



## How much is sustainability worth in luxury food? The case of the Pistacchio Verde di Bronte PDO

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### ABSTRACT

This study explores how sustainability-related information affects consumers' willingness to pay for Pistacchio Verde di Bronte PDO, a luxury agri-food product. Using an experimental auction with multiple price lists and random-effects interval regression models, the results show that transparent communication about environmentally sustainable practices increases perceived value, although the effects vary across consumer segments. While PDO certification remains an important signal of quality, transparency of costs related to the implementation of environmentally sustainable practices, such as Integrated Pest Management, increases perceived equity and justifies premium price. These findings contribute to the literature on credence goods, perceived quality, and segmentation, offering practical insights for producers and policymakers on how to design targeted sustainability communication strategies in differentiated premium markets.

### 1. Introduction

Increasing attention to environmental sustainability has changed the agricultural landscape, prompting producers and consumers to rethink traditional production methods (Young et al., 2023).

In recent decades, the need to reduce the environmental impact of agricultural activities such as pest control has led to the development of innovative production methods that reduce harmful and pollutant emissions (Barzman et al., 2015; Lefebvre et al., 2015). Several Integrated Pest Management (IPM) methods have been developed to reduce the use of chemical pesticides, favoring the use of biological control agents, bio-pesticides and advanced monitoring technologies (Jaworski et al., 2023; Han et al., 2024; Yang et al., 2025). Such a shift is not only an important step towards more sustainable agricultural practices, but also responds to growing consumer demand for agricultural products produced using environmentally friendly methods (Van Loo et al., 2011; Zhou and Hu, 2023; Lee, 2025).

Although there are numerous studies on sustainability in agriculture and how consumers perceive the value of the sustainability of the end product (e.g. Grunert, 2011; Sánchez-Bravo et al., 2021; Jaeger et al., 2023), some aspects have still not been fully clarified. To illustrate, most of the scientific literature focuses on widely available agricultural

products such as fruit, vegetables and cereals, while niche products, often associated with "premium" quality have received less attention (Loureiro and Hine, 2002). This raises new questions about whether and how consumers are aware of the environmental impact of the production process of premium agricultural products and whether consumers evaluate the quality of a premium product that has been produced through environmentally sustainable agricultural practices.

In principle, consumer demand for sustainable agricultural products does not exclude so-called "premium" or "luxury" foods, i.e. foods that are refined in terms of texture, taste, fat content or other characteristics and are characterised by their quantity or quality (Van der Veen, 2003; Hartmann et al., 2016). To avoid ambiguity, we adopt the definition of "premium" foods as products that have superior quality characteristics, such as taste, origin or production method, and that are priced higher than conventional alternatives (Loureiro and Umberger, 2003). On the other hands the term "luxury" food refers to products that, in addition to premium characteristics, have symbolic or cultural value and are often associated with prestige, rarity or strong geographical identity (Hartmann et al., 2016).

This is of interest insofar as sustainability is also becoming an important value driver for luxury products (Hennigs et al., 2013). Luxury brands in the fashion and food sectors are investing heavily in 'green

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premium' strategies, where sustainability is a key component of perceived quality (Kapferer and Michaut, 2015; Athwal et al., 2019).

The question therefore arises as to whether consumers perceive high-quality food from sustainable production as even more exclusive and desirable. This would make sustainability a new differentiation criterion that, in addition to other aspects, could create added value for luxury foods that are already highly valued. With this in mind, we have focused our study on a high-end agri-food product with growing international reputation, namely Pistacchio Verde di Bronte (Sicily-Italy), which was awarded the PDO (Protected Designation of Origin) label and is increasingly recognized for its distinctive organoleptic qualities and use in gourmet culinary contexts (Wilson et al., 2018; Arena et al., 2007).

Although Pistacchio Verde di Bronte PDO can be used in everyday products such as ice cream or pastries, it remains a product with exceptional sensory characteristics, distinct terroir-based organoleptic qualities, symbolic value within Italian gastronomy and high market prices per kilogram, which together support its positioning in the luxury agri-food segment in the sense defined by Hartmann et al. (2016). From a theoretical point of view, luxury goods are often defined as products whose demand increases with price due to their signaling function, what Veblen called "conspicuous consumption". Although the Pistacchio Verde di Bronte PDO may not fully conform to Veblen's classic definition of a luxury good, its high price, territorial uniqueness, limited production and use in gourmet or culturally symbolic culinary contexts suggest characteristics typical of "accessible luxury" or "cultural luxury" food products (Hartmann et al., 2016). Furthermore, the consumption of such products may reflect preferences based on identity and cultural capital rather than utilitarian value alone.

