WEP Wine Economics and Policy Just accepted

Influence of Information about Fungus-Resistant Grape Varieties on Hedonic Ratings by Consumers – a Central Location Test in Germany

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Please cite this article as:

Kiefer C., Szolnoki G. (2024), Influence of Information about Fungus-Resistant Grape Varieties on Hedonic Ratings by Consumers – a Central Location Test in Germany?, **Wine Economics and Policy**, *Just Accepted.*

DOI: 10.36253/wep-16110

Abstract

As the wine industry faces increasing challenges from grapevine diseases, Fungus-Resistant Grape Varieties (FRGVs) offer a promising solution for sustainable production. To evaluate their market potential, our study investigates how knowledge of FRGVs affects consumer hedonic quality assessments and willingness to pay for wines produced from these innovative varieties compared to those made from conventional grape varieties. The study utilises data from a central location test conducted with 244 consumers in Germany featuring 8 different wines. The sample was carefully selected to ensure representativeness across gender, age and frequency of wine consumption. The data were analysed using descriptive and multivariate statistical techniques. The results indicate that consumers rate the hedonic quality and willingness to pay for wines made from FRGVs similarly to wines produced from conventional grape varieties when tasted without any prior information about the FRGVs in viticulture. However, providing consumers with information prior to tasting results in a positive effect on their assessment of hedonic quality and willingness to pay for wines made from FRGVs. By offering information about the positive effects of resistant grapes in viticulture, it is possible to enhance consumer acceptance and increase their willingness to pay for wines from FRGVs..

Key words: PIWI, innovation, wine quality, sustainability, sensory quality

1. Introduction

Fungus-resistant grape varieties (FRGVs) assume a pivotal role in realising the objectives outlined in the Farm to Fork Strategy [1], primarily by mitigating the necessity for fungicide applications in plant protection efforts [2]. This transition not only contributes to a reduction in CO2 emissions but also demonstrates the preservation of soil integrity and the advancement of biodiversity [3]. Beyond the ecological effects, the cultivation of FRGVs holds the potential for economic and societal benefits [2,4–6], thus exerting a positive influence across all dimensions of sustainability [7].

Despite the growing demand for organic food [8], challenges such as the unappealing nomenclature of grape varieties, divergent taste profiles, the established market dominance of conventional grape varieties (CGVs) and the heightened advisory demands associated with FRGVs collectively impede consumer acceptance [2,4,9–11]. Consequently, despite the expanding interest, the production of FRGVs remains at a marginal level in established as well as new wine-producing countries like Italy, France, the USA, Brazil, Denmark, Poland and Germany [12–16]. It is important to note that while FRGVs can complement organic production, they represent a distinct approach within sustainable viticulture. Nevertheless, the utilisation of these varieties holds promise in both organic and conventional viticulture, particularly for diminishing the reliance on fungicides [17].

The phenomenon of assimilation and contrast, as described by Tajfel & Wilkes (1963) [18], is related to the discussion of consumer neophobia. According to Ram & Sheth (1989) [19], it is crucial to break down entrenched conventional perspectives, which could indicate a tendency to assimilate when consumers receive information that supports their existing beliefs. This could mean that consumers perceive information about resistant grape varieties as "different" or "not as good enough" when they already have a strong preference for CGVs.

To address the assimilation in consumer education, Pedneault and Provost (2016) [3] advocate for further research into effective communication strategies. Furthermore, studies affirm that disseminating information regarding the environmentally friendly production practices of FRGV wines positively influences the likelihood of purchase [20–22], considering that 46% of respondents attribute significance to the environmental impact of wine production. Kiefer and Szolnoki (2023) [10] conducted a qualitative study and found that providing information increased the willingness to pay in certain consumer groups. Thus, consumer education in this domain becomes indispensable [23] and is tested by the following hypothesis.

H1: The willingness to pay for wines made from resistant grape varieties is comparable with to that of wines produced from conventional grape varieties.

Sensory distinctions between wines produced from FRGVs and conventional grapes negatively impact consumers' willingness to pay [20]. Similar to organically produced wines, FRGVs confront

the historical challenge of overcoming perceptions of inferior quality [3,24]. However, several studies affirm that wines produced from FRGVs can attain comparable quality levels to those produced from CGVs [4,8,11,17,25–28]. Analytically, the study by González-Centeno et al. (2019) [25] stated results for red wine FRGVs, demonstrating promising total phenol content, anthocyanin and proanthocyanin levels, volatile compounds and sensory properties when compared to established red grape varieties, such as Cabernet Sauvignon, Merlot and Syrah. While discrepancies exist in colour, taste, overall balance, astringency and body, the findings underscore the potential of these new grape varieties to yield wines of marketable quality. A study by Duley et al. (2023) [29] emphasises the need for optimisation in winemaking methods, addressing challenges posed by high protein levels, titratable acidity and pH as well as low tannin levels inherent in most FRGVs and their derivative wines. This forms the basis for the subsequent hypothesis:

H2: The sensory quality perception of wines made from resistant grape varieties is comparable to that of wines produced from conventional grape varieties.

However, numerous studies underscore that increased knowledge about FRGV positively correlates with increased consumer willingness to purchase [20]. Noteworthy is Nesselhauf et al.'s (2019) [30] revelation that consumers with a high level of involvement and receptiveness to innovations from the organic sector are predisposed to purchasing wines derived from FRGVs. Additionally, Mann et al. (2012) [31] discover that enhanced knowledge about organic production augments the likelihood of consumers opting for organic wines. On the producer side, concerns have arisen about providing information on resistant varieties, as it can discredit the other CGVs and, thus, reduce their value [32]. Furthermore, the provision of information on environmentally friendly production practices enhances subjective quality perceptions [33]. The following hypothesis was therefore formulated to test the influence of information on both sides at the sensory level.

H3: The sensory quality perception of wines made from resistant grape varieties increases with the provision of information about resistant grape varieties.

H4: The provision of information about resistant grape varieties has a negative impact on the evaluation of conventional grape varieties.

H5: The willingness to pay for wines made from resistant grape varieties increases with the provision of information about resistant grape varieties.

