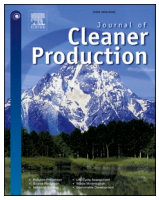
Journal of Cleaner Production 475 (2024) 143574

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro



From vineyard to glass: Measuring consumers' willingness to pay for innovative rootstock-produced wine through an experimental auction

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ARTICLE INFO

Handling Editor: Jian Zuo

Keywords:
Wine
Viticulture
Water-saving techniques
M4 rootstock
BDM
WTP
Consumption

ABSTRACT

Availability of new rootstocks in vineyards offers improved sustainability and adaptability to changing climatic conditions. However, the adoption of these innovations in the wine industry can be hindered by consumer perceptions and uncertainty about the intrinsic and extrinsic characteristics of the new rootstock-produced wines. This study aims to address these concerns by examining consumer preferences towards M4 rootstock-produced wines through a consumer test and a willingness-to-pay assessment based on a Becker-DeGroot-Marschak auction analysis. A non-hypothetical experiment design, involving 201 wine consumers from the Veneto and Friuli Venezia Giulia regions of Italy, was employed to identify differences in new patterns of wine consumption due to the information provided. Results show that consumers do not identify noticeable taste differences between wines produced with innovative and traditional rootstocks. However, when informed about the water-saving benefits, their willingness to pay for wines made with the innovative rootstock is 5% higher than for wines using traditional rootstocks. This additional willingness to pay becomes statistically insignificant after tasting the wine. The introduction of the M4 rootstock among vine growers appears to be an effective solution in meeting consumer demand for high-quality products made with environmentally-friendly methods that conserve scarce resources, such as water. The findings of this study contribute to the ongoing debate on the development of sustainable and economically viable viticultural practices that address the challenges posed by climate change.

1. Introduction

The success of grapevine cultivation for wine production, commonly referred to as a vineyard, is fundamentally influenced by the choice of the lower part of the vine and the roots, jointly known as the rootstock. This critical relationship is underscored by a substantial body of research in this domain (Marín et al., 2021). The rootstock not only ensures the vine's adaptation to specific pedo-climatic conditions but also helps achieve a harmonious vegetative-productive balance in sync with the oenological aspirations. Historically, the selection of rootstocks has been limited, predominantly featuring genotypes derived from a narrow genetic pool of American species, primarily developed in the early 20th century as a response to the phylloxera crisis.[1] These rootstocks, while successful in addressing the immediate phylloxera problem, have shown limited genetic variability compared to the possibilities offered by contemporary advancements in genetic improvement.

In the current century, the role of rootstock in viticulture has largely remained confined to its original purpose of addressing the phylloxera crisis, without evolving to incorporate agronomic values that have revolutionized other fruit tree cultivations.[2] However, the landscape is gradually changing, with new rootstocks being developed to enhance the sustainability of viticulture, especially in response to the pressing

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[1] The arrival of Phylloxera vastatrix in Europe in the second half of the 19th century resulted in far-reaching changes in viticultural research and techniques, which led to the constitution of grapevines in which the root apparatus (rootstock) is from the American species and the epigeal part (grafted variety) is V. vinifera. In Italy, the constitution of the Consorzi Antifillosserici (1901) and the scientific input of numerous researchers and technicians, including among the others Guttuso (1906), Paulsen (1908), Dalmasso and Sutter (1915), Dalmasso et al. (1929-1931), and private companies, allowed the diffusion of the grafting technique for the reconstitution of vineyards with American rootstocks.

[2] E.g. dwarfing rootstocks, in apple growing and in cherry growing, which have changed the production system of these species.

https://doi.org/10.1016/j.jclepro.2024.143574
Received 20 January 2024; Received in revised form 14 August 2024; Accepted 3 September 2024
Available online 6 September 2024

challenges posed by climate change. The urgency of this development cannot be overstated, given scientific predictions indicating a potential reduction of up to 50% in traditional viticultural lands by 2040 due to climate impacts (Howard, 2016; Jones et al., 2005). In response, the scientific community is actively seeking solutions to enable winegrowers to adapt to global warming and preserve viticulture in areas facing high drought risk, while concurrently limiting water resource consumption and safeguarding the landscape in agricultural regions (Sacchelli et al., 2016; Santos et al., 2020).

Among the various strategies to adapt to climate change, the M4 rootstock emerges as a particularly promising innovation. Characterized by its high drought resistance and reduced water usage, M4 aligns with sustainable viticultural practices (Galletto et al., 2014). The potential substitution of traditional rootstocks with innovative ones like M4 presents an opportunity not only in terms of cost-effectiveness but also in fulfilling the broader principles of sustainable development (Di Vita et al., 2024).

Despite the proven agronomic benefits of the M4 rootstock (Scienza et al., 2001), its adoption among vine growers is not without challenges, primarily due to uncertainties including the consumer response to wines produced from M4-grafted varieties. Indeed, the diffusion of innovations in agriculture, and particularly in viticulture, often encounters resistance, largely attributable to apprehensions about market acceptance and consumer preferences (Di Vita et al., 2024). Consumers preferences of wines produced using the M4 rootstock remain unknown and represent the research gap that our study aims to address.

By investigating the overall research question of whether consumers might appreciate wines produced with M4 rootstocks, our study seeks to provide new insights into consumer behavior and examine an innovative variable—water-reducing rootstocks—through consumer reactions in real-world settings. To the best of our knowledge, this is the first experimental auction to assess consumer willingness to pay (WTP) for wine produced using these innovative rootstocks. While experimental auctions are increasingly used in behavioral economics and marketing, particularly with respect to valuing wine sensory features from variety viewpoints, they have not yet been applied to evaluating the combination of rootstocks and variety for wine consumers in a climate change context.

Following the approach proposed by Vecchio et al. (2019), and Galletto et al. (2021), we implemented an in-store experiment at an Italian winery. This experiment, involving a sample of 201 wine consumers, utilizes the Becker-DeGroot-Marschak (BDM) method in a non-hypothetical setting. Our application of the BDM method is structured in distinct rounds, each designed to isolate and measure different influences on consumer WTP. The first round focuses on evaluating the impact of providing information about the innovative characteristics of the M4 rootstock and its environmental implications. This step is crucial in understanding how the awareness of M4's sustainability and technological advancement influences consumer valuation and WTP. In the second round, the experiment progresses to assess the effect of taste. In this round, consumers are presented with the opportunity to taste wines produced from the M4 rootstock, juxtaposed with those from traditional rootstocks. This sensory evaluation is instrumental in determining whether the organoleptic qualities of M4 wines meet or do not meet the standards set by traditional rootstocks. The whole experiment enables a comprehensive understanding of the main factors influencing WTP. Should the findings reveal that M4 wines are perceived favorably in terms of their intrinsic (taste) and extrinsic characteristics (environmental impact) and attract comparable or higher willingness to pay, it could significantly encourage vine growers to embrace this innovative rootstock.

Our results show that consumers are inclined to pay a slight premium for wines produced from the innovative M4 rootstock when they are made aware of its water-saving benefits. However, after tasting, this price premium seems to vanish. Our research contributes to the current debate on sustainable viticulture by providing concrete insights into consumer acceptability of drought-resistant rootstocks. Moreover, our results could support the development of targeted sustainability marketing strategies, thereby increasing the value proposition of sustainable wine products.

The paper is organized as follows: The second section delves into the relevant background literature, providing a detailed context for the study. The third section describes the methodologies applied, encompassing both the consumer test and the BDM auction analysis. The fourth section presents the key findings from these analyses. Finally, the paper concludes with a discussion on the implications of these findings, highlighting their relevance to vine growers and the wine industry.

2. Literature background

2.1. Sustainable wine and consumer preferences

Sustainable vitiviniculture, as defined by the OIV (2011), represents a comprehensive strategy that encompasses grape production and processing systems. It integrates economic sustainability of structures and territories, the production of high-quality products, and takes into account precision in sustainable viticulture practices, environmental risks, product safety, consumer health, and the valuation of heritage, historical, cultural, ecological, and landscape aspects (OIV, 2011). This definition highlights that sustainability in the wine sector requires a holistic approach that integrates the cultural, historical, and ecological dimensions that distinguish wine as a premium product (Wei et al., 2023). Enhancing the sustainability of viticulture involves bolstering ecosystem services, reducing input usage, and minimizing environmental impact, while ensuring substantial socio-economic benefits. These improvements should not jeopardize the cultural and historical heritage of wine production, which needs to be preserved (Wagner et al., 2023).

This balanced approach is increasingly important as sustainable wine consumption gains prominence in the global market (Santini et al., 2013; Borrello et al., 2021a,b).[3] The increasing prominence of sustainable wine consumption in the global market has emerged as a notable trend in recent years (Mariani and Vastola, 2015; Borrello et al., 2021a, b). This trend aligns with the viticulture sector's efforts to address climate change (Provost and Pedneault, 2016; Mian et al., 2022). In response, the wine industry has been adapting by incorporating environmentally friendly practices, recognizing not only their ecological benefits but also the evolving demands of consumers (Caracciolo et al., 2013; Sogari et al., 2016; Bazoche, 2015). Indeed, there has been a significant increase in consumer awareness and preference for eco-friendly or more sustainable wine production methods (Schäufele and Hamm, 2017; Tait et al., 2019). For instance, consumers have demonstrated a willingness to pay up to 20% more for wines that clearly display sustainability attributes, such as being organic or biodynamic (Migliore et al., 2020). Regarding the organic wine market, although it is still relatively small in market share, it is strongly aligned with these pro-environmental attitudes and a preference for sustainable products, experiencing annual growth (Schäufele and Hamm, 2018; Janssen et al., 2020; Fabbrizzi et al., 2021; Maesano et al., 2021).

When examining the consumer decision-making process in purchasing sustainable wines, factors such as individual perceptions and trust in certification schemes play a significant role. Concerns about pesticide use also influence these decisions (Ugalde et al., 2021). Additionally, preferences are shaped by the type of sustainable practices adopted in wine production and its specific sustainability attributes, like water-saving practices, for example (Peterson et al., 2019; Fernández-Serrano et al., 2022). Furthermore, the degree to which consumers are willing to pay a premium for sustainable wines varies. This variability

[3] For a comprehensive review of sustainability in the wine sector, readers are encouraged to consult the works of Wei et al. (2023), Wagner et al. (2023), Santini et al. (2013) and Mariani and Vastola (2015).

depends on several factors, including the wine's origin and critic ratings (Tait et al., 2019; Capitello and Sirieix, 2019; Ruggeri et al., 2020).

