

## Article

# Designation and Certification Strategies for Fungus-Resistant Grape Wines: An Exploratory Study in Italy

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**Abstract:** Fungus-resistant grapes (FRGs), or *pilzwidstandfähig* (PIWI) in German, are obtained through crossbreeding *Vitis vinifera* and other *Vitis* species. FRG adoption is among the most promising strategies to pursue and improve sustainability in the wine industry; however, actual spread and impact on sustainability will largely depend on designation and certification possibilities and procedures for FRG wines, in line with the framework set by the European Union (EU) Regulation 2021/2117. The aim of this study is to discuss the potential impact on consumers' preferences of four hypothetical designation and certification settings for FRG wines: (I) new names without certification; (II) extended use of the original *Vitis vinifera* variety names without certification; (III) new names and ad-hoc designations (Protected Designation of Origin, PDO); (IV) extended use of the original *Vitis vinifera* variety names and existing PDOs. Participants' reactivity to the alternatives was tested through market simulations on a non-probabilistic sample of 301 Italian university students. According to the results, extension of existing names and PDOs is the best option to enhance industry sustainability, preserve its quality paradigm, and fairly manage competition between traditional and new wines. Still, further investments are needed to promote FRG adoption and development.

**Keywords:** sustainability; fungus-resistant grape varieties; certification; consumers; conjoint

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## 1. Introduction

Sustainability is becoming more and more important to consumers as well as international organizations [1–8]. The European Green Deal is a clear example of the EU's commitment to making the agricultural industry more sustainable by significantly reducing the use of chemical inputs [9,10]. In this context, the selection of FRGs is one of the most promising strategies to increase the sustainability and reduce negative externalities of viticulture and the wine industry [11]. Currently available FRGs are produced through hybridization of *Vitis vinifera* with other *Vitis* varieties [12,13]. First attempts at producing FRGs date back to the XIX century, when specific varieties were selected to save European viticulture from American fungus diseases. However, the quality of resulting wines was not in-line with the marketing needs and strategies of the industry, which soon favored the adoption of fungicides and American rootstocks [12]. Starting with the second half of the XX century, new hybrid varieties, obtained by crossbreeding *Vitis vinifera* with other *Vitis* species, were selected to reduce the need for vineyard treatments and improve the environmental sustainability of grape production [14]. The quality of wines produced with these early FRGs was considered lower than original *Vitis vinifera* wines; nevertheless, adequate communication on their environmental and sustainability features could positively influence consumers'

perception and appreciation [15,16]. Conversely, current-generation hybrids can preserve up to 99% of the original *Vitis vinifera* genome [17], resulting in wines with quality standards in line with the original ones, even though, clearly, with different organoleptic and sensory profiles [12,16]. Even if the resistance to fungal infection is not absolute, and resistance circumvention cases have been recorded [18], the overall performance of FRG varieties is mostly appreciated, and they represent an additional tool for more sustainable viticultural models. Due to their novelty, FRG adoption is still limited, but on the rise. In Italy, for instance, FRG growing is allowed on seven regions (Trentino-Alto Adige, Veneto, Friuli Venezia Giulia, Lombardy, Emilia-Romagna, Marche, Abruzzo), and the authorization process is ongoing in Lazio, Campania and Apulia: according to some estimates, the FRG growing area occupies 600–800 hectares [19]. PIWI International is an international working group founded in 1999 in Switzerland, which supports adoption and diffusion of FR grapes and wines, and its logo can be used to brand and market 100% FRG wines [20].

In a recent study, Celotti et al. [21] analyzed the results of an experiment in which a panel of wine-tasting experts was asked to blind taste and evaluate seven wines from two FRGs (Soreli and Fleurtaï) and twelve wines from the original *Vitis vinifera* (Tocai Friulano). The aim of the study was to verify whether FRG wines could preserve the typicality of the original wines, specifically, Lison Classico DOCG (Denominazione di Origine Controllata e Garantita, the highest quality and most restrictive Italian wine designation of origin which, together with Denominazione di Origine Controllata, or DOC, is the national equivalent of the EU Protected Designation of Origin, PDO). According to the results, the two FRG wines are organoleptically similar to the original wines; hence, they could potentially be integrated in the DOCG without distorting the identity of the product. Soreli and Fleurtaï offer considerably better quality than previous FRG generations, as they preserve typicality and organoleptic characteristics expected from existing and reputed terroirs. This implies that replacing original grape varieties with these FRGs may not only reduce the need for agrochemical inputs, but also preserve existing names, certifications and designations. In addition to this, some authors affirm that sustainability of FRG wines is further enhanced by their compatibility with organic production practices, which could actually benefit from lower production costs and reduced copper accumulation in vineyard soil [16,22,23].

Up until the end of 2021, the EU forbade FRG use in PDO wines, as well as the use of the original *Vitis vinifera* varietal name for 100% FRG wines, in order to guarantee consumers' expectations over terroir certifications. Even though simply unknown to consumers, only fantasy names or FRG varietal names were allowed. The inability to benefit from the reputation of the original varieties slowed the adoption of FRGs, thus delaying environmental and health benefits linked to their use [16,24]. Still, FRGs were already representative of "a new quality paradigm rooted in the minimal needs of pesticides and operations in the vineyard [...] challenging the traditional quality paradigm based on *Vitis vinifera* varieties" [1] (p. 4). In other words, FRG wines were ready to compete with conventional wines through the definition of a quality paradigm which reflects consumers' growing attention to environmental and health issues.

