sustainability

MDPI

Article

Adoption and Impact of Fungus-Resistant Grape Varieties within German Viticulture: A Comprehensive Mixed-Methods Study with Producers

Christoph Kiefer * and Gergely Szolnoki

Department of Wine and Beverage Business, Geisenheim University, Von-Lade-Str. 1, 65366 Geisenheim, Germany; gergely.szolnoki@hs-gm.de

* Correspondence: christoph.kiefer@hs-gm.de

Abstract: The reduction of phytosanitary treatments in viticulture is widely demanded by policymakers and consumers. An important solution is the use of resistant grapes, which can cut plant protection applications by up to 80%. Although this is a significant improvement, viticulture is mainly carried out with traditional grapes. Therefore, the aim of this paper is to identify the factors that encourage the cultivation of fungus-resistant grape varieties (FRGV), as well as the challenges and opportunities in marketing. Our study used an exploratory sequential mixed-methods model design. In the first step, data were collected through 48 in-depth interviews and analyzed. Based on the qualitative results, a survey of 422 producers was conducted. The quantitative research results were segmented by company size and production type to provide a deeper understanding. The main drivers for cultivation are the ecological benefits resulting from the reduction of pesticide use, with organic producers particularly motivated by sustainability goals. Smaller producers are driven by the opportunity to introduce a new wine style, whereas larger producers are more cautious and focus on cost savings. The cultivation of resistant grape varieties is restricted by a large number of varieties, lack of experience, and unfavorable characteristics from initial generations of resistant grapes. A low level of grape variety prominence and customer awareness, as well as unattractive variety names, negatively affect producer acceptance. To facilitate higher market acceptance, it is important to offer attractive grape varieties, directly communicate them to consumers, and provide information about the sustainable effects.

Keywords: sustainability; innovation; pilzwiderstandsfähig; organic; company size; production type; viticulture

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

Academic Editor: Georgios Koubouris

Received: 16 April 2024
Revised: 24 June 2024
Accepted: 10 July 2024
Published: 16 July 2024

1. Introduction

Facing the ongoing threat of *Plasmopara viticola*, agricultural practices in both organic and conventional viticulture increasingly depend on copper-based treatments [1]. However, the detrimental effects of copper [2] have led to calls for alternative solutions [3,4]. A key strategy to mitigating these effects is the adoption of fungus-resistant grape varieties (FRGV), which have gained importance due to their environmental and economic benefits [5–8]. This approach not only reduces CO_2 emissions and soil degradation but also enhances biodiversity and economic viability, especially in steep-slope viticulture [5,9–12].

The importance of FRGV is slowly being recognised globally, with their adoption in prominent wine-producing countries such as Italy, France, and the USA, and in emerging markets such as Brazil, Denmark, and Poland [13–17]. Despite this growth, their penetration in the German wine market is limited, accounting for only about 3% of vineyards [18].

The replanting of a vineyard is a decision with long-term consequences [19]. Wineries typically plant grape varieties that offer the best combination of labor input, quality, and market potential. Zachmann et al. (2024) [20] emphasized the crucial role of policy measures

and industry support in encouraging the adoption of FRGV, taking into account the long-term planting cycles and the initial resilience of winegrowers. Pedneault and Provost (2016) [8] attributed winemakers' reluctance to grow FRGV to skepticism about their market potential. According to various studies, this is due to their unusual names, the fact that they include wines with different flavor profiles, the high status of 'traditional' grape varieties in the German market, and the increased advisory effort required for FRGV, all of which reduce consumer acceptance [6,9,21,22].

To increase market potential, several studies have made suggestions. Pedneault and Provost (2016) [8] and Bavaresco (2019) [23] suggested that further research was needed, to find ways to educate consumers through communication strategies. Fuentes Espinoza et al. (2018) [24] showed that willingness to pay increases with more information. Mann et al. (2012) [25] also found that greater knowledge of organic production increases the likelihood of buying organic wines, while other studies have confirmed an increase in purchase likelihood when information about the environmentally friendly production of FRGV wines is provided [24,26]. In a study conducted by Pomarici and Vecchio (2019) [27], 46% of respondents stated that the impact of wine production on the environment is important and that they were open to purchasing environmentally friendly wines, as stated by Nesselhauf et al. (2019) [28].

Several studies have shown that the quality of FRGV wines can be considered equivalent to that of traditional varieties [22,29–31]. Nevertheless, Fuentes Espinoza et al. (2018) [24] found a lower willingness to pay for FRGV, due to sensory discrepancies with traditional grape varieties, and because, like organically produced wines, FRGV are still struggling to overcome the low quality of their early years [8,32,33].

While existing studies have explored general motivations and barriers for adopting FRGV, the specific attitude of producers about resistant grapes remains insufficiently explored. This study aimed to fill this gap by investigating producers' perceptions of FRGV, examining the reasons for their reluctance, and identifying the challenges and opportunities for FRGV production and market integration in Germany. This research was structured around three research questions (RQ), derived from qualitative findings and supported by quantitative analysis:

RQ1: What motivates wineries to switch their production to fungus-resistant grape varieties?
RQ2: What challenges do fungus-resistant grape varieties face in the market?
RQ3: Which instruments are crucial for market establishment?

2. Materials and Methods

Our study followed a sequential exploratory mixed-methods design model [34]. This experimental design involves collecting and analyzing qualitative data in the first step, followed by quantitative research guided by the results of the qualitative study. Finally, the results of the quantitative research are analyzed and interpreted [35,36]. Additionally, the interpretation phase involves comparing and evaluating the results from both the qualitative and the quantitative research. To achieve this, we utilized a 'joint display', as shown in the Appendix A (Table A1), to enable a visual comparison of the results, making similarities and differences immediately apparent [37]. Figure 1 illustrates the structure and provides insight into the procedures and outputs of the individual steps. This approach enabled us to gain a deep understanding of the motivators for cultivation, the current market challenges, and the tools for establishing FRGV.

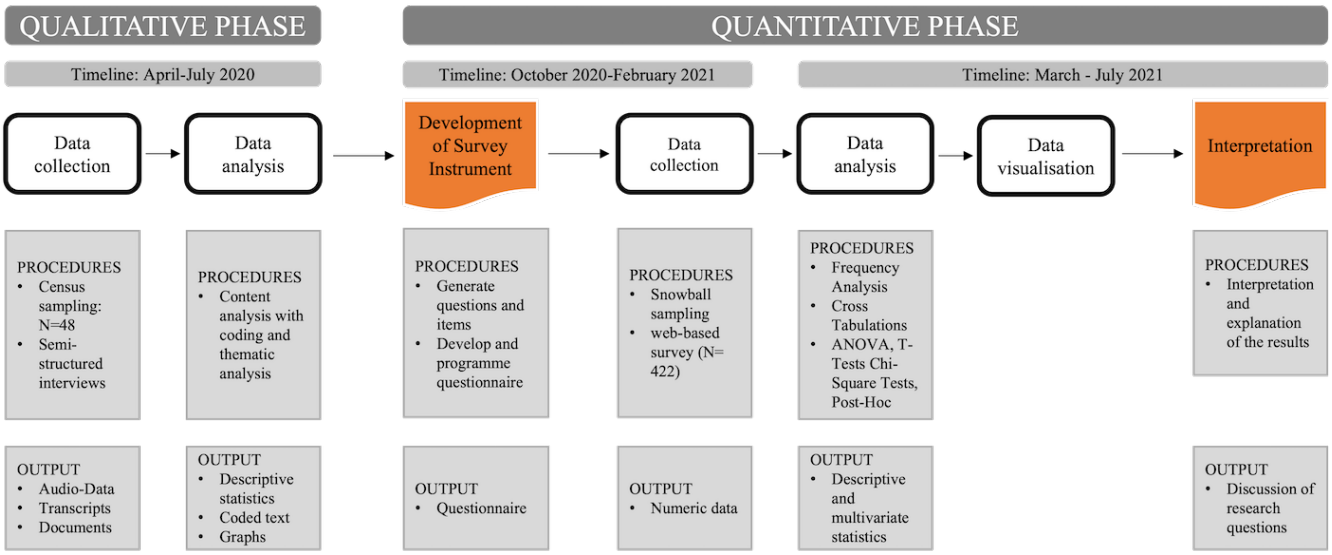

Figure 1. Structure of the sequential exploratory mixed-methods research design (inspired by Berman (2017) [38]).

2.1. Qualitative Data Collection and Analysis

The data for the initial qualitative study were collected between April and June 2020 by conducting semi-structured in-depth interviews with directors of selected German wineries, either in person or via telephone. The interviews, which lasted an average of 25 min, focused on three main areas: (i) reasons for adopting FRGV; (ii) vinification; and (iii) the impact of resistant grape varieties on the German wine market. A total of 16 questions were asked. To ensure unbiased data collection and insights into their reluctance to adopt FRGV, wineries without resistant grape varieties were interviewed, using an adjusted version of the guideline. The study aimed to uncover both the opportunities and challenges associated with these grape varieties, as well as to understand the factors influencing their rejection or adoption.