Although existing literature investigating consumer motives and barriers associated with FRGVs, research focusing on the impact of information on hedonic sensory quality and price estimation remains limited. This study attempts to bridge this research gap by examining consumers' sensory evaluations of wines produced from FRGVs in a comprehensive three-stage model.

2. Materials and Methods

In order to examine the influence of information on FRGVs and their positive environmental impact, a cross-sectional design was employed using the central location test (CLT) methodology. This commonly used test procedure involves controlled testing in a standardised environment. The products to be evaluated by the participants are typically presented without attributes that directly affect sensory perception, which may introduce some artificiality into the testing process but enables a controlled measurement [34].

2.1 Materials

Eight representative and experimental samples from resistant and conventional grape varieties were selected for consumer evaluation based on market share and sensory attributes. The samples were produced by our cooperative partner, Weincampus Neustadt, which conducts research on the oenological development of resistant grape varieties. These wines were specifically produced for research purposes of grapes from the institutes' vineyards, which are dedicated and managed exclusively for scientific study. This ensures that the wines are consistent with the experimental requirements and tailored for accurate evaluation in our study. In total, four different red wines and four different white wines were tested, with each group including two wines produced from FRGVs and two from CGVs. The following Table 1 presents the grape varieties along with their codes and analytical data.

Table 1: Presentation of the samples categorised by fungus-resistance and conventional grape varieties, including the utilized grape variety, the corresponding codification and analytical data.

Type	Grape Variety	Code (blind/informed)	Alcohol %vol.	Sugar g/L	Acidity g/L	Volatile Acid g/L	Free SO_2 mg/L	Total SO_2 mg/L
White Grape Varieties								
FRGV	Sauvignac	582/642	12.53	6.20	7.20	.33	33	77
FRGV	Muscaris	468/975	12.02	8.30	6.40	.34	21	83
CGV	Riesling	674/312	12.25	4.70	6.80	.34	26	78
CGV	Sauvignon Blanc	361/543	12.74	11.00	5.50	.49	30	65
Red Grape Varieties								
FRGV	Satin Noir	625/436	13.06	3.80	5.20	.63	28	66
FRGV	Laurot	514/874	12.82	7.30	5.80	.47	30	102
CGV	Merlot	734/154	13.34	4.20	5.00	.44	28	98
CGV	Cabernet Sauvignon	275/235	14.83	3.70	5.50	.64	31	106

The vinification process was meticulously and equally conducted for both the FRGV and conventional wines to ensure the production of comparable samples for consumer evaluation. For the white wine, the process began with manual harvesting followed by crushing without destemming. In some variations (Muscaris & Sauvignon Blanc) with extended skin contact, a maceration of approximately 18 hours was allowed. The subsequent steps included pressing, flotation with N^2 for must clarification, yeast addition and, in selected cases (Sauvignac & Riesling), the introduction of medium-toasted wood chips at the time of yeast addition. After 24 hours, nutrient supplementation was provided, and the fermentation occurred in stainless steel tanks at 18°C. Post-fermentation, the wine underwent racking to separate it from the coarse lees followed by the addition of 70 mg/L SO^2. For the red wines, the process commenced with manual harvesting followed by destemming. Two variations were explored: a mesh fermentation (Cabernet Sauvignon & Satin Noir) and a mesh fermentation with 10% juice extraction (Merlot & Laurot). The subsequent steps included yeast addition and, in case of Cabernet Sauvignon and Satin Noir, the incorporation of medium-toasted wood chips. After 24 hours, lactic acid bacteria were introduced for simultaneous malolactic fermentation. Pressing occurred after 14 days, once the fermentation was complete. The wine was then allowed to settle overnight and decanted. In December/January, the wines were sulphured with 100 mg/L. These carefully executed vinification processes contributed to the diverse range of samples representing both resistant and conventional grape varieties in our consumer hedonic sensory study.

2.2 Test Procedure

The samples were randomly assigned to two different orders to ensure balance, and each consumer evaluated the same wine samples in two separate steps. Approximately 60 ml of each wine sample was poured into a standardised wine glass and served with a three-digit code.

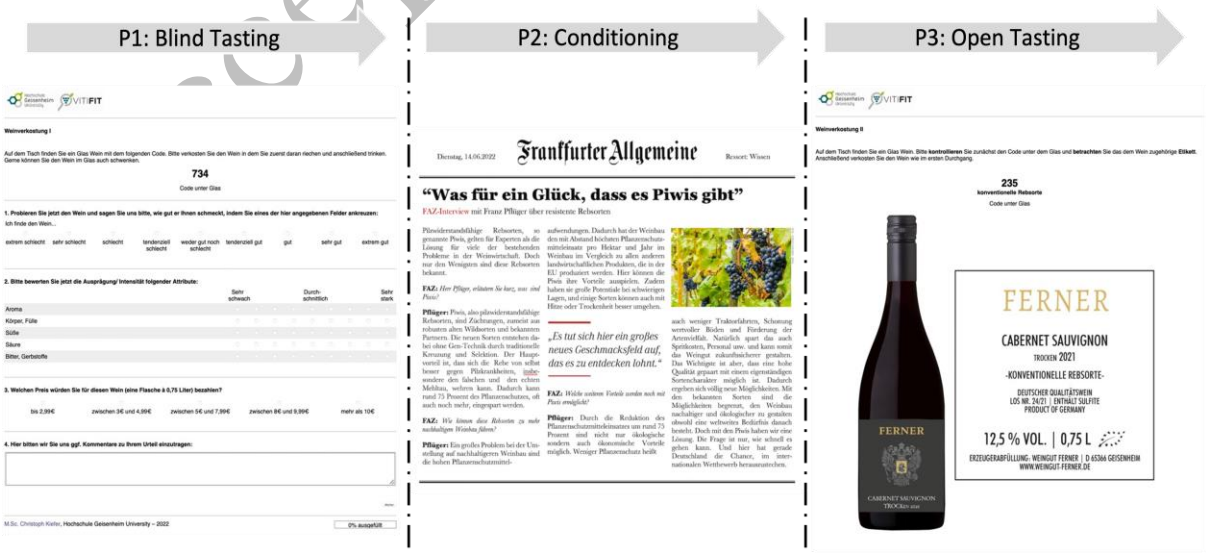

Figure 1: Schematic description of the progression of the three-step test procedure.