With the introduction of the EU Regulation 2021/2117 [25], the European Parliament and Council have enabled producers "to use vine varieties that are better adapted to changing climatic conditions and that have higher resistance to disease". In detail, article 1 of the Regulation updates the EU Regulation 1308/2013 [26] to: (1) allow the use of *Vitis vinifera* and other *Vitis* hybrids in geographical indications; (2) include in the production specification "the contribution of the designation of origin or geographical indication to sustainable development"; and (3) explicitly list the reduction in pesticide use among sustainability standards (article 210b). In other words, Regulation 2021/2117 acknowledges the contribution of FRGs to sustainability in viticulture, and hence removes legal barriers to widespread adoption, challenges conventional paradigms which separate

quality and sustainability, and, finally, grants producer groups freedom on FRG certification and geographical indication strategies.

While FRG growing and wine production practices and related literature are already well-developed [16,27,28], the new possibilities provided by Regulation 2021/2117 demand further knowledge on consumers' understanding and acceptance of such products. Few studies have explored actual interest in FRG wines, mainly focusing on their sensory profile [29] or sustainability attributes [11,15,30,31]; however, as FRGs start to conquer space in the wine industry, researchers and practitioners should broaden the discussion of marketing and geographical designation strategies, as well consumers' acceptance and perception of these strategies. The aim of this exploratory study is to evaluate the impact of different hypothetical FRG marketing and PDO extension strategies and identify potential conflicts that may emerge within the industry. To this end, we decided to build and test an analytical model to measure consumers' preferences for alternative geographical designations for FRG wines; furthermore, we decided to explore whether additional attributes, such as the presence of the organic certification or the inclusion of sustainability claims, might alter consumers' preferences for FRG wines. To this end, a conjoint analysis (CA) was performed to evaluate consumers' reactions to four potential strategies, namely: (I) new names without certification; (II) extended use of the original *Vitis vinifera* variety names without certification; (III) new names and ad-hoc PDOs; and (IV) extended use of the original *Vitis vinifera* variety names and existing PDOs. The following section will detail the methodology used in our study; the results are presented and discussed in Section 3; finally, concluding remarks and implications are discussed in Section 4.

## 2. Materials and Methods

Conjoint analysis is a multivariate technique widely used to study how consumers evaluate the relative importance of different product attributes. In CA, consumers' decision-making process is analyzed in the context of realistic simulations of purchase choices, as participants are asked to express their preferences for product alternatives, each characterized by different attribute levels [32–36]. In our study, CA was used to evaluate consumers' potential reactions to different origin designation strategies for FRG wines, in other words, their inclusion in existing PDOs or the creation of new ones. Additionally, association of FRG wines with the organic certification and with a sustainability claim were considered, in order to verify whether these could influence consumers' responsiveness to FRG wines. CA allows to estimate, for each respondent, the contribution of each level (partial utility) in determining the overall preference (total utility) for the presented alternative products. Table 1 lists the variables used to describe potential alternative strategies that could be used to commercialize FRG wines. Given the exploratory intent of this study, hypothetical and extreme, though realistic, situations were considered as well.

**Table 1.** Variables selected in the experimental design.

Wine Attributes	Levels
Wine name	Sauvignon; Soreli; Sauvignon Rytos
Designation of origin	DOC; None
Organic certification	Organic wine; None
Pesticide claim	We cut pesticide use by 80%; None
Price (EUR/0.75 l bottle)	3.00; 6.00; 9.00

The three alternative names recall three white-grape variety names. Sauvignon is the original *Vitis vinifera* vine name; Sauvignon Rytos (Sauvignon Blanc × Bianca) is an FRG variety whose name recall the original *Vitis vinifera* variety; Soreli (Friulano × Kozma 20-3), meaning “sun” in Friulan language, is an invented FRG name with no connection with

the original *Vitis vinifera* variety it originates from, and potentially unknown to consumers. The three names were associated with all the hypothetical wines included in the survey form. In order to build more realistic computer simulations, FRG names were only used for FRG wines, while the *Vitis vinifera* name was used both for conventional and FRG wines.

With respect to the designation of origin, the two alternatives were the presence or absence of the Denominazione di Origine Controllata (DOC), the Italian quality designation equivalent to the European PDO. In the case of experimental DOC alternatives, no geographical specification was included in order to reduce respondents' emotional bias. Furthermore, the proposed alternatives could include (or lack) the EU organic wine certification.

Additional information on the wines could include the catchword "We cut pesticide use by 80%". The use of the term "pesticide" simulates sustainability communication strategies based on consumers' emotionality [15,37].

Finally, three different price levels (EUR 3.00, EUR 6.00, EUR 9.00) per 0.75-L bottle were considered. These price levels cover the basic and commercial premium wines, which represent almost 80% of the wines sold in large retail chains in the study area and in Italy in general [38]. On the one hand, the proposed price brackets are coherent with the sample's spending power; on the other hand, this allows to differentiate between participants who use price as a quality clue and those who interpret it as a direct function of production cost.

