iVES OENO One vine & wine

DOI: https://doi.org/10.20870/oeno-one.2026.60.1.9456

OPEN ACCESS

ENOLOGY ORIGINAL RESEARCH ARTICLES

Receptiveness of the wine industry to fungus-resistant grape varieties in the south of France

Marc-Antoine Dolet[1], Elie Maza[1], Olivier Geffroy[2], Yves Le Fur[3], Caroline Paire[2,4], Foued Cheriet[4], Hervé Hannin[4], Isabelle Ferrané[5], Soline Caillé[6], Alain Samson[6,7], Valérie Olivier[1,*], Christian Chervin[1,*]

[1] LRSV, AGIR, Université de Toulouse, AgroToulouse INP, Castanet-Tolosan, France
[2] PPGV, Université de Toulouse, Ecole d'Ingénieurs de Purpan, Toulouse, France
[3] CSGA, Université Bourgogne Europe, Institut Agro Dijon, France
[4] MoISA, Université de Montpellier, Institut Agro Montpellier, Montpellier, France
[5] IRIT, Université de Toulouse, CNRS, Toulouse INP, Toulouse, France
[6] SPO, Université de Montpellier, Institut Agro Montpellier, France
[7] INRAE, Unité expérimentale de Pech Rouge, Gruissan, France

Article number: 9456

*correspondence:
valerie.olivier@toulouse-inp.fr
christian.chervin@toulouse-inp.fr

Associate editor:
Maria Tiziana Lisanti

Received:
14 June 2025

Accepted:
9 December 2025

Published:
12 January 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

The adoption of fungus-resistant grape varieties (FRGs) represents a promising pathway for steering viticulture towards more sustainable production methods by reducing the use of phytosanitary inputs. At the time of writing, the dissemination of these varieties remains limited, partly due to constraints within the wine industry (*i.e.*, cost of planting and cultivar limitations associated with Protected Designation of Origin).

This study was conducted with commercial wines made from two types of grape: *Vitis vinifera* and FRGs. A panel of 96 participants from the wine industry in the Occitanie region (south of France) conducted sensory evaluations. The panel performed the evaluations both blind and having been informed about type of grape in a combination of short CATA (Check-All-That-Apply) sessions followed by questions exploring their interest in FRGs and expected plantations in the coming years.

The results of the sensory analyses underlined the absence of any notable difference in liking or in the sensory profiles of the wines, whether tasted blind or not. Indeed, disclosure of the type of grape used to make the wines did not alter participants' perceptions or evaluations. Furthermore, the analysis of questionnaire data revealed a typology of three adopter profiles: i) "Sceptics": older professionals from private wineries who were generally unfavourable towards the adoption of FRGs, ii) "Receptives": cooperative members who showed measured support for innovation, and iii) "Observers": young, non-decision-making individuals with heterogeneous opinions. This industry panel predicted that there could be 25 % of vineyard areas planted with FRGs in Occitanie within the coming 30 years.

This study offers insights into the future adoption of this new plant material within the wine industry.

KEYWORDS: CATA, wine, fungus-resistant grapevines, sustainable production, producers

INTRODUCTION

The development of fungus-resistant grapevine varieties (FRGs) has been underway for several decades, dating back to the first generations of non-spontaneous hybrid vines in the early 20th century (Yobrégat, 2018). This development has marked a significant shift in European viticulture. Traditionally, *Vitis vinifera*, the species used for wine production, has shown high susceptibility to these pathogens, leading to a heavy reliance on chemical fungicides to ensure yield and quality (Töpfer & Trapp, 2022; Eisenmann *et al.*, 2023). European research institutions and breeding programmes, particularly in Western Europe, have accelerated efforts to develop disease-resistant cultivars. This shift responds to three key drivers: growing environmental concerns, regulatory pressure to reduce pesticide use, and increasing societal demand for more sustainable agricultural practices.

Countries such as France, Germany, Italy, and Switzerland have been at the forefront of this transition, with long-term public research initiatives such as INRAE's ResDur program in France or the Julius Kühn-Institut's breeding efforts in Germany, and the movement promoting FRGs in viticulture known as PIWI, standing for *Pilzwiderstandsfähige Rebsorten* (Paire *et al.*, 2024). These new varieties are often the result of complex interspecific crosses between traditional *Vitis vinifera* and other wild species carrying natural resistance genes, followed by extensive backcrossing to recover desirable oenological traits. While initially met with scepticism, particularly in terms of wine quality and market acceptance (Teissedre, 2018), these resistant varieties have gained traction due to their potential to drastically reduce fungicide applications, between 50 % and 90 % in some cases, without compromising productivity (Töpfer & Trapp, 2022; Eisenmann *et al.*, 2023).

Today, FRGs are increasingly being integrated into experimental vineyards, organic viticulture, and certain PDO (Protected Designation of Origin) frameworks, albeit still cautiously and unevenly across regions (Dolet *et al.*, 2024); in France, the Occitanie region stands at the forefront of this planting dynamic. The Occitanie region, with its two major cities Montpellier and Toulouse, is France's largest wine-producing area, with over 250,000 hectares of vineyards that produce more than 30 % of the national wine volume. The climate ranges from Mediterranean to oceanic (Joly *et al.*, 2010). As the leading region in terms of surface area planted with FRGs, it alone accounted for 70 % of the national plantings of these new varieties in 2021, representing about 860 hectares out of a total of 1,200 hectares in France, driven in particular by vineyards along the Mediterranean coast (Dolet *et al.*, 2024). However, it is important to note that these figures remain marginal in comparison with the total French vineyard area, which covers approximately 783,000 hectares (OIV, 2025).

The planting of FRGs is still at an early stage, as numerous challenges hinder their adoption by the wine sector. The challenges most frequently cited are the naming of these varieties, as their names are unfamiliar to consumers and producers, the long-term effectiveness of disease resistance, the restrictive nature of specifications, and the current lack of clear market demand (Montaigne *et al.*, 2016; Montaigne *et al.*, 2021; Geffroy *et al.*, 2024a; Kiefer & Szolnoki, 2024a; Zachmann *et al.*, 2024; Piccoli & Viganò, 2025). One of the main challenges to FRG development could be their alleged sensory inferiority (Pedneault & Provost, 2016; Teissedre, 2018), a hypothesis that was tested in the present study. This is an ongoing matter of debate, as in recent studies on South Tyrol wines from northern Italy trained panellists were not able to distinguish between wines made from FRG and those made from *V. vinifera*, whether red (Duley *et al.*, 2025a) or white (Duley *et al.*, 2025b). These studies conclude that barriers to commercial adoption may be producer and consumer unfamiliarity with FRGs rather than wine quality.

In France, studies focusing on the adoption process of FRGs by producers have only recently been initiated at the time of writing, and they remain scarce in other countries (Finger *et al.*, 2022; Kiefer & Szolnoki, 2024b; Zachmann *et al.*, 2024; Piccoli & Viganò, 2025), but there is already a substantial body of literature investigating consumer acceptance of wines made from FRGs in France, Germany, Switzerland, Italy, and Canada (Espinoza *et al.*, 2018; Nesselhauf *et al.*, 2019; Borello *et al.*, 2021; Borello *et al.*, 2024; Sillani *et al.*, 2022; Vecchio *et al.*, 2022; Kiefer & Szolnoki, 2023; Kiefer & Szolnoki, 2024c; Paire *et al.*, 2025; Blake & Bowen, 2025). Additionally, the Swiss, German, and Italian teams cited above insist on the importance of understanding the pros and cons of FRG adoption by growers to better support the industry regarding this innovation.