The tasting took place in a controlled environment using a three-step method [35,36], as shown in Figure 1. Initially, participants took part in a blind tasting where they were presented with four different wines in a complete block design, as implicated by Macfie et al. (1989) [37] to avoid first-order carry-over effects. The bottles were coded, the wine was brought to an equal temperature and poured evenly per sample to avoid bias. Subsequently, the participants were provided with general information in the form of a newspaper article about the characteristics of resistant grape varieties (see also Figure A1 in the appendix). In the next step, a conditioned tasting was conducted, where the same four wines were presented again, this time with the grape variety openly indicated and information about the resistant grape varieties provided. Additionally, labels were shown to the participants in the accompanying questionnaire to establish a visual association.

2.3 Sample Description

A representative sample of 244 consumers was recruited through a panel provider using an online screening questionnaire at locations in Munich, Frankfurt and Berlin. The participating consumers were compensated with a remuneration of 20 EUR. The distribution of the participants is based on the age and gender distribution of German wine consumers, as reported by the 'GFK Wine Consumer Report' (2020), which was derived from representative surveys of over 30,000 participants [38].

The participants were <29 years (15%), 30–49 years (45%) and <50 years (39%) old, 46% female, 52% male and 2% diverse. Compared to the German population [38], the sample is overrepresented by males (50%) and middle-aged participants (36%). All participants consume wine (at least once per month) resulting in 56% of the participants stated that they consume wine more than once a week, and 12% mentioned that they consume wine less than twice a month.

Furthermore, half of the participants in the sample completed university degree which results in a higher educated sample compared to the German population (22%). In terms of monthly net household income, 60% of the sample earning less than 3,000 EUR, which indicates that the sample has a lower income level than the German population as a whole, where 38% have a monthly net household income below 2,500 EUR (Central Bureau for Statistics, 2019) [39]. Table 2 provides a comprehensive overview of the sample distribution, allowing for a deeper understanding of its characteristics.

Table 2: Sociodemographic and wine consumption behavioural characteristics of the participants.

Soc. Variable	Level	n	% of Sample	% of German Population	Behaviour Variable	Level	n	% of Sample (SD)
Gender	Female	112	45.9	50	Wine Consumption Frequency	Several times a week	58	23.8
	Male	127	52.1	50		Once a week	79	32.4
	Diverse	5	2.0	NA		Two to three times a month	78	32.0
Age	< 29	37	15.2	19		Once a month	27	11.1
	30–49	111	45.5	36		Less than once a month	2	.8
	> 50	96	39.3	45	Taste Preferences	Dry	96	39.3
Education	High school or less	6	2.5	34		Semi dry	77	31.6
	Secondary school	55	22.5	31		Sweet	51	20.9
	Upper secondary school	61	25.0	13		Extra sweet	20	8.2
	University degree	122	50.0	22	Wine Type	White wine	244	46.1 (22.3)
Income	< €1,000	12	4.9	NA		Rosé	244	20.3 (17.6)
	€1,000–€2,000	41	16.8	NA		Red wine	244	34.3 (22.9)
	€2,000–€3,000	94	38.5	NA	Purchase Channel	Discounter	244	18.9 (24.0)
	> €3,000	46	18.9	NA		Supermarket	244	44.7 (31.2)
	Not specified	51	20.9	NA		Specialised wine store	244	18.0 (22.7)
						Wine estate	244	8.7 (14.6)
						Online retail	244	9.4 (19.5)
					Willingness To Pay		244	7.1 (3.1)

In addition to sociodemographic information, the participants were asked about their wine consumption patterns. Within the sample, the highest share of 39% of the participants reported that they prefer dry wines, and 46% reported their preferences for white wine. The preferred purchase channel was the supermarket, chosen by almost half of the sample participants, followed by

discounters (19%) and specialised wine stores (18%).

Table 3 presents the absolute and relative distributions of various parameters that indicate the attitudes towards wine and purchase criteria within the sample. On a 5-point scale ranging from 1 (I completely disagree) to 5 (I completely agree), the average interest in wine is above average (mean: 4.06), indicating a strong interest in wine among the participants. Conversely, the average involvement score is below the neutral midpoint (mean: 2.89), suggesting moderate levels of involvement. Additionally, there is a notable interest in new grape varieties with a mean score of 4.21, while the relevance of sustainability in wine production receives a neutral indication (mean: 3.50). This indicates a moderate influence of neophobia on the participants' evaluation of the wine tasting and can therefore be neglected in the analysis.

Regarding different purchase criteria evaluated on a 5-point scale ranging from 1 (not important at all) to 5 (very important), taste has a high influence (mean: 4.89). All the other criteria scores range from 3.26 (bottle design) to 3.77 (origin), indicating a heterogeneous pool of influential factors in the purchase decision, depending on personal preferences.

Table 3: Wine involvement and purchase criteria (alpha = .73).

Habits	Variables	Mean	Median	SD
Wine Involvement	I am very interested in wine.	4.1	4.0	.8
	My wine knowledge is above average.	2.9	3.0	.9
	When buying wine, I value sustainability.	3.5	4.0	.9
	I like to try new grape varieties.	4.2	4.0	.8
Purchase Criteria	Price	3.5	3.0	.9
	Design	3.6	4.0	1.0
	Certification	3.3	3.0	1.1
	Brand	3.4	3.5	1.1
	Information	3.4	3.0	1.1
	Origin	3.6	4.0	1.2
	Grape Variety	3.8	4.0	1.1
	Seal	3.4	3.5	1.1
	Taste	4.9	5.0	.4

2.4 Data

The data were collected using a digital questionnaire developed through an online tool called SoSciSurvey [40] and administered on a tablet computer. The participants were provided with an explanation of the testing station at the beginning and then given instructions to follow in the questionnaire during the tasting. The questionnaire included questions regarding the sensory perception of the wines, preference ratings, reactions to the information on resistant grape varieties and sociodemographic and behavioural characteristics of the participants. Each group of 5–6 participants took approximately 30 minutes to complete the questionnaire, and this process was carried out up to 9 times per day.