After identifying the variables, the Conjoint algorithm from IBM SPSS Statistics 20 was used to build an experimental orthogonal design for preference detection through CA [15,39]. The same software was also used to estimate participants' individual preference functions and preference probabilities in market simulations. The orthogonal design included 16 unique experimental profiles and two additional control profiles. Individual preference functions considered linear relationships for the price variable, while all other variables were treated as categorical. The use of orthogonal design to produce alternatives based on level combinations allows to estimate principal effects as well as partial preferences for attribute levels that are independent from the other attributes in the experimental design, but not independent from other factors. Such factors can be grouped into five main categories: (I) market type and purchase situation; (II) product attributes that influence consumers' choice but are not used to describe the test products; (III) consumers' internal stimuli, such as socio-demographic characteristics, personal beliefs, attitude, emotional state; (IV) external and contextual stimuli controlled by the researcher, such as the survey participation method; and (V) uncontrollable external stimuli, related, for example, to the environment in which the test takes place [32,40,41].

Respondents were presented printed handouts for preference detections which described the 18 alternatives of the orthogonal design. A sample card is reproduced in Table 2. The preference expression task was introduced by the following description: "Viticulture is one of the most impactful agricultural activities. Even though vineyards occupy only 3.3% of the total European agricultural area, the sector consumes 65% of pesticides. Some researchers have implemented a vine genetic improvement program and selected some disease-resistant hybrid grape varieties. The project may promote the adoption of new vines and the reduction up to 80% of pesticide use in vineyards".

**Table 2.** Preference collection form.

Code	Bottle Description	Preference
368	Soreli; 3.00€	
514	Soreli; DOC; 3.00€	
601	Soreli; We cut pesticide use by 80%; 3.00€	
630	Sauvignon; We cut pesticide use by 80%; 3.00€	
903	Soreli; Organic; We cut pesticide use by 80%; 3.00€	

308	Sauvignon Rytos; DOC; Organic; 3.00€
145	Sauvignon; DOC; We cut pesticide use by 80%; 3.00€
595	Soreli; DOC; 9.00€
619	Soreli; Organic; We cut pesticide use by 80%; 6.00€
555	Sauvignon; DOC; Organic; 9.00€
468	Sauvignon Rytos; We cut pesticide use by 80%; 9.00€
930	Soreli; DOC; Organic; We cut pesticide use by 80%; 6.00€
504	Sauvignon Rytos; 3.00€
216	Sauvignon; Organic; 9.00€
875	Sauvignon Rytos; DOC; We cut pesticide use by 80%; 6.00€
749	Soreli; 6.00€
164	Sauvignon Rytos; Organic; 3.00€
708	Soreli; DOC; Organic; We cut pesticide use by 80%; 3.00€

Imagine being at the supermarket to buy white wine. Compare the following products and grade your preference for each one on a scale from 1 (minimum preference) to 100 (maximum preference).

Respondents were then asked to simulate being at a supermarket to purchase white wine, then rank the alternative products presented on a scale from 1 (minimum preference) to 100 (maximum preference). As the preference collection form suggests, it should be acknowledged that: (1) respondents did not have access to the whole set of information usually considered when choosing wine; (2) two variables (pesticide use information and organic certification) out of five were directly related to product sustainability; (3) all participants were exposed to the term “pesticide” and the associated emotional charge; (4) information on FRG wines was incomplete; hence, participants could only hypothesize that wines described by the pesticide reduction information actually were FRG wines; (5) geographical indication and certification regulation was considered identical for conventional and FRG wines, and FRG wines could indifferently carry the original *Vitis vinifera* names or new names; and (6) exactly half (9 out of 18) of the alternatives included the pesticide-reduction information. Rather than a model of an existing market, the choice set reproduces a hypothetical market in which half of the wines, both organic and conventional, are produced with 80% less pesticides and consumers are informed of this possibility; in other words, 50% of the products included in our simulation can reduce pesticide use with the same intensity as existing FRGs.

As summarized in Table 3, five market simulations were performed, one for each denomination strategy and possibility considered. The first four simulations compared four *Vitis vinifera* and two FRG wines each, while simulation S5 included 8 FRG wines. In each simulation, wines were characterized by unique combinations of name, presence or absence of the designation of origin (DOC), and price level. Only FRG wines could bear the catchword “We cut pesticide use by 80%”. S1 considers two Soreli FRG wines; hence, these names have no connection with the original *Vitis vinifera* and no designation of origin protects them. In S2, FRG wines can be named after the original *Vitis vinifera* variety: we considered two differently priced FRG Sauvignon wines. FRG wines in S3 were two Soreli DOC (new name and associated PDO). S4 represents the situation in which existing *Vitis vinifera* names and PDOs can be extended to FRG wines; therefore, two differently priced Sauvignon FRG DOC were considered. Finally, in order to compare simultaneously all the alternative strategies, S5 only included the 8 FRG wines from simulations 1 to 4. A Logit model was used to estimate individual preference probabilities for each simulation, and respective means were compared using IBM SPSS *t*-test tables ( $p < 0.05$ ).