Interviews were conducted with 48 wine producers, which, according to Ritchie et al. (2003) [39] and Creswell (2014) [40], constituted an adequate sample size. This sample size allowed us to balance data saturation with the complexities of handling extensive data sets.

The sample included 45 individual wineries and three cooperatives, primarily focusing on organic farming, with two-thirds cultivating FRGV. The sample acquisition focused on heterogeneity, including both traditional and contemporary wineries, as well as those with varying levels of recognition. It encompassed wineries that were actively marketing FRGV and those that incorporated these varieties more subtly, such as unnamed cuvée blends. The proportion of FRGV to the total vineyard area varied among the wineries. Wineries that were not cultivating FRGV were also included in the study, to provide a comprehensive perspective. Special attention was given to traditional wineries that are known for a specific grape variety, such as the Mosel Region and Riesling, to understand their reluctance to use FRGV. Efforts were made to ensure that this subgroup was as diverse as the overall sample, with variations in size, region, and philosophy. Respondents' personal information was withheld, to maintain confidentiality.

The study collected primary data through recorded interviews, which were later transcribed. Before the interviews started, consent for recording was obtained. Before content analysis, the researchers established a foundation of theoretical assumptions by using open, axial, and selective coding techniques [41], informed by an extensive literature review. The first step was to filter the transcribed data, to identify relevant themes and patterns. The themes were then organized into categories, using inductive reasoning, and they were examined through content analysis [42]. The qualitative data analysis was structured using MAXQDA (version 20) software [43], which facilitated a methodical and effective

exploration. The integration of interviews, transcription, coding, and specialized software, such as MAXQDA, ensured a comprehensive and nuanced data analysis.

2.2. Quantitative Data Collection and Analysis

After analyzing the qualitative data, an online survey was conducted between January and February 2021, to gather quantitative data. The results of the qualitative study grounded the survey's design and objectives.

2.2.1. Survey Design and Analysis

A questionnaire was designed, to cover all relevant aspects identified in the previous qualitative analysis. This was done by dividing specific domains into coded variables and items, which allowed for the conversion of open-ended explorations from the qualitative phase into structured, closed-ended questions. The encoded segments covered a wide range of topics, including the potential and challenges of growing resistant grape varieties, their current position in the market, consumer preferences, and the various opportunities, barriers, and operational considerations in viticulture. Each segment combined variables from different areas explored during the qualitative inquiry. The vinification was reported as unproblematic in the qualitative study, and it was, therefore, not included in the quantitative study. The questionnaire was divided into five main sections.

After an introduction, the first section asked about characterization, specifically focusing on the organizational structure, size, and location of the companies. Investigations were made regarding the adoption of resistant grape varieties, including the rationale behind their utilization or non-utilization, the varieties favored, and the scale of their cultivation (quantified in hectares (ha)). The following section aimed to identify specific predictions and difficulties in the cultivation of resistant grape varieties through a series of multiple-choice queries, thereby deducing the three most important factors relevant to cultivation. Eleven principal categories were evaluated, using a five-point Likert scale. The influence of a distinct FRGV label was also evaluated through a concise three-point scale: negative, neutral, or positive effect. The following section analyzed market perceptions by comparing the competitive viability of resistant varieties with conventional grapes. This was done using a four-point scale from 'worse' to 'better'. Additionally, the evolution of demand over the past and future five years was examined, using two five-point scales, ranging from 'very low demand' to 'very high demand'. The final section examined the challenges faced by the market and the necessary strategies for market penetration. The respondents were given the option to select up to three alternatives.

The data were collected through a quantitative online survey, using the SoSciSurvey platform (version 3.4.14) [44]. A total of 1351 individuals were reached through an internal mailing list and various German consortia (e.g., Demeter and Ecovin), and 604 respondents participated, resulting in a response rate of 44.7%. The dataset was cleaned to exclude incomplete responses, anomalies, redundancies, and fast movers. This resulted in a definitive sample size of 422 wine producers. As the sample size was adequate after a single survey iteration, subsequent rounds were deemed unnecessary. The sample size required, as calculated according to Kadam and Bhalerao (2010) [45], was 375, based on a population of 15,151 (representing the total number of wineries in Germany [18]), a 95% confidence interval, and a 5% margin of error. On average, the participants spent 7.4 min (median: 6.8 min) completing the survey, with 90% of the participants finishing within 2.9 to 14.2 min.

The data were segmented by production type and company size (based on yield area in ha) to provide a more homogeneous and in-depth analysis of the producers' opinions. The study employed a range of techniques to analyze the data, including generating contingency tables with frequencies and percentages and Pearson's chi-squared test for independence with the statistical software R (version 4.3.0) [46]. Comparisons of means were performed, using both the Welch two-sample *t*-test and ANOVA. The effect size of the latter was quantified by Eta squared (η^2). Correlational analyses were conducted, using Spearman's rank correlation rho. The association and effect size were explored, using

measures such as Cramer's V, the phi coefficient, and Cohen's d. These measures offered a nuanced understanding of the strengths and patterns within the dataset.

2.2.2. Sample Description

The quantitative sample distribution was comparable with the qualitative study, as shown in Table 1. The participating wineries covered all wine-growing regions in Germany and varied in their geographical distribution. The sample mainly consisted of wineries, with 403 out of a total of 422 producers, representing 93.4%. The remaining producers ran as cooperatives. The sample exhibited a wide range of company sizes. The majority of producers cultivated an area of less than 10 ha, with the frequency decreasing as the area cultivated increased. The segmentation by production type revealed that conventional wine producers made up the majority, with a share of 70.9%, while organic producers constituted 29.1% of the sample.

Table 1. Sample table of quantitative and qualitative survey results by characteristics.

Characteristics	Production Type				Company Size								Qualitative Sample
	Organic		Conventional		<10 ha		10–20 ha		>20 ha		Total		
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*
Firm Type													
Winery	119	95.9	284	92.3	175	96.6	143	97.9	85	81.7	403	93.4	45
Cooperative	4	4.1	15	7.7	0	3.4	0	2.1	19	18.3	19	6.6	3
Company Size													
<10 ha	48	39.0	127	42.5	175	100.0	0	0.0	0	0.0	175	41.5	23
10–20 ha	42	34.1	101	33.8	0	0.0	143	100.0	0	0.0	143	33.9	14
>20 ha	33	26.8	71	23.7	0	0.0	0	0.0	104	100.0	104	24.6	11
Production Type													
Organic	123	100.0	0	0.0	48	27.4	42	29.4	33	31.7	123	29.1	39
Conventional	0	0.0	299	100.0	127	72.6	101	70.6	71	68.3	299	70.9	9

Overall, the sample indicated a preference among small-to-medium-sized conventional wineries to participate in FRGV production. Although organic wineries were evenly distributed across all size classes, larger wineries tend to favor both organic production and participation in FRGV production.

3. Results

The qualitative and quantitative study results are presented sequentially, due to the research design.

3.1. Qualitative Results

The decision to include FRGV in the product range was mainly driven by the reduction of plant protection efforts. The main reason cited was the resulting reduction in copper. Additionally, the decision was influenced by problematic locations, such as those in close proximity to residential areas, steep slopes, and fungus-prone locations, as well as cost-intensive locations. The decision-making process for grape variety selection was primarily based on cultivation advantages rather than market development.

Many winegrowers considered there to be a high risk in planting resistant grapes, due to their lack of experience with these varieties in cultivation. Additionally, issues encountered with first-generation varieties, such as Regent, Bronner, or Johanniter, contributed to this perception. The wineries that were interviewed expressed a desire for increased knowledge transfer through research, associations, and collaboration among themselves to facilitate the exchange of information on resistant grape production.

The marketing of wine from FRGV presented several challenges. Producers reported that consumers had insufficient knowledge of grape varieties, which increased the risk of making a purchase. This effect was intensified by the unattractive names of the grape varieties, such as Regent, Johanniter, or Bronner, which could only be marketed with increased effort. Newly bred grape varieties such as Cabernet Blanc, Pinotin, and Muscaris were considered less problematic as they were based on well-known grape varieties and were, therefore, more familiar to customers. FRGV wines were mainly marketed directly, due to the need for an explanation of these grape varieties by the participants.

The participants stated that FRGV wines would be accepted better on the market if customers could taste them before purchasing. They believed that it is the responsibility of wineries to raise awareness of this grape variety. This is because the customer and sales structure are mainly direct and personal, promoting trust and reducing the purchasing risk of an innovative product. Some producers have expressed concerns that disseminating information about resistant grape varieties may pose a risk of discrediting their existing product range, which mainly consists of conventional varieties. However, according to the participants, the conviction of the producers, their willingness to take risks, and their knowledge about these new varieties would allow FRGV to be widely disseminated.

3.2. Quantitative Results

The quantitative results are divided into production-relevant and sales-relevant sections.

