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Exploring market potential and consumer preferences for fungus-resistant grape varieties: A discrete choice analysis in Germany

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Keywords: Pilzwiderstandsfähig Innovation Organic Sustainability Clogit	While fungus-resistant grape varieties (FRGVs) offer comprehensive sustainable benefits, their slow adoption and consumer preferences warrant investigation. Therefore, a discrete choice model for key parameters influencing consumer perceptions, including product attributes, pricing, grape variety preferences, labelling and information dissemination, was constructed based on a representative sample of 1276 wine consumers in Germany. The data were analysed using a conditional logit utility model to gain insights into the preferences and willingness to pay (WTP) of each product attribute. Due to the low level of awareness of these grape varieties, the sample was divided into two groups: a control group and an experimental group, which was conditioned prior to the study to investigate the market potential of FRGVs. The results show that the conditioned group exhibited a stronger inclination towards FRGVs, indicating an increased awareness of environmentally friendly practices. Price sensitivity was influenced by conditioning, with consumers being more sensitive to higher prices after being informed. The study highlights the importance of informed consumer education in promoting environmentally

sustainable products like wine from FRGVs.

1. Introduction

The production of wine grapes necessitates the extensive use of pesticides, particularly fungicides, to ensure a viable crop (Golge and Kabak, 2018). However, this excessive application of fungicides within the wine industry raises concerns regarding environmental sustainability and public perception of plant protection (European Commission, 2020).

In response to these concerns, the concept of fungus-resistant grape varieties (FRGVs) has emerged as a promising solution in viticulture (Bavaresco, 2019; Borrello et al., 2021). These newly developed grape varieties require fewer fungicides, making production processes more cost- and time-efficient while addressing environmental concerns (Fuller et al., 2014). Additionally, FRGVs have the potential to attract consumers seeking eco-friendly alternatives (Pekkanen et al., 2018).

However, despite their potential benefits, FRGVs face challenges in gaining market acceptance. The wine industry has expressed scepticism, fearing that consumers may be hesitant to try wines made from these new grape varieties (Kiefer and Szolnoki, 2024a). To address this concern, researchers have highlighted the importance of educating consumers about the environmental benefits associated with FRGVs

(Pedneault and Provost, 2016). However, Nesselhauf et al. (2020) noticed a lack of research regarding the diffusion of FRGVs and consumer preferences. Therefore, it is crucial to examine the importance of purchase criteria linked to FRGVs and assess consumers' willingness to pay (WTP) for them to gain valuable insights for the wine industry.

The objective of this study is to promote the market penetration of FRGVs by examining the relevant product attributes and consumer willingness to pay. The study addresses a significant research gap by analysing consumer preferences for specific wine bottle attributes derived from FRGVs. The findings are of both theoretical and practical significance for the wine industry, offering recommendations to enhance the acceptance and dissemination of FRGVs, thereby supporting sustainable wine production.

2. Conceptual background

FRGVs are created by crossbreeding European vitis vinifera with resistant American or Asian varieties possessing natural resistance to fungal diseases (Eibach and Töpfer, 2003). These hybrid varieties combine the desirable wine quality of European vitis vinifera with disease resistance, offering benefits like a reduced need for fungicide use,

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time and cost savings, lower carbon emissions and positive environmental effects (Pedneault and Provost, 2016). However, the adoption of FRGVs remains limited, and their international market presence is relatively low (Becker and Toldam-Andersen, 2015; Central Bureau for Statistics, 2023a; Stefanini et al., 2019). Borrello et al. (2021) attribute this to regulatory obstacles and the wine industry's reluctance to innovate. According to Doye et al. (2005), Fechter et al. (2018), Pomarici and Vecchio (2019) and Sloan et al. (2010), insufficient consumer acceptance is the key factor that influences producers' willingness to cultivate these newly bred varieties, thereby affecting their market penetration (Kiefer and Szolnoki, 2024a).

As highlighted by Kiefer and Szolnoki (2023), Nesselhauf et al. (2020) and Vecchio et al. (2022), several product attributes significantly influence consumers' acceptance when purchasing wine from FRGVs. Accordingly, Fig. 1 presents a schematic framework that outlines these key aspects affecting consumer purchasing decisions related to FRGV. These factors include the awareness and acceptance of grape variety designations, the impact of specific labels and certifications, and the role of wine labelling information. This literature-based model is employed to analyse the interactions between these variables and to comprehend their influence on consumer behaviour. The hypotheses proposed are derived directly from this framework and aim to provide crucial insights for the marketing of FRGVs. The following section outlines the fundamental literature that constitutes the basis for this model.

When making purchasing decisions, the German wine market prioritises grape varieties (Ginon et al., 2014; Lockshin and Corsi, 2012; Sogari et al., 2016). The relative novelty and unfamiliarity of FRGV denominations to consumers present a sales and communication challenge (Kiefer and Szolnoki, 2024b). Effective marketing strategies and communication efforts are crucial to inform consumers about the existence, quality, advantages and characteristics of these grape varieties (Pedneault and Provost, 2016). Accordingly, it is necessary to understand which patterns in grape variety denominations are beneficial to gain a deeper understanding of the attractiveness of current grapes and the adaption of newly bred grapes. A recent study by Sillani et al. (2022) investigated consumer perceptions, including their acceptance of varietal names for resistant grapevine varieties compared with traditional varieties. The results showed significant potential for extending the names of new varieties, such as Cabernet Blanc or Souvignier Gris, offering a crucial competitive edge compared to traditional grapevine varieties. Consequently, the following hypotheses were proposed:

H1. The use of familiar grape variety names for newly developed grape varieties significantly influences customers' purchase decision compared to

grape varieties that are completely unfamiliar to customers.

H2. Conventional grape varieties are purchased significantly more frequently compared to resistant grape varieties by uninformed consumers.