**Table 3.** FRG wine designation and certification strategies and simulation plan.

Strategy	Description	Simulation
New name	New name, no PDO specification	S1
Vinifera name	Original Vitis vinifera name, no PDO specification	S2
New PDO terroir	New name, new PDO	S3
Vinifera PDO terroir	Original Vitis vinifera name, existing PDO	S4
Direct comparison	Direct comparison among the four strategies	S5

Respondents were selected among students present at study halls in a few Italian universities. The final non-probabilistic convenience sample (Table 4) included 301 participants, mostly male (56.5%) and aged 19–26 years old. More than 80% of participants declared buying and consuming wine at least occasionally. As the survey sample not representative of any clear population, the generalization of the results to any population beyond the study participants may be limited.

**Table 4.** Sample characteristics (n = 301, %).

Variable	Categories	Value
Gender	Male	56.5
	Female	43.5
	Total	100.0
Family income (EUR/month)	<1000	4.0
	1000–2000	28.2
	2001–3000	52.5
	3001–4000	5.6
	4001–5000	6.0
	>5000	3.7
	Total	100.0

### 3. Results

#### 3.1. Participants' Preference System

Table 5 provides an overview of the average respondent's preference system. According to the results, participants consider the wine name as the primary attribute (27.9% relative importance) when choosing wine. The relative importance of other attributes ranges from 15.9% (price) to 19.7% (pesticide-reduction catchphrase). Sauvignon Rytos, that is, the FRG wine whose name recalls the original Vitis vinifera variety, was the name that enjoyed the highest partial preference (2.1); conversely, the FRG wine carrying a brand-new name, Soreli, was the least appreciated. The presence of the designation of origin, organic certification and pesticide-reduction information granted higher average partial preferences than their absence. Average partial preferences for the two price levels were both positive, with the EUR 9.00 price bracket being the favorite one: this suggests that most respondents (56.4%) interpreted price as a proxy for quality. Correlation coefficients between expressed and estimated preference support the use of the model for market simulations.

**Table 5.** Relative importance of wine attributes in product preference and partial preference for the attribute levels (n = 301).

Wine Attributes	Relative Importance		Levels	Partial Preference	s.e.
	%	s.e.			
Wine name	27.9	0.9	Soreli	-1.8	0.4
			Sauvignon Rytos	2.1	0.5
			Sauvignon	-0.3	0.5
Designation of origin	17.7	0.7	DOC	4.1	0.3
			None	-4.1	0.3
Organic certification	18.7	0.7	Organic wine	4.2	0.3
			None	-4.2	0.3
Pesticide information	19.7	0.7	We cut pesticide use by 80%;	5.3	0.4
			None	-5.3	0.4
Price (EUR/0.75 l bottle)	15.9	1.1	3	1.9	0.5
			9	5.8	1.5
Total	100.0		Constant	53.8	1.1

Pearson's R = 0.915 (0.000); Kendall's Tau = 0.856 (0.000); Kendall's Tau (control) = 0.98 (0.000).

Further considerations of participants' preference system emerge from the analysis of information reported in Table 6. The average difference between maximum and minimum partial preference for wine names included in the test was equal to 17.5/100: in other words, if compared to the least favorite name, the use of the most favorite wine name granted, on average, a 17.5% increase in preference for that bottle. Additional product information (namely, designation of origin, organic certification, and reduced use of pesticides) resulted in increased preference by, respectively, 11.1, 12.0, and 13.2 points, even though differences between them are not statistically significant ( $p < 0.05$ ). This implies that the overall effect of information on sustainability, that is, organic certification and reduced pesticide use, was equal to the terroir recognition value.

**Table 6.** Contribution of the variables to preference formation for a wine bottle (average difference between maximum and minimum partial preference for the two levels, n = 301).

Attribute	Levels	Difference between Partial Preferences
Wine name	Sauvignon–Soreli	10.8 <sub>a</sub>
	Sauvignon Rytos–Soreli	11.2 <sub>a</sub>
	Sauvignon Rytos–Sauvignon	13.1 <sub>a</sub>
Designation of origin	Present–absent	11.1 <sub>a</sub>
Organic certification	Present–absent	12.0 <sub>a</sub>
Pesticide information	Present–absent	13.2 <sub>a</sub>
Price	9.00 EUR/bottle–3.00 EUR/bottle	12.5 <sub>a</sub>

Means that share the same letter in the subscript (a) are not statistically different according to the t-test ( $p \leq 0.05$ ).