The impact of sustainable wine attributes on consumer preferences varies also across different consumer segments, influenced by socio-demographic factors, behavioral patterns, and socio-psychological characteristics (Sogari et al., 2016; Vecchio, 2013). Individuals deeply involved in the wine culture and concerned about environmental issues are notably influenced by sustainable wine attributes (Waldrop et al., 2017, 2019; Lerro et al., 2021; Pomarici and Vecchio, 2014). Notably, environmentally conscious consumers, particularly millennials, show a willingness to spend more on sustainable wines (Compés et al., 2021; Simeone et al., 2023). This trend is especially evident among the majority of millennials who consider sustainability a key factor in wine selection (Olsen et al., 2015; Sogari et al., 2017).

Young Italian consumers, for instance, demonstrate a high willingness to pay for water-saving labels and are influenced by trust in sustainability labels and pro-environmental attitudes. They prioritize carbon footprint claims over the visual appeal of wines (Gallenti et al., 2019; Bandinelli et al., 2020). This preference for environmental claims over traditional esthetic aspects is pronounced among younger consumers, who are also willing to pay a premium for wines with environmental labels (Gow et al., 2022). Factors such as urban living, gender, and age further influence this millennial preference (Pomarici and Vecchio, 2014; Gazzola et al., 2022). Additionally, other demographics, including females, married individuals, and those with higher education levels, also demonstrate a preference for sustainably produced wines (McGarry Wolf and Higgins, 2017; Schäufele and Hamm, 2017; Sellers-Rubio & Nicolau-Gonzalbez, 2016).

Given this setting of increasing consumer interest and willingness to pay for sustainable wine attributes, our study analyzing consumer preferences towards wine produced using innovative rootstock water-saving techniques becomes highly relevant. This approach represents a relevant facet of sustainable viticulture, directly addressing the growing concerns about water usage in agriculture. By exploring both the intrinsic (taste) and extrinsic (environmental impact) effects of these sustainable practices on consumers, our research aims to contribute on the discussion between wine environmental sustainability and consumer perceptions. This dual focus is particularly relevant considering the varied landscape of consumer preferences, as indicated by previous studies.

2.2. The M4 rootstock and the water scarcity problem

The innovative M4 rootstock presents an interesting nexus between viticultural practices and the evolving preferences of consumers towards sustainable wine attributes. As consumers become increasingly aware of and concerned about environmental sustainability, particularly in the context of wine production, the significance of rootstocks like M4 might become more evident.

Indeed, the M4 rootstock, a product of the M rootstock series developed by the University of Milan, stands out as a notable advancement in the Italian viticultural landscape.[4] This series emerged from a rigorous genetic improvement program initiated in the early 1980s, culminating in its inclusion in the national register in 2014, with ongoing evaluations of its performance across different vine-growing areas. The distinguishing feature of the M4 rootstock is its high resistance to drought, a critical attribute considering the increasing water scarcity challenges in viticulture. Compared to traditional rootstocks, M4 exhibits superior root architecture and density, leading to more efficient water usage (Galletto et al., 2014).

Beyond its drought resistance, M4 also enhances certain wine qualities. It contributes to higher acidity, lower sugar content in grape juice, and improved phenolic ripening, particularly significant under hot summer conditions (Corso et al., 2016; Merli et al., 2016). These characteristics align well with current consumer preferences for wine taste, suggesting a potential positive impact on wine consumption patterns. The adaptability of M4-rootstock wines to varying climatic conditions, both in southern and northern Italy, as well as in other wine-producing regions worldwide, further underscores its relevance in the face of global climate change.

The strategic adoption of M4 rootstock can substantially reduce irrigation requirements, especially in drought-prone areas.[5] This reduction in water use not only addresses the immediate concerns of vineyard sustainability but also mitigates the need for extensive public investment in water supply infrastructure for viticulture. By facilitating more efficient water use, the introduction of M4 rootstock can contribute to the overall sustainability of the wine sector, a critical consideration in contemporary wine consumption literature that increasingly emphasizes environmental factors (Galletto et al., 2014). In greater detail, given an average grape production of 120 quintals per hectare (q/ha) for 85 hL (hl) of wine, the estimated water consumption is approximately 82,000 hL per hectare (hl/ha). Meggio et al. (2014) documented the notable drought resilience of M4 rootstock, which is attributed to its capacity to sustain higher levels of photosynthetic activity and improved water retention during periods of stress. The study demonstrated that M4 rootstock could reduce water consumption by about 30% under drought conditions when compared to traditional rootstocks, thus preserving vine health and grape quality. Consequently, the water footprint of vineyards can be significantly reduced. This finding is also supported by a recent survey conducted by the University of Milan and the Winegraft company,[6] which reports that the M4 rootstock can reduce water consumption by up to 40% (Berti, 2022).

Promising economic outcomes from the use of M4 rootstock have been observed across Italy, especially in drought-prone areas such as the northeast and Sicily (Galletto et al., 2014). Economic analysis from this study suggests that M4 usage yields higher net revenues compared to traditional rootstocks, offering significant economic benefits for regions that adopt this technology.

3. Materials and methods

The impact of adopting innovative rootstocks for grape production on consumers' wine preferences was assessed using a non-hypothetical Becker-DeGroot-Marschak (BDM) auction conducted as an in-store experiment. This approach was chosen to enhance the ecological validity of our findings while closely simulating real-life decision-making environments. The BDM auction mechanism is widely recognized in experimental economics for its robustness in eliciting true consumer

[4] In Italy, the viticultural landscape is characterized by the predominance of a limited number of rootstocks, with the top five varieties (1103p, kober5bb, So4, 110r, 420a) occupying approximately 78% of the rootstock area (VCR, 2021). This scenario presents a challenge: the Italian vineyard, stretching from Val d'Aosta to the slopes of Etna, encompasses a wide variety of terrains, climates, cultivation systems, grape varieties, and oenological goals. Yet, this diversity rests on a rather narrow base of rootstock varieties. Many of these rootstocks were adopted from other regions without comprehensive evaluation of their suitability for the diverse conditions of Italian viticulture.

[5] To assess the diffusion of the M4 rootstock, it is possible to refer to the data reported by Rauscedo Cooperative Nurseries, the most prominent Italian company in the production of vine rootstocks, concerning the M rootstock series. These data indicate that the company supplied 1.7 million plants in the 2022/2023 wine year. Between 2020 and 2023, their distribution has increased by 300%, with the objective of Rauscedo Nurseries for 2025 being to achieve 1600 ha/year of new plantings with M rootstocks (Berti, 2022).

[6] The Winegraft company, founded in 2014 by a group of leading Italian wineries to support the development of research on the new generation of rootstocks, has established 30 experimental vineyards, from which the first agronomic and oenological results are now being collected.

valuations in a non-hypothetical setting (Vecchio et al., 2019). The auction was conducted in a winery setting, leveraging the natural context to enhance the realism of the consumer experience. This allowed us to directly observe consumer behavior in an environment that mimics typical market conditions, thereby minimizing artificiality and maximizing the relevance of the results to real-world settings. More specifically, following Galletto et al. (2021) the impact on preferences is quantified in monetary terms as individuals' willingness to pay by implementing a mixed within/between-subjects experimental design (Charness et al., 2012).

Participants in the BDM procedure offered their WTPs for the auctioned products in a closed envelope after each round that differs in the amount and type of information bidders received. At the end of the experiment, following usual procedures, a specific round as well as one of the offered products were randomly selected to identify the product and the corresponding bids that will be truly considered in the auction. Finally, the sale price was also randomly drawn and those bidders that offered a price greater than the sale price effectively purchased the product at that price. As widely discussed in the literature, since the sale price was drawn at random, the BDM mechanism is considered incentive-compatible, namely participants are incentivized to reveal their real WTP (Corrigan and Rousu, 2006). The use of monetary metrics as well as the examination of actual in-store purchase decisions of consumers as generated by the BDM mechanism have the advantage to reduce both the hypothetical and social desirability biases, incentivizing bidders to openly reveal their preferences (Del Giudice et al., 2018). Moreover, the monetary metrics may provide relevant insights on the effective marketability of the proposed innovation. Even if BDM in-store procedure might suffer from some biases, such as anchoring effect (Bohm et al., 1997) endowment and auction procedure effects (Lusk et al., 2004; Corrigan and Rousu, 2006), for the above-mentioned advantages, this mechanism is far to be new for food economists (see eg. Costanigro et al., 2011; Vecchio et al., 2019).

Following Harrison and List (2004), the full experimental design will be clarified in the next subparagraph, including participants and wine characteristics, details on the BDM auction, and the different information received by participants.

3.1. The study design

The sample size was set at 200 to satisfy a medium to small level of effect size ($f^2 = 0.4$), achieving a statistical power of 0.90 and alpha of 0.05, according to the a priori power analysis conducted in G*Power 3.1 (Faul et al., 2009).[7] The resulting sample size aligns with those used in other studies with similar experimental settings. (Borrello et al., 2022; Galletto et al., 2021; Vecchio et al., 2019).

The study was designed in two rounds to isolate and assess various influences on consumer willingness to pay (Fig. 1). The initial round focused on evaluating the impact of providing information about the M4 rootstock's innovative characteristics and its environmental implications. Subsequently, the second round aimed to evaluate how taste influenced consumer preferences.