Here, we developed a method that combines existing ones: a short CATA session (Check-All-That-Apply) followed by a questionnaire to characterise panellist opinion. CATA is a widespread, descriptive sensory method that is particularly adapted to non-trained panels (Buck & Kemp, 2018; Jaeger *et al.*, 2023), in which they tick predefined attributes to characterise a product. This method is often combined with a hedonic evaluation of the product, which is carried out after the CATA questions (Geffroy *et al.*, 2024b). Because it has been shown that revealing information about the production process of food products can influence hedonic evaluation (Reis *et al.*, 2017; Souza-Gonzaga *et al.*, 2021), we investigated whether revealing that wines were made with FRGs would influence wine producers' scoring, as an approach to determining whether growers hold a positive or negative bias towards FRGs. We also asked them if they had recognised the wines made with FRGs, as there was no such data at the time we set up the experiments. Finally, the post-CATA questionnaire was used to build a typology of our industry panel, based on their interest in FRGs and their estimation of FRG plantings in years to come, as this was also unknown.

MATERIALS AND METHODS

1. Sampling of wine industry panels

Participants were recruited with the help of grower associations and management committees of cooperative cellars, which organised meetings of three to nine people with M. A. Dolet. We aimed to ensure diversity in our sample by covering various vineyard areas (departments of the Occitanie region), climate influences (Mediterranean or oceanic), types of wineries (cooperatives or independent producers), and age and number of years of experience in the sector, as well as considering whether they were decision-makers or not, and whether they were specialized or not (single job-holding or not). The socio-economic characteristics of the participants are specified in Table S1.

All sessions were carried out between July 2024 and January 2025. In total, we held 19 sessions (of three to seven people) across the entire Occitanie region, which was divided into two main climatic zones: Mediterranean and oceanic, according to Joly *et al.* (2010). Using these authors' cartography, we grouped the true and altered Mediterranean climates as "Mediterranean", and the altered oceanic and south-west basin climates as "oceanic". The sample comprised 96 participants, comprising 73 winegrowers, 46 cooperative members, 27 independent winemakers, and 23 professionals who were viticulture and oenology extension officers, classified as "extension". Among them, 61 and 35 were sourced from the Mediterranean and oceanic climatic zones, respectively. Participation was voluntary and unpaid.

2. Wine selection

Six wines, four whites and two reds, were chosen from commercial wines produced in the Occitanie region. This selection was based on an initial characterisation of commercial and experimental wines conducted by an expert jury in Montpellier. These six wines comprised two white wines made from *Vitis vinifera* (one Chardonnay, one blend of Sauvignon/Chardonnay), two white wines made from FRGs (one Floreal, and one blend of Souvignier gris/Floreal/Soreli), one red wine made from *Vitis vinifera* (Merlot) and one red wine made from FRG (Cabernet noir). We aimed at representing similar quality wines already available on the market and costing between 5 and 10 € per bottle. The number of FRG white wines marketed at the time of the study was greater than that of red wines. The chemical analyses of these wines are detailed in supplementary data. The restricted number of wines is inherent to the method we propose here, in which the wines are used in a step prior to the questionnaire.

3. Session schedule and questionnaire

Each session lasted approximately 1.5 hours and was performed in small groups of four to six participants. To conduct our study, a questionnaire had been designed to be given out during meetings with the wine industry panel. An English version of the questionnaire is provided in supplementary data.

At the beginning of the session, all the participants were asked to provide written informed consent to participating in the study and were assured that any data given would remain anonymous.

In the first part of the questionnaire, sociodemographic data were collected to characterise the participants. These variables included gender, age, place of residence, production mode, and occupation (cooperative members, independent winemakers, technical advisors, and consultants), as well as years of experience in the profession and potential dual employment status (for those having another job). The term "extension people", used in this article, was restricted to viticulture and oenology technical advisers and decision-makers regarding planting.

3.1. First blind tasting of the wine samples

A sensory test was then run in two parts, as explained below.

Participants were given the first part of the questionnaire. The four white wines, followed by the two red ones, were served one at a time. Each sample of 20 mL was associated with a three-digit code and was presented in random order, as has been described previously (Geffroy *et al.*, 2024b). The wines were served at a temperature of 16 °C. For each sample, panellists were asked to characterise the wines in terms of sensory attributes using the CATA method, and to score their liking on a scale from 1 to 9 (Geffroy *et al.*, 2024b). In this exercise, there were 13 attributes for white wines and 12 for reds (see questionnaire in supplementary data). These attributes were chosen among terms used by the expert jury (section 2 "Wine selection"). A small number of attributes was used to limit the session time; in addition, Jaeger *et al.* (2023) have recently shown that a small number of attributes often ensures robustness of the CATA analysis. A question was asked to investigate whether the participants were able to distinguish between wines made from FRGs and those made from *Vitis vinifera* varieties. The first part of the questionnaire was then collected.

3.2. Second tasting with disclosure of grape type and second part of the questionnaire

The same procedure as above was followed, except that the participants were informed of the type of grape (*Vitis vinifera* or FRG) used to make the wine. The codes attributed to the FRG wines were revealed prior to the second tasting, without giving the exact name of the variety to avoid any bias due to preference of some panellists for a given variety. The aim of this disclosure was to explore whether such information could bias their ratings. After tasting, participants were asked to classify as positive or negative the sensory attributes selected for each wine in the CATA questionnaire.

3.3. Final questions

We collected a series of answers about (i) whether the panellists recognised the wines made from FRGs or not, (ii) the level of interest in FRGs, measured using an unstructured continuous scale, as in the exemplarity measurement study by Loison *et al.* (2014), (iii) the expected

percentage of vineyard area that would be planted with FRGs in 30 years' time in their wine region (using a discrete scale of 0 to 100 %), and (iv) whether the participants' opinions changed after the session (a binary dichotomous variable).

At the end of each session, the participants were provided with a wine analysis sheet containing precise information on the evaluated wines, including the grape variety that was used and the main chemical characteristics (alcohol content, acidity, SO_2, etc.). The industry panellists were provided with these data in return for the time they had given. However, the wine names, brands, and estates were never disclosed at any point.

4. Data analyses

The statistical analyses related to the CATA and hedonic evaluations of the wines were conducted using both R software (v. 2022.07.1) for the correspondence analyses, ANOVAs and Tukey's *post hoc* tests – as previously developed in Geffroy *et al.* (2024b) – and Excel for *t*-tests and chi-square tests. The raw data and R scripts are available as supplementary data.

The typological analysis of participant profiles was carried out using Modalisa software (v. 9.1, Kynos, Paris). To this end, we selected a set of 10 variables: gender, age, production method (or occupation), decision-maker or not, years of experience, vineyard climate, engagement in multiple professional activities, personal interest in planting resistant varieties, the projected percentage they might represent in the participant's local vineyard environment in 30 years' time (*i.e.*, roughly one vine generation), and whether participants had changed their opinion about FRGs after the session. The numerical variables were transformed into qualitative variables by constructing classes of similar frequency, and a multiple correspondence analysis (MCA) and a hierarchical ascending classification (HAC) were performed. Chi-square tests identified significant classes to interpret participant profiles, which were subsequently plotted on the factorial map along with their class assignments.