3.2.1. Production

The study analyzed 422 producers and found that 64.9% of them cultivated FRGV, with areas ranging from 0.03 to 60 ha. The majority of producers used small areas for resistant varieties, with a median of 1 ha, with organic producers using significantly larger areas than conventional producers. The breakdown by production type and company size, as shown in Table 2, reveals that 80.5% of the organic and 58.5% of the conventional wine producers cultivated FRGV. This was supported by statistically significant differences in probability (p value < 0.001, V = 0.209). The cultivation of FRGV was less common on small farms (less than 10 ha) at 56.6%, compared to medium and large companies at 69.9% and 72.1%, respectively. This difference is statistically significant (p-value < 0.01, V = 0.148). Although most producers (68.7%) used less than 10% of their total area for FRGV, there was considerable variation in the intensity of use. The organic and smaller producers were the exception, as the share of FRGV in the total area was significantly higher compared to the other groups.

Further analysis was carried out to understand why some participants did not produce FRGV. Initially, the data were examined in relation to future production of FRGV. It was discovered that 48.3% of the companies that had not yet started growing FRGV were open to integrating FRGV into their production in the future, while 51.7% were not considering it.

The willingness to cultivate FRGV in the future varied slightly according to the current orientation and size of the company. The attitudes of organic and non-organic producers towards FRGV were almost equally divided, with 45.8% and 48.8% in approval, and 54.2% and 51.2% against, respectively. Company size appeared to be a factor, with producers larger than 20 ha being the most willing to grow FRGV (55.2%), while smaller farms (less than 10 ha) were the least willing (45.3%). However, no significant differences were found by production type or company size (p-values of 0.9654 and 0.664, respectively).

According to the quantitative and qualitative analysis, the primary motivation for producers to grow FRGV was the reduction of phytosanitary measures (65.9%), with larger companies responding more favorably (73.1%), as shown in Table 3. Furthermore, 43.6% of the respondents highlighted the holistic sustainability aspect of FRGV. It is noteworthy that organic wine producers assigned significantly more importance to this aspect and also viewed FRGV as a natural next step, which underscores the importance of the sustainable nature of these varieties. In contrast, conventional wineries prioritized more cost-effective cultivation (23.4%) or experimenting with new varieties (21.1%). Of the respondents, 17.8%

cited the possibility of adding an innovative wine style to the portfolio, with new grape varieties as a motivation, with smaller wineries citing this point significantly more often.

Table 2. Descriptive statistics and chi-square test with phi/Cramer's V post hoc analysis for evaluating FRGV distribution.

	Production Type						**Company Size**							
	Organic		**Conventional**				**<10 ha**		**10–20 ha**		**>20 ha**			
Characteristics of FRGV Production	***n***	**%**	***n***	**%**	χ^2	***V***	***n***	**%**	***n***	**%**	***n***	**%**	χ^2	***V***
Current Production														
Yes	99	80.5	175	58.5	17.503 ***	0.209	99	56.6	100	69.9	75	72.1	9.297 **	0.148
No	24	19.5	124	41.5			76	43.4	43	30.1	29	27.9		
Future Production														
Yes	11	45.8	61	48.8	0.002	0.022	34	45.3	22	48.9	16	55.2	0.819	0.074
No	13	54.2	64	51.2			41	54.7	23	51.1	13	44.8		
Area														
<0.5 ha	19	20.2	79	45.4			52	53.6	35	35.4	11	15.3		
0.5–1 ha	26	27.7	41	23.6			23	23.7	28	28.3	16	22.2		
1–2 ha	22	23.4	27	15.5	19.27 ***	0.268	15	15.5	19	19.2	15	20.8	49.46 ***	0.304
2–5 ha	21	22.3	18	10.3			7	7.2	14	14.1	18	25.0		
>5 ha	6	6.4	9	5.2			0	0.0	3	3.0	12	16.7		
Area Ratio to Total														
>5%	21	22.3	93	53.4			22	22.7	43	43.4	49	68.1		
5–10%	25	26.6	45	25.9			25	25.8	28	28.3	17	23.6		
10–20%	18	19.1	16	9.2	37.534 ***	0.374	13	13.4	17	17.2	4	5.6	57.928 ***	0.329
20–50%	24	25.5	10	5.7			24	24.7	8	8.1	2	2.8		
>50%	6	6.4	10	5.7			13	13.4	3	3.0	0	0.0		

Note: The order of the items is based on the frequency of mentions. Asterisks denote cells with significant differences from their expected values, as indicated by their standardized residuals (** $p < 0.01$, *** $p < 0.001$).

Table 3. Descriptive statistics and chi-square test with phi/Cramer's V post hoc analysis to evaluate various production reasons and threats with resistant grape varieties categorized by production type and company size.

	Production Type						**Company Size**							
	Organic		**Conventional**				**<10 ha**		**10–20 ha**		**>20 ha**			
Production Items	***n***	**%**	***n***	**%**	χ^2	**Φ**	***n***	**%**	***n***	**%**	***n***	**%**	χ^2	***V***
Reason														
Fungicide Reduction	82	66.7	196	65.6	1.43	0.07	103	58.9	99	69.2	76	73.1	4.25	0.11
Sustainability Aspect	65	52.8	119	39.8	3.07 °	0.1	77	44.0	65	45.5	42	40.4	1.83	0.07
Cost Efficiency	14	11.4	70	23.4	9.95 **	0.18	28	16.0	31	21.7	25	24.0	1.87	0.07
Experimental	14	11.4	63	21.1	6.97 **	0.15	24	13.7	27	18.9	26	25.0	4.39	0.11
Innovative Wine Style	22	17.9	53	17.7	0.05	0.02	39	22.3	25	17.5	11	10.6	8.61 *	0.16
Organic Evolution	51	41.5	24	8.0	59.45 ***	0.43	26	14.9	30	21.0	19	18.3	1.03	0.06
Labour Time Savings	16	13.0	44	14.7	0.43	0.04	25	14.3	19	13.3	16	15.4	0.48	0.04
Terrain Challenges	20	16.3	26	8.7	3.21 °	0.11	15	8.6	15	10.5	16	15.4	2.56	0.09
Uniqueness	6	4.9	20	6.7	0.48	0.05	8	4.6	13	9.1	5	4.8	2.58	0.09
Consultancy Improvement	3	2.4	11	3.7	0.25	0.04	7	4.0	3	2.1	4	3.8	1.32	0.06
Planning Certainty	6	4.9	7	2.3	0.8	0.07	9	5.1	2	1.4	2	1.9	5.21 °	0.12
Threat														
Grape Variety Surplus	37	30.1	85	28.4	1.69	0.09	31	17.7	53	37.1	38	36.5	11.76 **	0.21
Experience Gap	40	32.5	69	23.1	0.16	0.03	46	26.3	33	23.1	30	28.8	4.16	0.13
Simple Resistance	34	27.6	68	22.7	0.08	0.03	37	21.1	41	28.7	24	23.1	0.98	0.06
Traditional Company Structures	32	26.0	50	16.7	0.67	0.06	23	13.1	34	23.8	25	24.0	3.57	0.12
Quality Limits	13	10.6	35	11.7	1.17	0.08	14	8.0	19	13.3	15	14.4	1.43	0.07
Outdated Breeding Goals	22	17.9	22	7.4	4.57 *	0.14	15	8.6	18	12.6	11	10.6	0.32	0.04
Rot Resistance	7	5.7	29	9.7	3.61 °	0.13	15	8.6	14	9.8	7	6.7	1.14	0.07
Wasp Damage	8	6.5	24	8.0	1.1	0.08	15	8.6	10	7.0	7	6.7	1.74	0.08

Note: The order of the items is based on the frequency of mentions. Asterisks denote cells with significant differences from their expected values, as indicated by their standardized residuals (° $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).

However, the quantitative analysis showed moderate importance (10.9%) for growing on problematic terrain, which was one of the top three factors in the qualitative research. Organic producers cited terrain challenges significantly more often, which were characterized by proximity to residential areas, steep slopes, or susceptibility to fungal diseases. The aspects of uniqueness (6.2%), consultancy improvement (3.3%), and planning certainty (3.1%) appeared to be less important.

The results of Table 3 reveal that the four main threats to viticulture resistant grapes were the oversupply of varieties (28.9%), lack of experience (25.8%), limited resistance (24.2%), and traditional farm structures (19.4%). The organic producers saw significantly greater challenges posed by outdated breeding objectives. The medium and larger farms were significantly more affected by the oversupply of grape varieties than the smaller producers. Physiological threats, such as wasp damage or lack of rot resistance, were not stated as relevant threats.

3.2.2. Sales

Our study on marketing resistant grape varieties provides a comprehensive perspective. It begins with an evaluation of past demand and future expectations. It is evident that the demand for wine from resistant grapes had moderately increased in most cases, with 35.7% of respondents confirming this trend. Organic producers were more likely to report a significant increase in demand than conventional producers. Smaller companies were also more likely to report higher demand than larger companies. A statistical comparison supported the observations made, indicating a more positive development of demand stated by organic producers and smaller companies. The future outlook was optimistic, with 56.0% of respondents expecting a moderate increase in demand and 23.0% expecting a strong increase. Similar to the previous assessment, organic and smaller companies had significantly more optimistic expectations. The respondents tended to base their future expectations on past experiences, especially those who had experienced a strong increase in demand in the past: 93.1% of them expected a continued strong increase. Spearman's statistical test confirmed a positive correlation between past and expected future demand.