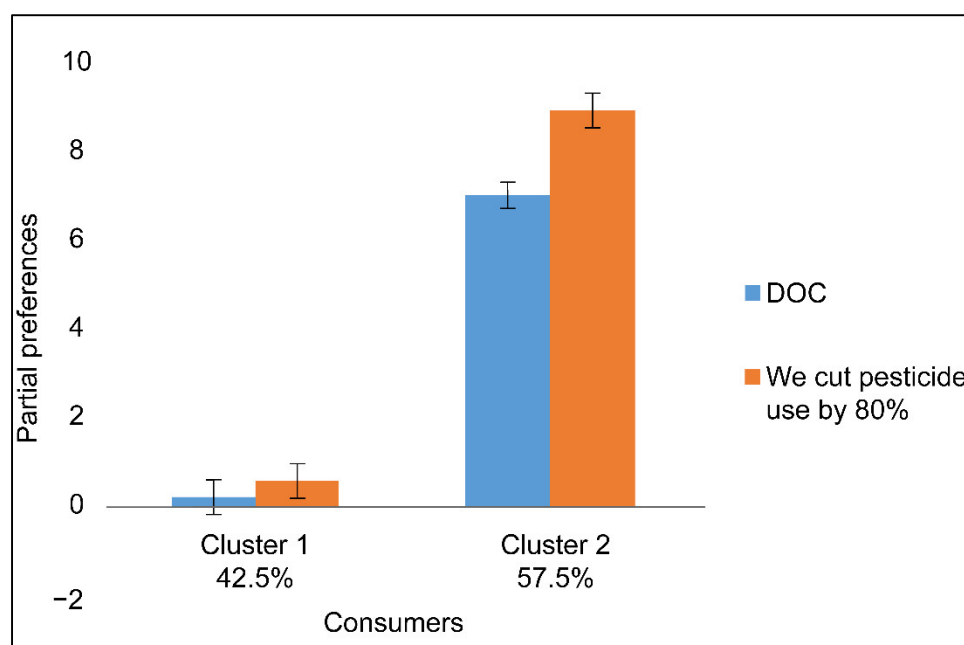
Furthermore, Table 7 reports correlations between PDO, organic certification and pesticide-reduction information. Preference for organic certification did not show statistically significant correlation with neither the designation of origin nor the declaration on pesticides. On the contrary, correlation between preference for DOC wine and preference for reduced pesticide use is positive and significant ( $p < 0.01$ ), even though relatively small. To rephrase this, while appreciations for DOC and organic wines are independent, positive valuing of the designation of origin increases with preference for information on reduced pesticide use.

**Table 7.** Pearson’s correlation between partial preferences for certifications and information (n = 301).

	DOC	We Cut Pesticide Use by 80%
Organic wine	−0.002	0.023
We cut pesticide use by 80%	0.215 **	

\*\* Correlation is significant at the 0.01 level (2-code).

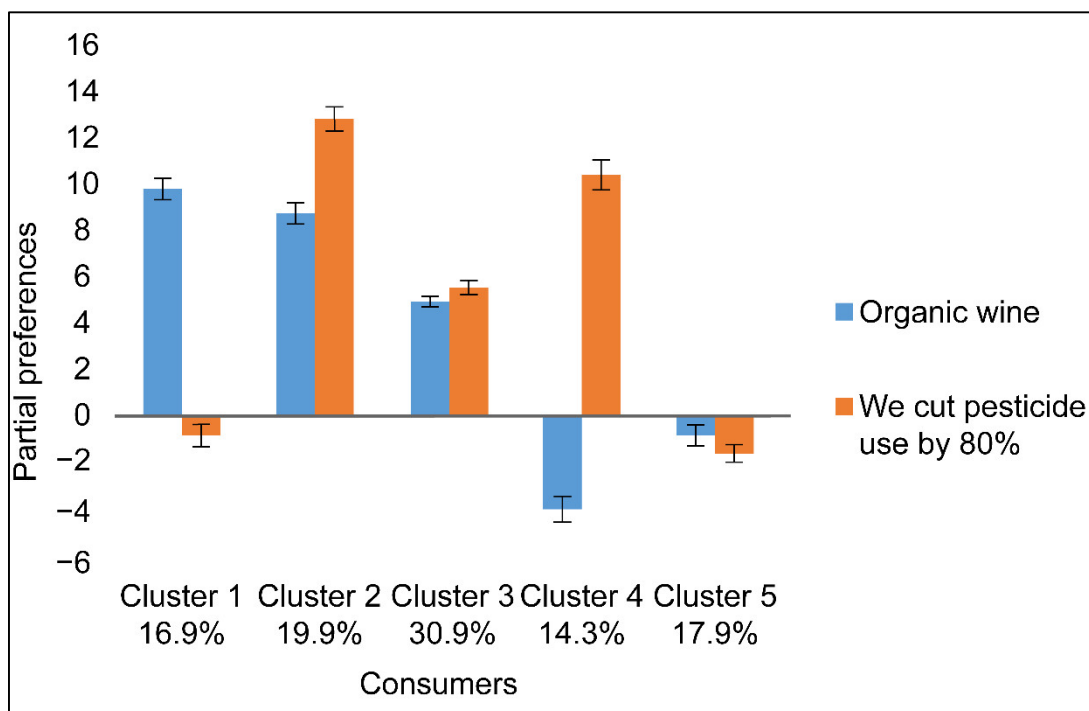
Using the IBM SPSS TwoStep clustering algorithm, cluster analysis was then performed to group participants according to their characteristics and preference structure. The first iteration focused on partial preferences for the designation of origin and information on reduced pesticide use. As graphically represented in Figure 1, two groups were identified: the first one, counting 42.5% participants, was substantially indifferent to both attributes; the second group (57.5% of the sample) showed instead appreciation for the two. We can assume that consumers who positively value the DOC are also particularly responsive to FRG communication strategies based on environmental sustainability.