RESULTS AND DISCUSSION

1. No impact of information release on hedonic rating

In a first step, to measure the overall perceived quality of the wines that these grapes can produce and the impact of revealing information about grape type, we conducted a multiple comparison of the mean hedonic scores recorded for each wine; the first was conducted blind (referred to as "1st"), and the second with disclosure of grape type (referred to as "2nd"). The mean hedonic scores assigned to the six wines are shown in Figure 1. We found that there was never a significant difference between the 1st and 2nd scores of an identical wine; thus, the information about the grape type did not generate any changes in the liking score. In other words, the participants did not systematically overrate or underrate the wines based on this contextual information. There was therefore no negative halo effect (Nisbet & Wilson, 1977) or expectancy effect associated with the varietal origin, whether it was perceived as innovative (resistant) or traditional *(Vitis vinifera)*. We were mindful of the fact that FRGs might still be subject to criticism that stems from the collective memory of winegrowers due to the alleged lower quality of wines made from hybrid varieties in the early 20th century, which preceded those now being marketed (Meloni & Swinnen, 2013; Teissedre, 2018).

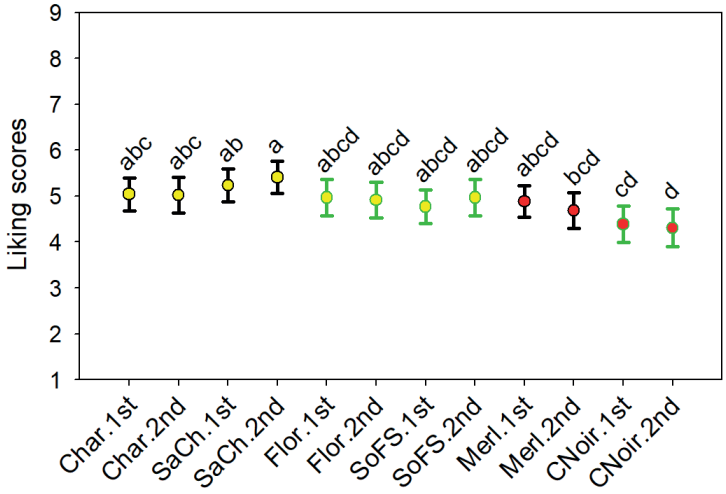


FIGURE 1. Liking scores as a function of the wine and the timing of the sensory evaluation, without or with information about grape type. "SaCh" stands for Sauvignon/Chardonnay blend, "Char" for Chardonnay, "Flor" for Floreal, "SoFS" for a Souvignier/Floreal/Soreli blend, "Merl" for Merlot, and "CNoir" for Cabernet noir. "1st" stands for initial tasting without information, "2nd" for second tasting after disclosure of the information about codes attributed to FRG wines. Values are means of $n = 96$ with error bars indicating standard error. Black error bars indicate *Vitis vinifera* and green error bars FRGs; yellow circles indicate white wines and red circles red wines. Different lower-case letters indicate statistically significant differences at $p < 0.05$ (Tukey's test).

However, our results show that cultivar information released prior to tasting did not bias the liking scores, in contrast to what has previously been shown with other food products (Reis *et al.*, 2017).

Figure 1 also highlights some variability between the wine colours, with red wines receiving lower scores than some whites, but it was not the purpose of this test. Indeed, given the limited number of tested wines, it is difficult to draw any general conclusion between whites and reds, the aim of the test being to focus on information bias.

2. No distinction of wines made from FRGs in blind tastings

Furthermore, we aimed to assess whether wines from these FRG varieties possess a strong identity, particularly as previous studies have shown that some FRG wines are tagged as low-quality wines (Pedneault & Provost, 2016). If this were the case, one would expect participants to be able to recognise these wines at rates higher than would be expected by chance. To investigate this, after the first blind tasting phase, we asked participants whether they believed they had recognised the wines made from FRGs and those made from *Vitis vinifera*. These results are illustrated in Figure 2.

Given that each session included four white wines (two *Vitis vinifera* and two FRGs) and two red wines (one *Vitis vinifera* and one FRG), the possible numbers of correct identifications were 0, 2, or 4 for white wines, and 0 or 2 for red wines. In Figure 2, these values are expressed as percentages of wrong answers; for example, 0, 2, or 4 for white wines correspond to 100 %, 50 % and 0 % of wrong answers. These possible outcomes are shown on the X axes of the two graphs. The values on the Y axes represent the number of responses across all 19 sessions. The results of Figure 2 clearly show that wrong answers were predominant for the white wines (on the right side of the graph), and that there was a slightly higher proportion of wrong answers for the red wines. The chi-square goodness of fit tests of these observed distributions, compared to expected values under random answers, resulted in *p*-values of 0.0002 and 0.2207 for white and red wines respectively, showing that wrong answers were significantly higher for white wines and that answers were not significantly different from random distribution for red wines. However, the main findings are the high percentages of error for both types of wine. It can therefore be deduced that the participants did not distinguish the FRG wines from the *Vitis vinifera* wines.

3. Three behavioural profiles regarding FRGs, determined among participants

The MCA and HAC led to the identification of three participant profiles: A, B, and C (detailed below). The distance matrix, individual coordinates, and dendrogram are available in the supplementary data. The list of contributions which helped us to interpret each profile below is shown in Table 1.

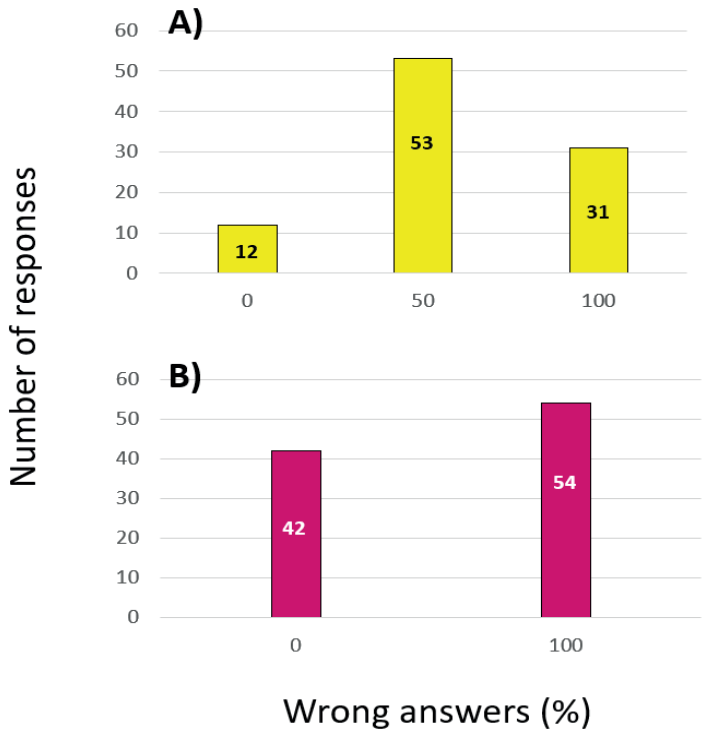


FIGURE 2. Number of responses as a function of the percentage of wrong answers to the question "Which wine was made using *Vitis vinifera* and which was made using FRGs?", *n* = 96 wine industry panellists, A) wrong answers for white wines: "0" = good distinction of the four wines, "50" = distinction of only two out four, and "100" = no distinction (*i.e.*, 100 % wrong answers), and B) wrong answers for red wines: "0" = good distinction of the two wines, and "100" = no distinction.