The samples were evaluated on the established 9-point hedonic scale [41] from 1 (very bad) to 9 (very good) for overall taste, beginning with the question, "How much do you like the wine?". Additionally, participants evaluated the wine on a scale of 1 (very low) to 9 (very high) in terms of aroma, body, sweetness, acidity and bitterness. This was done to ascertain the impact of fundamental sensory attributes on wine quality [28]. Finally, participants were asked to indicate the price they would be willing to pay for a 0.75-litre bottle of the wine, with price estimation evaluated on a 5-point scale from "< 3.99 EUR" to "> 10.00 EUR", which covers the main price range of the German wine market [42].

In the subsequent analysis, the collected data are analysed quantitatively with R [43]. Appropriate statistical methods such as the Mann-Whitney U test [44] are used to evaluate sensory perception and preference, aiming to investigate potential differences between resistant and conventional grape varieties. Since the study involved a paired comparison, the test was appropriately adjusted. Furthermore, the analysis of variance (ANOVA) [45] was employed to assess the sensory attributes of each wine sample, with a view to elucidating the impact on quality perception. To further clarify the group differences, a post hoc analysis is performed using the Dunn test with Holm adjustment [46,47]. Finally, a proportional odds logistic regression analysis [48] is carried out to analyse the effects of various factors that influence the interest in resistant grape varieties.

3. Results

The following chapter presents the outcomes derived from the conducted study. Specifically, the impact of information on the evaluation of FRGV wines was analysed. Due to the non-normal distribution of the data, non-parametric tests were employed [49].

3.1 Overall Comparison

In the initial phase, the assessments of the tasting samples from the blind tasting were analysed. This

was done with the aim of gaining insight into the deviations among the samples and establishing a foundation for the subsequent analyses. To facilitate the analysis, the wines from FRGVs and those from conventional grape varieties were aggregated into a single variable. This aggregation was accomplished using the means of the taste ratings and price evaluations. On the 9-point scale, the FRGV wines received an average overall taste rating of 5.77, while the conventional wines recorded 5.69. On the 5-point price scale ranging from 1 "< 3.99 EUR" to 5 "> 10.00 EUR", a price range for the FRGV and conventional wines was indicated as being between 3.00 EUR and 7.99 EUR, with the FRGV wines being rated as slightly more expensive. A mean comparison for both rating categories was conducted using the Mann-Whitney U test, revealing no significant differences, as depicted in Table 4. Consequently, it can be inferred that consumers provided a qualitatively and price-wise equivalent assessment, suggesting a neutral basis for further tests and supporting the hypothesis that the hedonic quality and price evaluations of FRGV wines do not differ from those of conventional wines. Thus, hypotheses 1 and 2 can be confirmed.

Table 4: Comparison of the evaluation of the hedonic quality and price of the wine from FRGVs and CGVs with a focus on the grape varieties.

Stage		FRGV		CGV		*V*	*r*
	Measure	*M*	*SD*	*M*	*SD*		
Blind							
	Quality	5.77	1.29	5.69	1.38	11688.5	.087
	Price	2.31	.78	2.25	.79	7834.5	.071
Informed							
	Quality	6.17	1.35	6.01	1.37	13264.5	.115
	Price	2.84	.89	2.69	.84	10882.5*	.145

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$. $^{****}p < .0001$.

Subsequently, the conditioning effect (i.e. the influence of information presentation on the perception of FRGV wines and its impact on viticulture) was examined and is also shown in Table 4. When evaluating the ratings from the conditioned stage, the hedonic quality of the conventional wines was rated as 6.01, while that of the FRGV wines received a slightly higher score of 6.17. However, this difference was not statistically significant (p = .283), indicating that we cannot assert with certainty that there was a genuine difference in the taste ratings between the FRGV and conventional wines after the participants received information. In the conditioned tasting, where the participants received information about the wines in advance, the price evaluation of the FRGV wines was on average higher (2.84) than that of the conventional wines (2.69). This suggests that the participants were willing to pay a higher price for the FRGV wines after receiving information about them. This

difference was statistically significant (p = .015) but with a small effect, indicating an increase in the price evaluation between the FRGV and conventional wines after the participants received the information.

To statistically verify the change in ratings, representing the conditioning effect, a mean comparison using the Mann-Whitney U test was conducted, as shown in Table 5. This facilitated the examination of the difference between the unconditioned, blind evaluation and the evaluation when information was available.

Analysing the change in hedonic quality revealed interesting results. In both categories and with regard to the wines from resistant grape varieties and conventional wines, a highly significant improvement was observed. While the FRGV wines exhibited an increase of .4 with an effect size of .291, the conventional wines showed a slightly lower, but still relatively large, increase of .32 with an effect size of .233. Both changes are considered highly significant, indicating a moderate positive effect of conditioning and mentioning grape varieties. Thus, hypothesis 3 can be confirmed.

Table 5: Comparison of the evaluation of the hedonic quality and price of the wine from FRGVs and conventional grape varieties with a focus on the conditioning effect.

Grape Type	Blind		Informed		V	r
Measure	M	SD	M	SD		
FRGV Wine						
Quality	5.77	1.29	6.17	1.35	6785.5****	.291
Price	2.31	.78	2.84	.89	3275.5****	.531
CGV Wine						
Quality	5.69	1.38	6.01	1.37	7773***	.233
Price	2.25	.79	2.69	.84	3088****	.486

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$. $^{****}p < .0001$.

A similar but stronger pattern emerged regarding the price evaluation. Positive effects were observed due to conditioning, with both the FRGV and CGV categories showing significant increases in price evaluations. The increase in the FRGV ratings was stronger (r = .531) compared to those of the wines from CGVs (r = .486). Therefore, hypothesis 4 can be rejected, as the evaluation of the conventional grape varieties improved despite the information presentation. Hypothesis 5 is confirmed.

3.2 Comparative Analysis of Grape Varieties

In the following section, the aggregated ratings of the FRGV and CGV wines are presented to provide more detailed insights. These are broken down into blind tasting and conditional tasting and summarised in Table 6. The table contains hedonic quality and price assessment as well as sensory

attributes ratings. This enables a comprehensive interpretation of the differences between the grape varieties. Table 6 shows the mean values for each attribute together with the corresponding standard deviations. In addition, ANOVA and Dunn test statistics are presented for each stage and attribute. This analysis reveals significant differences between the groups.