Special labels and certifications play a vital role in consumer trust and acceptance of sustainable and environmentally friendly products, including wines. Constitutional or state-issued seals tend to elicit higher consumer trust (Thøgersen, 2010). However, the presence of multiple seals with varying standards can lead to confusion among consumers (Sogari et al., 2016). The willingness to pay for sustainable wine is influenced by the quality rating and type of labelling, with higher-quality wines showing reduced positive effects from an organic label (Abraben et al., 2017). To understand the influence of such a specific label on the preference for wine from resistant grapes, the following hypotheses was proposed:

H3. Introducing a specific labelling seal for wine made from resistant grape varieties on the bottle significantly increases the likelihood of customers purchasing wide made from resistant grape varieties.

Information on wine bottles significantly influences consumers' purchase behaviour (Szolnoki et al., 2010). Consumers rely on label information to make informed choices and express preferences for specific attributes or qualities of wine (Jarvis et al., 2010; Mueller et al., 2010). Information such as grape variety, region of origin, vintage, oenological methods, organic or sustainable certifications, health claims and nutritional content impact consumers' preferences and willingness to pay (Costanigro et al., 2014; Di Vita et al., 2019; Everett et al., 2018; Tait et al., 2019). Additional label information, including tasting notes and awards, significantly influences consumers' preferences, allowing them to assess the quality and taste characteristics of wine (Ghvanidze et al., 2017; Mazzocchi et al., 2019).

The availability of information regarding FRGVs and their benefits is crucial in shaping consumer perceptions and purchase behaviour (Kiefer and Szolnoki, 2023). Studies have shown that consumers' willingness to pay increases when provided with information about the advantages of resistant grape varieties (Fuentes Espinoza et al., 2018). Similarly, knowledge of sustainable production techniques is positively correlated with the likelihood of purchasing wines (Mann et al., 2012). Indeed, the positive impact of information on purchasing behaviour, particularly related to environmentally friendly production methods, has been validated in several studies (Borrello et al., 2021; Di Vita et al., 2024; Nesselhauf et al., 2020; Vecchio et al., 2022). From this, it can be concluded that information has a significant influence on purchasing



Fig. 1. Schematic framework of the theoretical model.

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habits. Consequently, the following hypotheses were formulated:

H4. Including information about FRGVs on the back label significantly improves the consumer purchase likelihood compared to a back label without such information.

H5. Providing information on the unique attributes that characterise resistant grape varieties significantly enhances the consumer purchase likelihood.

Studies have demonstrated that the design and aesthetics of wine labels play an important role in appealing to consumers and evoking certain associations (Barrena et al., 2021a; Monteiro et al., 2019; Mueller and Szolnoki, 2010). Classic and elegant designs are often associated with prestige wines (Celhay, 2022; Öztürk and Ertamay 2019), while colourful, more innovative and modern label compositions can appeal to younger consumers or occasional purchases (Firsova and Xi, 2022). Conversely, humorous labels are more likely to be rejected (Lunardo and Rickard, 2019). Therefore, the following hypotheses was formulated:

H6. The use of a natural style label has a significant positive effect on the likelihood of purchasing wines made from resistant grape varieties.

Price is a significant factor influencing consumer decision-making in the wine industry (Bruwer et al., 2017; Szolnoki et al., 2010). Consumers consider price in relation to perceived quality, value for money and their own budget constraints (Bruwer et al., 2017). Studies have demonstrated that low-involved consumers are significantly influenced by price when evaluating and selecting wines (Lewis and Zalan, 2014; Wise Lozano and Arroyo, 2022).

However, consumers' willingness to pay the price can also be influenced by other factors, such as quality perception, organic or sustainability certifications and information on the label (Mueller et al., 2010). Interestingly, while price can act as a barrier to purchasing sustainable wine, it also serves as an indicator of quality, especially in the Prestige segment (Schäufele and Hamm, 2020). A study by Kiefer and Szolnoki (2023) found that the price sensitivity of wines produced from FRGVs decreased among certain target groups when they were informed about the advantages of resistant grape varieties for viticulture. Consequently, the following hypothesis was proposed:

H7. Providing information on the distinctive attributes of resistant grape varieties leads to a significant increase in willingness to pay.

H8. Consumers who are informed about the advantages of resistant grape varieties demonstrate significantly higher willingness to pay for wine made from such varieties compared to those who are not informed.

The existing literature highlights the importance of effective communication and marketing strategies to educate consumers about resistant grape varieties, their benefits and their role in sustainable and environmentally friendly wine production. Factors like price, label design, information content and familiarity with grape varieties significantly influence consumers' purchasing decisions. Therefore, it is crucial for wine producers and marketers to understand consumer preferences, perceptions and willingness to pay for organic, sustainable or environmentally friendly wines. Consequently, this study focuses on the main bottle components that influence the probability of consumers purchasing wine made from FRGVs. This will facilitate a more profound understanding of the characteristics that are most important to consumers, thereby enabling the formulation of practical implications.

3. Methodology

Discrete choice experiments (DCEs) have become a popular method for investigating consumers' preferences and estimating their WTP for specific attributes or qualities. In the context of wine consumer studies, DCEs have been widely utilised to explore preferences for sustainability certifications, packaging, label information and other characteristics (Costanigro et al., 2014; Di Vita et al., 2019; Everett et al., 2018; Ghvanidze et al., 2017; Jarvis et al., 2010; Mazzocchi et al., 2019; Mueller et al., 2010; Nesselhauf et al., 2020; Pabst et al., 2021; Tait et al., 2019).

The underlying principle of this methodology is that consumers reveal their preferences by choosing among different product combinations. By manipulating the choice conditions, valuable information can be inferred about consumers' preferences for specific attributes. Rooted in random utility theory and consistent with Lancaster's consumer theory, DCEs examine the trade-offs consumers make between relevant attributes of a product when making purchasing decisions (Lancaster, 1966; McFadden, 1973).