Participants were recruited by the winery, as registered customers, and randomly assigned to either a *type*-A session (N = 101) or a *type*-B session (N = 100) based on a random draw. All the sessions have been carried-out in a private tasting room of the winery. In both session types, participants joined the two consecutive rounds, in each of which they were asked to bid on four wines: two traditional rootstock wines (SO4 - Sangiovese and K5BB Montepulciano) and the corresponding wines produced with innovative rootstock (M4- Sangiovese and M4- Montepulciano). *Type*-A and *type*-B sessions have been identically carried-out with the only difference in the amount and type of information participants received once they joined the first round. Participants in type-A and type-B sessions evaluated the same set of wines. However, participants in *type-A* were encouraged to pay attention to the likely differences in the wines expressed by the rootstocks while participants in *type-B* were informed that any eventual differences could be attributed to the terroir. The information scenarios for both *type*-A and *type*-B sessions are included in Appendix A. In *type-B session* we decided to move the attention of the participants on identifying eventual differences associable to different terroir to reproduce the same level of attention that participants in *type-A* dedicated to looking for eventual differences provided by different rootstocks. In both *type*-A and *type*-B sessions, the participants were asked to indicate their bids based on the given information, and on visual stimuli, without tasting the product (round 1: no taste).

In the second round, the participants tasted the wines (smell, and in mouth) (round 2: full tasting) and then indicated their offer price for the four wines. To summarize, each participant submitted 8 bids (4 wines × 2 rounds). Participants received cash compensation of €10€. However, as this might overestimate the expressed WTP, participants were invited to specify how they would allocate the received cash in the future. This would minimize house money/windfall effect (Galletto et al., 2021). Wines were served using random order among the different sessions to control for any potential order effects (List et al., 2011). A total of 12 sessions (six *type*-A, six *type*-B) have been organized. At the beginning of the experiment, participants were given a questionnaire to collect their main socio demographic information (age, gender, income, education), wine involvement and consumption habits. More in detail, consumers were asked when and where they usually buy wine and at what price. To prevent collusion between participants, no form of communication was permitted among the bidders during the auction.

As discussed earlier, participants in both *type*-A and *type*-B sessions evaluated and tasted the same wines. Consequently, even though *type*-B participants were primarily concerned with terroir differences, they evaluated wines just like *type*-A participants, focusing on differences in rootstock (innovative vs traditional). Each participant provided a total of eight WTP evaluations for the four wines they tasted. For each participant (i) and each wine variety (j - either Sangiovese or Montepulciano), we can calculate the WTP differences between traditional and innovative rootstocks as follows:

$$\Delta WTP_{i,j} = WTP(Innovative)_{i,j} - WTP(Traditional)_{i,j} \quad (1)$$

Furthermore, we observed differences in WTP based on the information provided in the two session types (*type*-A, focusing on rootstocks and environmental implications; *type*-B, emphasizing varietal differences and grape origins). Additionally, there were differences within participant responses from round 1 to round 2. This allows us to quantify four distinct monetary effects.

$$Pure\ Info\ Effect: E\left[\Delta WTP_{i,j}(A.1)\right] - E\left[\Delta WTP_{i,j}(B.1)\right] \quad (2)$$

The Pure Information Effect (PIE, Equation (2)) measures the impact of information about innovative rootstocks and their environmental implications on participant preferences, as reflected in ΔWTP or price premiums. While visual stimuli might similarly affect ΔWTP in both session types, the observed differences between sessions can be attributed solely to the information provided about the innovative versus traditional rootstocks.

We hypothesize that PIE is positive: H1: Pure Info Effect >0.

$$Taste\ Effect: E\left[\Delta WTP_{i,j}(B.2) - \Delta WTP_{i,j}(B.1)\right] \quad (3)$$

The Taste Effect (Equation (3)) represents the difference in participant preferences due to the taste differences (including smell and mouthfeel) between wines made from innovative and traditional rootstocks. Participants in *type*-B sessions, who received only generic information about different terroirs, were the focus for this measurement. We

[7] An additional participant joined unexpectedly during the final session, bringing the total to 201. This individual was included to maintain group cohesion and does not significantly affect the study's statistical power.

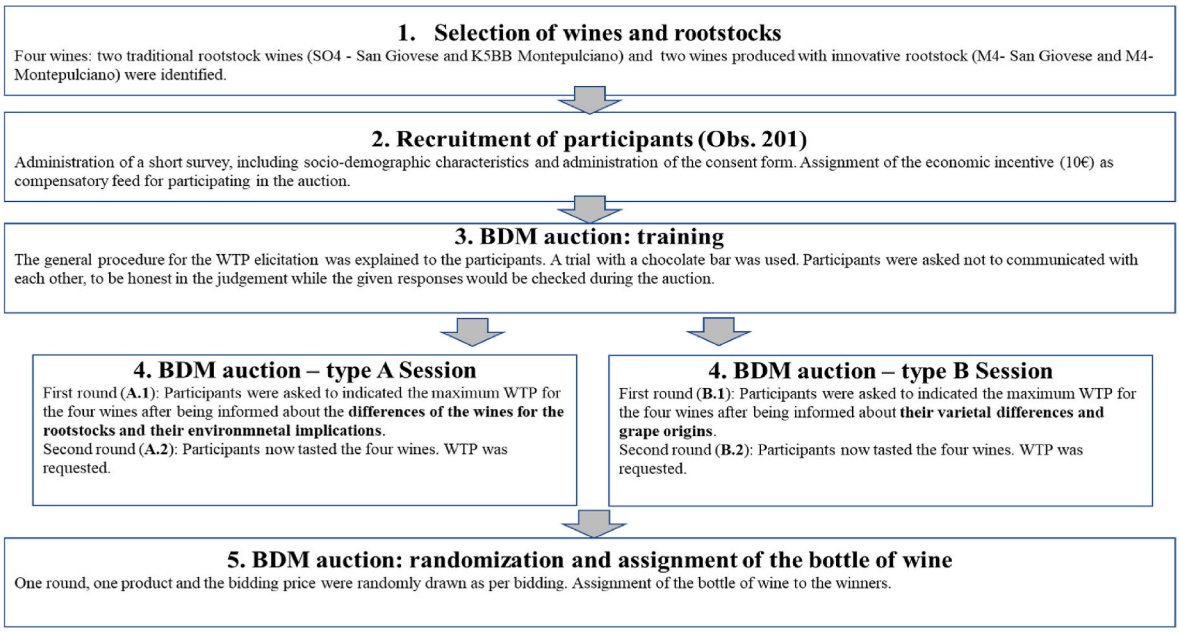

Fig. 1. The experimental procedure followed in the evaluation of M4 rootstock wines.

do not anticipate a significant impact of the innovative rootstock on the tasting experience.

Thus, we hypothesize: H2: Taste Effect = 0.

$$\textit{Info Effect once Tasted} : E\left[\Delta WTP_{ij}(A.2) - \Delta WTP_{ij}(B.2)\right] \quad (4)$$

The Info Effect Once Tasted (Equation (4)) assesses how information about the different rootstocks might influence the tasting experience. If H1 is confirmed, it is possible that the quality expectations set by this information could affect both the tasting experience and consumer perceptions (Vecchio et al., 2019). The hypothesis under test is H3: Info Effect once Tasted ≠ 0.

$$\textit{Dissonance Effect of the Info} : E\left[\Delta WTP_{ij}(\text{A.2}) - \Delta WTP_{ij}(\text{A.1})\right] - E\left[\Delta WTP_{ij}(\text{B.2}) - \Delta WTP_{ij}(\text{B.1})\right] \quad (5)$$

Lastly, we explore the Dissonance Effect (DE) linked to information about the environmental advantages of the innovative rootstock, as defined in Equation (5). A non-zero DE implies a mismatch between consumers' initial expectations about the innovative rootstock and their actual experience when tasting the wine. Conversely, a DE of zero would signify that the information provided in advance perfectly aligns with the consumers' sensory experience during tasting. Specifically, a DE greater than zero indicates that consumers initially had lower expectations, which are positively exceeded upon tasting the wine. Alternatively, a DE less than zero suggests that consumers' high pre-tasting expectations are not met, leading to a negative discrepancy. This phenomenon highlights how information can shape consumer expectations. As noted in previous studies like Vecchio et al. (2019), wine consumers often misjudge the quality of wine based on preconceived notions.

Our current hypothesis, H4, posits that the DE of the Information is not zero. However, existing literature does not provide a clear direction (positive or negative) for this hypothesis. Thus, our investigation is exploratory in nature, seeking to understand the influence of informational dissonance on wine evaluation.

3.2. Participant characteristics

The data on socio-demographic features are summarized in Table 1. The survey was completed by a total of 201 participants, who are almost entirely residents of the regions of Veneto (75%) and Friuli-Venezia Giulia (17%). It was accomplished in observance of the COVID-19 spread prevention guidelines between December 2021 and May 2022. The majority of respondents are male (62%), a percentage that is similar to that shown by most of surveys about Italian wine consumers. Within the sample, singles (46%) and married people (45%) are almost equally represented. Almost half of them has a monthly household income of between €2000 and €4,000, and high school (47%) followed by graduate or postgraduate degree (37%) are the most common education levels. It was not surprising to find that age groups between 25 and 50 years and over 50 years made up a larger number of respondents (88%), who more frequently are wine consumers in Italy.

The participants were assigned to one of two sessions (type-A and type-B) based on a random draw. Before conducting the experimental auction, the informational treatments were tested to ensure that respondents perceived them as intended[8] (Borrello et al., 2021a,b).

There is not a significant difference between the two groups in terms of the demographic factors of gender (Pearson chi2 = 2.28, Pr = 0.13), age (Pearson chi2(3) = 3.88, Pr = 0.14), households' income (Pearson chi2(2) = 3.25, Pr = 0.20), and marital status (Pearson chi2(3) = 4.23, Pr = 0.24), while there is a bland difference between the two sessions in terms of schooling, higher in the first group (Pearson chi2(3) = 7.44, Pr = 0.06).

Moreover, we compared the answers about purchasing and consumption habits across the samples of the two treatments and found no statistically significant difference. Most of the participants buy the wine themselves (94%), purchasing it, in many cases, in the supermarket (52%), mostly between 5 and 15 euros (71%), with over 55% of respondents consuming wine 2–3 times a week.

[8] After presenting the information using a read-aloud format and slides projected on a screen, we verified that participants accurately recalled and assessed the information provided during the wine evaluation process. Given that the participants were wine consumers with a genuine interest in wine, and considering the location of the study, we assumed that the communicated information was perceived as intended. However, it is important to note that a specific manipulation check was not conducted.