Table 6: Sensory acceptance of the tested wine samples in the blind and conditioned stages of the experiment.

Stage Samples	Overall Taste[1]	Aroma[2]	Body[2]	Sweet-ness[2]	Acidity[2]	Bitter-ness[2]	Price[3]
Blind							
Riesling	5.13^{ab} (2.25)	5.73^{abc} (1.72)	4.47^{a} (1.62)	4.19^{a} (1.89)	5.65^{b} (1.82)	5.22^{ab} (1.82)	2.81^{ab} (1.28)
Sauvignon Blanc	5.26^{abc} (2.31)	5.10^{a} (1.53)	4.78^{a} (1.56)	5.16^{b} (1.92)	5.36^{ab} (1.83)	4.64^{a} (1.83)	3.35^{c} (1.01)
Sauvignac	4.96^{a} (2.21)	5.89^{bc} (1.73)	5.51^{bc} (1.71)	4.28^{a} (1.84)	5.27^{ab} (1.64)	5.50^{b} (2.00)	2.84^{ab} (1.16)
Muscaris	5.61^{abc} (2.20)	5.26^{ab} (1.69)	5.85^{c} (1.75)	5.23^{b} (2.00)	5.11^{ab} (1.84)	4.49^{a} (1.77)	3.13^{bc} (1.34)
Merlot	5.22^{abc} (2.09)	5.87^{bc} (1.91)	5.46^{bc} (1.98)	3.85^{a} (1.86)	5.70^{b} (1.90)	5.72^{b} (2.18)	2.52^{a} (1.31)
Cabernet Sauvignon	5.89^{bc} (2.40)	6.14^{c} (1.88)	4.96^{ab} (1.70)	4.28^{a} (1.96)	5.69^{b} (1.79)	5.60^{b} (1.81)	3.12^{bc} (1.34)
Satin Noir	6.09^{c} (2.49)	6.01^{c} (1.74)	4.78^{a} (1.55)	4.08^{a} (1.82)	5.68^{b} (1.71)	5.88^{b} (1.75)	2.98^{abc} (1.25)
Laurot	5.00^{ab} (2.33)	6.12^{c} (1.78)	4.99^{ab} (1.63)	4.37^{a} (2.13)	4.95^{a} (1.69)	5.54^{b} (1.88)	3.16^{bc} (1.26)
ANOVA (F(7,968))	*4.12****	*6.04****	*9.12****	*8.19****	*3.34***	*8.87****	*5.29****
η2	*.029*	*.042*	*.062*	*.056*	*.024*	*.060*	*.037*
Conditioned							
Riesling	5.20^{ab} (2.19)	4.80^{a} (1.73)	5.64^{cd} (1.67)	4.38^{a} (1.67)	5.80^{d} (1.73)	5.15^{ab} (1.73)	2.49^{a} (.89)
Sauvignon Blanc	4.40^{a} (2.12)	5.56^{bc} (1.46)	5.20^{bc} (1.56)	4.29^{a} (1.75)	4.19^{a} (1.72)	4.80^{a} (1.84)	3.65^{c} (1.03)
Sauvignac	5.89^{b} (2.26)	6.47^{d} (1.72)	5.98^{d} (1.66)	4.82^{a} (1.83)	5.38^{cd} (1.79)	5.00^{ab} (1.87)	3.30^{bc} (1.29)

Muscaris	4.54[a] (2.18)	5.52[bc] (1.46)	6.08[d] (1.53)	5.53[b] (1.65)	5.08[bc] (1.70)	4.52[a] (1.66)	3.63[c] (1.05)
Merlot	5.74[b] (2.38)	6.12[cd] (1.86)	5.94[d] (1.76)	4.22[a] (1.96)	5.87[d] (1.87)	5.70[b] (1.94)	3.17[b] (1.29)
Cabernet Sauvignon	5.79[b] (2.39)	6.42[d] (1.74)	4.19[a] (1.51)	4.67[a] (1.90)	5.74[cd] (1.86)	5.69[b] (1.85)	3.49[bc] (1.18)
Satin Noir	4.63[a] (2.39)	5.46[b] (1.64)	5.23[bc] (1.67)	4.48[a] (1.85)	5.42[cd] (1.79)	5.14[ab] (2.03)	3.50[bc] (1.14)
Laurot	4.37[a] (2.20)	5.32[ab] (1.60)	4.97[b] (1.71)	4.84[ab] (1.91)	4.61[ab] (1.81)	5.08[ab] (1.83)	3.54[bc] (1.28)
ANOVA (F(7,968))	*10.42****	*15.09****	*18.53****	*6.71****	*13.96****	*5.86****	*13.63****
η2	*.07*	*.098*	*.118*	*.046*	*.092*	*.041*	*.09*

Note: All variables were logarithmically transformed prior to the post hoc analysis, but the original mean scores are presented in the table above. Superscript letters indicate groups that are significantly different based on the Dunn test with Holm adjustment.

[1] 9-point scale from 1 (very bad) to 9 (very good). [2] 9-point scale from 1 (very low) to 9 (very high). [3] 5-point scale from 1 "< 3.99 EUR" to 5 "> 10.00 EUR". *p = < .05 **p = < .01 ***p = < .001

The preliminary findings suggest that wines from both conventional and resistant grapes have the potential for sensory consumer appeal. In the blind tasting, the FRGV Satin Noir received the highest rating of 6.1, surpassing the conventional variety Cabernet Sauvignon with a rating of 5.9. These were followed by Muscaris with 5.6, Sauvignon Blanc with 5.3 and Merlot with 5.2. The FRGV Sauvignac received the lowest rating of 5.0. However, during the conditioned and open tasting, this ranking was reversed. In this scenario, Sauvignac (5.9), Cabernet Sauvignon (5.8) and Merlot (5.7) emerged as the top-rated varieties. Varieties such as Sauvignon Blanc and Muscaris, which received high ratings in the blind tasting, experienced a decline in their scores in the conditioned tasting. This suggests that preconceived notions may adversely affect the perception of these wines. In the conditioned tasting, Laurot and Satin Noir received notably lower overall ratings. These findings highlight the significant impact of context and expectations on wine evaluation and underscore the absence of consistent patterns in the assessment of conventional versus resistant grape varieties. The disparity between the blind and conditioned tastings was pronounced.