The individual's marginal utility is derived from DCEs by presenting respondents with several purchase scenarios, either hypothetical or real, in which they choose between alternative products described by different combinations of attribute levels (Lancaster, 1966). Consumers indicate their preferred alternative within each choice set, providing insights into attribute preferences and their relative importance. By asking participants to choose between product alternatives with varying attribute levels, DCEs indirectly capture preferences and enable the estimation of individual-level part-worth utilities.

3.1. Attributes and levels

A discrete choice model is based on a selection of attributes (e.g. price) corresponding to the topic, which are mapped vertically in different dimensions or levels (e.g. EUR3.99, EUR6.99, EUR9.99). The attributes used in this study were selected based on our previous qualitative study (Kiefer and Szolnoki, 2023), which investigated consumers' attitudes towards FRGVs. The relevance of the individual attributes was verified with the literature on price (Nesselhauf et al., 2020; Vecchio et al., 2023), grape variety (Sillani et al., 2022; Sloan et al., 2010; Sogari et al., 2016), seal (Sogari et al., 2016; Thøgersen, 2010), information (Fuentes Espinoza et al., 2018; Szolnoki et al., 2010) and label design (Barrena et al., 2021a; Monteiro et al., 2019; Mueller and Szolnoki, 2010) and assessed as reliable and comprehensive. This resulted in the following five attributes, which are relevant for the marketing success of resistant grape varieties (see Table 1).

The attributes are targeted at FRGV marketing tools and can thus provide valuable insights into participants' preferences regarding the purchase decision of wine made from FRGVs. The attributes and levels used in the selection experiment were specifically chosen or developed for this purpose.

The price range considered in the experiment (EUR3.99, EUR6.99 and EUR9.99) reflected the price range of wines available in German supermarkets and discounters, which account for a significant proportion of wine sales in Germany (German Wine Institute, 2023). For the attributes Label and Seal, designs developed especially for this study were used. The three labels differ in their appearance. The 'Natural' label is defined by a natural appearance using bees and floral patterns, whereas the 'Standard' and 'Prestige' labels have a more minimalist appeal. The 'Prestige' label is distinguished from the 'Standard' label by a conspicuous emblem and embossing. In a preliminary study involving 58 participants, various labels were assigned to the label segments. For the purposes of this study, the three most frequently selected labels per

Table 1

Illustration of the attributes and levels of the discrete choice experiment.

#	Attribute	Level
1	Price	EUR3.99, EUR6.99, EUR9.99
2	Grape	Cabernet Blanc, Bronner, Riesling, Chardonnay
3	Seal	Present, Absent
4	Information	Technical, Emotional, None
5	Label	Natural, Winery, Prestige

segment were chosen from among those assigned. The attribute 'Seal' was a binary variable that indicated its presence or absence. A seal was developed to indicate whether the wine was made from FRGVs. The labels are shown in Figs. 4 and 5 in the Appendix.

As already shown in Nesselhauf et al. (2020) and Kiefer and Szolnoki (2023), familiarity with a grape variety is an important factor that influences consumers' purchase decision. Since resistant grape varieties are unknown and new breeds will continue to remain unknown in the future as the grape variety pool increases, we take the approach of fundamentally investigating the designation in this study. Therefore, we go one step further and test different FRGV grape variety denominations, which differ fundamentally from each other. For this purpose, the grape varieties Cabernet Blanc, which is a hybrid form of Cabernet and Blanc, Bronner, a grape variety not associated with wine according to Kiefer and Szolnoki (2023), as well as their conventional counterparts Chardonnay and Riesling. By comparing these grape varieties, the aim is to test forms of appellation that could be a decisive factor in purchasing behaviour.

Finally, an attribute was added that refers to the conditioning on the bottle. For this purpose, information is presented in three different forms. The first level consists of an emotion-based text, the second level describes the benefits of FRGVs in a technical context and the third level presents no information. Thus, the value of information on the bottle can be measured in different forms (based on Ghvanidze et al., 2017; Pabst et al., 2021).

3.2. Choice task design and questionnaire procedure

We used a Bayesian approach in the experimental design, which assumes a prior distribution of likely parameter values and optimises the design over that distribution rather than assuming a single fixed antecedent for each attribute (Sándor and Wedel, 2001). The design of the experiment involved a three-step process, following Bazzani et al. (2017) and Scarpa et al. (2007). First, a d-optimal design was generated without any specification of prior information and was used for the pilot survey of 79 consumers. d-optimal designs are thought to optimise the precision of model parameter estimates by maximising the determinant of the information matrix (Montgomery, 2022). Data retrieved from this pilot survey were analysed using a conditional logit model, and the coefficient estimates and variances for the different attributes were used as Bayesian antecedents to inform the final design (Bliemer and Rose, 2010).

The choice experiment consisted of 18 individually composed choice sets for each participant. The choice sets were constructed with the idefix package within R (R Core Team, 2023; Traets et al., 2020). The participants were randomly divided into two groups, which were differentiated by prior conditioning. The conditioning was conducted via a newspaper article that outlined the characteristics and advantages of viticulture with resistant grapes (see Fig. 6 in the Appendix). This made it possible to investigate the effect of conditioning on the totality of attributes. Prior to the start of the conditioning process, a series of screening questions were posed to ascertain the gender, age and wine consumption habits of the participants. This was intended to facilitate the approximation of a representative sample of the study population. Participants were then requested to make the 18 choices between three alternatives, one of which was always the option not to buy either of the two products presented in the choice task, in order to estimate the marginal utility of the no-choice alternative (see Fig. 2). To avoid path dependency and a possible ordering effect, the order of the questions in each block was randomised for each participant. The first part of the questionnaire collected personal data with screening options while the choice sets were presented. In the third part, subjects were asked to describe their consumption habits related to wine products and their familiarity with the topics covered in the experiment.