**Figure 1.** Sample clustering according to partial preferences for DOC attribute and reduced pesticide use information (average partial preferences, n = 301).

The relationship between organic certification and information on pesticide reduction is less straightforward (Figure 2). According to the TwoStep analysis, five clusters can be identified. Overall, 67.7% of participants appreciated the organic certification (clusters 1, 2 and 3), while 65.1% showed appreciation for the pesticide-reduction attribute (clusters 2, 3 and 4). Cluster 1, which groups 16.9% of the respondents, supported the organic certification while slightly disliking the pesticide catchphrase. Respondents who fell in clusters 2 and 3 (50.8% of respondents overall) appreciated both attributes, although to a different extent. Cluster 4 (14.3%) was averse to the organic certification, but positively perceived the pesticide-reduction declaration. Finally, respondents grouped in cluster 5 (17.9%) are indifferent or mildly averse to both attributes. With respect to organic certification, these results suggest that: (1) some consumers value organic products but do not trust unconfirmed or uncertified information on reduced pesticide use; (2) some consumers appreciate both organic certification and uncertified information on reduced pesticide use; and (3) the presence of the uncertified information on reduced pesticide use could attract organic certification-averse consumers. Nevertheless, it should be noted that our

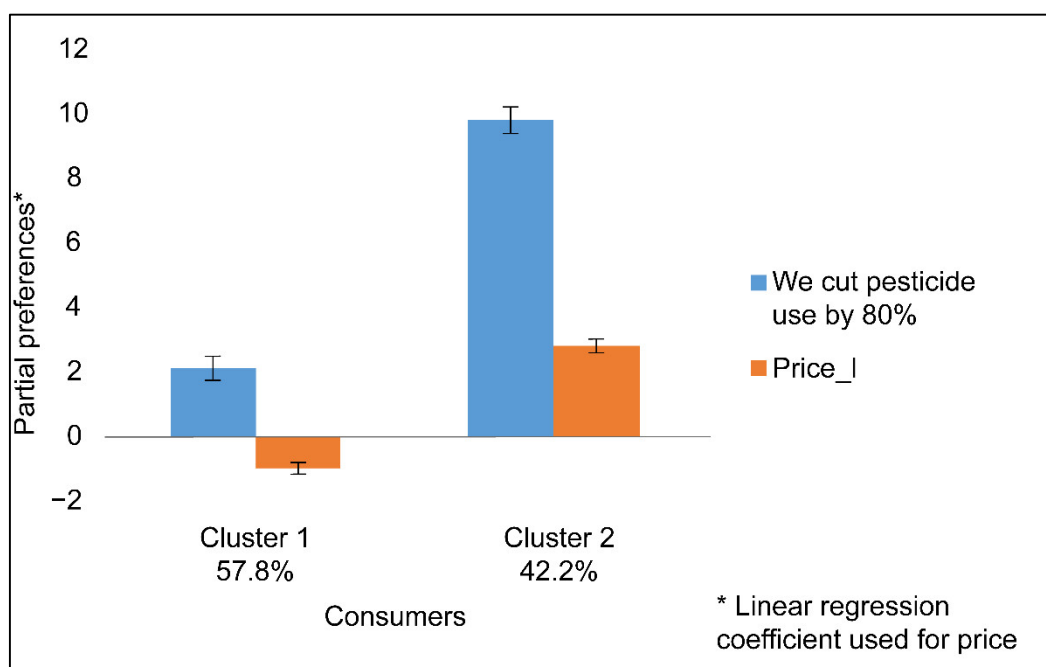


sample showed significantly higher appreciation for organic wines than previously reported in the literature [42,43]; hence, our respondents' preference system strongly features sustainability and diverges from the average wine consumers'. It is not clear, however, whether this depends on specific sample characteristics or on the structure of the preference collection form, on which half of the presented wines declared reduction in pesticide use. Should the second be true, it would imply that the diffusion of FRG wines may drive consumers' preference system towards sustainability. Further studies should investigate this possibility, in the light of its relevance for the future of the wine industry and marketing.



**Figure 2.** Sample clustering according to partial preferences for organic certification and reduced pesticide use information (average partial preferences,  $n = 301$ ).

Finally, the third cluster analysis (Figure 3) considered partial preferences for the pesticide-reduction declaration and the linear regression coefficient between price and total preference, as estimated with CA. Respondents in cluster 1 prefer low-priced wines; hence, the price coefficient is negative, while the opposite is valid for cluster 2. Both clusters present average partial preferences for the pesticide catchword, even though these were slightly higher in the case of cluster 2. We can, therefore, assume that pesticide information would successfully support both market penetration strategies (lower price) and market skimming strategies (higher price). Furthermore, such information, even if not certified, may be particularly valuable to consumers who interpret price as a quality clue.



**Figure 3.** Sample clustering according to partial preferences for reduced pesticide use information and price coefficient (average partial preferences,  $n = 301$ ).

### 3.2. Designation of Origin and Naming Strategies in Market Simulations

Table 8 summarizes the results of market simulations for the different naming and designation of origin strategies. All the simulations included both low- and high-priced versions of all the wines, in order to verify whether consumers who read price as a quality proxy or as a cost indicator behave differently.