The participants perceived the competitiveness of resistant grape varieties differently. While the majority of producers considered these varieties to be of equal value but still capable of development (54.7%), a significant proportion considered them to be less competitive (31.3%) compared to traditional grapes. Only a minority, 9.4%, considered FRGV to be equal or better than conventional varieties. The assessment differed between organic and conventional producers, with organic farms tending to be slightly more positive. Analysis by company size showed that larger producers were more critical than small and medium-sized companies.

Table 4 shows that marketing faced several challenges. The main challenge for the surveyed producers was the low level of grape variety recognition (56.2%). The producers also expressed concerns about explanatory demand (53.1%), the irreplaceability of established grape varieties (33.9%), and the conservative nature of consumers (21.8%). The conservative attitude of consumers was one of the major challenges stated by the organic producers, with 33.3% of the votes. This effect was intensified by unattractive grape designations (30.6%), such as Regent, Johanniter, and Bronner, which required increased effort on the part of the producers. Resistance to fungal diseases and the term 'PIWI' (the common name for FRGV in German-speaking countries) were generally not conducive to sales (27.7%). However, market penetration could also be affected by an unusual wine style (14.5%), limited availability (7.8%), and an insufficient image (7.8%). Notably, the organic (7.3%) and larger producers (10.5%; 13.5%) were less affected by an unconventional wine style, while the smaller wineries (8.0%) were less affected by limited availability.

Table 4. A descriptive statistics and chi-square test with phi/Cramer's V post hoc analysis was conducted to evaluate various market threats and instruments for resistant grape varieties categorized by production type and company size.

	Production Type						Company Size							
	Organic		Conventional				<10 ha		10–20 ha		>20 ha			
Marketing	*n*	%	*n*	%	χ^2	**Φ**	*n*	%	*n*	%	*n*	%	χ^2	***V***
Threats														
Grape Variety Recognition	64	52.0	173	57.9	0.5	0.04	96	54.9	76	53.1	65	62.5	4.48	0.11
Explanatory Demand	63	51.2	161	53.8	0.01	0.01	95	54.3	76	53.1	53	51.0	0.51	0.04
Grape Variety Irreplaceability	39	31.7	104	34.8	0.09	0.02	53	30.3	56	39.2	34	32.7	1.86	0.07
Unusual Varietal Name	38	30.9	91	30.4	0.03	0.01	50	28.6	54	37.8	25	24.0	4.4	0.11
Unemotional Topic	32	26.0	85	28.4	0.05	0.02	42	24.0	43	30.1	32	30.8	1.93	0.07
Conservative Consumers	41	33.3	51	17.1	14.09 ***	0.2	40	22.9	36	25.2	16	15.4	2.92	0.09
Sustainability Aspect Irrelevant	13	10.6	58	19.4	3.85 *	0.11	26	14.9	32	22.4	13	12.5	4	0.1
Unconventional Wine Style	9	7.3	52	17.4	5.94 *	0.13	32	18.3	15	10.5	14	13.5	4.65 °	0.11
Insufficient Image	14	11.4	19	6.4	2.7	0.09	10	5.7	9	6.3	14	13.5	6.72 *	0.13
Limited Availability	13	10.6	20	6.7	1.54	0.07	14	8.0	6	4.2	13	12.5	6.52 *	0.13
Instruments														
Focus on Sustainability	49	39.8	144	48.2	1.44	0.07	79	45.1	68	47.6	46	44.2	0.02	0.01
Increase in Consumer Acceptance	50	40.7	135	45.2	0.22	0.03	63	36	73	51	49	47.1	6.73 *	0.13
Attractive Varietal Selection	32	26	87	29.1	0.1	0.02	46	26.3	41	28.7	32	30.8	0.77	0.04
Winery Conviction	27	22	89	29.8	1.8	0.07	55	31.4	35	24.5	26	25	3.03	0.09
Presence in Gastronomy	45	36.6	66	22.1	10.33 **	0.17	47	26.9	38	26.6	26	25	0.14	0.02
Political Support	41	33.3	63	21.1	7.68 **	0.15	40	22.9	37	25.9	27	26	0.41	0.03
Information Dissemination	16	13	80	26.8	7.88 **	0.15	45	25.7	33	23.1	18	17.3	2.65	0.08
Quality Enhancement	25	20.3	66	22.1	0.01	0.01	35	20	30	21	26	25	1.29	0.06
Events/Tastings	26	21.1	58	19.4	0.2	0.03	45	25.7	27	18.9	12	11.5	8.75 *	0.15

Note: The order of the items is based on the frequency of mentions. Asterisks denote cells with significant differences from their expected values, as indicated by their standardized residuals (° $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).

Various measures were required to penetrate the market. According to the producers surveyed, sustainability (45.7%) was an important marketing tool to focus on. Consumer acceptance needed improvement, in general (43.8%), stated the larger companies. Offering attractive grape varieties (28.2%), such as Cabernet Blanc, Muscaris, and Souvignier Gris, was also crucial for market penetration. However, it was important to promote these varieties with conviction (27.5%) as part of an active marketing strategy that presented them as lifestyle products that told a story of sustainability. Additionally, there was a desire for a stronger presence in gastronomy (26.3%) and support from government or associations (24.6%), especially among organic producers. Information accounted for 22.7% of the votes and was considered significantly more important by conventional producers (26.8%) than by organic producers (13%). Events and tastings received the lowest number of votes (19.9%) but were particularly more important to smaller companies.

To address the multitude of grape varieties, the participants saw the introduction of a standardized label for resistant grapes as a promising measure to promote market penetration. Table 5 shows that a majority of the producers believed that a distinctive label would have a positive or neutral impact. Specifically, 39.4% expected a positive effect, 54.3% expected a neutral effect, and only 6.3% feared a negative impact. Our statistical analyses indicated that this positive assessment of the label was largely independent of the type of production or company size.

However, according to the qualitative results, the term 'Pilzwiderstandsfähige Rebsorten (PIWI)' may be too difficult and unattractive for consumers. Therefore, the participants in the quantitative study were asked to rate alternative terms that could serve as a generic term. The highest-rated terms were 'Nachhaltige Rebsorten', with a mean value (MV) of 3.17, 'Pilzwiderstandsfähige Rebsorten (FRGV)' (MV = 3.04), and 'Innovative Rebsorten' (MV = 2.96). The respondents indicated that sustainability was currently a popular topic and that FRGV could be an important step towards achieving a higher level of sustainability. The term 'pioneer' and Anglicized terms were rated less favorably. However, the term 'sustainable pioneers' was rated significantly better by conventional producers (MV = 2.15), although still at a low level. The term 'sustainable grape varieties' was the lowest-rated term (MV = 1.96), but gained popularity with increasing company size.

Table 5. Comparison of various generic terms for resistant grapes, categorized by production type and company size.

	Production Type						Company Size							
	Organic		Conventional				<10 ha		10–20 ha		>20 ha			
Items	**M**	**SD**	**M**	**SD**	***t***	***Cohen's d***	**M**	**SD**	**M**	**SD**	**M**	**SD**	***F* (2,399)**	**η^2**
Nachhaltige Rebsorten (sustainable grape varieties)	3.00	1.29	3.23	1.30	−1.625	−0.179	3.12	1.29	3.14	1.35	3.28	1.26	0.48	0.002
Pilzwiderstandsfähige Rebsorten (PIWI) (fungus-resistant grape varieties)	2.92	1.30	3.08	1.24	−1.145	−0.129	3.16	1.24	3.01	1.25	2.86	1.27	1.89	0.009
Innovative Rebsorten (innovative grape varieties)	2.95	1.32	2.97	1.27	−0.147	−0.017	3.00	1.29	2.96	1.31	2.90	1.24	0.20	0.001
Robuste Rebsorten (robust grape varieties)	2.73	1.31	2.66	1.23	0.511	0.058	2.78	1.30	2.69	1.22	2.48	1.22	1.69	0.008
Neue Rebsorten (new grape varieties)	2.59	1.25	2.67	1.24	−0.624	−0.069	2.70	1.23	2.74	1.24	2.42	1.24	2.19	0.011
pioneer wines (FRGV)	2.47	1.33	2.21	1.25	1.849	0.210	2.18	1.22	2.36	1.32	2.33	1.33	0.82	0.004
Starke Reben (strong vines)	2.18	1.16	2.18	1.19	−0.017	−0.002	2.09	1.09	2.30	1.25	2.14	1.22	1.36	0.007
Nachhaltige Pioniere (sustainable pioneers)	1.88	1.03	2.15	1.20	−2.304 *	−0.239	2.06	1.18	2.15	1.14	1.99	1.15	0.56	0.003
pioneering wines (FRGV)	2.15	1.14	2.02	1.10	1.028	0.115	2.08	1.11	2.07	1.14	2.00	1.07	0.17	0.001
pioneering wine grapes (FRGV)	2.04	1.11	2.01	1.15	0.170	0.019	1.96	1.07	2.11	1.22	1.99	1.12	0.76	0.004
sustainable grape varieties	2.08	1.20	1.91	1.12	1.300	0.148	1.81	1.00	1.97	1.15	2.19	1.33	3.32 *	0.016

Note: The order of the items is based on the frequency of mentions. Asterisks denote cells with significant differences from their expected values, as indicated by their standardized residuals (* $p < 0.05$).