Recent research supports the idea that sustainability preferences are not evenly distributed across consumer groups. Piracci et al. (2024) show that WTP for sustainable attributes tends to be higher among consumers of premium or specialty foods, often linked to higher income, education, and awareness levels. These consumers are more likely to integrate ethical and environmental considerations into purchasing decisions. This heterogeneity justifies a targeted exploration of sustainability preferences within the luxury food segments and motivates our focus on Pistacchio Verde di Bronte PDO as a case study for high-end agri-food products.

More recently, Pistacchio Verde di Bronte PDO has also been interested in testing sustainable production techniques such as but not only the introduction of IPM techniques at farm level through the use of bio-pesticides and advanced pest monitoring to reduce the use of chemical pesticides (Gusella et al., 2024). These techniques not only preserve biodiversity and soil quality, but are also believed to preserve the organoleptic quality of the finished product (Arena et al., 2007; Melli-keche et al., 2024). However, a crucial aspect of consumer perception is information asymmetry (Nestorowicz, 2013), i.e. the difficulty in distinguishing between a product that has been grown using traditional methods and one that has been obtained using more sustainable methods. Recalling Akerlof's (1970) theory, information asymmetry can reduce willingness to pay (WTP) for higher value products because consumers do not have enough information to assess the real added value of sustainability. To illustrate, consumers may not be fully aware of the differences in cultivation methods for food products and may not be able to distinguish between a "luxury" and a "luxury sustainable" product. This phenomenon is relevant for Pistacchio Verde di Bronte PDO, as not all producers use environmentally sustainable practices and the lack of adequate information may prevent consumers from recognizing and evaluating the "sustainable" efforts of farmers.

Although previous studies have investigated sustainability signals for food (Sigurdsson et al., 2022), there is a need for evidence on how these factors affect premium or PDO-certified food. In particular, it is

understudied whether transparent information about sustainable practices and the associated costs can reduce information asymmetry and influence willingness to pay for luxury foods. This study aims to fill this gap by focussing on PDO Pistacchio Verde di Bronte and using a non-hypothetical experimental auction to test how cost-based sustainability information influences consumers' evaluations. It thus contributes to a better understanding of how the transparency of sustainable practices can add value and segment markets in the high-end agri-food sector.

This study addresses this question by examining the extent to which providing information about sustainable practices can reduce information asymmetry and influence consumer WTP. According to the "signaling" theory (Spence, 1973), the introduction of certifications and targeted communication strategies on could help producers to signal higher product quality. On this basis, this study contributes to closing the scientific gap on the role of information asymmetry in "luxury" food products and provides new insights into how communication can reinforce the perceived value of sustainability in such products. Specifically, the aim of this study is to examine whether consumers perceive ecologically sustainable farming practices as an additional factor for improving the quality of Pistacchio Verde di Bronte PDO. In particular, it examines the extent to which the use of IPM techniques that reduce environmental impact influences consumer perceptions of a food traditionally valued for its unique natural and organoleptic characteristics (Wilson et al., 2018). In this way, we can understand whether sustainability is included in consumers' quality assessment beyond the established reputation of the PDO label.

From this conceptual framework, two main research questions emerge:

- RQ1: How does information about sustainable farming practices, such as IPM, influence consumers' willingness to pay for luxury food?
- RQ2: How do individual consumer characteristics influence the willingness to pay for sustainably produced luxury food, for example by employing IPM farming practices?

The first research question (RQ1) investigates whether and how the communication of sustainability-related information particularly concerning IPM techniques affects consumers' willingness to pay for Pistacchio Verde di Bronte PDO. Analyzing the question through the lens of credence goods theory (Darby and Karni, 1973) and the problem of information asymmetry (Akerlof, 1970), consumers cannot directly observe the environmental impact of production methods. Consequently, signaling theory (Spence, 1973) suggests that transparent and detailed communication can increase perceived value and justify a higher price, as might happen when information is provided on the production costs incurred by farmers in implementing IPM techniques in pistachio orchards.