The assessment indicates that evaluating wine quality goes beyond the classification of grape varieties and whether they are innovative, resistant or conventional. It suggests that additional sensory components should be considered to enhance the overall evaluation. A detailed analysis of sensory

attributes in correlation with overall quality has revealed that multiple factors significantly influence taste assessment. Evaluations of hedonic quality ratings in both the blind and conditioned tastings were found to positively correlate with sensory attribute ratings. Additionally, the perceived intensity of acidity and bitterness also had a positive effect on overall hedonic quality assessments, indicating that these characteristics should be present in a robust sensory profile. The results indicate that there is a preference for wines with a lower residual sugar content, regardless of the tasting condition. This suggests that hedonic quality rating increase as sweetness level decrease. These findings highlight the importance of sensory quality and profiles in the comprehensive evaluation of wines, regardless of the grape variety's resistance or conventional status.

Considering the sensory characteristics, the differences between blind and conditioned tasting are particularly noticeable. The effect sizes are generally higher in conditioned tasting than in blind tasting, indicating a more precise differentiation of the ratings. The hedonic quality evaluation showed significant differences among the varieties. Riesling exhibited the greatest decrease, from 5.73 to 4.80, while two FRGVs, Sauvignac and Satin Noir, showed the greatest increase, with an average of approximately .5 points. The wine type and grape variety did not affect the hedonic quality evaluation. The body rating generally increased for every sample after conditioning, except for Cabernet Sauvignon, whose rating decreased from 4.96 to 4.19. The perception of sweetness generally increased in the conditioned tasting, although the differences were not as distinct as in the blind tasting. The rating for acidity remained largely unchanged, except for Sauvignon Blanc, whose rating shifted significantly from 5.36 to 4.19. The bitterness ratings exhibited a significant difference between conventional and resistant grape varieties. The ratings for CGVs remained largely unchanged or decreased slightly, while they sharply decreased for resistant red varieties. The effect size of the differences in this category decreased, indicating an equalisation of perceptions.

The evaluation of wine prices revealed that the conventional grape varieties of Sauvignon Blanc (3.35) and Cabernet Sauvignon (3.12), as well as the FRGVs Laurot (3.16) and Muscaris (3.13), received the highest ratings in the blind tasting. In the conditional tasting, the price assessment generally increased, except for Riesling, which decreased from 2.81 to 2.49. The ratings primarily reflect the sensory ratings, with the exception of Laurot, which received a lower rating. A decrease in acidity and bitterness, as well as an increase in sweetness, led to a higher price rating, regardless of the wine type or grape variety, indicating a grape variety-specific rating.

3.3 Regression Analysis of FRGV Quality Predictors

To gain a deeper understanding of the data, a multiple proportional odds logistic regression was conducted to examine the influence of various factors on the hedonic quality perception ratings of the

wine samples from resistant grapes. The model included a number of variables, including demographics (gender, age, education and income), wine preference (e.g. dry, semi-dry, sweet), frequency of consumption, rating of sensory attributes, interest in wine and FRGVs and several other factors, such as price, features, certification, brand, information, origin, grape variety and seal. The model shown in Table 7 was built by progressively reversing the model. Various tests were used to calculate the quality of the model. In the analysis, the multicollinearity of the model variables was first checked using the variance inflation factor, and no value above five was found. This indicates low multicollinearity and strengthens the stability of the model. Several pseudo-R^2 values were calculated, including McFadden (.36), CoxSnell (.54), Nagelkerke (.61) and AIC (350.68), indicating an acceptable model fit. The generalised Hosmer-Lemeshow test confirmed the fit of the ordinal model to the data, as the p-value was not significant (.553). The predictive performance of the model was assessed using a reference matrix with an accuracy of 67.5%, indicating satisfactory predictive performance. A likelihood ratio test showed that the model was significantly better than the null model, with a chi-squared statistic of 186.59 and a very low p-value (< .001). This highlights the superiority of the model in explaining the observed flavour ratings.

Table 7: Results of the multiple proportional odds model to analyse the impact of different variables on the taste ratings of the resistant grape samples.

Variables	Estimate	*SE*	*p*	Odds Ratio	95% CI	
					LL	*UL*
Intercept 1 (bad/mid)	10.998	1.62	< .001	-	-	-
Intercept 2 (mid/good)	14.395	1.769	< .001	-	-	-
Gender (female)	.701	.304	.021	2.016	1.116	3.692
Purchase Probability[a]	1.779	.231	< .0001	5.923	3.838	9.523
Price Rating (FRGV)[b]	1.352	.209	< .0001	3.864	2.602	5.921
Wine Interest[c]	.486	.180	.007	1.626	1.147	2.330
Sustainability[d]	.620	.206	.003	1.858	1.248	2.808
Price[d]	.376	.184	.041	1.457	1.018	2.096
Information[d]	−.348	.137	.011	.706	.537	.921
Origin[d]	.443	.157	.005	1.558	1.151	2.131
Grape Variety[d]	−.447	.153	.004	.640	.470	.860
Organic Production[d]	−.470	.176	.007	.625	.440	.879

Note: CI = confidence interval; *LL* = lower limit; *UL* = upper limit.
[a] 5-point scale from 1 (very unlikely) to 5 (very likely). [b]5-point scale from 1 "< 3.99 EUR" to 5 "> 10.00 EUR". [c] 5-point scale from 1 (I completely disagree) to 5 (I completely agree). [d] 5-point scale from 1 (not important at all) to 5 (very important).