4. Discussion

Resistant grape varieties offer significant ecological, economic, and social advantages over conventional grape varieties, particularly in terms of reducing the need for phytosanitary measures [8]. Despite these benefits, these newly bred varieties have not gained widespread market acceptance. This study aimed to identify the reasons for this lack of success and to explore the barriers and opportunities for producing and selling wines from FRGV.

4.1. Production

Generally, a significant proportion of the sample cultivated FRGV. Among the wineries surveyed, the reduction of phytosanitary measures was one of the most important reasons for growing FRGV. The study shows that organic producers are increasingly willing to adopt FRGV, due to their holistic sustainable effect. This allows for the extension of the organic concept while reducing the risk of crop failure, particularly in problematic locations, such as those near residential areas, nature reserves, or with high fungus pressure [6]. Using these areas to cultivate resistant grape varieties provides social and community benefits, which could improve the reputation of wine producers in a sustainable manner [47,48].

Fungicide reduction not only protects the environment but also has economic advantages. Conventional producers mainly use it experimentally or to save costs, indicating a cautious and calculated approach. Eisenmann et al. (2023) [5] calculated a labor reduction of up to 76% within plant protection activities, and Doye et al. (2005) [9] indicated that a reduction in working time of up to 30% is possible, particularly in steep slopes. Vollmer (2013) [12] noted that steep slopes are progressively becoming extinct and that resistant grape varieties may offer a solution to counteract this trend. The increased costs and risks associated with introducing organic viticulture practices could be offset by the use of FRGV, encouraging more producers to adopt organic production.

Furthermore, smaller producers state that the incorporation of a new wine style into their range is a significant reason for cultivation. Recent studies have shown that FRGV can compete with traditional wines, in terms of quality [22,29–31], making it increasingly relevant as a novel wine style to differentiate in the competitive wine market. Wine producers are increasingly seeking alternatives, to act more ecologically or to compensate for the effects of policies such as CO_2 pricing, the green deal of the European Union, increases in energy expenses, and ongoing inflation [22]. Thus, these grape varieties can provide compensatory value, enabling wineries to adapt to future regulations. The quantitative study did not directly link planning security to this point, due to the low number of pro-

ducers who mentioned it. Only smaller wineries mentioned planning security through FRGV significantly more often than larger wineries, but still at a low level. Therefore, due to the numerous inconsistencies that still exist, FRGV cannot be associated with long-term planning certainty, although it is one of the most important aspects in the selection of a grape variety [19].

However, the data show that there is a population that does not grow FRGV at all. According to the qualitative results, many of the producers considered the risk of growing resistant varieties a crucial determinant. The main challenges to cultivating FRGV were the lack of experience among wine producers and the oversupply of resistant varieties, which was particularly noted by the larger producers over 10 ha. It seems that concentrating on a few grape varieties is more relevant, especially for pooling of resources [22].

The producers aimed to facilitate a constant exchange of experiences among wine producers, scientists, and other experts, as also stated in a study by Basler and Pfenninger (2003) [49]. Exchange of information decreases the likelihood of selecting inappropriate grape varieties and making insufficient decisions at viticulture and vinification, which can enhance the adoption of FRGV. This risk is also supported by the issues wine producers face with the first generation of resistant grapes. This situation has also been observed in organic farming, where the organic wine industry has struggled for decades with the inferior quality of the first organic wine producers [8,50]. Nowadays, numerous high-quality producers have transitioned to organic farming and are producing exceptional wines. As a low-quality example of the first generation, the grape variety Regent is often cited. However, newer crossbreeds cannot be distinguished, in terms of taste, from classic European grape varieties, as confirmed by several producers and the already stated literature. However, they still face prejudices resulting from experiences with the first generation [9]. This rejection is supported by a decrease in the cultivation area for first-generation varieties and an increase in the area for current FRGV, as reported by the producers and supported by data from the Central Bureau for Statistics (2023) [18].

4.2. Sales

Due to the numerous challenges in the market, the producers' demand assessment was cautious. Every second producer expected a moderate increase in demand for wine from FRGV in the future, with the organic and smaller companies agreeing more. In addition, over half of the producers considered that resistant varieties have the same competitiveness as existing traditional grape varieties. However, moderate consumer acceptance is the decisive factor impeding the spread of FRGV. This has been remarked on in previous studies [24,27,28] and is also mainly emphasized by larger companies in this study. Consumer acceptance is negatively affected by unfamiliar and occasionally unconventional grape variety names. Grape varieties play a crucial role in the German retail sector as they are the primary means of advertising on the shelf [19,51]. Larger companies whose primary sales channel is retail [52] have noted that an insufficiently well-presented image of FRGV can negatively impact sales [26,53] because of the high-quality image of established grapes. In addition, limited availability was also mentioned by the larger manufacturers, which, according to the results of the qualitative study, was due to the high demand from retailers to be contracted. The study also found that resistant grape varieties often have unattractive names, such as Regent, Solaris, or Bronner. In order to reduce the risk of purchase, hybrid grape variety designations, such as Cabernet Blanc, Pinot Nova, or Souvignier Gris, which include parts of well-known grape varieties, are preferred [54]. This has been confirmed by studies conducted by Doye et al. (2005) [9], Fechter et al. (2018) [6], and Montaigne et al. (2016) [19]. In direct sales, where upstream tasting supports the purchase decision, taste profiles based on well-known wine styles are especially important [55]. In these scenarios, FRGV wine has higher acceptance among consumers [56].

According to both the interviewees and the surveyed wineries, branded cuvées are a potential tool for entering the market. The majority of those surveyed viewed marketing via cuvée as a market access opportunity. Fechter et al. (2018) [6] also recommended cuvée wines, with or without imaginative names, as a suitable solution to enable market access. The advantage of a cuvée is that wine producers can benefit from the ecological and economic advantages of resistant grape varieties without having to specifically market them. This allows for flexibility in the choice of grape varieties, making it possible to react to changes in the market or the dynamics of newer generations.

In addition, the organic producers perceived the conservative attitude of German wine consumers as a threat because they were unwilling to try innovative products. This aligns with the findings of Fechter et al. (2018) [6], where 81% of conventional wine drinkers were not convinced to buy FRGV wine. For conventional wine producers, sustainability is often an irrelevant aspect of marketing. Instead, they focus on producing wine in a traditional style that appeals to their consumer structure, which was highlighted in the qualitative study. The low market demand for unconventional wines may also be due to a lack of awareness about different grape varieties. Therefore, wineries, retailers, and gastronomy need to make increased efforts to market FRGV wine satisfactorily, as supported by Pedneault and Provost (2016) [8] and Fechter et al. (2018) [6]. The survey results indicate that sustainable characteristics are crucial for establishing these varieties in the market. In general, communicating the benefits of FRGV requires a significant amount of consultation work, which traders and producers may wish to avoid, as noted by Fechter et al. (2018) [6] and Sloan et al. (2010) [22]. Given the ongoing preference of customers for sustainably produced products [57], this factor will become increasingly important in the future, thereby reducing the discrepancy between advisory efforts and risk mitigation through sustainability aspects [58].

However, providing information, especially regarding the sustainability impact of these grape varieties, is a crucial tool for conventional producers to further enhance the image of FRGV. It is also important for informing consumers about the benefits of resistant grape varieties, to reduce the purchase risk [53]. Kiefer et al. (2024) [59] and Di Vita et al. (2024) [60] emphasized the necessity of addressing the characteristics of FRGV in a manner that is appropriate for the target group, in order to ensure the efficacy of the marketing measures. Organic wineries typically avoid using plant protection in marketing, as their consumers are often unaware of their use in organic viticulture. This is because the image of organic cultivation could be negatively impacted if the use of plant protection measures was widely known [6].

Organic wineries focus more on political and association support. This can lead to demands for subsidies that promote the use of pesticides, which Pomarici et al. (2016) [26] and Zachmann et al. (2024) [20] also stated. Additionally, associations can provide effective advertising measures that smaller organic wineries cannot afford. Small wineries mention events and tastings as important tools to spread the acceptance of FRGV. In the qualitative study, the wineries considered it their responsibility to provide these explanations, to raise awareness of these varieties.

Due to the need for explanation, wine made from resistant varieties is often marketed directly [6,14,22]. Finger et al. (2022) [14] also showed that wineries that primarily market directly are more inclined to cultivate FRGV compared to wineries that primarily market their wines through retail channels. If a tasting is possible, it can have a significant impact on the purchase decision, as demonstrated by Pomarici et al. (2017) [56]. In retail trade, customers are often influenced by price, label, and product placement when making a purchase decision, due to the lack of consultation or tasting facilities [51,53]. Therefore, sales through off-trade channels typically occur in retail stores with knowledgeable staff and a diverse selection of wines or at specialist shops where these factors are also available.