TABLE 1. Contribution of significant classes to participant profiles. Each profile is defined by variables, significant classes, the number of individuals in each class ("Freq." for frequency), gaps between observed and expected frequencies under independence ("Deviat." for deviation), percentage of maximum deviation (PMD), and the *p*-value of the chi-square test assessing the independence of the profiles and the classes (** for *p*-value < 0.01; *** for *p*-value < 0.001).

Profiles	Variables	Classes	Freq.	Deviat.	PMD	*p*-value khi-2
Observers	Gender	Female	14	9	65 %	***
	Age	Young (< 38 years old)	14	6	44 %	***
	Occupation	Extension	19	14	82 %	***
	Decision-maker	Non-decision-maker	19	14	82 %	***
	Years of experience	Short experience (< 10 years of exp.)	13	5	38 %	***
Sceptics	Climate	Mediterranean	26	5	42 %	**
	Gender	Male	32	6	85 %	***
	Age	Senior (50+ years old)	26	15	68 %	***
	Decision-maker	Decision-maker	31	6	75 %	***
	Years of experience	Long experience (24+ years of exp.)	24	13	66 %	***
	Interest/10	Low interest (less than 5.4/10)	22	11	56 %	***
	Future/100	Future-low (less than 20 %)	16	7	38 %	***
Receptives	Age	Middle-aged (38 to 49 years old)	21	9	52 %	***
	Occupation	Cooperative	29	9	44 %	***
	Decision-maker	Decision-maker	39	8	80 %	***
	Years of experience	Medium experience (10 to 23 years of exp.)	22	8	45 %	***
	Interest/10	Medium interest (from 5.4/10 to 7.6/10)	23	10	59 %	***
	Future/100	Future-high (30 % and more)	29	10	45 %	***

i. **Profile A**, named **"Observers"**: mostly composed of individuals with heterogeneous responses and levels of interest; their main shared characteristics are that they tend to be young, female, and non-decision-makers.
ii. **Profile B**, named **"Sceptics"**: primarily composed of individuals who are older than the sample average and decision-makers, and who manage independent wineries located in Mediterranean climates; both their interest in planting FRGs and the future they project for these varieties in their region are low.
iii. **Profile C**, named **"Receptives"**: mainly composed of members of cooperative wineries in oceanic climate zones, with a moderately declared interest in FRGs, and a more optimistic outlook regarding their future compared to the other two profiles.

The data projection shown in Figure 3 accounts for 51.38 % of the total inertia (axis 1 = 35.65 %; axis 2 = 15.73 %). Axis 1 primarily contrasts two general participant profiles based on characteristics such as decision-making status, gender (men *vs* women), age (young *vs* senior), climate (Mediterranean *vs* oceanic), and production role or occupation (cooperative *vs* extension). Axis 2 more clearly differentiates individuals based on their estimation of future planting of FRGs (low *vs* high).

This typological analysis of the participants allowed the panel to be better characterised (*i.e.*, potential adopters of FRGs) and illustrates the heterogeneity of these potential adopters. Barham *et al.* (2014), stated that the process of technological adoption in agriculture is neither linear nor driven by factors of equal intensity, and that it is necessary to take into account the heterogeneity of decision-makers in order to understand the dimensions of learning. Thus, these profiles can provide insight into growers who are open to FRGs.

According to Dressler (2024), age appears to be a significant factor in the adoption of new practices at work. Indeed, as indicated in Table 1, it serves as a determining factor across the three profiles. Additionally, the most receptive profiles may correspond – to varying degrees – to leader and follower roles, which have been identified as key actors in the adoption of new agro-environmental practices in the green behaviour literature (Javaid *et al.*, 2023). Moreover, these profiles include producers who show interest in the future of FRGs, although we have not directly and thoroughly assessed the extent of their interest in them. For now, these decision-makers are not necessarily the readiest to plant FRGs. Indeed, as noted by Barham *et al.* (2018), receptiveness to advice can slow down adoption among

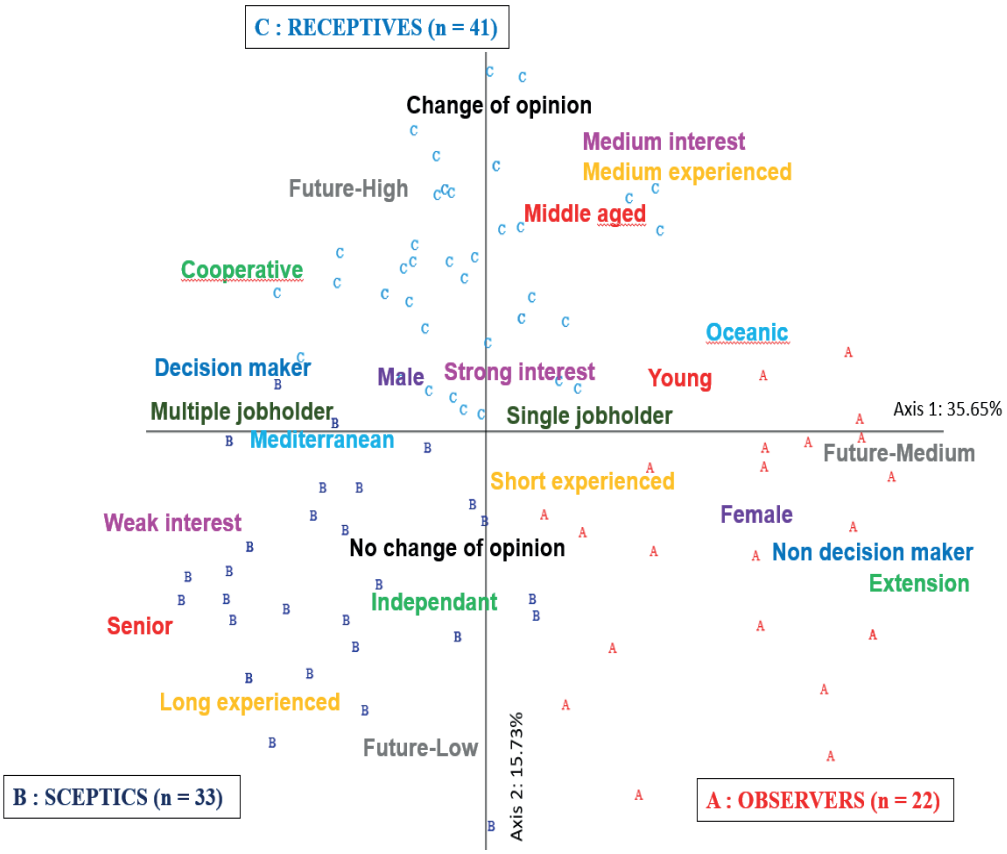


FIGURE 3. Typological analysis of participants. The sample of participants was classified according to the following criteria: vineyard climate (light blue), gender (violet), age (red), number of years of experience (yellow), production method (light green), decision-making role (dark blue), multiple job-holding (dark green), personal interest in FRGs (pink), projected future of FRGs in the region (grey), and change of opinion following the session (black). These variables were pre-processed and grouped into equal-sized classes, ranging from two to three categories depending on the nature of the response (dichotomous qualitative, discrete or continuous quantitative, etc.), based on the data available in the file "Database with typology" provided in the supplementary data. The three profiles (A, B, C) derived from the same original variables and appear in the graph. The colours of the profile classes are not related to the colours of the criteria.

individuals with high cognitive abilities, as they tend to delay the integration of advice into their decision-making processes. Conversely, such advice can accelerate adoption among individuals with lower cognitive abilities, as they will learn more about the technology in a shorter period of time.