Table 7 displays the results of the multiple proportional odds logistic regression, which demonstrate

the significant influence of various variables on the hedonic quality evaluation of wine from resistant grapes. One particular result is that female participants exhibit a preference for the sensory characteristics of FRGV wines, as evidenced by an odds ratio (OR) of 2.016. Furthermore, the data show that an increased purchase probability is significantly correlated with a better taste rating of these wines (OR = 5.923). Similarly, a positive correlation between the hedonic price rating and quality rating for FRGV wines was found (OR = 3.864). Additionally, individuals with an interest in wine tend to rate FRGV wines more favourably (OR = 1.626), suggesting that a general interest in wine leads to a more open attitude towards new or specific types of wine. Furthermore, the study found that consumers who value sustainability tend to rate the hedonic quality of FRGV wines more highly (OR = 1.858).

Additionally, the importance of price when purchasing wine was found to have a positive influence on taste perception (OR = 1.457), highlighting the complex nature of price perception and its impact on hedonic quality rating. A minor influence of information in the purchase decision is associated with a more critical perception of quality, as indicated by an OR of .706 for the importance of information. The significance of regional preferences and terroir is emphasised by the OR of 1.558 for the origin of the wine. A lower emphasis on grape variety when making a purchase decision is associated with a negative impact on the hedonic quality rating (OR = .64). This suggests that individuals who place less importance on grape variety tend to rate FRGV wines more highly in terms of quality. Additionally, an OR of .625 indicates a negative impact when organic production is less important for quality rating. This suggests that individuals who are less concerned about organically produced wine tend to rate the hedonic quality of FRGVs more highly.

4. Discussion

Several sensory studies have been conducted with both experts and consumers to evaluate the sensory characteristics of wines made from FRGVs, which is crucial to understanding consumer preferences [50]. In general, providing information can enhance sensory acceptance [51,52], particularly in relation to ecological production methods [35]. However, the influence of information on consumers' sensory perception has yet to be investigated.

Although the area under cultivation is limited, and only 12% of the German population is familiar with wines from resistant grape varieties [13,53], it is important to recognise the benefits of these grape types [4]. This highlights the need for more extensive education [10,11,54]. Therefore, a three-stage test was conducted to determine the influence of information on sensory acceptance and to assess possible future changes in perception.

The results of the blind tasting showed moderate differences in the evaluation by the subjects, both

in terms of hedonic quality and price, thus providing a neutral basis for the evaluation of the conditioning effect. The study indicates that hedonic sensory quality does not have a direct influence on price perception. It was found that individual wines with higher quality ratings did not necessarily receive higher prices. The hedonic quality assessment of wines from resistant and conventional grape varieties showed moderate differences, with the former being rated higher. This indicates that these products are comparable in quality and competitiveness.

In a qualitative study conducted by Kiefer and Szolnoki (2024b) [53], producers expressed concerns that providing information on resistant grape varieties could potentially discredit CGVs. This is due to the fact that resistant grape varieties are often considered a niche product and cover only a small part of the product range [11,32]. As a result, many producers tend not to emphasise the advantages of FRGVs. However, the results indicate that conditioning can also improve the hedonic quality of conventional grape varieties. Additionally, the moderate differences in hedonic quality assessment between resistant and conventional varieties (also shown by González-Centeno et al., 2019) [25] could potentially alleviate producers' concerns. Therefore, it may be advisable to provide information in the marketing context to ensure that recipients are well informed and the effect of neophobia can be reduced.

During the conditioned tasting, adjustments in price perception were observed in response to the information provided. It was noted that wines that received higher hedonic quality ratings, such as Riesling and Cabernet Sauvignon, were also rated higher in terms of price. On average, conventional wines received lower ratings compared to FRGVs, suggesting that consumers were less sensitive to price after conditioning. According to other studies, there are certain consumer groups who are less sensitive to price and willing to pay more [10,20].

Both the blind and conditioned taste tests showed significant changes across all the categories, which is expected since providing information about products that have been tasted tends to lead to significant variation [35,55]. The hedonic quality and price assessment of the wines from both resistant and conventional grape varieties showed significant improvement. This fragment highlights the potential advantages of providing information about the characteristics of resistant grape varieties. The findings are consistent with previous studies on positive conditioning effects [20,23,33], suggesting that various sensory attributes can directly impact quality perception and indirectly influence the perceived value of wine samples. The study suggests that resistant grape varieties have the potential to produce wines that are sensorially appealing by the consumers. The ratings of the wines in the tasting tests varied independently of the grape variety category, indicating that wine quality is determined by various factors.

It was observed that the perception and evaluation of the wines were significantly influenced by the

tasting conditions. In the blind tasting, certain resistant varieties were found to have scored higher than conventional ones, suggesting that the former can compete with or even surpass conventional varieties in sensory terms, provided there are no biases. This observation is supported by other studies [25,28,33].

The change in most of the ratings when prior information is provided emphasises the importance of expectations and prior knowledge. The principles of assimilation and contrast as described by [18] may be relevant in this regard. If consumers have certain perceptions of wine based on their perception of grape varieties, this could influence their preferences during tasting. For example, if consumers have a strong preference for conventional grape varieties, they might tend to rate wines from resistant varieties as less appealing due to assimilation effects, even if they are of high quality. On the other hand, consumers who are open to new experiences or have an aversion to conventional varieties may find wines from resistant varieties a refreshing alternative due to contrast effects. Therefore, it is important to consider developing strategies to enhance the acceptance of resistant varieties, with a focus on quality and the sensory profile based on conventional grape varieties [28,33,56].

Furthermore, the combination of sensory information from tasting and additional information can enhance the preservation of acquired knowledge about resistant grape varieties [57]. Both types of grape variety exhibit positive correlations between aroma intensity and the perception of acidity and bitterness, as well as their overall ratings. This underscores the importance of the sensory profile beyond the grape variety category. However, it is important to note that external information usually has a greater impact on consumer perception than sensory characteristics [58].