In this study, the attributes used to build the products were presented and briefly explained to consumers before the choice experiment started. Each choice experiment was introduced with the following text to clarify the situation: 'Imagine you are standing in front of a wine shelf in the supermarket and want to buy a wine for a convivial evening with friends. There are now the following wines, all of which will suit your taste. Please choose the wine that appeals to you the most or if neither wine appeals to you, you can also choose the "None of them" option'. The 'No-buy' option was included to check if the decision was only made on the basis of the choice or if there was a real preference for the selected wine. The spontaneous purchase scenario was selected to simulate the typical experience of purchasing wine in a retail setting, which represents a significant proportion of wine purchases in Germany (Dressler, 2018). This choice of scenario ensured a highly relevant data structure.

3.3. Statistical analysis

The survey was designed as a dual-response choice experiment to elicit the preference for one of the options in the choice sets and include the none option in a second question. First, the multinomial logit model



Fig. 2. Procedure of the questionnaire.

was used to analyse the preferences for different product attributes. This model is based on the probability that a participant selects a particular option, depending on the product attributes present. The modelling was carried out using the R package 'nnet' (Venables and Ripley, 2002) utilising the following functional equation:

$$P(Y_i = j | X_i) = rac{e^{eta_j X_i}}{\sum_{k=1}^J e^{eta_k X_i}}$$

where $P(Y_i = j | X_i)$ represents the probability that participant *i* selects option *j* based on the product attributes X_i . The β coefficients quantify the influence of the attributes on the choice decision, where *J* represents the total number of options.

To test the assumption of independence of irrelevant alternatives (IIA), a likelihood ratio test (McFadden, 1973) was carried out utilising the lmtest package (Zeileis and Hothorn, 2002). The result showed significant differences, which indicated that the IIA assumption was not fulfilled for the given data set.

Based on these findings, the conditional logit model (cLogit) was used as a suitable alternative to model the preferences reflecting choice set-specific correlations. The cLogit model considers the probability that a participant will select a particular option from a choice set based on the specific attributes of that set. The estimation of the cLogit model was performed using the R package 'survival' (Therneau, 2024; Therneau and Grambsch, 2000). Preference modelling was performed according to the following functional equation:

choice_{ij} =
$$\beta_0 + \beta_1 \times \text{No Choice}_{ij} + \beta_2 \times \text{Price}$$
: EUR 6.99_{ij} + β_3
 $\times \text{Price}$: EUR 3.99_{ij} + $\beta_4 \times \text{Grape}$: Cabernet Blanc_{ij} + β_5
 $\times \text{Grape}$: Bronner_{ij} + $\beta_6 \times \text{Grape}$: Riesling_{ij} + β_7
 $\times \text{Seal}$: Yes_{ij} + $\beta_8 \times \text{Info}$: Technical_{ii} + β_9

 \times Info : Emotional_{ii} + β_{10}

where $choice_{ij}$ represents the choice decision for participants *i* in the choice set *j*, with the β coefficients quantifying the influence of each attribute on the choice decision.

The estimated coefficients of the cLogit model were used to quantify the direction and strength of the influence of each attribute on the selection decision. The Wald Test was performed to understand the statistical differences between the control and the conditioned group. Furthermore, the relative importance of the attributes was calculated and visualised to illustrate the importance of the different product features. Additional data modulation was performed with the help of 'reshape2' (Wickham, 2007).

Finally, marginal WTP (mWTP) was derived to quantify how much a consumer is willing to pay for a change in certain attributes. It was calculated according to the following functional equation:

$$mWTP_{\text{Attribute}} = -\frac{\beta_{\text{Attribute}}}{\beta_{\text{Price}}}$$

where $\beta_{\text{Attribute}}$ stands for the coefficient of the attribute under consideration in the cLogit model, β_{Price} is the coefficient of the price attribute. The mWTP value indicates how much the price should change in order to achieve the same effect as one unit of the attribute under consideration.

3.4. Data

The data for this study were collected through an online consumer panel after conducting a technical test of the questionnaire and its wording. Participants in the survey were incentivised by the panel operator, receiving EUR 5 per participant. The panel operator also ensured that individuals who had participated in a wine-related survey within one year prior to this survey were excluded. The screening criteria for the participants were set based on the age and gender distribution of the German population Central Bureau for Statistics (2023b) and the wine consumption frequency of the 'GFK Wine Consumer Report' in 2020, which was derived from representative surveys involving over 30,000 Germans (Kolb, 2020). Specifically, to be eligible for the survey, participants needed to indicate their wine consumption behaviour, with only those who consume wine more than once a month being accepted. On average, it took participants 15.5 min to complete the survey, with 90 percent of participants completing it within a range of 4.9 to 34.2 min.

3.5. Sample description

Table 2 shows the distribution of the sample based on sociodemographic aspects. There were minimal demographic differences between the unconditional (naïve/control) and informed (conditioned) groups, indicating that the group structure was equally distributed, which is crucial for a comparison of the results.

In addition to socio-demographic factors, particular attention was paid to the frequency of wine consumption. As noted, people who do not consume wine were excluded. The distribution of the frequency of consumption is comparable with other studies (Kolb, 2020) and thus represents an additional indication of robust sampling. Overall, it can be stated that the sample was representative, both in general and separately in the two conditioning strands.

4. Results

The following section presents the results of the discrete choice experiment at various stages of analysis. First, the relative importance of

Table 2

Baseline characteristics of the full sample as well as the characteristics of the naive and conditioned groups.