At the end of the questionnaire, we asked the following question: "Did this sensory session change your opinion about FRG wines? Why?". The sensory analyses changed the opinion of only 13 % of participants towards a better opinion of the FRGs, mainly because they were positively surprised by the quality of the tasted FRG wines. This aspect warrants further research.

4. Liking scores varied depending on panellist profile

Next, we drew on the results derived from the typological analysis of participant profiles to retrospectively reassess and compare participants' liking scores. We conducted a second ANOVA followed by a Tukey *post hoc* test. The results are reported in Figure 4 and show that the ratings given by the "Receptives" and "Sceptics" groups are significantly different, with the "Receptives" using higher liking scores than the "Sceptics". As for the "Observers", their average rating falls in an intermediate position, but is not significantly different from either of the other two profiles. This supports the idea that they represent a generally more passive or undecided group.

The typological profile significantly influenced the measured liking. This is not surprising, as it has already been shown that liking scores depend on the context of the sensory analyses (*i.e.*, laboratory or home tests), and the panellist profile (Sinesio *et al.*, 2021).

5. Measure of interest for FRGs by producers only

The results reported in Figure 5 highlight the interest shown in FRGs by 74 producers, based on their type of production mode (independent or cooperative) and on the climatic situation of their vineyard (oceanic or Mediterranean).

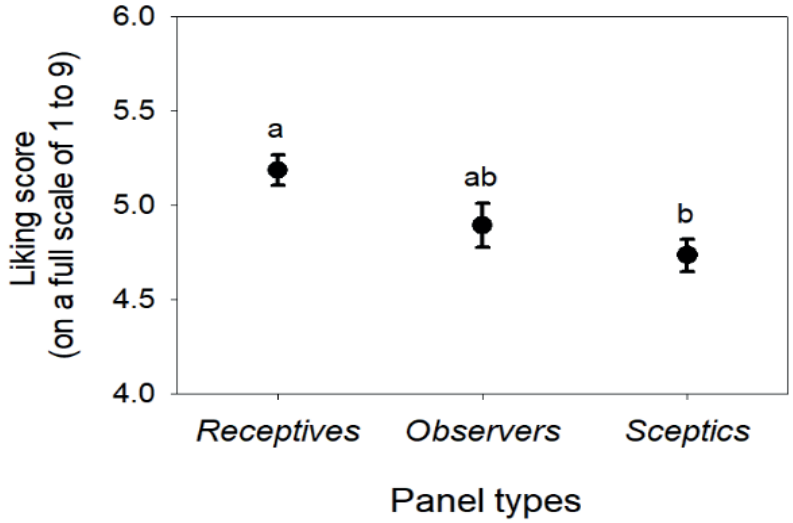


FIGURE 4. Liking scores as a function of the panellist profiles. Mean scores of 41 Receptives, 22 Observers, and 33 Sceptics. Mean scores given for all wines, regardless of the grape. Error bars show the standard errors. Letters indicate statistically significant differences with *p*-value < 0.05 (Tukey's test).

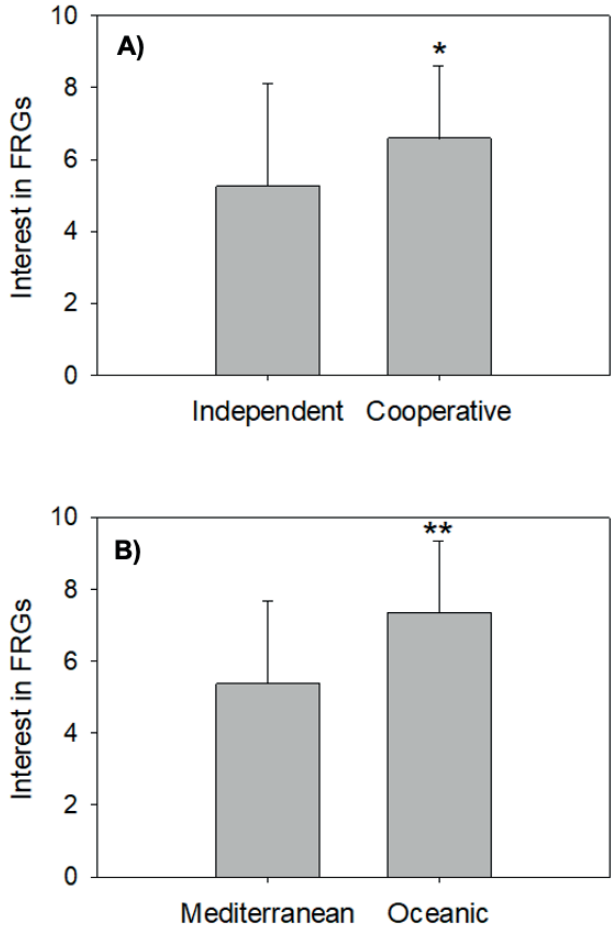


FIGURE 5. Interest in FRGs among producers, measured using scores on a continuous scale from 0 to 10 cm in relation to two variables: A) production mode and B) vineyard climate. Bars show means of *n* = 27, independent; *n* = 46, cooperative; *n* = 47, Mediterranean; *n* = 26, oceanic. Error bars show standard errors, asterisks indicate statistical significance levels, using *t*-tests, with a *p*-value < 0.05 (*) and a *p*-value < 0.01 (**).

Regarding production modes, the producers who are members of cooperatives showed a significantly higher interest in FRGs than the independent producers: the average interest score of over 6 for cooperative members was significantly higher than the average score of 5 for independents. This suggests that cooperative members may be more inclined to plant FRGs in the coming years. Independent producers showed less interest in FRGs than cooperative producers (Figure 5); this could be due to the fact that the former may face more constraints when putting new products on the market (Geffroy *et al.*, 2024a), in comparison with the latter, who bring their grapes to a cooperative, which takes care of winemaking and market access. Consumer acceptance is clearly another critical aspect that needs to be considered; some initial studies have been published on consumer acceptance, but they focus on a limited number of commercialised products (Espinoza *et al.*, 2018; Kiefer & Szolnoki, 2024c). Regarding vineyard climate, producers located in oceanic zones exhibited the greatest interest in FRGs (mean scores above 7), in contrast to those in Mediterranean zones who showed more moderate interest (mean around 5.5). This geographical contrast may reflect different regional dynamics in terms of innovation adoption and may be due to wetter climate and higher disease pressure in oceanic zones. Additionally, as a consequence of climate change, the more frequent wet springs and summers that boost fungus-disease development may be a critical factor governing the need to adopt FRGs (van Leeuwen *et al.*, 2024); these more frequent wet events may occur in both oceanic and Mediterranean zones.