Table 1
Sample socio-demographic characteristics and participants' habits related to wine (N = 201).

	Total sample		Rootstock treatment		No rootstock treatment	
	Freq.	%	Freq.	%	Freq.	%
Gender						
Male	125	62.2%	68	67.3%	57	57.0%
Female	76	37.8%	33	32.7%	43	43.0%
Age						
From 18 to 25	24	11.9%	16	15.8%	8	8.0%
From 26 to 50	90	44.8%	40	39.6%	50	50.0%
50 or older	87	43.3%	45	44.6%	42	42.0%
Education						
Elementary	6	3.0%	4	4.1%	2	2.0%
Middle school	24	12.2%	9	9.2%	15	15.2%
High School	93	47.2%	40	40.8%	53	53.5%
Graduate and postgraduate	74	37.6%	45	45.9%	29	29.3%
Household's income						
Less than €1999	67	35.1%	28	29.5%	39	40.6%
€2000–4000	96	50.3%	50	52.6%	46	47.9%
More than €4000	28	14.7%	17	17.9%	11	11.5%
Marital status						
Single	90	45.7%	38	38.8%	52	52.5%
Married	88	44.7%	48	49.0%	40	40.4%
Widowed	3	1.5%	2	2.0%	1	1.0%
Other	16	8.1%	10	10.2%	6	6.1%
Wine purchaser						
Yes	189	94.0%	94	93.1%	95	95.0%
No	12	6.0%	7	6.9%	5	5.0%
Purchase channels						
Wine shop/bar	22	12.5%	13	14.9%	9	10.1%
Online	24	13.6%	16	18.4%	8	9.0%
Supermarket	91	51.7%	37	42.5%	54	60.7%
Cellar door	18	10.2%	9	10.3%	9	10.1%
Others	21	11.9%	12	13.8%	9	10.1%
Purchasing price (per bottle)						
Less than €5.00	23	12.1%	14	14.6%	9	9.6%
€5.00–9.99	72	37.9%	30	31.3%	42	44.7%
€10.00–14.99	63	33.2%	32	33.3%	31	33.0%
€15.00–30.00	30	15.8%	19	19.8%	11	11.7%
More than €30.00	2	1.1%	1	1.0%	1	1.1%
Consumption frequency						
Every day	56	28.4%	29	29.9%	27	27.0%
2–3 times a week	109	55.3%	54	55.7%	55	55.0%
2–3 times a month	32	16.2%	14	14.4%	18	18.0%

3.3. Product characteristics

The auctioned products were four varietal wines made by Vivai Cooperativi Rauscedo from microvinification of wines from traditional rootstocks and innovative rootstocks (i.e., M4) selected by the University of Milan (Scienza et al., 2001); these innovative rootstocks were selected for their specific resistance to drought (Galletto et al., 2014). The study compared two varietal vines created by grafting Sangiovese into SO4 rootstock and Montepulciano d'Abruzzo into K5BB rootstock (hereafter called traditional rootstock wines) with two varietal wines created by grafting the same varietal wine onto M4 rootstock (hereafter called innovative rootstock wines).

Therefore, the only difference between traditional rootstock and innovative rootstock wines was due to the interaction between the lower and upper parts of the joined plants, as all other management characteristics remained the same: grape production parcel, vineyard cultivation technique (i.e., pruning, fertilization, vine protection from diseases, canopy management, etc), harvest date (October 2020), winemaking technique, vintage (2020), and packaging (i.e., bottle shape and format, cork, and labels).

The decision to focus on Sangiovese and Montepulciano was driven by their prominent roles in Italy's viticulture (Rinaldi et al., 2020). As well-known varieties, Sangiovese and Montepulciano d'Abruzzo play major roles in the varietal composition of some Protected Designations of Origin, particularly in Central Italy (e.g., Chianti DOCG, Colline Teramane Montepulciano d'Abruzzo DOCG), and are also prevalent in many other Italian wine regions, making them familiar to most Italian wine consumers. Due to their widespread recognition, these grapes were chosen to minimize variables unrelated to rootstock innovations, ensuring that participants' responses were informed by a well-understood baseline of sensory characteristics (Plott and Zeiler, 2005; Zhao and Kling, 2004). This approach allowed us to isolate the effects of the rootstock changes from other potential influences, such as unfamiliarity with the grape type, thus enabling a focused examination of consumer responses to new rootstock technologies within a familiar context.[9]

The composition parameters of the wines are summarized in Table 2. In the context of winemaking, the chemical characteristics of the final wines, despite displaying some differences, were rather similar between each of the two couples of wines produced using innovative (M4) and non-innovative rootstocks (K5BB and SO4).

4. Results

4.1. Research hypotheses on WTP differences

Table 3 displays the differences in Willingness to Pay between wines made with innovative and traditional rootstocks. During the visual wine-tasting phase, participants indicated a willingness to pay significantly more for wines produced with M4 rootstock (p-value = 0.034) when they were informed about this feature, showcasing the Pure Information Effect (PIE). The average ΔWTP of the PIE, from the baseline outcomes, was €0.36 per bottle, which is a modest premium price increase of about 5%. This confirms hypothesis H1 (Pure Info Effect >0), demonstrating that consumers are willing to pay a small additional amount when they know the wines are made from drought-resistant rootstock.

Regarding hypothesis H2, our findings show no significant difference in the WTP for the four wines during blind tasting in the *type*-B session, indicating that consumers do not perceive any taste differences attributable to the innovative rootstock. This lack of perceived difference held true whether the wine varieties were considered separately or combined. H2, Taste Effect = 0, is thus confirmed.

For hypothesis H3, we compared ΔWTP between fully informed tastings (round II, *type*-A session) and general informed tastings (round II, *type*-B session). The results showed that the Info Effect Once Tasted did not significantly differ from zero. This suggests that the quality expectations set by the information about the resistant rootstock did not

Table 2
Descriptive features of the wine's composition.

Parameters	Montepulciano d'Abruzzo		Sangiovese	
	K5BB	M4	SO4	M4
Reducing sugar (g/L)	3.29	3.10	2.84	2.82
Total phenols (Folin-Ciocalteu) (mg/L)	2301	2025	2141	2128
Total anthocyanins (mg/L)	431	362	251	212
Titratable acidity (g tartaric acid/L)	5.80	5.48	5.60	5.58
Tartaric acid (g/L)	3.78	3.30	2.86	2.91
Malic acid (g/L)	0.14	0.15	0.52	0.52
Lactic acid (g/L)	0.85	0.81	0.68	0.74
pH	3.45	3.46	3.51	3.53
Ethanol (% v/v)	12.45	12.58	12.40	12.47
Volatile acidity (g/L)	0.56	0.55	0.49	0.57

[9] Moreover, these varieties are expression of regions that are more severely hit by drought in comparison with Northern Italy (Boatto et al., 2017).

Table 3
Means (€) and standard errors of willingness-to-pay differences amongst innovative and traditional rootstocks grafted on Sangiovese and Montepulciano according to information and wine tasting.

	Hypotheses	Sangiovese			Montepulciano			Total		
WTP (Innovative - Traditional)		Mean	std. err	*p*-value	Mean	std. err	*p*-value	Mean	std.err	*p*-value
(A1 - B1): Pure Info Effect	H1: pure information effect >0	0.476	0.247	0.055	0.240	0.218	0.273	0.355	0.167	0.034
A1 (info rootstock)		0.177	0.134		0.106	0.218		0.141	0.089	
B1 (no info on rootstock)		−0.300	0.117		−0.134	0.186		−0.214	0.143	
(A2 - B2): Info Effect once Tasted	H3: Info effect once Tasted ≠ 0	−0.053	0.327	0.872	−0.176	0.316	0.579	−0.118	0.227	0.604
A2 (info rootstock)		−0.208	0.182		−0.123	0.184		−0.170	−0.053	
B2 (no info on rootstock)		−0.155	0.272		0.053	0.256		0.129	0.188	
(A2-A1) – (B2-B1): Dis. Effect of the Info	H4: Dissonance effect <0	−0.529	0.301	0.083	−0.415	0.297	0.165	−0.473	0.210	0.026
(A2 – A1) (taste effect | info on rootstock)	H2: Taste effect = 0	−0.380	0.200		−0.229	0.210		−0.311	0.159	
(B2 – B1) (taste effect | no info on rootstock)		0.140	0.340		0.190	0.187		0.160	0.230	

Note: Independent samples *t*-tests with Welch's correction were used to address unequal variances between groups.

translate into the actual tasting experience. Thus, while there is a positive effect of knowing about the drought-resistant rootstock, this perception disappears after tasting the wine. So, in that case, H3, Info Effect once Tasted ≠ 0, cannot be confirmed.

Lastly, the Dissonance Effect (DE) was found to be statistically significant (*p*-value = 0.026), supporting hypothesis H4, DE ≠ 0. However, the negative value of the DE indicates consumer dissatisfaction. It seems that consumers expected wines from the drought-resistant rootstock to taste better than those from traditional rootstocks. Their lack of significant taste difference upon actual tasting led to disappointment. This negative ΔWTP suggests that consumers discount the maximum price they are willing to pay for information about the new rootstock after tasting and realizing the wine does not meet their quality expectations.

Specifically for Sangiovese wines, both the PIE and DE were significant, albeit to a lesser degree than in the overall sample. For Montepulciano wines, all hypotheses showed no significant differences. This might be due to consumers having higher expectations for Sangiovese, commonly used in renowned Tuscan wines, compared to Montepulciano, often seen as a base for inexpensive, mass-consumed wines.

4.2. Drivers of WTP differences

In the second part of our results, we explored whether individual socio-demographic factors and attitudes influence the differences in consumers' WTP for wines made from innovative versus traditional rootstocks (see Tables 4 and 5).

Firstly, as concerns the determinants of the Pure Info Effect (comparing A.I vs. B.I sessions), we found that all examined variables significantly contribute to WTP differences, though to varying extents. Specifically, after learning about the benefits of innovative rootstock wines, males with graduate degrees aged between 26 and 50 showed a higher WTP (*p*-value <0.01). Additionally, wine connoisseurs were willing to pay an extra €1.45 per bottle, those with higher household incomes an extra €0.65 per bottle, and frequent wine consumers an additional €0.44 per bottle.