Baseline characteristics	Naïve, Contro Group	/ pl	Conditioned I Group		German population	Full sample	
	n	%	n	%	%	n	%
Gender							
Female	461	52.2	177	45.0	50.0	638	50.0
Male	422	47.8	216	55.0	50.0	638	50.0
Age							
> 29 years	159	18.0	66	16.8	20.0	225	17.6
30-49 years	304	34.4	109	27.7	34.0	413	32.4
> 50 years	420	47.6	218	55.5	46.0	638	50.0
Highest Education							
High school/	245	27.8	135	34.3	34.0	380	29.8
some college							
Secondary	276	31.3	115	29.3	31.0	391	30.6
School							
Upper secondary	188	21.3	66	16.8	13.0	254	19.9
school							
University or	174	19.7	77	19.6	22.0	251	19.7
postgraduate							
degree							
Income							
<1000€	346	39.1	168	42.8	NA	514	40.3
1001€-2000€	263	29.8	102	26.0	NA	365	28.6
2001€-3000€	130	14.7	64	16.3	NA	194	15.2
>3000€	96	10.9	33	8.4	NA	129	10.1
Not specified	48	5.4	26	6.6	NA	74	5.8
Wine Consumption							
Several times a	84	9.5	44	11.2	10.4	128	10.0
week							
Once a week	112	12.7	32	8.1	15.1	144	11.4
Two to three	237	26.8	113	28.8	18.6	350	27.4
times a week							
Once a month	122	13.8	61	15.5	16.5	183	14.3
Less than once a	328	37.1	143	36.4	39.4	471	36.9
month							

individual attributes in the experiment is analysed in detail. Particular attention is paid to the conditioning effect in order to understand the change in the influence of the individual attributes on the purchase decision as a result of the conditioning. The utilities are then listed for each level. The groups of unconditioned and informed participants are considered separately. The difference in the coefficients and the conditioning effect per level are described below.

4.1. General purchase utilities

Table 3 presents the relative purchase priorities by attribute as a percentage alongside with the change in log-likelihood. The analysis of log-likelihood change, based on the likelihood-ratio test comparing log-likelihood changes across models, identifies which attribute has the most significant impact on purchasing decisions (Lancsar et al., 2007). The table includes values for the control group (uninformed) and the conditioned group (informed) as well as the differences between them.

The findings indicate that price is a more critical factor for the naive group (52.2 %) than for the conditioned group (34.1 %), representing a difference of -18.1 %. Furthermore, the substantial change in log-likelihood of 69.0 % indicates that price significantly influences model prediction. Conversely, the importance of the grape variety is reversed, with the naive group at 22.3 % and the conditioned group at 30.6 %, representing an 8.3 % difference. The minimal change in log-likelihood of -0.7 % suggests that the effect of grape type is relatively consistent between the two groups.

Similar patterns are observed for the attributes 'Seal' and 'Information,' while the label design demonstrates a clear shift in favour of conditioning, with a -5.8 % difference. In the naive/control group, the coefficient is 15.9 %, indicating a moderate influence of product information on purchasing decisions. After model adjustment, the importance rises to 27.8 %, highlighting a stronger impact of product information post-adjustment. The observed differences between the groups indicate a 23.2 % change in log-likelihood, suggesting a significant divergence in the impact of product information between the two groups.

In conclusion, there is a shift in purchasing attributes from fundamental factors like price and labelling to characteristics that facilitate the recognition of wines from FRGVS, thereby underscoring the ongoing importance of grape variety, regardless of conditioning.

4.2. Part-worth utilities by level

This analysis compares the results of the discrete choice experiment in two groups, a control and conditioned group, focussing in particular on the shifts in the individual attributes. As indicated in the notes in Table 4, the parameters represent a robust and highly fitting model for both groups.

In Table 4, the 'No Buy' attribute of the control group displays a negative coefficient, indicating a clear understanding of wine purchasing habits due to the high probability of actually buying one of the products shown. Conversely, there is a significant positive coefficient in the conditioned group, signalling an increased willingness not to choose any of the products shown. Different price levels have varying effects on purchase decisions within the two groups. Particularly at EUR 3.99, the

positive influence is more pronounced in the conditioned group.

The choice of grape variety also impacts participants' purchase decisions. The resistant grape varieties are more appealing to members of the conditioned group compared to the naive group. When comparing the utility values of the two resistant grape varieties, it becomes evident that Bronner only marginally differs from Cabernet Blanc. Thus, hypothesis 1 regarding the positive effect of associating familiar grape varieties is rejected. The grape variety Chardonnay is strongly negatively influenced by conditioning, while Riesling is rated slightly higher. Consequently, it can be inferred that the familiarity of the grape variety has a significant influence on the purchase decision among unconditioned individuals, thereby confirming hypothesis 2, although with a diminished effect when information is provided.

The presence of a seal that indicates the usage of resistant grapes in production influences purchasing decisions on a marginal level. In the conditioned group, the presence of a seal has a clearer positive effect, confirming hypothesis 3, although at a lower utility level compared to the other attributes.

Purchase decisions are more influenced by the presence of information on the label than by the specific type of information offered. Both groups exhibit a strong preference for information, with the conditioned group displaying a higher preference for technical and emotional details compared to the control group. Consequently, hypothesis 4 is supported. Moreover, the conditioned group demonstrates a higher preference for attributes indicative of the use of resistant grape varieties, such as grape types, seals and information provided on the label, as illustrated in Fig. 3. Thus, hypothesis 5 is affirmed, as there is a significant positive correlation between information about resistant grapes and the likelihood of purchasing FRGV.

The effect of labelling varies between the two groups. Specifically, the 'Winery' label has a more pronounced negative impact in the conditioned group, whereas the naturally designed label elicits positive perceptions in both groups. Consequently, hypothesis 6 is confirmed, which suggests that a natural label can enhance the likelihood of wine purchases overall, especially when associated with wine made from resistant grapes.

4.3. Marginal WTP

In addition to the relative importance of the attributes, the procedure described in the Methods section can be used to calculate the amount individuals are willing to pay for specific attribute values. As shown in Table 5, the FRGVs Cabernet Blanc and Bronner have a significantly higher WTP compared to conventional varieties. The influence of information on WTP is clearly recognisable, supporting hypotheses 7. The provision of information on the label led to a significantly higher WTP in the conditioned group compared to the uninformed group.