Another potential solution to enhance the marketing of various grape varieties is to use a generic term, as recommended by [22]. In a qualitative study, producers expressed that this would serve as a useful reference point for consumers and support the recognition of the numerous grape varieties. However, the term 'Pilzwiderstandsfähige Rebsorten (PIWI)' may be too abstract for consumers who associate wine with a natural image where the use of fungicides has only a limited relevance. Although the qualitative research showed a critical reaction to the term 'Pilzwiderstandsfähige Rebsorten (PIWI)', it was highly ranked in the quantitative study. The main argument was that the term 'Pilzwiderstandsfähig (FRGV)' was already well-established in the professional area, both nationally and internationally. However, some experts were concerned about the term 'fungus-resistant'. They argued that consumers expect an emotional story behind the product and that sustainability is an important keyword here. Alternative terms, such as 'sustainable' or 'innovative' grape varieties, suggest a progressive image to the consumer, as the study has shown.

Finally, the research questions are addressed below, in order to provide a summary of the most important findings of this study. The primary motivation for wineries to switch to the cultivation of FRGV is the significant reduction in phytosanitary measures, which lowers both the environmental impact and production costs. In particular, organic producers value the holistic, sustainable effects of FRGV, which align with their organic concept and reduce the risk of crop failures in problematic locations. Additionally, smaller producers perceive the introduction of a novel style of wine as a competitive advantage.

The market challenges faced by fungus-resistant grape varieties include moderate consumer acceptance, unfamiliar and unconventional grape variety names, and the conservative attitude of wine drinkers towards innovative products. Additionally, larger producers have identified the limited availability and inadequate image of FRGV as potential obstacles to sales. These challenges are further compounded by a lack of experience and by prejudices due to the first generation of resistant vines.

Branded cuvées represent an important tool for market introduction, offering flexibility and reducing the specific marketing needs for FRGV. It is essential to communicate effectively the sustainable benefits of FRGV, as well as to use hybrid grape variety names that incorporate well-known grape varieties. Direct marketing strategies, events, tastings, and the support of political and association initiatives can also increase consumer awareness and acceptance, which, in turn, will encourage producers to cultivate FRGV.

5. Conclusions, Limitations, and Future Research

Producers widely accept the cultivation and vinification of FRGV, due to the potential reduction of phytosanitary use. However, many producers are still unaware of the importance of these varieties for the future, in achieving economic sustainability and meeting policy targets.

The new FRGV generations, with their hybrid varietal designations and better adapted flavor profiles, will make it easier for producers to choose these varieties. In a market such as Germany, which is dominated by grape varieties, it is crucial to consider these factors for successful market penetration. The use of a central term is a topic of controversy among manufacturers, but it could potentially exploit the advantages of a generic brand. With the ongoing trend towards ecologically produced products, actively communicating the benefits of FRGV could drive rapid awareness and have a positive impact at various levels of the value chain. Once winemakers see the potential in selling FRGV wines, they may be more open to growing these varieties.

This study has several limitations, of which the following are probably the most important. The qualitative study was conducted mainly with organic wineries, which may have distorted the results and the experimental design for the subsequent quantitative study. Therefore, adjustments had to be made in the quantitative study, to ensure that the arguments of the predominantly organic wineries could be applied to the general population. Additionally, the moderator had limited experience in conducting interviews. Therefore, the results of the first three interviews were excluded in certain sections of

the study. However, the data quality improved as the study progressed. Additionally, it is important to mention that this study was limited to Germany, due to geographical proximity and funding constraints.

Future studies should investigate consumer acceptance through focus group discussions and a quantitative survey of wine consumers. Therefore, the study should determine and analyze findings on the awareness, acceptance, and barriers of FRGV among German consumers. Additionally, sensory tests should be conducted, to determine the acceptance of current wines from newer generations of resistant grape varieties. Finally, to ensure comparability of results, the experimental setup should be extended to other relevant wine-growing countries.

Author Contributions: Conceptualization, G.S.; methodology, G.S. and C.K.; software, G.S.; validation, C.K. and G.S.; formal analysis, C.K.; investigation, G.S. and C.K.; resources, G.S.; data curation, G.S.; writing—original draft preparation, C.K.; writing—review and editing, G.S.; visualization, C.K.; supervision, G.S.; project administration, G.S.; funding acquisition, G.S. All authors have read and agreed to the published version of the manuscript.

Funding: 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 (BÖLN) under the funding number 2818OE004.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The transcripts of the expert interviews and the survey data conducted for this study have been securely stored on the Geisenheim University server, protected by a password. In compliance with privacy regulations and to ensure the confidentiality of participant information, access to the dataset can only be granted upon request. Please contact the authors for further details and to request access to the data.

Acknowledgments: We thank Demeter, Ecovin, Bioland, and PIWI International/Germany for providing quantitative study participants.

Conflicts of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

Table A1. Joint display comparison of the results from the qualitative and quantitative study.

	Qualitative Study: Interviews (*n* = 48)	**Quantitative Study: Survey (*n* = 422)**		
Category	**Participant Statements**	**Items**	***n***	**%**
RQ1a. Production Reasons	"Here we expect to have less pressure in plant protection and therefore to benefit from the resistance of the grapes". "Everywhere near residential areas is that the environment and fellow people are not or minimally polluted". "We can then reduce crop protection products, reduce crossings, i.e., reduce crop protection measures so that we can work more cost-effectively".	Fungicide Reduction	278	65.9
		Sustainability Aspect	184	43.6
		Cost Efficiency	84	19.9
		Experimental	77	18.2
		Innovative Winestyle	75	17.8
		Organic Evolution	75	17.8
		Labor Time Savings	60	14.2
		Terrain Challenges	46	10.9
		Uniqueness	26	6.2
		Consultancy Improvement	14	3.3
		Planning Certainty	13	3.1
RQ1b. Production Threats	"There are about 10 leading varieties that everyone knows, but there are also so many side shows that are an enormous wealth of varieties, which people do not even know". "What resistant grape varieties are still available? Here, information and empirical values on individual grape varieties are missing". "There's a focus on the traditional varieties, because the whole wine business is kind of a traditional story".	Grape Variety Surplus	122	28.9
		Experience Gap	109	25.8
		Simple Resistance	102	24.2
		Traditional Company Structures	82	19.4
		Quality Limits	48	11.4
		Outdated Breeding Goals	44	10.4
		Rot Resistance	36	8.5
		Wasp Damage	32	7.6
RQ2a. Consumer Demand Estimation 5 years back (past) 5 years further (future)	"I think that demand will increase but only if the supply increases". "With the general discussion about sustainability, pesticides, environmental protection it could become more of an issue in the market in the next few years". "Unfortunately, demand is not yet as high as we would like, but I am still optimistic that it will develop positively".	Very Low Demand (past)	46	10.9
		Low Demand (past)	114	27.1
		Neutral (past)	80	19.0
		High Demand (past)	151	35.7
		Very High Demand (past)	31	7.34
		Very Low Demand (future)	6	1.5
		Low Demand (future)	52	12.2
		Neutral (future)	31	7.3
		High Demand (future)	235	55.6
		Very High Demand (future)	98	23.0

Table A1. *Cont.*

	Qualitative Study: Interviews (*n* = 48)	**Quantitative Study: Survey (*n* = 422)**		
Category	**Participant Statements**	**Items**	***n***	**%**
RQ2b. Market Competitiveness	"No competitiveness at the moment, but potential for it". "The consumer has to get used to it for a long time, and as long as there are still alternatives, I don't see it being that easy to bring FRGV onto the market."	Worse Developing Equal Better	133 231 39 19	31.4 54.8 9.3 4.5
RQ2c. Market Threats	"The customers know just the grape varieties that are already known anyway" "The problem is just it is a cultural product of wine and if you talk about Riesling or Spätburgunder with a history (…) and the other is a new one. There are certainly interested people but not to the extent as for the common grape varieties". "We notice that the name somehow plays a role. Cabernet Blanc is a great choice here and the customer can imagine what it means, even on the shelf".	Grape Variety Recognition Explanatory Demand Grape Variety Irreplaceability Unusual Varietal Name Unemotional Topic Conservative Consumers Sustainability Aspect Irrelevant Unconventional Wine Style Insufficient Image Limited Availability	237 224 143 129 117 92 71 61 33 33	56.2 53.1 33.9 30.6 27.7 21.8 16.8 14.5 7.8 7.8
RQ3a. Marketing Instruments	"Sustainability is one thing that is gaining in value. (…) In the context of sustainability, FRGV can be mentioned in any case". "If demand increases, then that is generated by the winemakers". "Institutions like the regional advertisement, "Pfalzweinwerbung", "Rheinhessenweinwerbung" they are all called (…)". "I think that if more winemakers (…) consciously bring them closer to the people, it will just give itself over the years".	Focus on Sustainability Increase in Consumer Acceptance Attractive Varietal Selection Winery Conviction Presence in Gastronomy Political Support Information Dissemination Quality Enhancement Events/Tastings	193 185 119 116 111 104 96 91 84	45.7 43.8 28.2 27.5 26.3 24.6 22.7 21.6 19.9
RQ3b. Influence of a uniform FRGV label	"I put a sustainability label on it because it's a sustainable grape variety but what about my other wines that I sell?" "At least that would be a basis that could be justified" "It's difficult with all the seals. I don't know if it doesn't further confuse the consumer. Because there are just too many seals".	Negative effect No effect Positive effect	27 228 167	6.3 54.0 39.6