Secondly, in the context of Info Effect once Tasted with full information about the innovative rootstock wines compared to general information (A.II vs. B.II), no significant WTP differences were observed. Thirdly, when keeping session information constant (A.I vs. A.II), it was noted that consumers who tasted the wines showed a significantly lower WTP for new rootstocks compared to those who did not taste the wines in detail. Intriguingly, the same factors that were significant in the pure information context were significant here as well (*p*-value <0.05), but with a negative impact.

Fourthly, when general information on wine varieties and terroirs was given (B.I vs. B.II), the results were similar to the information effect after tasting. None of the socio-demographic and attitude variables analyzed were effective in explaining WTP differences.

Lastly, the Dissonance Effect of the Info was more pronounced among younger consumers (under 26 years), women, those with less subjective wine knowledge, moderate wine consumers, and those in intermediate income brackets (€2000 - €4000 per household). Their revised ΔWTP for innovative rootstock wines, compared to traditional ones, was significantly lower than initially stated, and negative across all indicators.

Table 4
Drivers of WTP differences amongst innovative and traditional rootstocks wines – information effects.

	A.I - B.I (Pure Info Effect)			A.II - B.II (Info Effect once Tasted)		
	Mean	std. err	*p*-value	Mean	std. err	*p*-value
	0.355	0.167	0.034	−0.118	0.227	0.604
Age:						
Younger than 26	0.357	0.338	0.296	−0.948	0.616	0.131
26-50	0.676	0.194	0.001	0.069	0.274	0.801
More than 50	0.084	0.172	0.627	−0.152	0.220	0.490
Gender:						
Women	0.232	0.211	0.273	−0.270	0.304	0.376
Men	0.409	0.147	0.006	−0.051	0.199	0.797
Education:						
Primary&secondary	−0.292	0.307	0.344	−0.368	0.326	0.264
Diploma	0.394	0.181	0.031	−0.320	0.247	0.197
Graduate or post - graduate	0.634	0.193	0.001	0.170	0.312	0.586
Wine knowledge:						
A little	0.349	0.172	0.044	−0.177	0.241	0.464
Fairly	0.321	0.181	0.078	0.047	0.245	0.848
Very	1.449	0.653	0.046	−0.853	1.121	0.462
Wine consumption:						
2–3 times a month	0.275	0.292	0.351	0.384	0.423	0.367
2–3 times a week	0.312	0.171	0.071	−0.191	0.245	0.437
Every day	0.437	0.220	0.050	−0.289	0.288	0.317
Income:						
Less than € 2000	0.367	0.206	0.077	0.067	0.294	0.820
Between € 2000 and € 4000	0.310	0.170	0.069	−0.102	0.246	0.680
More than € 4000	0.645	0.390	0.100	−0.351	0.483	0.471

Note: Independent samples *t*-tests with Welch's correction were used to address unequal variances between groups.

5. Discussion

Facing climate change has stimulated innovative solutions in viticulture aimed at mitigating negative impacts and enabling adaptation at both the firm and regional levels (Quénol et al., 2014; Santos et al., 2020; Gutiérrez-Gamboa et al., 2021). Our research supports the promising potential of the M4 rootstock for vine growers. This rootstock not only facilitates high-quality production (Corso et al., 2016; Merli et al., 2016) but also aligns with consumer demand for environmentally

Table 5
Drivers of WTP differences amongst innovative and traditional rootstocks wines – taste and dissonance effects.

	A.II - A.I (Taste effect informed)			(B.II - B.I) (Taste Effect non informed)			(A.II - A.I) - (B.II-B.I) (Dissonance)		
	Mean	std.err	*p*-value	Mean	Std.err	*p*-value	Mean	Std.err	*p*-value
	−0.311	0.159	0.038	0.161	0.230	0.337	−0.473	0.210	0.026
Age:									
Younger than 26	−0.168	0.305	0.584	1.218	0.747	0.113	−1.386	0.562	0.015
26-50	−0.310	0.191	0.106	0.364	0.274	0.186	−0.674	0.368	0.069
More than 50	−0.380	0.171	0.028	−0.058	0.249	0.815	−0.322	0.316	0.310
Gender:									
Women	−0.329	0.214	0.126	0.306	0.305	0.318	−0.635	0.209	0.003
Men	−0.332	0.141	0.019	0.179	0.221	0.419	−0.511	0.275	0.065
Education:									
Primary&secondary	−0.108	0.321	0.738	0.110	0.373	0.768	−0.218	0.516	0.673
Diploma	−0.519	0.187	0.006	0.213	0.248	0.391	−0.732	0.338	0.032
Graduate or post - graduate	−0.226	0.170	0.186	0.338	0.367	0.360	−0.564	0.405	0.166
Wine knowledge:									
A little	−0.326	0.173	0.061	0.260	0.240	0.281	−0.586	0.228	0.011
Fairly	−0.231	0.170	0.177	0.154	0.281	0.583	−0.385	0.342	0.262
Very	−1.222	0.448	0.014	1.126	1.629	0.515	−2.349	1.299	0.073
Wine consumption:									
2–3 times a month	−0.154	0.318	0.630	−0.167	0.394	0.673	0.012	0.727	0.987
2–3 times a week	−0.256	0.163	0.118	0.320	0.271	0.240	−0.576	0.229	0.013
Every day	−0.506	0.224	0.026	0.339	0.297	0.257	−0.845	0.400	0.036
Income:									
Less than € 2000	−0.264	0.218	0.228	0.122	0.281	0.665	−0.386	0.435	0.376
Between € 2000 and € 4000	−0.201	0.167	0.230	0.303	0.271	0.265	−0.504	0.230	0.030
More than € 4000	−0.795	0.307	0.012	0.317	0.622	0.613	−1.112	0.583	0.058

Note: paired samples *t*-tests for repeated measures within the same group were used.

friendly products.

Previous studies, such as those by Galletto et al. (2014), have shown the economic benefits of drought-resistant rootstocks like M4. These innovations are increasingly recognized in the wine industry's environmental performance standards, as noted by Ene et al. (2013) and Costa et al. (2016). There is a growing call from consumers and environmental groups for companies to reduce the water footprint of their products, recognizing both community and environmental benefits (Rinaldi et al., 2016). Additionally, understanding consumer perceptions of drought and climate change is critical for sustainable water management, as it can identify barriers to behavioral change (Lynn, 1989). However, while wines produced using drought-tolerant rootstocks might be favored by consumers for their lower environmental impact, introducing new rootstocks could be seen as departing from traditional practices in an industry where historical heritage is extremely significant (Di Vita et al., 2024).

Our findings indicate that consumers are willing to pay a modest premium (5% higher) for wines made from the innovative M4 rootstock when informed about the water-saving benefits. The results support those reported by Di Vita et al. (2024) indicating that wines produced from innovative rootstocks are particularly appealing to consumers. This preference may be attributed to historical challenges such as phylloxera, which necessitated the adoption of new rootstocks. Over time, this has fostered consumer acceptance of wines derived from these innovations. Consequently, consumers might tend to view these rootstocks as a non-intrusive and effective response to climate challenges (Di Vita et al., 2024). On a broader level, the results align with those reported by Forbes et al. (2009) and Barber (2012), who highlight a growing consumer awareness of environmental issues in the wine sector, driving a shift toward eco-friendly products. Similarly, Pomarici et al. (2018) observed a strong preference for sustainable wines among millennials, although these studies do not specifically focus on rootstocks. These consumers are more willing to pay extra for wines that are labeled as saving water, as shown by Casado-Díaz et al. (2020). Furthermore, Cappelli et al. (2020) found that consumers' belief in sustainability labels and their pro-environmental attitudes significantly influence their purchasing decisions.

While the 5% increase in WTP is promising, it might not sufficiently incentivize winegrowers to widely adopt the innovative rootstocks unless paired with external support. Such support could include government or regional subsidies aimed at promoting sustainable viticulture (Doğan et al., 2020). Indeed, although the price premium might not offset the higher expenses involved in transitioning existing vineyards to these new rootstocks, it is important to note that the cost comparison becomes more favorable when establishing new vineyards. This is because the initial investment in grafted vines of these innovative rootstocks is comparable to that of traditional ones. Nonetheless, the financial viability of adopting these rootstocks is contingent upon the specific phase in the vineyard's lifecycle and prevailing market conditions (Galletto et al., 2014).

This 5% increase might be seen as a conservative estimate, given that the relatively minor water scarcity issues in the study area may exert less influence on consumer perceptions, especially concerning their valuation of drought-resistant rootstocks like M4. Nevertheless, in regions where water scarcity is more acute, consumers could demonstrate a higher willingness to pay (WTP) for such innovations, spurred by a direct awareness of the implications of water shortages. Consequently, the WTP for wines produced using water-efficient rootstocks could be significantly higher in these areas (Pomarici et al., 2018). Moreover, other segments more concerned by drought risk as well as communication efforts in highlighting the benefit of the M4 may support higher premiums (Di Vita et al., 2024).

The second main result is that vine growers can be soundly assured about the quality of wines produced by using the M4, given that no taste effect was evidenced in our experiment for both the two varietal wines (Meggio et al., 2014; Corso et al., 2016). However, the fact that the information effect when wines are tasted is null suggests that wineries should avoid any message linking the use of innovative rootstock with organoleptic quality. Indeed, the dissonance effect, which results in negative results without stressing any sensorial properties of the M4-based wines, could imply dissatisfaction after the first tasting, preventing fidelity to wines produced by the new rootstock.

The DE is particularly high for young generations, perhaps meaning high expectations from this group of consumers, which are then deluded once they have tested the M4-based wines. While direct studies on cognitive dissonance in wine consumer preferences, especially among

Generation Y, are limited, existing research does suggest that factors like label design and brand can significantly influence their wine quality expectations. Masson et al. (2008) discussed the impact of non-sensory cues on perceived quality, focusing on the example of low-alcohol wine. They suggested that when there is a difference between a consumer's expectations and the actual performance of the wine, the consumer will adjust their perception of the product to align with their expectations in order to maintain consistency. Similarly, it is plausible to assume that when the wine's quality, as perceived through information, does not match the actual hedonic liking experience, it may result in consumer dissatisfaction or dissonance.