**Table 8.** Preference probabilities for different FRG naming and designation-of-origin strategies (%).

Grape Variety	Strategy	Wine <sup>1</sup>	Price	S1	S2	S3	S4	S5
Vitis vinifera		Sauvignon	Low	2.2 <sub>a</sub>	3.2 <sub>a</sub>	3.3 <sub>a</sub>	4.6 <sub>a</sub>	
			High	4.6 <sub>a</sub>	4.6 <sub>a</sub>	6.1 <sub>a,b</sub>	6.4 <sub>a</sub>	
		DOC	Low	18.3 <sub>b</sub>	16.7 <sub>b</sub>	9.6 <sub>a,b</sub>	7.3 <sub>a</sub>	
			High	26.5 <sub>c</sub>	22.7 <sub>b,c</sub>	12.0 <sub>b</sub>	7.3 <sub>a</sub>	
FRG hybrid	New name	Soreli	Low	21.6 <sub>b,c</sub>				6.5 <sub>a</sub>
			High	26.8 <sub>c</sub>				6.7 <sub>a</sub>
	Vitis vinifera name	Sauvignon	Low		22.2 <sub>b</sub>			3.4 <sub>a</sub>
			High		30.6 <sub>c</sub>			5.3 <sub>a</sub>
	New PDO	Soreli DOC	Low			29.1 <sub>c</sub>		13.7 <sub>a,b</sub>
			High			39.9 <sub>d</sub>		19.1 <sub>b</sub>
Existing PDO	DOC	Sauvignon	Low				30.1 <sub>b</sub>	18.5 <sub>b,c</sub>
		DOC	High				44.3 <sub>c</sub>	26.8 <sub>c</sub>
Total				100.0	100.0	100.0	100.0	100.0

In each column, means that share the same letter in the subscript (a, b, c, d) are not statistically different according to the t-test ( $p \leq 0.05$ ). <sup>1</sup> FRG wines include the claim “We reduced pesticide use by 80%”.

Simulation S1 aimed to evaluate whether an FRG wine without PDO (Soreli) could be preferred over well-known varietal wines, either protected or not by a PDO (Sauvignon DOC and Sauvignon). According to the results, the association of the name Soreli with the pesticide-reduction information determines higher preference probability than standard Sauvignon, and no difference in probability than Sauvignon DOC ( $p < 0.05$ ). With respect

to pricing strategies, the highest selection probabilities are associated to Sauvignon DOC ( $p < 0.05$ ), while no statistically significant difference exists between Soreli and standard Sauvignon.

In S2, the FRG wine is named as the original *Vitis vinifera* wine, and its preference probability is compared to *Vitis vinifera* Sauvignon and Sauvignon DOC. The FRG Sauvignon characterized by the pesticide-reduction information has higher probability to be chosen than the standard *Vitis vinifera* Sauvignon, and no difference in probability to Sauvignon DOC ( $p < 0.05$ ). Higher priced FRG Sauvignon is more likely to be chosen.

S3 considers the possibility of protecting the FRG wine under a new PDO (Soreli DOC). Sorely DOC with reduced pesticide use is more likely to be chosen than both Sauvignon and Sauvignon DOC ( $p < 0.05$ ). Again, the higher priced FRG wine is more likely to be chosen.

The situation in which FRG wines can be named after original *Vitis vinifera* variety names and enjoy the same protection (FRG Sauvignon DOC) is reproduced in S4. In this case, preference probability for the FRG wine is higher than both *Vitis vinifera* standard Sauvignon and Sauvignon DOC ( $p < 0.05$ ). In addition to this, preference probability for the *Vitis vinifera* Sauvignon DOC is not different than standard *Vitis vinifera* Sauvignon, if the pesticide use reduction catchphrase is used on the market. Once again, higher pricing strategies result in higher selection probability for the FRG wine.

The last simulation (S5) provides direct comparison among the four FRG naming and designation strategies. DOC FRG wines are more likely to be preferred over standard FRG wines ( $p < 0.05$ ), while comparison with identically protected FRG and *Vitis vinifera* wines (both either standard or DOC wines) determines no statistically significant difference in preference probability. Higher priced *Vitis vinifera* PDOs show higher preference probability than FRG wines with new names and new PDOs, regardless of their price level.

#### 4. Discussion and Conclusions

Emerging environmental challenges, together with increasingly demanding consumers, call for the adoption of sustainability strategies across all industries, and the wine industry is not exempt from such reflections. As FRGs gain popularity among wine producers, the introduction of EU Regulation 2021/2117 enables the inclusion of these hybrid varieties in existing PGIs and PDOs, as well as the possibility of specifying in their production regulations the environmental benefits of FRG use. This decision is expected to radically modify European viticulture, its competitive scenario and the wine market. Based on these premises, our study applied CA to explore how consumers may potentially react to alternative hypothetical strategies for the certification and geographic designation of future wines. According to the results, communication on positive environmental externalities of FRGs is appreciated by our respondents, who, additionally, showed no prejudice to the inclusion of FRG wines in existing PDOs, currently reserved for *Vitis vinifera* products. These considerations echo other studies that highlight the importance of intrinsic quality attributes on consumers' appreciation of PDO wines [44,45]: as long as FRG wines respect the quality and sensory profiles of original *Vitis vinifera* products, their adoption in existing PDOs would likely not hamper consumers' trust in geographical indications.