The label exerted an influence on WTP as well. While the winery label showed an exhibited positive effect on WTP, a label resembling a natural or high-quality design tended to be negatively impacted by conditioning. Moreover, the presence of a seal increased WTP in the conditioned group compared to the control group, indicating the recognisability of using resistant grape varieties and its positive impact on WTP. Thus, hypothesis 8 is confirmed. The aggregate overview of the hypothesis decisions is presented in Table 6 below.

Table 3

Relative effect sum of different determinants to show importance of the tested purchase attributes.

A 11	tte Naïve/Control		0 11:1: 1		0 0:0	0 5:5		
Attribute			Conditioned		Group Differences			
	Coefficient (%)	Change in log-likelihood (%)	Coefficient (%)	Change in log-likelihood (%)	Coefficient (%)	Change in log-likelihood (%)		
Price	52.2	69.0	34.1	49.9	-18.1	-19.1		
Grape	22.3	15.8	30.6	15.1	8.3	-0.7		
Information	15.9	7.4	27.8	30.6	11.9	23.2		
Label	8.8	7.7	3.0	0.6	-5.8	-7.1		
Seal	.8	.1	4.6	3.9	3.8	3.8		

Table 4

Part-worth utilities of the tested levels separated by the naive and conditioned groups.

Attributes	Levels	Naïve/Control			Conditioned		Control vs. Co	Control vs. Conditioned	
		Coefficient	SE	Z-Stat	Coefficient	SE	Z-Stat	Wald (=)	p-value
No Buy	No Buy	08	.06	-1.26	.56	.09	5.72***	30.57	< 0.001
Price	EUR 3.99	.64	.05	14.02***	.91	.07	12.95***	10.74	< 0.01
	EUR 6.99	.30	.06	5.19***	.35	.09	3.83***	.20	.655
	EUR 9.99	94	Omitted	Level	-1.26	Omitted Level			
Grape	Cabernet Blanc	13	.06	-2.054*	.52	.1	5.26***	30.62	< 0.001
	Bronner	11	.04	-2.837**	.33	.06	5.38***	36.75	< 0.001
	Riesling	.16	.05	3.445***	.28	.07	3.98***	2.18	.14
	Chardonnay	.09	Omitted Level		-1.14	Omitted Level			
Seal	Present	.01	.03	.472	.17	.05	3.75***	8.39	< 0.01
	Absent	01	Omitted	Level	17	Omittee	l Level		
Info	Technical	.16	.06	2.633**	.60	.09	6.56***	15.82	< 0.001
	Emotional	.13	.03	3.928***	.43	.05	8.54***	26.14	< 0.001
	None	29	Omitted	Level	-1.03	Omitted Level			
Label	Winery	10	.04	-2.456*	08	.06	-1.30	.07	.788
	Prestige	.05	.04	1.271	03	.07	44	1.12	.291
	Natural	.05	Omitted	Level	.11	Omittee	l Level		

Naive: Concordance= 0.599 (se = 0.006), Likelihood ratio test= 594.4 on 11 df, p=<0.001, Wald test = 579.2 on 11 df, p=<0.001, Score (logrank) test = 597.6 on 11 df, p=<0.001; Conditioned: Concordance= 0.626 (se = 0.009), Likelihood ratio test= 486.9 on 11 df, p=<0.001, Wald test = 467 on 11 df, p=<0.001, Score (logrank) test = 500.4 on 11 df, p=<0.001; Sig. classes. * = p < 0.05; **= p < 0.01; ***= p < 0.001.



Fig. 3. Part-worth utility differences between naive and conditioned groups.

Table 5 WTP of the tested levels separated by the naive and conditioned groups.

Attributes	Levels	Naïve/Control	Naïve/Control		Conditioned	Conditioned		
		WTP€ (SE)	95 % CI		WTP€ (SE)	95 % CI		WTP€
No Buy	No Buy	-10.63 (0.68)	-11.96	-9.30	-5.90 (0.73)	-7.32	-4.48	4.73€
Grape	Cabernet Blanc	-1.32 (0.50)	-2.30	-0.34	2.96 (0.54)	1.90	4.02	4.28
	Bronner	-1.03 (0.36)	-1.74	-0.33	2.30 (0.40)	1.53	3.08	3.33
	Riesling	1.44 (0.39)	0.67	2.20	1.61 (0.42)	0.78	2.43	0.17
	Chardonnay	0.91	Omitted Level		-6.87	Omitted Level		-7.78
Seal	Present	0.12 (0.27)	-0.41	0.65	1.06 (0.29)	0.49	1.64	0.94
	Absent	-0.12	Omitted Level		-1.06	Omitted Level		-0.94
Info	Technical	1.42 (0.45)	0.54	2.30	3.43 (0.46)	2.54	4.32	2.01
	Emotional	1.21 (0.29)	0.63	1.78	2.91 (0.32)	2.27	3.55	1.70
	None	-2.63	Omitted Lev	Omitted Level		Omitted Level		-3.71
Label	Winery	-0.93 (0.36)	-0.15	1.26	-0.33 (0.38)	-1.08	0.41	0.60
	Prestige	0.56 (0.36)	-1.64	-0.22	0.06 (0.38)	-0.69	0.81	-0.50
	Natural	0.37	Omitted Lev	vel	0.27	Omitted Le	evel	-0.10

5. Discussion

A comprehensive examination of the product features related to FRGVs, considering individual attribute levels, yielded profound

insights. Of particular interest is the heightened significance of the 'No Buy' option in the conditioned group, suggesting a higher rejection rate of the product combinations presented. This indicates that individuals who are informed about FRGVs are more discerning when purchasing

Table 6

Summary of hypotheses.