Both of the two significant effects highlighted in this paper suggest varied pricing and communication strategies based on the distribution channel (Kotler and Keller, 2012; Moon and Cho, 2023). In the off-trade, emphasizing the drought-resistant rootstock and its environmental benefits, along with a modest premium over wines produced with traditional rootstocks, can be effective. This approach leverages findings like Maciejczak's (2020) on consumers' willingness to pay more for climate-adapted production. Conversely, in the on-trade sector, where wines are bought and tasted simultaneously, it is advisable to avoid highlighting these aspects extensively. Here, the focus should be more on immediate sensory experience, as Schmit et al. (2013) note the dominance of sensory effects in consumer valuation in such settings, and excessive emphasis on the rootstock's attributes might lead to cognitive dissonance and potential consumer disappointment.

For viticulture to become more resistant and resilient, putting it in a stronger position to face the challenges of counteracting the effects of rising temperatures in vineyards (Van Leeuwen and Darriet, 2016), the increased frequency of extreme weather events, and the consequent decrease in water availability for agricultural use, specific policy interventions appear crucial from the perspective of developing climate change adaptation strategies (Boselli et al., 2016; Van Leeuwen et al., 2019).

The adoption of specific production techniques should align closely with consumer preferences and corresponding marketing strategies (Stanco et al., 2020). Firstly, maintaining a consistently high quality standard for wines produced using new rootstocks is crucial to meet the expectations of consumers, especially among wine novices, aficionados, regular buyers, and both younger and middle-aged demographics.

Secondly, marketing initiatives must be strategically designed to effectively communicate the value of using drought-resistant rootstocks. The adoption of a specific green label could help to solidify the brand's reputation for sustainability among consumers. Through such targeted marketing, consumers are directed towards making choices that are in line with their expectations and environmental attitudes (Migliore et al., 2020; Pagliarini et al., 2013; Schmit et al., 2013). This strategy not only emphasizes the significant environmental benefits provided by the innovative rootstocks but also stimulates consumers' variety-seeking behaviour, motivated by the need to discover new stimuli and acquire experiential knowledge, as supported by research from Caracciolo et al. (2022).

6. Conclusions

The innovative M series rootstocks could represent a significant advancement in the water uptake efficiency of wine grape production. These rootstocks demand considerably less water than traditional vine-grafted varieties, thus increasing the vinicultural ecosystem's resilience, especially in terms of resistance to prolonged water stress under extreme heat conditions. From the consumer perspective, our findings empirically demonstrate no notable differences in the quality perception of wines produced with these innovative rootstocks. Moreover, when the sustainability attributes of these wines are effectively communicated, consumers demonstrate a greater willingness to pay a premium for them—approximately 5% more. This price increase has the potential to balance out the elevated costs linked to grape production when stressed by water shortage and mitigate the risks associated with adopting this innovative approach in vineyard management. Our study's focus on water-reducing rootstocks offers new insights into consumer valuation of sustainability in viticulture, marking a significant step forward in the research on how advanced agricultural practices influence market dynamics. Furthermore, identifying the specific consumer strata most responsive to these innovations enables targeted marketing strategies that could accelerate the adoption of sustainable practices in the sector.

Our study, while insightful, presents several limitations that should be acknowledged. Firstly, the participant selection was not random but followed a first-come sequence, which might introduce biases in the sample representation. Secondly, the participants were exclusively from the Veneto Region. This area has historically been less affected by drought-related issues in agriculture, particularly in viticulture, which could influence local perceptions and experiences related to climate-adaptive viticulture practices. Thirdly, the choice of wines for the study—two specific varieties—might not fully represent the typical preferences of the majority of consumers in the Veneto Region, potentially skewing their appreciation and evaluation.

Additionally, the use of the Becker-DeGroot-Marschak auction mechanism within a real-store setting introduces a complexity that might impact consumer bidding behavior. This method, while providing realistic valuation, might be influenced by factors such as the immediate retail environment, peer influence, or situational buying habits, which are not typically present in more controlled experimental settings. Moreover, the study did not perform a manipulation check, and therefore, caution should be exercised when interpreting the findings. Finally, this study focused on a single case study, potentially limiting the applicability of our hypotheses to different food products or experimental settings.

While our design facilitated a controlled investigation of the proposed hypotheses, the scope for directly generalizing these findings to broader, real-world contexts is indeed limited. This constraint is not unique to our study but is a characteristic of experimental research more broadly. The controlled conditions that allow for the isolation and examination of specific variables also necessitate caution when considering the application of these findings beyond the experimental setting. Furthermore, our focus on understanding the nature of information effects, rather than quantifying a universally applicable WTP, underscores the need for further research.

To comprehensively validate our findings and overcome these limitations, further research across diverse geographical contexts is necessary. Future studies should consider a wider variety of wines and employ random sampling methods to ensure a broader representation. Additionally, exploring different auction formats or settings might provide more insights into consumer valuation behavior. Such expansive research would enhance our understanding of consumer responses to wines produced with innovative rootstocks like the M series and offer a more generalized view of the market's reception to sustainable viticulture practices.

CRediT authorship contribution statement

Luigino Barisan: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation. **Luigi Galletto:** Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Deborah Franceschi:** Writing – review & editing, Writing – original draft, Investigation, Data curation. **Francesco Caracciolo:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Formal analysis, 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.

Acknowledgements

This research did not receive any specific grant from funding agencies in the public, commercial, or.

not-for-profit sectors. We want to thank the Paladin Winery for its valuable cooperation.

Appendix A

In *type*-A sessions, participants received the following information on the difference of the rootstocks used for the four wines and on the environmental advantages of those wines using M4 rootstocks:

"*Climate change could have very serious effects on the future production of wine grapes. Some scientific studies have estimated that by 2040 the land traditionally used for viticulture will be reduced by about 50%. The scientific community is working to identify some solutions to allow winegrowers to counter the effects of global warming and preserve viticulture in drought-prone soils, limit the consumption of water resources and protect the landscape in marginal agricultural areas. The selection of new rootstocks that are more resistant to drought and other environmental stresses might represent one of the solutions. In front of you are presented two types of PDO wines obtained in a company located on Italian territory and Sangiovese and Montepulciano grapes are used to make the wines. The only difference is in the rootstock. The rootstocks represent the root systems and the lower part of the vine on which the different varieties of wine grapes are grafted.*

W and X wines were produced with a rootstock normally used in the vineyard, while Y and Z wines were produced with a new rootstock which, in addition to saving water where the vine is irrigated, allows to preserve viticulture in land subject to drought and thus protect the landscape and the agricultural landscape";

In *type*-B sessions, participants received the following information on the terroir characterizing the four different wines:

"*Terroir is a fundamental element in determining the sensory characteristics of wine, i.e., a geographical differentiation of the wine product. It depends on how the physical and biological features of the growing environment, the microclimate of the parcel where the vineyard is, and the winegrower's knowledge, skills, and ways of growing work together.*

In front of you are presented two types of wines obtained from a winery situated in a Protected Designation of Origin region of Central Italian. Each type of wine is obtained in two different parcels with specific characteristics in terms of pedology, topography, landscape, biodiversity, and climate.

The Sangiovese and Montepulciano grapes are used to make the wines, which are produced on two parcels called "Terroir WX" and "Terroir YZ". Wines W and X wines were produced within "Terroir WX", while Y and Z wines were produced in "Terroir YZ".

References

Bandinelli, R., Acuti, D., Fani, V., Bindi, B., Aiello, G., 2020. Environmental practices in the wine industry: an overview of the Italian market. Br. Food J. 122, 1625–1646. https://doi.org/10.1108/BFJ-08-2019-0653.

Barber, N., 2012. Consumers' intention to purchase environmentally friendly wines: a segmentation approach. Int. J. Hospit. Tourism Adm. 13 (1), 26–47.

Bazoche, P., 2015. Sustainable wine choice. Retrieved from. https://doi.org/10.1016/B978-0-08-100596-5.21406-6.

Berti, E., 2022. I portainnesti M sono la risposta alla siccità? Ecco i dati dello studio dell'Università di Milano. I grandi vini. https://www.igrandivini.com/non-solo-vino/portainnesti-m/.

Boatto, V., Barisan, L., Teo, G., 2017. Evaluation of irrigation resources for emergency drought situations in the production of the Conegliano Valdobbiadene Prosecco's DOCG. Aestimum 31–49.

Bohm, P., Lindén, J., Sonnegård, J., 1997. Eliciting reservation prices: Becker–DeGroot–Marschak mechanisms vs. markets. Econ. J. 107 (443), 1079–1089. https://doi.org/10.1111/j.1468-0297.1997.tb00008.x.

Borrello, M., Cembalo, L., Vecchio, R., 2021a. Role of information in consumers' preferences for eco-sustainable genetic improvements in plant breeding. PLoS One 16.

Borrello, M., Cembalo, L., Vecchio, R., 2021b. Consumers' acceptance of fungus resistant grapes: future scenarios in sustainable winemaking. J. Clean. Prod. 307, 127318 https://doi.org/10.1016/j.jclepro.2021.127318.

Borrello, M., Cecchini, L., Vecchio, R., Caracciolo, F., Cembalo, L., Torquati, B., 2022. Agricultural landscape certification as a market-driven tool to reward the provisioning of cultural ecosystem services. Ecol. Econ. 193, 107286 https://doi.org/10.1016/j.ecolecon.2021.107286.

Boselli, M., Tempesta, G., Fiorilo, M., Brandi, M., 2016. Resistance and resilience to changing climate of Tuscany and Valpolicella wine grape growing regions in Italy. In: BIO Web of Conferences, vol. 7. EDP Sciences.

Capitello, R., Sirieix, L., 2019. Consumers' perceptions of sustainable wine: an exploratory study in France and Italy. Economies 7 (2), 33. https://doi.org/10.3390/economies7020033.