Table A1. *Cont.*

	Qualitative Study: Interviews (*n* = 48)	**Quantitative Study: Survey (*n* = 422)**		
Category	**Participant Statements**	**Items**	***n***	**%**
RQ3c. Generic Term	"The connection fungus and wine that makes FRGV maybe it needs a new name. It describes pretty well what the variety can but in connection with wine and pleasure". "The term PIWI has the problem also in itself, what can one imagine under it".	Nachhaltige Rebsorten (sustainable grape varieties)		3.17 *
		Pilzwiderstandsfähige Rebsorten (FRGV) (fungus-resistant grape varieties)		3.04 *
		Innovative Rebsorten (innovative grape varieties)		2.96 *
		Robuste Rebsorten (R2) (robust grape varieties)		2.68 *
		Neue Rebsorten (new grape varieties)		2.65 *
		pioneer wines (FRGV)		2.28 *
		Starke Reben (strong vines)		2.18 *
		Nachhaltige Pioniere (sustainable pioneers)		2.07 *
		pioneering wines (FRGV)		2.06 *
		pioneering wine grapes (FRGV)		2.02 *
		sustainable grape varieties		1.96 *

Note: The data marked with an asterisk are mean values.

References

1. Schumacher, S.; Mertes, C.; Wohlfahrt, Y.; Kaltenbach, T.; Schwab, S.; Eisenmann, B.; Kauer, R.; Bleyer, G.; Berkelmann-Loehnertz, B.; Fuchs, R. VITIFIT: Aiming for Copper Reduction in Organic Viticulture-Improvement of Established Strategies and New Techniques for Plant Protection against *Plasmopara viticola*. In Proceedings of the 9th International Workshop on Grapevine Downy and Powdery Mildews (GDPM 2022), Cremona, Italy, 20–22 July 2022; Volume 50, p. 03008. [CrossRef]
2. Burandt, Q.C.; Deising, H.B.; Von Tiedemann, A. Further Limitations of Synthetic Fungicide Use and Expansion of Organic Agriculture in Europe Will Increase the Environmental and Health Risks of Chemical Crop Protection Caused by Copper-Containing Fungicides. *Environ. Toxicol. Chem.* **2024**, *43*, 19–30. [CrossRef]
3. Hardt, C.; Franzen, K. *Forschungsbedarf Aus Sicht Der Praxis-Winzer: Wissenstransfer Rückwärts*; Dienstleistungszentrum Ländlicher Raum–Rheinpfalz, Institut für Weinbau und Oenologie: Neustadt/Wstr., Germany, 2018. Available online: http://www.orgprints.org/33194/ (accessed on 9 July 2024).
4. Wang, J.; Ma, T.; Wei, M.; Lan, T.; Bao, S.; Zhao, Q.; Fang, Y.; Sun, X. Copper in Grape and Wine Industry: Source, Presence, Impacts on Production and Human Health, and Removal Methods. *Compr. Rev. Food Sci. Food Saf.* **2023**, *22*, 1794–1816. [CrossRef] [PubMed]
5. Eisenmann, B.; Wingerter, C.; Dressler, M.; Freund, C.; Kortekamp, A.; Bogs, J. Fungicide-Saving Potential and Economic Advantages of Fungus-Resistant Grapevine Cultivars. *Plants* **2023**, *12*, 3120. [CrossRef] [PubMed]
6. Fechter, C.; Sesselmeier, W.; Zill, L. *Akzeptanz Neuer Rebsorten bei den Weinkonsumenten: Teilprojekt im Rahmen des Internationalen Verbundprojekts Vitifutur*; Staatliches Weinbauinstitut Freiburg: Freiburg im Breisgau, Germany, 2018. Available online: https://www.vitifutur.net/download/Akzeptanz%20neuer%20Rebsorten%20bei%20den%20Weinkonsumenten.pdf (accessed on 9 July 2024).
7. Miclot, A.S.; Delmotte, F.; Bourg, J.; Mazet, I.D.; Fabre, F.; Delière, L. Four Years of Monitoring of Disease-Resistant Grapevine Varieties in French Vineyards. In Proceedings of the 9th International Workshop on Grapevine Downy and Powdery Mildews (GDPM 2022), Cremona, Italy, 20–22 July 2022; Volume 50, p. 02008. [CrossRef]
8. Pedneault, K.; Provost, C. Fungus Resistant Grape Varieties as a Suitable Alternative for Organic Wine Production: Benefits, Limits, and Challenges. *Sci. Hortic.* **2016**, *208*, 57–77. [CrossRef]
9. Doye, E.; Hoffmann, C.; Michl, G. *Etablierung Eines Anbausystems Pilztoleranter Rebsorten für den Ökologischen Weinbau: Zusammenfassender Schlussbericht: Az.:18214*; Ministerium für Ländlichen Raum und Verbraucherschutz Baden-Württemberg: Stuttgart, Germany, 2005.
10. Strub, L.; Mueller Loose, S. The Cost Disadvantage of Steep Slope Viticulture and Strategies for Its Preservation. *OENO One* **2021**, *55*, 49–68. [CrossRef]
11. Strub, L.; Stoll, M.; Loose, S.M. The Effects of Low-Input Training Systems on Viticultural Costs on Flat Terrain and Steep Slope Sites. *OENO One* **2021**, *55*, 415–429. [CrossRef]
12. Vollmer, E. *Entwicklung und Bewertung Neuer Pflanzenschutzverfahren für den Weinbau in Steillagen*; Justus-Liebig-Universität Giessen: Giessen, Germany, 2013.
13. Becker, J.R.; Toldam-Andersen, T.B. *The Wine Industry in Denmark*; University of Copenhagen: Copenhagen, Denmark, 2015. Available online: https://vinavl.dk/wp-content/uploads/2020/01/Wine-industry-in-Denmark.pdf (accessed on 9 July 2024).
14. Finger, R.; Zachmann, L.; McCallum, C. Short Supply Chains and the Adoption of Fungus-resistant Grapevine Varieties. *Appl. Econ. Perspect. Policy* **2022**, *45*, 1753–1775. [CrossRef]
15. Renner, W. *PIWIS – around the World*; PIWI-International: 2021. Available online: https://piwi-international.de/2021/10/piwis-around-the-world/ (accessed on 9 July 2024).
16. Souza, A.L.K.; Brighenti, A.F.; Brighenti, E.; Caliari, V.; Stefanini, M.; Trapp, O.; Gardin, J.; Dalbó, M.A.; Welter, L.J.; Camargo, S.S. Performance of Resistant Varieties (PIWI) at Two Different Altitudes in Southern Brazil. In Proceedings of the 41st World Congress of Vine and Wine, Punta del Este, Uruguay, 19–23 November 2019; Volume 12, p. 01021. [CrossRef]
17. Stefanini, M.; Tomazetti, T.; Rossarolla, M.; Costa, A.; Bruna, E.; Malinovski, L.; Silva, A.; Nodari, R.; Guerra, M. Phenology and thermal requirements of disease-resistant genotypes (PIWI) grown in the Goethe Grape Valley region of Brazil. *Acta Hortic.* **2019**, *1248*, 141–148. [CrossRef]
18. Central Bureau for Statistics. *Land-Und Forstwirtschaft, Fischerei: Landwirtschaftliche Bodennutzung: - Rebflächen -*; Central Bureau for Statistics: Wiesbaden, Germany, 2023.
19. Montaigne, E.; Coelho, A.; Khefifi, L. Economic Issues and Perspectives on Innovation in New Resistant Grapevine Varieties in France. *Wine Econ. Policy* **2016**, *5*, 73–77. [CrossRef]
20. Zachmann, L.; McCallum, C.; Finger, R. Determinants of the Adoption of Fungus-Resistant Grapevines: Evidence from Switzerland. *J. Wine Econ.* **2024**, 1–33. [CrossRef]
21. Pertot, I.; Caffi, T.; Rossi, V.; Mugnai, L.; Hoffmann, C.; Grando, M.; Gary, C.; Lafond, D.; Duso, C.; Thiery, D.; et al. A Critical Review of Plant Protection Tools for Reducing Pesticide Use on Grapevine and New Perspectives for the Implementation of IPM in Viticulture. *Crop. Prot.* **2017**, *97*, 70–84. [CrossRef]
22. Sloan, P.; Legrand, W.; Krauss, K. The Integration of Fungus Tolerant Vine Cultivars in the Organic Wine Industry: The Case of German Wine Producers. *Enometrica Macerata EUM* **2010**, 37–50.
23. Bavaresco, L. Impact of Grapevine Breeding for Disease Resistance on the Global Wine Industry. *Acta Hortic.* **2019**, *1248*, 7–14. [CrossRef]