Hypothesis	Results	Decision
H ₁ The use of familiar grape variety names for developed grape varieties significantly inf customers' purchase decision compared to varieties that are completely unfamiliar to customers.	r newly $p > 0.05$ luences o grape	Rejected
H ₂ Conventional grape varieties are purchase significantly more frequently compared to grape varieties by uninformed consumers.	p = 0.14 p = 0.14	Accepted
H ₃ Introducing a specific labelling seal for wi from resistant grape varieties on the bottl significantly increases the likelihood of cu purchasing wide made from resistant grap.	ine made $p < 0.01$ e istomers e varieties.	Accepted
H ₄ Including information about FRGVs on the significantly improves the consumer purch likelihood compared to a back label with information.	back label $p <$ hase 0.001 but such	Accepted
H ₅ Providing information on the unique attri characterise resistant grape varieties signi enhances the consumer purchase likelihoo	butes that $p <$ ficantly 0.001 od.	Accepted
H ₆ The use of a natural style label has a signi positive effect on the likelihood of purcha made from resistant grape varieties.	ficant $p =$ sing wines 0.788	Accepted
H ₇ Providing information on the distinctive at resistant grape varieties leads to a signific increase in willingness to pay.	tributes of $p <$ ant 0.001	Accepted
H ₈ Consumers who are informed about the are of resistant grape varieties demonstrate si higher willingness to pay for wine made f varieties compared to those who are not i	$\begin{array}{ll} \mbox{lvantages} & p < 0.05 \\ \mbox{gnificantly} \\ \mbox{rom such} \\ \mbox{nformed.} \end{array}$	Accepted

wine and, therefore, require more targeted marketing (Di Vita et al., 2024; Kiefer and Szolnoki, 2023).

Consumers prioritise price significantly when making choices in the wine market (Szolnoki et al., 2010). Studies have shown that consumers consider price in relation to perceived quality, value for money and budget constraints (Bruwer et al., 2017). A detailed analysis of different price levels demonstrated that conditioning has a significant influence on perceived value. In particular, the group that had undergone conditioning exhibited a markedly increased propensity to purchase at a price of EUR 3.99, in comparison to the control group. This observation aligns with the findings of (Borrello et al., 2021), which highlight that price becomes a critical factor in the purchase decision for wines from FRGVs, especially when the perceived value in terms of sustainability is emphasized. Those exposed to targeted information demonstrated heightened responsiveness to specific price points, a finding consistent with previous studies (Lewis and Zalan, 2014; Wise Lozano and Arroyo, 2022). This underscores the significance of the pricing of wine produced with resistant grapes in the context of its perceived value and utility. Nevertheless, Kiefer and Szolnoki (2023) posited that certain consumer groups may exhibit reduced price sensitivity following the provision of information, necessitating the implementation of targeted pricing strategies for distinct audiences.

The study identifies wine from resistant grape varieties based on three attributes: grape variety, information and seal. The analysis of the grape varieties shows interesting differences in the preferences of the naive and conditioned groups. In the conditioned group, FRGVs were associated with a heightened positive inclination in purchase decisions and WTP compared to conventional grape varieties, which aligns with the findings of (Kiefer and Szolnoki, 2023). This could suggest an elevated consumer awareness of more environmentally friendly and sustainable farming practices when informed about FRGVs (Pedneault and Provost, 2016). Conversely, Riesling, a conventional grape variety, was associated with increased attractiveness in the conditioned group. This could indicate that conditioning increases the appreciation of certain established grape varieties. Additionally, according to Sillani et al. (2022), name adaptation has no significant influence if further information about FRGVs is available on the label. This presents marketing opportunities for other resilient grape varieties like Bronner, Solaris or the currently most cultivated variety, Regent (Central Bureau for Statistics, 2023a).

The presence of a seal on a product significantly influences purchasing decisions (Thøgersen, 2010). Although traditional seals, such as organic or origin labels, signify controlled product conditions, consumer trust in these labels is generally low, and the abundance of seals can be overwhelming (Sogari et al., 2016). However, as Borrello et al. (2021) noted, a seal can serve as a strong trust signal, particularly when it clearly communicates that the grape varieties were produced in an environmentally friendly and sustainable manner. This study's findings support Borrello et al. (2021), showing that a specific FRGV labelling seal positively impacted purchase decisions when consumers were informed. This suggests that conditioning consumers to value recognisable labels may underscore the need for specific labelling, especially given low involvement with FRGVs.

As demonstrated by Kiefer and Szolnoki (2023), the general public's awareness of FRGVs in Germany is limited, as is their understanding of which grape varieties are considered resistant. The introduction of a seal enabling the simple labelling of wines made from resistant grape varieties would greatly facilitate consumer purchasing decisions. In contrast to the conditioned group, this effect was less pronounced in the control group, which again demonstrates that conditioning has a significant influence on consumers' perceptions and evaluation of the seal. Consequently, the effectiveness of a seal is strongly related to the prevalence and knowledge of wine consumers about the benefits of resistant grape varieties. This observation emphasises the dynamic role of the importance of a seal in shaping consumer preferences for wines made from resistant grapes and trust in seals.

The role of label information in consumer decision-making is well documented. Previous research has identified labels as a critical factor in informing and guiding consumer preferences in the wine industry (Jarvis et al., 2010; Mueller et al., 2010). The study of labelling preferences in the control and conditioned groups provides insights into the complex dynamics involved in conditioning perceptions of wine labels.

In the study, a number of different label designs were selected that cover relevant areas for FRGV wines on the wine market (Dressler, 2018; Kiefer and Szolnoki, 2023). These labels exhibited an interesting dynamic, with the 'natural' label exerting a stronger positive influence on the purchase decisions of the conditioned group. This indicates that the pursuit of naturalness and authenticity in label design is appealing to a specific target group, and the appeal of the sustainability-promoting properties of FRGVs is linked to label elements that reflect a natural image (Firsova and Xi, 2022).

Nevertheless, when designing labels, it is important to consider the value of natural-looking labels, as they can help to address a broad audience and avoid the use of unattractive or humorous designs (Lunardo and Rickard, 2019). In contrast, the label style of a commercial winery tended to elicit negative reactions. This indicates that the association with a standardised label design does not necessarily lead to a positive perception and is modulated by more valuable, individual or even special elements (Celhay, 2022; Öztürk and Ertamay 2019). It is important that producers adhere to their own philosophy in label design, ensuring that the values expressed in the philosophy are reflected in the design of the bottle and that the bottle design is authentic (Barrena et al., 2021a; Monteiro et al., 2019).