6. Information disclosure did not alter sensory characterisation

Having found that the disclosure of information had no notable effect on the hedonic scores themselves (Figure 1), we now wished to determine whether the same would hold true for sensory attributes**,** as indicated by other studies on wines and disclosure of information (Souza-Gonzaga *et al.*, 2021). To this end, we conducted two correspondence analyses to explore the attributes used to qualify the white wines by the panellists before (Figures 6A and 6B) and after the disclosure of information (Figures 6C and 6D). We observed

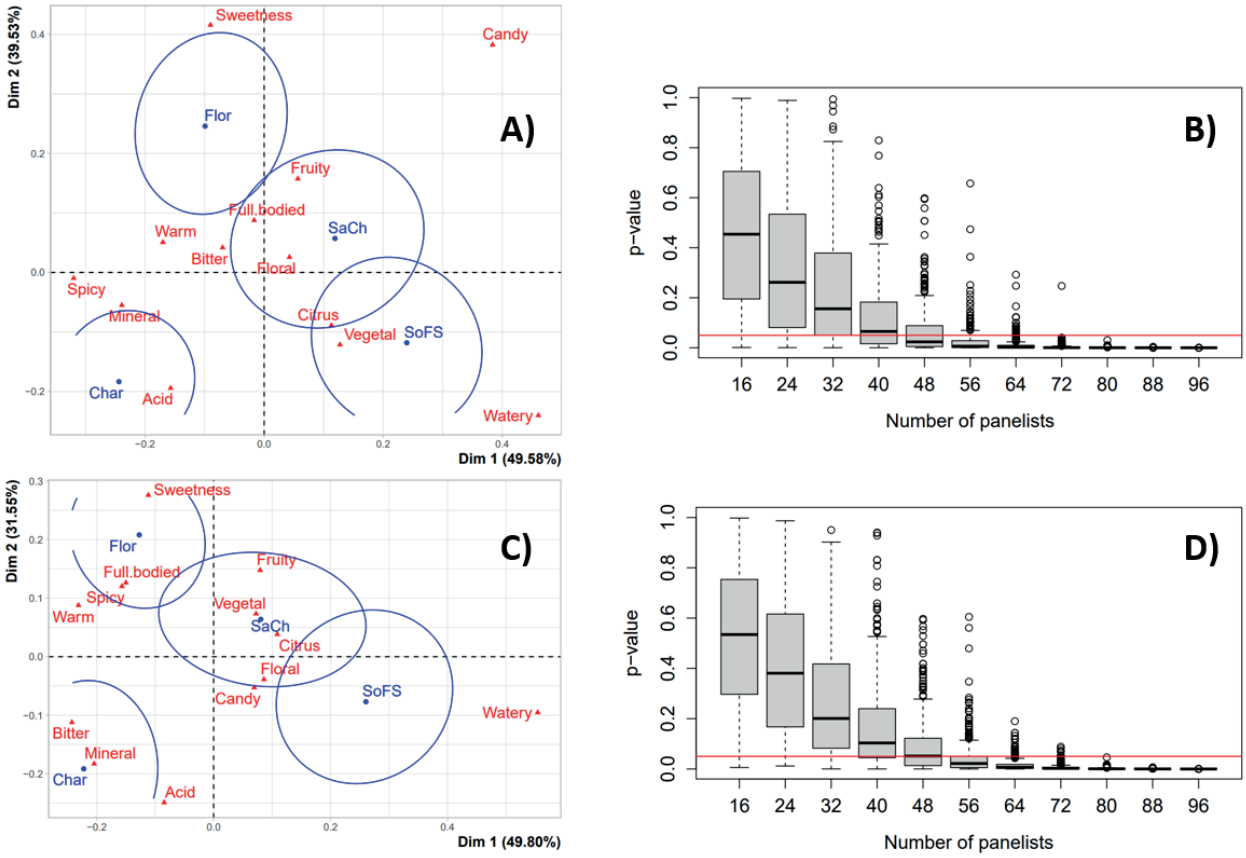


FIGURE 6. Results of the correspondence analyses, linking the white wines presented during the experiment (in blue) and the attributes (in red) from the questionnaire, A) and B) show the CATA results of the tasting phase BEFORE disclosure of the information regarding the grape type (*i.e.*, FRG or *Vitis vinifera*); C) and D) show the CATA results of the second tasting phase AFTER disclosure of the information. "SaCh" stands for Sauvignon/Chardonnay blend, "Char" for Chardonnay, "Flor" for Floreal, and "SoFS" for a Souvignier/Floreal/Soreli blend. The ellipses indicate the variability or dispersion of the overall responses. The panels B) and D) show the *p*-value of the chi-square test of independence between attributes and wines, as a function of the number of panellists, and the red line shows the 0.05 limit.

no marked difference in the projections of attributes and wines before and after disclosure of information regarding the type of grapes used to make the wines (*i.e.*, FRGs or *Vitis vinifera)*. The wines are consistently associated with certain groups of attributes: Chardonnay retains its acidic and mineral profiles, and Floreal stands out for its sweetness, the blend of Sauvignon/Chardonnay for its fruity and floral character, and the blend of Souvignier gris/Floreal/Soreli for its citrus notes. The ellipses are quite small, suggesting good identification of the wines' differences. The *p*-values of the khi-2 tests were below 0.05 for 64 panellists (Figures 6B and 6D), showing there was a strong dependency between the wines and attributes in our sensory tests; in other words, the sensory characterisation is reliable with a total number of 96 panellists. These results were obtained with white wines only, as a correspondence analysis with only two red wines was not possible.

In short, we observed no changes: the disclosure of information had no effect on how industry members characterised the white wines.

7. Expected proportion of FRGs in vineyard renewal

We asked the participants: "What percentage of vineyard area do you think FRG will occupy in your department in 30 years?", this period corresponding to the lifespan of grapevine in the oceanic part of Occitanie (Table 2); the average percentage was found to be 26 %. Considering that the current total vineyard area of Occitanie is 245,869 hectares (Table 2), 26 % would represent 63,926 hectares of FRGs to be planted. This would require an average planting rate of 2,131 hectares of FRG varieties per year over three decades. Given the current mean annual plantation in the Occitanie region (around 6,295 hectares per year, see Table 2), this means that more than one-third of new plantings would need to involve these FRG varieties to match the estimate put forward by professionals. This may be an overestimation, but it is based on industry representative declarations. The question of whether grapevine nurseries will be able to adapt remains open.

CONCLUSION AND PERSPECTIVES

This study, conducted with 96 industry participants in Occitanie, aimed to investigate how FRGs are perceived within the wine industry. Disclosing information about the nature of grape varieties based on their tolerance to fungal diseases did not lead to any bias in the evaluation of wines made from 100 % FRGs. In the blind tastings, the participants did not differentiate between the wines produced from FRGs and those made from *Vitis vinifera* grapes. This had already been observed in recent studies, which showed no difference in liking between FRG and *Vitis vinifera* wines (Kiefer & Szolnoki, 2024c; Duley *et al.*, 2025b). The present study does not allow us to state whether the hedonic appreciation, or the different sensory profiles of the wines would be obstacles to adoption. This will be addressed more specifically in the result of a new study that has recently been initiated. Additionally, it seems also relevant to highlight other aspects related to relationships between actors within the sector or to vineyard work.

