Acetaldehyde Addition on the Sensory Perception of Syrah Red Wines. *Foods,* 11, 1963. https://doi.org/10.3390/foods11121693

Geffroy, O., Morère, M., Lopez, R., Pasquier, G., & Condoret, J. S. (2020). Investigating the aroma of Syrah wines from the Northern Rhone Valley using supercritical CO2-dearomatized wine as a matrix for reconstitution studies. *Journal of Agricultural and Food Chemistry*, *68*(41), 11512-11523. https://doi.org/10.1021/acs.jafc.0c04328

Homich, L. J., Elias, R. J., Heuvel, J. E. V., & Centinari, M. (2017). Impact of fruit-zone leaf removal on rotundone concentration in Noiret. *American Journal of Enology and Viticulture*, 68(4), 447-457. https://doi.org/10.5344/ajev.2017.16106

International Organization for Standardization. (1994). Sensory analysis — General guidance for the selection, training and monitoring of assessors — Part 2: Experts (ISO Standard No. 8586-2:1994).

Joly, D., Brossard, T., Cardot, H., Cavailhes, J., Hilal, M., Wavresky, P. (2010). Les types de climats en France, une construction spatiale. *Cybergeo: European Journal of Geography*. 501. https://doi.org/10.4000/cybergeo.23155

Koenig, L., Symoneaux, R., Pouzalgues, N., Cariou, V., Vigneau, E., & Coulon-Leroy, C. (2023). Development of a Hierarchical Rate-All-That-Apply (HRATA) methodology for the aromatic characterisation of wine. *Oeno One*, 57, 175-190. https://doi.org/10.20870/oeno-one.2023.57.1.5531

Macfie, H. J., Bratchell, Nicholas., Greenhoff, Keith., & Vallis, L. V. (1989). Designs to balance the effect of order of presentation and first-order carry-over effects in hall tests. Journal of Sensory Studies, 4(2), 129–148. https://doi.org/10.1111/j.1745-459X.1989.tb00463.x

Meyners, M., Castura, J. C., & Carr, B. T. (2013). Existing and new approaches for the analysis of CATA data. *Food Quality and Preference*, *30*(2), 309–319. https://doi.org/10.1016/j.foodqual.2013.06.010

Paire, C., Dolet, M. A., Hannin, H., Samsom, A., Olivier, V., Chervin, C., ... & Cheriet, F. (2024). History of breeding programmes for fungus resistant grape varieties in Europe, France and the Occitanie region. *IVES Technical Reviews, vine and wine*. https://doi.org/10.20870/IVES-TR.2024.8262

Paire, C., Cheriet, F., Samson, A., Chervin, C., Arino, A., Ruetsch, G., ... & Geffroy, O. (2025a). A novel application of the consumer rejection threshold method to the design of binary red wine blends prepared from traditional and fungus-resistant varieties. *OENO One*, 59(2), 8484. https://doi.org/10.20870/oeno-one.2025.59.2.8484

Paire, C., Schalk, M., Geffroy, O., & Cheriet, F. (2025b). Proclamer ou taire la résistance des variétés de vigne dites "résistantes" aux maladies : une étude exploratoire sur le contenu informationnel des étiquettes de vins. In *19e Journée du Marketing Agroalimentaire (JMAM)*, Montpellier, France

Parr, W. V., Maltman, A. J., Easton, S., & Ballester, J. (2018). Minerality in wine: Towards the reality behind the myths. Beverages, 4(4), 77. https://doi.org/10.3390/beverages4040077

Pedneault, K., Dorais, M., Angers, P. (2013). Flavor of Cold-Hardy Grapes: Impact of Berry Maturity and Environmental Conditions. J. Agric. Food Chem. 61, 10418–10438. https://doi.org/10.1021/jf402473u

Reynier, A. (2011). Manuel de viticulture: guide technique du viticulteur. Lavoisier

Robinson, A. L., Boss, P. K., Solomon, P. S., Trengove, R. D., Heymann, H., & Ebeler, S. E. (2014). Origins of grape and wine aroma. Part 1. Chemical components and viticultural impacts. *American journal of enology and viticulture*, 65(1), 1-24. https://doi.org/10.5344/ajev.2013.12070

Roland, A., Schneider, R., Razungles, A., & Cavelier, F. (2011). Varietal thiols in wine: discovery, analysis and applications. *Chemical reviews*, *111*(11), 7355-7376. https://doi.org/10.1021/cr100205b

Schneider, C., Onimus, C., Prado, E., Dumas, V., Wiedemann-Merdinoglu, S., Dorne, M. A., Lacombe, M. C., Piron, M. C., Umar-Faruk, A., Duchêne, E., Mestre, P., & Merdinoglu, D. (2019). INRA-ResDur: The French grapevine breeding programme for durable resistance to downy and powdery mildew. *Acta Horticulturae*, 1248, 207–214 https://doi.org/10.17660/ActaHortic.2019.1248.30

Seinforin, B.; Caillé, S.; Nikolantonaki, M.; Saucier, C. Evidence for Discriminant Specific Tastes in ChardonnayWines Among Other White Wines. Foods 2025, 14, 2870. https://doi.org/10.3390/foods14162870

Siebert, T. E., Barker, A., Pearson, W., Barter, S. R., de Barros Lopes, M. A., Darriet, P., ... & Francis, I. L. (2018). Volatile compounds related to 'stone fruit'aroma attributes in Viognier and Chardonnay wines. *Journal of Agricultural and Food Chemistry*, 66(11), 2838-2850. https://doi.org/10.1021/acs.jafc.7b05343

Slegers, A., Angers, P., Ouellet, É., Truchon, T., & Pedneault, K. (2015). Volatile compounds from grape skin, juice and wine from five interspecific hybrid grape cultivars grown in Québec (Canada) for wine production. *Molecules*, 20(6), 10980-11016. https://doi.org/10.3390/molecules200610980

Sun, Q. (2011). Chemosensory And Viticultural Studies Of Hybrid And Non-Vinifera Grape Species And Resulting Wines. Dissertation

This, P., Lacombe, T., & Marchal, C. (2024). Grapevine Domestication and Selection. *Genetics of Domestications*, 185. https://doi.org/10.1002/9781394332519.ch11

Töpfer, R., Hausmann, L., Harst, M., Maul, E., Zyprian, E., & Eibach, R. (2011). New horizons for grapevine breeding. *Fruit, Vegetable and Cereal Science and Biotechnology*, 5(1), 79-100

Torregrosa, L., Lacombe, T., & Ojeda, H. (2024). Vignes tolérantes aux maladies fongiques : des variétés à fruits pour une viticulture en transition agroécologique (1st ed.). Editions France Agricole

Valentin, D., Chollet, S., Lelièvre, M., & Abdi, H. (2012). Quick and dirty but still pretty good: A review of new descriptive methods in food science. *International Journal of Food Science & Technology*, 47(8), 1563-1578. https://doi.org/10.1111/j.1365-2621.2012.03022.x

van Leeuwen, C., Barbe, J. C., Darriet, P., Geffroy, O., Gomès, E., Guillaumie, S., ... & Thibon, C. (2020). Recent advancements in understanding the terroir effect on aromas in grapes and wines. *Oeno One*, 54(4), 985-1006. https://doi.org/10.20870/oeno-one.2020.54.4.3983

Yobrégat, O. (2018). Introduction to resistant vine types: a brief history and overview of the situation. *Oeno One*, *52*(3), 241-246. https://doi.org/10.20870/oeno-one.2018.52.3.2220