Cappelli, L., D'Ascenzo, F., Arezzo, M., Ruggieri, R., Gorelova, I., 2020. The willingness to pay in the food sector: testing the hypothesis of consumer preferences for some made in Italy products. Sustainability 12 (15), 6275. https://doi.org/10.3390/su12156275.

Caracciolo, F., Cembalo, L., Pomarici, E., 2013. The hedonic price for an Italian grape variety. Ital. J. Food Sci. 25 (3), 289.

Caracciolo, F., Furno, M., D'Amico, M., Califano, G., Di Vita, G., 2022. Variety seeking behavior in the wine domain: a consumers segmentation using big data. Food Qual. Prefer. 97, 104481.

Casado-Díaz, A.B., Sellers-Rubio, R., Rodriguez-Sanchez, C., Sancho-Esper, F., 2020. Predictors of willingness to pay a price premium for hotels' water-saving initiatives. J. Trav. Tourism Market. 37 (7), 773–784. https://doi.org/10.1080/10548408.2020.1761125.

Charness, G., Gneezy, U., Kuhn, M.A., 2012. Experimental methods: between-subject and within-subject design. J. Econ. Behav. Organ. 81 (1), 1–8. https://doi.org/10.1016/j.jebo.2011.08.009.

Compés, R., Faria, S., Gonçalves, T., Rebelo, J., Navarro, V., Elorz, K., 2021. The shock of lockdown on the spending on wine in the Iberian market: the effects of procurement and consumption patterns. Br. Food J. https://doi.org/10.1108/BFJ-03-2021-0258.

Corrigan, J.R., Rousu, M.C., 2006. Posted prices and bid affiliation: evidence from experimental auctions. Am. J. Agric. Econ. 88 (4), 1078–1090. https://doi.org/10.1111/j.1467-8276.2006.00917.x.

Corso, M., Vannozzi, A., Ziliotto, F., Zouine, M., Maza, E., Nicolato, T., Vitulo, N., Meggio, F., Valle, G., Bouzayen, M., Müller, M., Munné-Bosch, S., Lucchin, M., Bonghi, C., 2016. Grapevine rootstocks differentially affect the rate of ripening and modulate auxin-related genes in cabernet sauvignon berries. Front. Plant Sci. 7, 69. https://doi.org/10.3389/fpls.2016.00069.

Costa, J.M., Vaz, M., Escalona, J., Egipto, R., Lopes, C., Medrano, H., Chaves, M.M., 2016. Modern viticulture in southern Europe: vulnerabilities and strategies for adaptation to water scarcity. Agric. Water Manag. 164, 5–18. https://doi.org/10.1016/j.agwat.2015.09.016.

Costanigro, M., McFadden, D.T., Kroll, S., Nurse, G., 2011. An in-store valuation of local and organic apples: the role of social desirability. Agribusiness 27 (4), 465–477. https://doi.org/10.1002/agr.20276.

Del Giudice, T., Stranieri, S., Caracciolo, F., Ricci, E.C., Cembalo, L., Banterle, A., Cicia, G., 2018. Corporate social responsibility certifications influence consumer preferences and seafood market price. J. Clean. Prod. 178, 526–533. https://doi.org/10.1016/j.jclepro.2018.01.194.

Di Vita, G., Califano, G., Raimondo, M., Spina, D., Hamam, M., D'Amico, M., Caracciolo, F., 2024. From roots to leaves: understanding consumer acceptance in implementing climate-resilient strategies in viticulture. Aust. J. Grape Wine Res. 2024 (1), 8118128.

Doğan, H.P., Aydoğdu, M.H., Sevinç, M.R., Cançelik, M., 2020. Farmers' willingness to pay for services to ensure sustainable agricultural income in the GAP-Harran Plain, Şanlıurfa, Turkey. Agriculture 10 (5), 152.

Ene, S.A., Teodosiu, C., Robu, B., Volf, I., 2013. Water footprint assessment in the winemaking industry: a case study for a Romanian medium size production plant. J. Clean. Prod. 43, 122–135. https://doi.org/10.1016/j.jclepro.2012.12.033.