Moreover, the findings suggest that various demographic and psychographic factors, including gender, purchasing inclination, interest in wine, sustainability appreciation, price perception and attitudes towards regional origin and organic production, have a significant impact on the assessment of hedonic quality and therefore the acceptance of wines produced from FRGVs. The study confirms that female participants tend to favour the taste of wines from resistant grape varieties, which is consistent with the findings of a previous qualitative study conducted by Kiefer and Szolnoki (2023) [10]. Furthermore, it suggests that a positive taste perception is strongly associated with the purchase probability, indicating that the initial sensory impression is a key predictor of taste evaluation. This highlights the importance of reducing the risk associated with the first purchase [2]. Thirdly, with an increasing interest in and appreciation for sustainability in viticulture, the hedonic quality perception of FRGVs is being positively influenced and provides an opportunity to market wines from FRGVs to consumer groups that are interested in wine and sustainable wine production [30,54,59]. Finally, it can be inferred from the correlation between the price and quality evaluations that pricing may

serve as a quality indicator in consumer perception, as suggested by Weber et al. (2021) [28]. To effectively develop the market, it is recommended to use a pricing strategy that targets either the upper segment for unique products with an individual sensory profile or the lower to middle segment for products with a known sensory profile.

The study suggests that individuals who possess a general interest in wine and value sustainability may exhibit a more positive and receptive attitude towards wines produced from FRGVs. In order to increase awareness and acceptance of sustainable viticulture, it is essential to conduct education and awareness campaigns, as highlighted by Doye et al. (2005) [4], Kiefer and Szolnoki (2023) [10] and Sloan et al. (2010) [11].

The study examines the complex relationship between price, information and origin in wine purchasing decisions. It is proposed that a positive perception of quality is associated with a diminished effect of information and a decreased importance of the grape variety. This indicates that consumers often use familiar grape varieties as benchmarks. Promoting transparency and education on the benefits of wines produced from FRGVs could enhance acceptance and overcome barriers [60]. In particular, the product label should provide information on the sensory characteristics and benefits of the production of FRGVs adapted to the target group [52]. This reduces the asymmetry of information and thus facilitates the consumer's purchase decision [54].

5. Conclusions

This study highlights the significant potential of FRGVs to successfully establish themselves in the future wine market. By combining distinctive sensory characteristics with environmental benefits, FRGV wines could offer an appealing option for consumers who value quality, sustainability and innovation. The communication of information about FRGV wines is considered crucial in increasing their market acceptance and contributing to more sustainable viticulture. A well-thought-out marketing strategy is needed to effectively communicate the unique sensory profile and environmental benefits of FRGVs, considering the complex relationship between price, information and origin.

The present study has limitations that could potentially influence its interpretation. The psychoactive effect of wine, particularly in terms of contributing to a favourable mood, could affect evaluations as well as the learning effect created by the variety of products. In real-world scenarios, additional factors such as social context or prior experiences could also influence consumer behaviour and sensory perceptions, aspects that this controlled environment study does not fully accommodate a real-life tasting experience. Additionally, the data collected are based on self-reported information from the participants, and these could be strengthened in a future study by adding actual purchase

decisions and general interests of the participants to improve reliability. It has been suggested that the presence of self-confidence or personal involvement may lead to bias, as the willingness to pay more may not be limited to FRGV wines but may also extend to conventional wines. Furthermore, the assumption that providing specific information increases acceptance is currently being questioned. To gain a more accurate interpretation of the results, it may be beneficial to include control groups with non-FRGV-specific information, which could help clarify the role of information content. Finally, the sample is highly educated compared to the general German population, which may result in a different processing of information. This higher level of education could amplify the influence of information, potentially introducing bias into the results.

It is suggested that future research adopts a similar testing approach and focuses on consumers' actual purchasing decisions, information sources and interests. This would allow for a more accurate assessment of purchase propensity and further strengthen the study's validity and applicability. A study with an international focus could be conducted to explore the perception of FRGV wines in global markets while considering cultural differences and global marketing trends. Furthermore, future studies could evaluate the impact of education and awareness campaigns on consumer knowledge, attitudes and behaviour, using both quantitative and qualitative analysis to measure their effectiveness. Additionally, incorporating an experimental auction method or a discrete choice model in future research could provide more truthful WTP estimations, offering deeper insights into consumer purchasing behaviour and enhancing the practical applicability of the findings.

Acknowledgements

We would like to thank Ulrich Fischer and Marc Weber from Weincampus Neustadt for providing the wine samples. This work was supported by the Federal Ministry of Food and Agriculture within the Federal Programme of Organic Farming and Other Forms of Sustainable Agriculture (BÖL), under the following funding number 2818OE004.

555 **Appendix**

556 Figure A.1: Newspaper article (English translation, originally written and presented in German)

Tuesday, 13.06.2023 **Frankfurter Allgemeine** Ressort: Knowledge

"What luck that there are Piwis"

FAZ-Interview with Franz Pflüger about resistant grape varieties

Experts consider fungus-resistant grape varieties, known as Piwis, to be the solution to many of the existing problems in the wine industry. However, only very few people are aware of these grape varieties.

FAZ: *Mr Pflüger, could you briefly explain what Piwis are?*

Pflüger: Piwis, i.e. fungus-resistant grape varieties, are cultivars, mostly from robust old wild varieties and known partners. The new varieties are created without genetic engineering through traditional crossing and selection. The main advantage is that the vine is better able to defend itself against fungal diseases, especially downy and powdery mildew. This means that around 75 per cent of plant protection can be saved, often even more.

FAZ: *How can these grape varieties lead to more sustainable viticulture?*

Pflüger: A major problem in the switch to more sustainable viticulture is the high level of pesticides used. As a result, viticulture has by far the highest use of pesticides per hectare and year in viticulture compared to all other agricultural products produced in the EU. This is where Piwis can show their advantages. They also have great potential in difficult locations, and some varieties can also cope better with heat or drought.

"A huge new field of flavours is opening up here that is worth discovering."

FAZ: *What other advantages are made possible with Piwis?*

Pflüger: By reducing the use of pesticides by around 75 per cent, not only ecological but also economic benefits are possible. Less plant protection also means fewer tractor journeys, protection of valuable soils and promotion of biodiversity.

Of course, this also saves petrol costs, personnel etc. and can therefore make the vineyard more future-proof. The most important thing, however, is that high quality paired with an independent varietal character is possible. This opens up completely new possibilities. With the known varieties, the possibilities for making viticulture more sustainable and ecological are limited, although there is a worldwide need for this. But with Piwis we have a solution. The only question is how quickly it can be realised. And this is where Germany in particular has the chance to stand out from the international competition.

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