The analysis of the information provided on the label, divided into technical and emotionally formulated texts and an option without information, shed light on the multi-layered influences of further information on the label and on the consumers' purchase decision. In the conditioned group, technical information about the grape varieties had a positive influence on the participants' purchase decision and WTP, which is consistent with the results of Vecchio et al. (2022) and Mann et al. (2012). This indicates that the targeted communication of specialised knowledge about grape varieties after emerging general knowledge about FRGVs leads to an increased appreciation and preference for

wines from resistant grapes (Di Vita et al., 2024; Pedneault and Provost, 2016). Furthermore, emotional information also played a decisive role in the conditioned group, as evidenced by an increased positive tendency towards emotionally charged information about grape varieties.

A lack of information on the label significantly reduces the purchase benefit and WTP for a product and was also a negative influencing factor on the purchase decision in the unconditional group (Tait et al., 2019). This suggests that information on the label, whether technically or emotionally formulated, has a strong influence on the purchase decision and WTP and should therefore be used to educate consumers about the benefits of FRGVs. These findings underscore the significance of targeted information strategies in wine marketing, particularly in light of the diverse preferences that can be shaped by different types of information (Fuentes Espinoza et al., 2018; Nesselhauf et al., 2020).

6. Conclusion

This study demonstrates that consumer education and targeted information strategies are of significant importance with regard to the perception and evaluation of wines produced from fungus-resistant grape varieties. The findings demonstrate that consumers who possess information are not only more selective but also more discerning, indicating an increasing desire for sustainability and responsible consumption. This reflects a broader societal trend whereby consumers are increasingly prioritising the environmental and ethical dimensions of their purchasing decisions.

The study demonstrates that the success of FRGVs in the market is contingent upon the efficacy with which their sustainable features and benefits are communicated. This highlights the necessity to position sustainable production methods not simply as a quality attribute, but as a crucial selling point. In an environmental and climate-conscious era, FRGVs present a promising avenue for enhancing the sustainability of the wine sector while addressing the growing consumer expectations. Therefore, the study offers a significant contribution to the understanding of how sustainable innovations such as FRGVs can be effectively positioned in an increasingly environmentally conscious market.

6.1. Practical implications

Informed consumers are more reluctant to buy, which makes targeted marketing measures necessary (Kiefer and Szolnoki, 2023). Pricing strategies should be tailored to the different consumer segments, as conditioned consumers react more strongly to specific price points (Kiefer and Szolnoki, 2024b; Lewis and Zalan, 2014; Wise Lozano and Arroyo, 2022). The presence of a specific FRGV label can positively influence the purchase decision, especially if consumers are informed about the importance of the label (Sogari et al., 2016; Thøgersen, 2010). Furthermore, label design plays a crucial role in this context. Labels that emphasise naturalness and sustainability are particularly popular with conditioned consumers (Firsova and Xi, 2022). In addition, the inclusion of technical and emotionally appealing information on labels has been shown to positively influence consumer purchase decisions and WTP (Mann et al., 2012; Vecchio et al., 2022).

6.2. Limitations and further research

The study's limitations include challenges in utilising attributes like seals, as both resistant and conventional grape varieties were used. This required the use of two different seals, which may have introduced a degree of bias into the utility measurement. Additionally, a conditional logit model was employed instead of the state-of-the-art mixed logit model, which would have been more effective in accounting for individual preference heterogeneity. It is also more flexible in specification, models more realistic choices and often results in a better empirical fit to the data than the conditional logit model. Nevertheless, due to several model parameters, the use of the mixed logit model was not feasible. Furthermore, the conditional sample was skewed towards older consumers, requiring a slight adjustment to the categorisation of the sample by age.

The study emphasises the need for further research to investigate potential discrepancies in consumer preferences and WTP across different market segments and countries. A nuanced comprehension of these segments, including their values and priorities, is vital for the development of effective marketing strategies and communication efforts that resonate with diverse audiences. Finally, future research could examine the long-term market impact of the acceptance of wines produced with resistant grapes, including factors like market share trends, consumer loyalty and the sustainability of demand.

CRediT authorship contribution statement

Christoph Kiefer: Writing – review & editing, Writing – original draft, Visualization, Validation, Formal analysis, Data curation, Conceptualization. **Gergely Szolnoki:** Writing – review & editing, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization.

Declaration of competing 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.

Data availability

Data will be made available on request.

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Data availability

Data will be made available on request.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the main author used DeepL Write pro (https://www.deepl.com/write) in order to improve the language. After using this tool/service, the main author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

Ethical Statement

During the screening process, participants were informed about compliance with data protection laws and the ethical principles of market research. It was emphasized that their data would be treated confidentially and anonymously. The interview was conducted solely for research purposes and not for advertising. The answers given would be treated confidentially, would not be used for other purposes, and would not be passed on to third parties without express authorization. Each participant was informed that they had the right to withdraw from the survey at any time without giving reasons. Appendix



Fig. 4. Design of the labels from 'Nature' (left) to 'Prestige' (right).



Fig. 5. Design of the seals. FRGV seal left, Conventional seal right.

Tuesday, 13.06.2023

Frankfurter Allgemeine

Ressort: Knowledge

"What luck that there are Piwis"

FAZ-Interview with Franz Pflüger about resistant grape varieties

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

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

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

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

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

"A huge new field of flavours is opening up here that is worth discovering." Of course, this also saves petrol costs, personnel etc. and can therefore make the vineyard more future-proof. The most important thing, however, is that high quality

FAZ: What other advantages are made possible with Piwis?

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



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

Fig. 6. Newspaper article on the conditioning phase.

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