24. Fuentes Espinoza, A.; Hubert, A.; Raineau, Y.; Franc, C.; Giraud-Héraud, E. Resistant Grape Varieties and Market Acceptance: An Evaluation Based on Experimental Economics. *OENO One* **2018**, *52*, 1–14. [CrossRef]
25. Mann, S.; Ferjani, A.; Reissig, L. What Matters to Consumers of Organic Wine? *Br. Food J.* **2012**, *114*, 272–284. [CrossRef]
26. Pomarici, E.; Amato, M.; Vecchio, R. Environmental Friendly Wines: A Consumer Segmentation Study. *Agric. Agric. Sci. Procedia* **2016**, *8*, 534–541. [CrossRef]
27. Pomarici, E.; Vecchio, R. Will Sustainability Shape the Future Wine Market? *Wine Econ. Policy* **2019**, *8*, 1–4. [CrossRef]
28. Nesselhauf, L.; Fleuchaus, R.; Theuvsen, L. What about the Environment?: A Choice-Based Conjoint Study about Wine from Fungus-Resistant Grape Varieties. *Int. J. Wine Bus. Res.* **2019**, *32*, 96–121. [CrossRef]
29. González-Centeno, M.R.; Chira, K.; Miramont, C.; Escudier, J.L.; Samson, A.; Salmon, J.M.; Ojeda, H.; Teissedre, P.L. Disease Resistant Bouquet Vine Varieties: Assessment of the Phenolic, Aromatic, and Sensory Potential of Their Wines. *Biomolecules* **2019**, *9*, 793. [CrossRef]
30. van der Meer, M.; Weibel, F.; Lévite, D.; Häseli, A. Acceptation Des Vins de Cépages Résistants Par Les Consommateurs: Résultats Du Projet TOPiwi 2007–2008. *Rev. Suisse Vitic. Arboric. Hortic.* **2010**, *42*, 147–150.
31. Rousseau, J.; Chanfreau, S.; Bontemps, E. *Les Cépages Résistants Aux Maladies Cryptogamiques: Panorama Européen*; Groupe ICV: Lattes, France, 2013.
32. Fuller, K.B.; Alston, J.M.; Sambucci, O.S. The Value of Powdery Mildew Resistance in Grapes: Evidence from California. *Wine Econ. Policy* **2014**, *3*, 90–107. [CrossRef]
33. Duley, G.; Ceci, A.T.; Longo, E.; Boselli, E. Oenological Potential of Wines Produced from Disease-resistant Grape Cultivars. *Compr. Rev. Food Sci. Food Saf.* **2023**, *22*, 2591–2610. [CrossRef] [PubMed]
34. Creswell, J.W.; Plano Clark, V.L.; Gutmann, M.L.; Hanson, W.E. An Expanded Typology for Classifying Mixed Methods Research Into Designs. In *Handbook of Mixed Methods in Social and Behavioral Research*; Sage: Thousand Oaks, CA, USA, 2003; pp. 209–240.
35. Creswell, J.W.; Plano Clark, V.L. *Designing and Conducting Mixed Methods Research*, 2nd ed.; SAGE: Thousand Oaks, CA, USA, 2011.
36. Teddlie, C.; Tashakkori, A. *Foundations of Mixed Methods Research: Integrating Quantitative and Qualitative Approaches in the Social and Behavioral Sciences*; Sage Publishing: Thousand Oaks, CA, USA, 2009.
37. Fetters, M.D.; Curry, L.A.; Creswell, J.W. Achieving Integration in Mixed Methods Designs-Principles and Practices. *Health Serv. Res.* **2013**, *48*, 2134–2156. [CrossRef]
38. Berman, E. An Exploratory Sequential Mixed Methods Approach to Understanding Researchers' Data Management Practices at UVM: Integrated Findings to Develop Research Data Services. *J. eSci. Librariansh.* **2017**, *6*, e1104. [CrossRef]
39. Ritchie, J.; Lewis, J.; Elam, G. Designing and Selecting Samples. In *Qualitative Research Methods*; Sage: London, UK, 2003; pp. 77–108.
40. Creswell, J.W. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, 4th ed.; SAGE Publications: Londun, UK, 2014.
41. Mayring, P. *Qualitative Content Analysis: Theoretical Background and Procedures*; Advances in Mathematics Education; Springer: Dordrecht, The Netherlands, 2015. [CrossRef]
42. Strauss, A.L.; Hildenbrand, A.; Hildebrand, B. *Grundlagen Qualitativer Sozialforschung: Datenanalyse und Theoriebildung in der Empirischen Soziologischen Forschung*; UTB: Stuttgart, Germany, 1998.
43. Kuckartz, U. *MAXQDA 2020*, version 20; VERBI Software: Berlin, Germany, 2019. Available online: https://www.maxqda.com (accessed on 9 July 2024).
44. Leiner, D.J. *SoSci Survey*, version 3.4.14; SoSci Survey GmbH: Munich, Germany, 2023. Available online: https://www.soscisurvey.de (accessed on 9 July 2024).
45. Kadam, P.; Bhalerao, S. Sample Size Calculation. *Int. J. Ayurveda Res.* **2010**, *1*, 55–57. [CrossRef]
46. Team, R.C. *R: A Language and Environment for Statistical Computing*; R Foundation for Statistical Computing: Vienna, Austria, 2023.
47. Bavaresco, L.; Squeri, C. Outlook on Disease Resistant Grapevine Varieties. In Proceedings of the CO.NA.VI.2020—8° Convegno Nazionale di Viticoltura, Udine, Italy, 5–7 July 2022; Volume 44, p. 06001. [CrossRef]
48. German Federal Government. *German Sustainable Development Strategy: Update 2021*; German Federal Government: Berlin, Germany, 2021. Available online: https://www.bundesregierung.de/resource/blob/974430/1940716/1c63c8739d10011eb116fda1aecb61ca/german-sustainable-development-strategy-en-data.pdf?download=1 (accessed on 9 July 2024).
49. Basler, P. *Andere Rebsorten: Robuste Rebsorten—Pilzwiderstandsfähige Rebsorten*; Stutz: Wädenswil, Switzerland, 2003; ISBN 9783859280724.
50. Jones, G.; Grandjean, E. Creating the Market for Organic Wine: Sulfites, Certification and Green Values. In *Varieties of Green Business*; Jones, G., Ed.; Edward Elgar Publishing: Cheltenham, UK, 2018; pp. 154–193. [CrossRef]
51. Szolnoki, G.; Herrmann, R.; Hoffmann, D. *Origin, Grape Variety or Packaging? Analyzing the Buying Decision for Wine with a Conjoint Experiment*; American Association of Wine Economists (AAWE): New York, NY, USA, 2010. Available online: https://wine-economics.org/working_paper/1-origin-grape-variety-or-packaging-analyzing-the-buying-decision-for-wine-with-a-conjoint-experiment/ (accessed on 9 July 2024).
52. Loose, S.; Pabst, E. Current State of the German and International Wine Markets. *Ger. J. Agric. Econ.* **2018**, *67*, 92–101.
53. Bruwer, J.; Chrysochou, P.; Lesschaeve, I. Consumer Involvement and Knowledge Influence on Wine Choice Cue Utilisation. *Br. Food J.* **2017**, *119*, 830–844. [CrossRef]

54. Sillani, S.; Marangon, F.; Gallenti, G.; Troiano, S.; Nassivera, F.; Carzedda, M. Designation and Certification Strategies for Fungus-Resistant Grape Wines: An Exploratory Study in Italy. *Sustainability* **2022**, *14*, 14871. [CrossRef]
55. Brunke, H.; Lapsley, J. T.; Mueller, R. A. E.; Tauscher, L. *"Tested Quality in the Glass": Wine Quality Certification in Germany*; American Association of Wine Economists (AAWE): New York, NY, USA, 2016. Available online: https://wine-economics.org/working_paper/tested-quality-in-the-glass-wine-quality-certification-in-germany/ (accessed on 9 July 2024).
56. Pomarici, E.; Lerro, M.; Chrysochou, P.; Vecchio, R.; Krystallis, A. One Size Does (Obviously Not) Fit All: Using Product Attributes for Wine Market Segmentation. *Wine Econ. Policy* **2017**, *6*, 98–106. [CrossRef]
57. Schäufele, I. Factors Influencing the Purchase Behaviour of Consumers for Organic Wine: An Analysis of Household Panel Data. Ph.D. Thesis, Universität Kassel, Kassel, Germany, 2018.
58. Vecchio, R.; Annunziata, A.; Parga Dans, E.; Alonso González, P. Drivers of Consumer Willingness to Pay for Sustainable Wines: Natural, Biodynamic, and Organic. *Org. Agric.* **2023**, *13*, 247–260. [CrossRef]
59. Kiefer, C.; Szolnoki, G. Consumer Preferences for Fungus-Resistant Grape Varieties: An Explorative Segmentation Study in Germany. *Br. Food J.* **2024**, *126*, 2271–2290. [CrossRef]
60. Di Vita, G.; Califano, G.; Raimondo, M.; Spina, D.; Hamam, M.; D'Amico, M.; Caracciolo, F. From Roots to Leaves: Understanding Consumer Acceptance in Implementing Climate-Resilient Strategies in Viticulture. *Aust. J. Grape Wine Res.* **2024**, *2024*, 8118128. [CrossRef]