Some additional considerations are necessary to fully read and understand our results: (1) at present, very few FRG wines can be named after their original *Vitis vinifera* varieties and protected under identical existing PDOs; (2) vineyard replacement will take place gradually, and winemakers will likely manage at once both *Vitis vinifera* and FRG varieties for an extended period of time; consequently, market penetration strategies should take into account both competition and cannibalization risks; (3) this study is based on the PIWI International FRG promotion perspective; hence, only 100% FRG wines and no blends were hypothesized; and (4) given the exploratory nature of our study, as well as the non-representativeness of the sample, the results only provide an overview of potential issues and obstacles that might emerge in the near future.

Carefully designed communication strategies may support the competitiveness of non-PDO protected FRG wines. On the contrary, the extension of existing PDOs to include FRG wines could likely exacerbate the conflict between the conventional terroir-based quality paradigm and the sustainability-based one, which Regulation 2021/2117 is expected to solve and overcome.

The introduction of new FRG-specific PDOs seems to be the most effective strategy to recompose the two conflicting quality paradigms, and provides interesting opportunities for both novel and more sustainable products; furthermore, as it could rely on existing FRGs, its adoption could require a relatively short timeframe. However, the extension of this strategy should be weighed against the leadership of *Vitis vinifera* products in the varietal wine market. If, on the one hand, this approach would likely make the adoption of FRGs more attractive, it could make sense from the environmental sustainability perspective; on the other hand, producers who have invested in *Vitis vinifera* varietal wines would hardly replace their vines in the short run, in particular if linked to prestigious appellations.

The third possibility considered in our simulations is the extension of existing PDOs to allow the inclusion of FRG wines. If compared to the adoption of FRG-specific PDOs, this strategy performed similarly in the case of lower priced bottles, and outperformed if applied to more costly items. In any case, such an approach may bring together the quality paradigm duality, even though intensified competition with identically named *Vitis vinifera* wines could increase the risk of product cannibalization. Intra-winery cannibalization could be limited by drifting away from the PIWI International promotional approach. For instance, a winery which produces Lison Classico DOCG with 30% FRG may promote the product claiming a 24% ( $0.30 \times 0.80$ ) reduced use of pesticides. However, in order to be effective, similar strategies require: (1) the existence of a third-party certification body to verify claims; (2) precise knowledge of consumers' responsiveness to different degrees of pesticide reduction in viticulture; and (3) a shared and recognized EU-wide certification system to guarantee consumers and limit confusion. Furthermore, advances in FRG hybridization and selection are mandatory, as no FRG alternatives are available for most European vines and wines yet: consequently, the large-scale adoption of similar strategies will likely demand major investments and an adequate timeframe, with the risk, in the medium run, of conflicting interests between early adopters of FRGs and their competitors [46], with the latter potentially interested in slowing the adoption of existing FRGs while waiting for newer varieties.

While our study raises issues and perspectives with which the wine industry, facing environmental sustainability issues and increasingly demanding consumers, will have to deal in the upcoming future, a number of limitations must be acknowledged. The sample used in our research suffers from limited geographical and sociodemographic representativeness, which limits the generalization of the results to the general population. Furthermore, our simulation only considered a generic wine-purchase occasion in a specific venue (i.e., the supermarket): clearly, these two factors heavily influence consumers' choice as well as expectations, and even if wine sales in large retail chains are becoming more and more important [36]; alternative venues and different consumption occasions may shift consumers towards different products. Additionally, our experimental design only included attributes and levels with which respondents would have likely been familiar; the inclusion of additional and potentially less known attributes, such as the PIWI branding, would have excessively increased respondents' task complexity: the decision to limit to 18 choice profiles was a necessary compromise between information and quality of the response. Fourth, our design was based on hypothetical producers' marketing strategies, which also include extreme possibilities (namely, the introduction of new designations for FRG wines, and the extension of the use of the original *Vitis vinifera* names): albeit realistic, their adoption might be less likely than softer approaches.

In spite of its limitations, the issues emerging from the analysis shift the discussion on FRGs from the technological side to more practical perspectives on consumers'

acceptance of these novel grapes and wines, and FRG conversion-related entrepreneurial and sectoral risks. Replication of the study with a representative sample of consumers is desirable in order to obtain reliable and generalizable results which could support the adoption of optimal production, protection and marketing strategies for FRG wines. Additionally, the influence of different purchase and consumption situations and motives should be assessed, together with relative context-dependent perception of FRG wines. Furthermore, future studies should look into consumers' acceptance of the inclusion of FRG wines in existing, valuable, well-reputed and appreciated traditional PDOs. The new possibilities introduced with Regulation 2021/2117 will likely require additional ruling and certification systems [47] to regulate criteria to allow *Vitis vinifera* substitution with FRG hybrids, guarantee fair competition during the transition phase and ensure consumer protection. Finally, while the focus of our study was on consumers' preference for alternative designation and certification strategies for currently hypothetical wine products, future research on FRG wines should consider how the sensory experience of actual products will influence perception [48] and actual purchase behavior.

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