However, the typological approach allowed us to account for a certain plurality of attitudes towards the adoption of FRGs. In particular, we distinguished "Receptives", "Observers", and "Sceptics" profiles among participants, which were strongly driven by factors such as age, production mode, and the vineyard's climate. Adopting FRGs requires the ability to project oneself into the long-term future of the vineyards, which might be challenging for producers who are at a later stage in their careers. Moreover, the adoption of FRG wines by PDOs is fairly recent and constantly evolving; therefore, the adoption of FRGs by winegrowers will inevitably be a slow process, but the oenological potential of FRGs is high (Duley *et al.*, 2023 and references herein; Piccoli & Vigano, 2025).

Given the limited number of participants, we did not seek to define the key determinants of FRG variety adoption in this study. This objective will be pursued through a broader survey. Defining these determinants among a larger number of wine industry representatives will provide a more precise understanding of the potential for dissemination of these grape varieties and the diversity of adoption pathways among different stakeholders in the industry.

TABLE 2. Vineyard renewal rates in the Occitanie region (2016–2021), oceanic and Mediterranean zones defined according to Joly *et al.* (2010), see "Material and methods".

Vineyard	Total surface (ha)	Mean annual removal (ha)	Mean annual plantation (ha)	Annual renewal rate (%)	Renewable surface over 30 years (ha)	Part of renewed vineyard over 30 years (%)
Oceanic	34,629	1,080	1,250	~3.1 %	37,500	~108 %
Mediterranean	211,240	5,129	5,045	~2.4 %	151,350	~71.6 %
Total for the two zones	**245,869**	**6,209**	**6,295**	**~2.56 %**	**188,850**	**~76.8 %**

*Source: DRAAF Occitanie (2023, 2024, 2025). https://draaf.occitanie.agriculture.gouv.fr/viticulture-du-bassin-sud-ouest-une-diversite-de-vignobles-agreste-dossier-no1-a8764.html; https://draaf.occitanie.agriculture.gouv.fr/viticulture-du-bassin-languedoc-roussillon-agreste-dossier-no1-avril-2024-a9027.html; https://draaf.occitanie.agriculture.gouv.fr/memento-de-la-statistique-agricole-d-occitanie-2025-a9377.html.

ACKNOWLEDGEMENTS

First and foremost, the authors would like to express their gratitude to all the wine industry representatives who agreed to participate in this study: for their availability and the interest they showed in our approach. Thanks to the editor and two anonymous reviewers for their time and fruitful comments. As this study is part of the activities of the "RESSENTI" project, itself part of the Vinid'Occ research programme, we would also like to thank the Occitanie region, Vignobles Foncalieu, and Grands Chais de France for their proactive and financial support.

REFERENCES

Barham, B. L., Chavas, J., Fitz, D., Ríos-Salas, V., & Schechter, L. (2014). Risk, learning, and technology adoption. *Agricultural Economics*, *46*(1), 11-24. https://doi.org/10.1111/agec.12123

Barham, B. L., Chavas, J., Fitz, D., & Schechter, L. (2018). Receptiveness to advice, cognitive ability, and technology adoption. *Journal Of Economic Behavior & Organization*, *149*, 239-268. https://doi.org/10.1016/j.jebo.2017.12.025

Blake, A., & Bowen, A. J. (2025). Product development approach to introducing a new wine style and grape varietal: *Marquette*. *Journal of Wine Research*, *36*(4),1-19. https://doi.org/10.1080/09571264.2025.2463104

Borrello, M., Cembalo, L., & Vecchio, R. (2021). Consumers' acceptance of fungus resistant grapes: Future scenarios in sustainable winemaking. *Journal Of Cleaner Production*, *307*, 127318. https://doi.org/10.1016/j.jclepro.2021.127318

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*, *190*, 114580. https://doi.org/10.1016/j.foodres.2024.114580

Buck, D., & Kemp, S. E. (2018). Check-all-that-apply and free choice description. *Descriptive analysis in sensory evaluation*, 579-607. https://doi.org/10.1002/9781118991657.ch17

Dolet, M., Paire, C., Cheriet, F., Geffroy, O., Fur, Y. L., Hannin, H., Samson, A., Caillé, S., Nougarède, S., Olivier, V., & Chervin, C. (2024). Resumption of the planting of grapevine varieties in France, referred to as "disease-resistant". *IVES Technical Reviews Vine And Wine*, 8261. https://doi.org/10.20870/IVES-TR.2024.8261

Dressler, M. (2024). Meeting Market and Societal Ambitions with New Robust Grape Varietals: Sustainability, the Green Deal, and Wineries' Resilience. *Agriculture*, *14*(12), 2138. https://doi.org/10.3390/agriculture14122138

Duley, G., Ceci, A. T., Longo, E., & Boselli, E. (2023). Oenological potential of wines produced from disease-resistant grape cultivars. *Comprehensive Reviews in Food Science and Food Safety*, *22*, 13155. https://doi.org/10.1111/1541-4337.13155

Duley, G., Ceci, A. T., Longo, E., Darnal, A., & Boselli, E. (2025b). Are white wines from disease-resistant hybrid grapes comparable to *Vitis vinifera*? A chemical and sensory analysis from South Tyrol. *OENO One*, *59*(2), 9203. 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. (2025a). 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

Eisenmann, B., Wingerter, C., Dressler, M., Freund, C., Kortekamp, A., & Bogs, J. (2023). Fungicide-Saving Potential and Economic Advantages of Fungus-Resistant Grapevine Cultivars. *Plants*, *12*(17), 3120. https://doi.org/10.3390/plants12173120

Espinoza, A. F., Hubert, A., Raineau, Y., Franc, C., & Giraud-Héraud, É. (2018). Resistant grape varieties and market acceptance: an evaluation based on experimental economics. *OENO One*, *52*(3), 2316. https://doi.org/10.20870/oeno-one.2018.52.3.2316

Finger, R., Zachmann, L., & McCallum, C. (2022). Short supply chains and the adoption of fungus-resistant grapevine varieties. *Applied Economic Perspectives And Policy*, *45*(3), 1753-1775. https://doi.org/10.1002/aepp.13337

Geffroy, O., Cheriet, F., Chervin, C., Hannin, H. Olivier, V., Samson, A., & Vanden Heuvel, J. (2024a). Opportunities and challenges in the adoption of new grape varieties by producers: A case study from the Northeastern United. *IVES Conference Series*, OIV 2024. https://doi.org/10.58233/byeRkD9y

Geffroy, O., Maza, E., Lytra, G., & Chervin, C. (2024b). 'Liking then CATA' or 'CATA then liking'? Impact of the hedonic question positioning on the wine sensory description and appreciation. *OENO One*, *58*(3) 8165. https://doi.org/10.20870/oeno-one.2024.58.3.8165