Fabbrizzi, S., Sottini, V., Cipollaro, M., Menghini, S., 2021. Sustainability and natural wines: an exploratory analysis on consumers. Sustainability 13 (14), 7645. https://doi.org/10.3390/su13147645.
Faul, F., Erdfelder, E., Buchner, A., Lang, A.G., 2009. Statistical power analyses using G* Power 3.1: tests for correlation and regression analyses. Behav. Res. Methods 41 (4), 1149–1160.
Fernández-Serrano, P., Tarancón, P., Bonet, L., Besada, C., 2022. Consumers' visual attention and choice of 'Sustainable Irrigation'-labeled wine: logo vs. text. Agronomy 12 (3), 685. https://doi.org/10.3390/agronomy12030685.
Forbes, S.L., Cohen, D.A., Cullen, R., Wratten, S.D., Fountain, J., 2009. Consumer attitudes regarding environmentally sustainable wine: an exploratory study of the New Zealand marketplace. J. Clean. Prod. 17 (13), 1195–1199. https://doi.org/10.1016/j.jclepro.2009.04.008.
Gallenti, G., Troiano, S., Marangon, F., Bogoni, P., Campisi, B., Cosmina, M., 2019. Environmentally sustainable versus aesthetic values motivating millennials' preferences for wine purchasing: evidence from an experimental analysis in Italy. Agricultural and Food Economics 7, 1–16. https://doi.org/10.1186/s40100-019-0132-x.
Galletto, L., Barisan, L., Boatto, V., Costantini, A.C., Lorenzetti, R., Pomarici, E., Vecchio, R., 2014. More crop for drop – climate change and wine: an economic evaluation of a new drought-resistant rootstock. Recent Pat. Food, Nutr. Agric. 6 (2), 100–112.
Galletto, L., Caracciolo, F., Boatto, V., Barisan, L., Franceschi, D., Lillo, M., 2021. Do consumers really recognise a distinct quality hierarchy amongst PDO sparkling wines? The answer from experimental auctions. Br. Food J. 123 (4), 1478–1493.
Gazzola, P., Grechi, D., Pavione, E., Gilardoni, G., 2022. Italian wine sustainability: new trends in consumer behaviors for the millennial generation. Br. Food J. https://doi.org/10.1108/BFJ-05-2021-0493.
Gow, J., Rana, R.H., Moscovici, D., Uguaglia, A.A., Valenzuela, L., Mihailescu, R., Coelli, R., 2022. Australian consumers and environmental characteristics of wine: price premium indications. Int. J. Wine Bus. Res. 34 (4), 542–566.
Gutiérrez-Gamboa, G., Zheng, W., Martinez de Toda, F., 2021. Strategies in vineyard establishment to face global warming in viticulture: a mini review. J. Sci. Food Agric. 101 (4), 1261–1269. https://doi.org/10.1002/jsfa.10766.
Guttuso, F.G., 1906. La ricostituzione dei vigneti fillosserati. Alberto Reber - Libreria della R. Casa, Palermo.
Harrison, G.W., List, J.A., 2004. Field experiments. J. Econ. Lit. 42 (4), 1009–1055. https://doi.org/10.1257/0022051043004577.
Howard, C., 2016. Climate change: times are a-changing – the effects of climate change on wine production practices. Wine & Viticulture Journal 31 (5), 17–22.
Janssen, M., Schäufele, I., Zander, K., 2020. Target groups for organic wine: the importance of segmentation analysis. Food Qual. Prefer. 79, 103785 https://doi.org/10.1016/j.foodqual.2019.103785.
Jones, G.V., White, M.A., Cooper, O.R., Storchmann, K., 2005. Climate change and global wine quality. Climatic Change 73 (3), 319–343. https://doi.org/10.1007/s10584-005-4704-2.
Kotler, P., Keller, K.L., 2012. Marketing Management, fourteenth ed. Pearson Education.
Lerro, M., Yeh, C.H., Klink-Lehmann, J., Vecchio, R., Hartmann, M., Cembalo, L., 2021. The effect of moderating variables on consumer preferences for sustainable wines. Food Qual. Prefer. 94, 104336 https://doi.org/10.1016/j.foodqual.2021.104336.
List, J.A., Sadoff, S., Wagner, M., 2011. So you want to run an experiment, now what? Some simple rules of thumb for optimal experimental design. Exp. Econ. 14, 439–457. https://doi.org/10.1007/s10683-011-9275-7.
Lusk, J.L., Feldkamp, T., Schroeder, T.C., 2004. Experimental auction procedure: impact on valuation of quality differentiated goods. Am. J. Agric. Econ. 86 (2), 389–405. https://doi.org/10.1111/j.0092-5853.2004.00586.x.
Lynn, M., 1989. Scarcity effects on desirability: mediated by assumed expensiveness? J. Econ. Psychol. 10 (2), 257–274. https://doi.org/10.1016/0167-4870(89)90023-8.
Maciejczak, M., 2020. Factors determining the purchase of wine from climate change adapted production. Annals of the Polish Association of Agricultural and Agrobusiness Economists 22 (2).
Maesano, G., Vita, G., Chinnici, G., Gioacchino, P., D'Amico, M., 2021. What's in organic wine consumer mind? A review on purchasing drivers of organic wines. Wine Economics and Policy 10 (1), 3–21. https://doi.org/10.36253/wep-9101.
Mariani, A., Vastola, A., 2015. Sustainable winegrowing: current perspectives. Int. J. Wine Res. 37–48.
Marín, D., Armengol, J., Carbonell-Bejerano, P., Escalona, J.M., Gramaje, D., Hernández-Montes, E., Intrigliolo, D.S., Martínez-Zapater, J.M., Medrano, H., Mirás-Avalos, J. M., Palomares-Rius, J.E., Romero-Azorín, P., Savé, R., Santesteban, L.G., de Herralde, F., 2021. Challenges of viticulture adaptation to global change: tackling the issue from the roots. Aust. J. Grape Wine Res. 27, 8–25. https://doi.org/10.1111/ajgw.12463.
Masson, J., Aurier, P., d'Hauteville, F., 2008. Effects of non-sensory cues on perceived quality: the case of low-alcohol wine. Int. J. Wine Bus. Res. 20 (3), 215–229. https://doi.org/10.1108/17511060810901037.
McGarry Wolf, M., Higgins, L.M., 2017. Segmenting the sustainable wine consumer. J. Food Distrib. Res. 48 (856–2018-3086), 109–110.
Meggio, F., Prinsi, B., Negri, A.S., Simone Di Lorenzo, G., Lucchini, G., Pitacco, A., et al., 2014. Biochemical and physiological responses of two grapevine rootstock genotypes to drought and salt treatments. Aust. J. Grape Wine Res. 20 (2), 310–323.
Merli, M.C., Magnanini, E., Gatti, M., Pirez, F.J., Pueyo, I.B., Intrigliolo, D.S., Poni, S., 2016. Water stress improves whole-canopy water use efficiency and berry composition of cv. Sangiovese (Vitis vinifera L.) grapevines grafted on the new drought-tolerant rootstock M4. Agric. Water Manag. 169, 106–114.
Mian, G., Nassivera, F., Sillani, S., Iseppi, L., 2022. Grapevine resistant cultivars: a story review and the importance on the related wine consumption inclination. Sustainability. https://doi.org/10.3390/su15010390.
Migliore, G., Thrassou, A., Crescimanno, M., Schifani, G., Galati, A., 2020. Factors affecting consumer preferences for "natural wine". Br. Food J. 122, 2463–2479. https://doi.org/10.1108/BFJ-07-2019-0474.
Moon, C., Cho, M., 2023. An exploratory study of wine supplier selection criteria using the revised IPA: comparison between on-premise and off-premise retailers. Foodservice Management Society of Korea.
OIV, 2011. *OIV guidelines for sustainable viticulture adapted to table grapes and raisins: production, storage, drying, processing and packaging of producets*—resolution OIV-VITI 422-2011. In: Paris.
Olsen, J.E., Atkin, T., Thach, L., Cuellar, S.S., 2015. Variety seeking by wine consumers in the southern states of the US. Int. J. Wine Bus. Res. 27 (4), 260–280.
Pagliarini, E., Laureati, M., Gaeta, D., 2013. Sensory descriptors, hedonic perception and consumer's attitudes to Sangiovese red wine deriving from organically and conventionally grown grapes. Front. Psychol. 4, 896.
Paulsen, F., 1908. In: Relazione tecnica sui lavori eseguiti nel cantiere di forzatura ed innesto meccanico delle viti americane presso la società di acclimazione e degli Agricoltori Siciliani in Palermo, Palermo. Stabilimento Tipografico Virzì.
Peterson, J., Richmond, F., Ferrara, A., Watts, K., Casassa, L., 2019. The Longevity of Sustainable Vineyard Practices. Wine Business Case Research Journal. https://doi.org/10.26813/wbcrj/2019.03.01/longevity.
Plott, C.R., Zeiler, K., 2005. The willingness to pay-willingness to accept gap, the 'endowment effect,' subject misconceptions, and experimental procedures for eliciting valuations. Am. Econ. Rev. 95 (3), 530–545.
Pomarici, E., Vecchio, R., 2014. Millennial generation attitudes to sustainable wine: an exploratory study on Italian consumers. J. Clean. Prod. 66, 537–545.
Pomarici, E., Asioli, D., Vecchio, R., Næs, T., 2018. Young consumers' preferences for water-saving wines: an experimental study. Wine Economics and Policy 7 (1), 65–76.
Provost, C., Pedneault, K., 2016. The organic vineyard as a balanced ecosystem: improved organic grape management and impacts on wine quality. Sci. Hortic. 208, 43–56. https://doi.org/10.1016/J.SCIENTA.2016.04.024.
Quénol, H., Marie, G., Barbeau, G., Van Leeuwen, C., Hofmann, M., Foss, C., Irimia, L., Rochard, J., Boulanger, J.P., Tissot, C., Miranda, C., 2014. Adaptation of viticulture to climate change: high resolution observations of adaptation scenario for viticulture: the ADVICLIM European project. Bull. OIV 87 (1001–1002-1003), 395–406.
Rinaldi, S., Bonamente, E., Scrucca, F., Merico, M.C., Asdrubali, F., Cotana, F., 2016. Water and carbon footprint of wine: Methodology review and application to a case study. Sustainability 8 (7), 621. https://doi.org/10.3390/su8070621.
Rinaldi, A., Moine, V., Moio, L., 2020. Astringency subqualities and sensory perception of Tuscan Sangiovese wines. Oeno One 54 (1), 75–85.
Ruggeri, G., Mazzocchi, C., Corsi, S., 2020. Drinking biodiversity: a choice experiment on Franciacorta sparkling wines. Br. Food J. 122 (8), 2531–2549. https://doi.org/10.1108/BFJ-06-2019-0451.
Sacchelli, S., Fabbrizzi, S., Menghini, S., 2016. Climate change effects and adaptation strategies in the wine sector: a quantitative literature review. Wine Economics and Policy 5 (2), 114–126.
Santini, C., Cavicchi, A., Casini, L., 2013. Sustainability in the wine industry: key questions and research trends a. Agricultural and Food Economics 1, 9. https://doi.org/10.1186/2193-7532-1-9.
Santos, J., Fraga, H., Malheiro, A., Moutinho-Pereira, J., Dinis, L., Correia, C., Moriondo, M., Leolini, L., Dibari, C., Costafreda-Aumedes, S., Kartschall, T., Menz, C., Molitor, D., Junk, J., Beyer, M., Schultz, H., 2020. A review of the potential climate change impacts and adaptation options for European viticulture. Appl. Sci. 10, 3092. https://doi.org/10.3390/app10093092.
Schäufele, I., Hamm, U., 2017. Consumers' perceptions, preferences, and willingness-to-pay for wine with sustainability characteristics: a review. J. Clean. Prod. 147, 379–394. https://doi.org/10.1016/J.JCLEPRO.2017.01.118.
Schäufele, I., Hamm, U., 2018. Organic wine purchase behaviour in Germany: exploring the attitude-behaviour-gap with data from a household panel. Food Qual. Prefer. 63, 1–11. https://doi.org/10.1016/J.FOODQUAL.2017.07.010.
Schmit, T.M., Rickard, B., Taber, J., 2013. Consumer valuation of environmentally friendly production practices in wines, considering asymmetric information and sensory effects. J. Agric. Econ. 64, 483–504.
Scienza, A., Failla, O., Brancadoro, L., 2001. Adaptation des porte-greffes et des cépages aux conditions pédo-climatiques de l'Italie. J. Int. Sci. Vigne Vin 32, 77–96.
Sellers-Rubio, R., Nicolau-Gonzalbez, J.L., 2016. Estimating the willingness to pay for a sustainable wine using a Heckit model. Wine Economics and Policy 5 (2), 96–104.
Simeone, M., Russo, C., Scarpato, D., 2023. Price quality cues in organic wine market: is there a Veblen effect? Agronomy. https://doi.org/10.3390/agronomy13020405.
Sogari, G., Mora, C., Menozzi, D., 2016. Sustainable wine labeling: a framework for definition and consumers' perception. Agriculture and Agricultural Science Procedia 8, 58–64. https://doi.org/10.1016/J.AASPRO.2016.02.008.
Sogari, G., Pucci, T., Aquilani, B., Zanni, L., 2017. Millennial generation and environmental sustainability: the role of social media in the consumer purchasing behavior for wine. Sustainability 9, 1–16. https://doi.org/10.3390/SU9101911.
Stanco, M., Lerro, M., Marotta, G., 2020. Consumers' preferences for wine attributes: a best-worst scaling analysis. Sustainability 12 (7), 2819.
Tait, P., Saunders, C., Dalziel, P., Rutherford, P., Driver, T., Guenther, M., 2019. Estimating wine consumer preferences for sustainability attributes: a discrete choice experiment of Californian Sauvignon blanc purchasers. J. Clean. Prod. 233, 412–420.

Ugalde, D., Renaud-Gentié, C., Symoneaux, R., 2021. Perception of French wine buyers regarding environmental issues in wine production. J. Wine Res. 32, 77–102. https://doi.org/10.1080/09571264.2021.1940902.

Van Leeuwen, C., Darriet, P., 2016. The impact of climate change on viticulture and wine quality. Journal of Wine Economics 11 (1), 150–167.

Van Leeuwen, Destrac-Irvine A., Dubernet, M., Duchêne, E., Gowdy, M., Marguerit, E., Pieri, P., Parker, A., de Rességuier, L., Ollat, N., 2019. An update on the impact of climate change in viticulture and potential adaptations. Agronomy 9 (9), 514. https://doi.org/10.3390/agronomy9090514.

Vecchio, R., 2013. Determinants of willingness-to-pay for sustainable wine: evidence from experimental auctions. Wine Economics and Policy 2 (2), 85–92.

Vecchio, R., Lisanti, M.T., Caracciolo, F., Cembalo, L., Gambuti, A., Moio, L., Siani, T., Marotta, G., Nazzaro, C., Piombino, P., 2019. The role of production process and information on quality expectations and perceptions of sparkling wines. J. Sci. Food Agric. 99 (1), 124–135.

Wagner, M., Stanbury, P., Dietrich, T., Döring, J., Ewert, J., Foerster, C., et al., 2023. Developing a sustainability vision for the global wine industry. Sustainability 15 (13), 10487.

Waldrop, M.E., McCluskey, J.J., Mittelhammer, R.C., 2017. Products with multiple certifications: insights from the US wine market. Eur. Rev. Agric. Econ. 44 (4), 658–682.

Wei, R., Wang, L., Ding, Y., Zhang, L., Gao, F., Chen, N., et al., 2023. Natural and sustainable wine: a review. Crit. Rev. Food Sci. Nutr. 63 (26), 8249–8260.

Zhao, J., Kling, C.L., 2004. Willingness to pay, compensating variation, and the cost of commitment. Econ. Inq. 42 (3), 503–517. https://doi.org/10.1093/ei/cbh077.

Dalmasso, G., Sutter, G., 1915. Contributo alla ricerca di buoni vitigni da vino rosso e di adatti portinnesti per la Provincia di Treviso, vol. XXI. Rivista di Viticoltura e Enologia, p. 5.