Jaeger, S. R., Chheang, S. L., Jin, D., Ryan, G. S., & Ares, G. (2023). How do CATA questions work? Relationship between likelihood of selecting a term and perceived attribute intensity. *Journal of Sensory Studies*, *38*(4), 1283. https://doi.org/10.1111/joss.12833

Javaid, M., Kumari, K., Khan, S. N., Jaaron, A. A., & Shaikh, Z. (2023). Leader green behavior as an outcome of followers' critical thinking and active engagement: the moderating role of pro-environmental behavior. *Leadership & Organization Development Journal*, *44*(2), 218-239. https://doi.org/10.1108/LODJ-07-2021-0361

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

Kiefer, C., & Szolnoki, G. (2023). Consumer Acceptance of Fungus-Resistant Grape Varieties—An Exploratory Study Using Sensory Evaluation Tests among Consumers in Germany. *Sustainability*, *15*(13), 10664. https://doi.org/10.3390/su151310664

Kiefer, C., & Szolnoki, G. (2024a). Exploring Market Potential and Consumer Preferences for Fungus-Resistant Grape Varieties: A Discrete Choice Analysis in Germany. *Future Foods*, *10*, 100449. https://doi.org/10.1016/j.fufo.2024.100449

Kiefer, C., & Szolnoki, G. (2024b). Adoption and Impact of Fungus-Resistant Grape Varieties within German Viticulture: A Comprehensive Mixed-Methods Study with Producers. *Sustainability*, *16*(14), 6068. https://doi.org/10.3390/su16146068

Kiefer, C., & Szolnoki, G. (2024c). Influence of Information about Fungus-Resistant Grape Varieties on Hedonic Ratings by Consumers – a Central Location Test in Germany. *Wine Economics And Policy*, *13*(2), 43-57. https://doi.org/10.36253/wep-16110

Loison, A., Symoneaux, R., Deneulin, P., Thomas-Danguin, T., Fant, C., Guérin, L., & Le Fur, Y. (2014). Exemplarity measurement and estimation of the level of interjudge agreement for two categories of French red wines. *Food Quality And Preference*, *40*, 240-251. https://doi.org/10.1016/j.foodqual.2014.10.001

Meloni, G., & Swinnen, J. (2013). The Political Economy of European Wine Regulations. *Journal Of Wine Economics*, *8*(3), 244-284. https://doi.org/10.1017/jwe.2013.33

Montaigne, E., Coelho, A., & Khefifi, L. (2016). Economic issues and perspectives on innovation in new resistant grapevine varieties in France. *Wine Economics And Policy*, *5*(2), 73-77. https://doi.org/10.1016/j.wep.2016.11.002

Montaigne, E., Coelho, A., & Zadmehran, S. (2021). A Comprehensive Economic Examination and Prospects on Innovation in New Grapevine Varieties Dealing with Global Warming and Fungal Diseases. *Sustainability*, *13*(23), 13254. https://doi.org/10.3390/su132313254

Nesselhauf, L., Fleuchaus, R., & Theuvsen, L. (2019). What about the environment?: A choice-based conjoint study about wine from fungus-resistant grape varieties. *International Journal Of Wine Business Research*, *32*(1), 96-121. https://doi.org/10.1108/IJWBR-09-2018-0049

Nisbett, R. E., & Wilson, T. D. (1977). The halo effect: Evidence for unconscious alteration of judgments. *Journal Of Personality And Social Psychology*, *35*(4), 250-256. https://doi.org/10.1037/0022-3514.35.4.250

OIV. (2025). State of the World Vine and Wine Sector in 2024. *International Organisation of Vine and Wine*. https://www.oiv.int/sites/default/files/2025-04/OIV-State_of_the_World_Vine-and-Wine-Sector-in-2024.pdf

Paire, C., Cheriet, F., Samson, A., Chervin, C., Arino, A., Ruetsch, G., Ithurralde, E., & Geffroy, O. (2025). 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). https://doi.org/10.20870/oeno-one.2025.59.2.8484

Paire, C., Dolet, M., Hannin, H., Samsom, A., Olivier, V., Chervin, C., Geffroy, O., & 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*, 8262. https://doi.org/10.20870/IVES-TR.2024.8262

Pedneault, K., & Provost, C. (2016). Fungus resistant grape varieties as a suitable alternative for organic wine production: Benefits, limits, and challenges. *Scientia Horticulturae*, *208*, 57-77. https://doi.org/10.1016/j.scienta.2016.03.016

Piccoli, A., & Viganò, F. (2025). Unveiling the Motivations Behind Cultivating Fungus-Resistant Wine Varieties: Insights from Wine Growers in South Tyrol, Italy. *Sustainability*, *17*(6), 2615. https://doi.org/10.3390/su17062615

Reis, F., Alcaire, F., Deliza, R., & Ares, G. (2017). The role of information on consumer sensory, hedonic and wellbeing perception of sugar-reduced products: Case study with orange/pomegranate juice. *Food Quality And Preference*, *62*, 227-236. https://doi.org/10.1016/j.foodqual.2017.06.005

Sillani, S., Marangon, F., Gallenti, G., Troiano, S., Nassivera, F., & Carzedda, M. (2022). Designation and Certification Strategies for Fungus-Resistant Grape Wines: An Exploratory Study in Italy. *Sustainability*, *14*(22), 14871. https://doi.org/10.3390/su142214871

Sinesio, F., Moneta, E., Di Marzo, S., Zoboli, G. P., & Abbà, S. (2021). Influence of wine traits and context on liking, intention to consume, wine-evoked emotions and perceived sensory sensations. *Food Quality And Preference*, *93*, 104268. https://doi.org/10.1016/j.foodqual.2021.104268

Souza-Gonzaga, L., Bastian, S. E., Capone, D. L., Danner, L., & Jeffery, D. W. (2021). Consumer perspectives of wine typicity and impact of region information on the sensory perception of Cabernet Sauvignon wines. *Food Research International*, *152*, 110719. https://doi.org/10.1016/j.foodres.2021.110719

Teissedre, P. (2018). Composition of grape and wine from resistant vines varieties. *OENO One*, *52*(3), 211-217. https://doi.org/10.20870/oeno-one.2018.52.3.2223

Töpfer, R., & Trapp, O. (2022). A cool climate perspective on grapevine breeding: climate change and sustainability are driving forces for changing varieties in a traditional market. *Theoretical And Applied Genetics*, *135*(11), 3947-3960. https://doi.org/10.1007/s00122-022-04077-0

van Leeuwen, C., Sgubin, G., Bois, B., Ollat, N., Swingedouw, D., Zito, S., & Gambetta, G. A. (2024). Climate change impacts and adaptations of wine production. *Nature Reviews Earth & Environment*, *5*(4), 258-275. https://doi.org/10.1038/s43017-024-00521-5

Vecchio, R., Pomarici, E., Giampietri, E., & Borrello, M. (2022). Consumer acceptance of fungus-resistant grape wines: Evidence from Italy, the UK, and the USA. *PLoS ONE*, *17*(4), e0267198. https://doi.org/10.1371/journal.pone.0267198

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

Zachmann, L., McCallum, C., & Finger, R. (2024). Determinants of the adoption of fungus-resistant grapevines: Evidence from Switzerland. *Journal Of Wine Economics*, *19*(3), 232-264. https://doi.org/10.1017/jwe.2023.36