The second research question (RQ2) explores potential heterogeneity in consumer response to this information. While some consumers may rely primarily on the PDO certification as a proxy for quality, others may perceive additional value in environmentally sustainable practices. This heterogeneity aligns with segmentation theory (Barry and Weinstein, 2009) and with existing literature showing that consumer behavior in relation to sustainability is shaped by individual characteristics, such as awareness, income, education, and values. Given the focus of this study on luxury food products, income is considered a particularly relevant demographic variable, as it is often associated with the affordability and consumption of luxury goods. Moreover, income is closely related to other demographic factors such as age, gender, and education, which are commonly used in market segmentation studies to profile consumer

preferences (Blackwell et al., 2006; Gil et al., 2000; Yue et al., 2009). While demographic variables alone may not fully capture consumers' underlying attitudes or behaviors, they offer a useful starting point for identifying distinct consumer segments and exploring structural heterogeneity in responses (Kihlberg and Risvik, 2007). Accordingly, income is included as a key segmentation criterion in this study to capture potential differences in how consumer groups respond to sustainability-related attributes.

Therefore, understanding these differentiated responses is essential for developing effective market and communication strategies for luxuryagri-food products.

To investigate the above research questions, an economic experiment on Pistacchio Verde di Bronte PDO was conducted involving a convenience sample of consumers in a non-hypothetical experiment in Sicily (Italy) in May and June 2024. Consumers' WTP was estimated by means of an Experimental Auction (EA) using the Multiple Price List (MPL) approach.

The results show that informing participants about sustainable pest management practices on farms growing Pistacchio Verde di Bronte PDO significantly increases consumers' WTP. This indicates that consumers also value the environmental benefits of the luxury food. However, the WTP for sustainability of the luxury food is a more complex and segmented phenomenon than previously thought.

This study has numerous practical implications for both producers and market and policy makers in terms of defining new marketing strategies and more effective communication techniques, as well as better market segmentation through the application of luxury pricing strategies.

## 2. Materials and methods

### 2.1. Data collection

The economic experiment conducted using the MPL approach (Drichoutis and Lusk, 2016; Selvaggi et al., 2025) was conducted in Bronte (Sicily) in May and June 2024. A total of 97 Sicilian consumers agreed to take part in the survey. Although the study involved a small sample, this is a common element in experimental auction research, which involves relatively small groups (Canavari et al., 2019).

Participants were recruited via social media from April 2024 and came from different locations in Sicily. Just in the invitation letter, each potential participant was informed that he or she would have to make a series of non-hypothetical choices according to an approach called experimental auction, a scientific incentive compatible method involving real consumer preferences.

Participants who agreed to take part in the experiment were invited in the experimental lab and randomly assigned to one of six planned and conducted experimental sessions (Table 1).

### 2.2. Experimental auction protocol

The experimental auction using the MPL approach was conducted only with participants who agreed to take part in the study and were invited to attend at a scheduled date and time, following the structured protocol below:

**Table 1**  
Experimental auction sessions.

Session ID	Date	Participants (n.)
1	May 23, 2024	13
2	May 23, 2024	22
3	May 27, 2024	17
4	May 28, 2024	11
5	June 10, 2024	17
6	June 11, 2024	17

1. Welcoming and ID Assignment: upon arrival, participants were welcomed and seated at individual computer stations. Each participant was randomly assigned an anonymous ID to ensure confidentiality.
2. Subgroups creation: all session participants were automatically assigned, via the system, to subgroups of 4 or 5 members each. The composition of the subgroups is anonymous: no participant knows which subgroup they belong to, nor who the other members of their subgroup are.
3. Explanation of EA Rules: the moderator explained how the EA mechanism works and provided details about the auctioned product i.e. a 100-g packet of shelled Pistacchio Verde di Bronte PDO.
4. Training Phase: in order to familiarize the participants with the MPL method, a trial session was conducted with a test product (a 0.5 kg pack of pasta).
5. EA sessions: each participant performed 16 rounds subdivided in 2 groups of 8 round each.
  - 5.1 Before the first group of 8 rounds, moderator provided information about shelled Pistacchio Verde di Bronte PDO, produced according to IPM farming practices;
  - 5.2 After the first group of 8 rounds, moderator provided information about the cost incurred by farmers to adopt the aforementioned IPM farming practices.
6. Winning procedure: at the end of the session, the moderator randomly drew both one ID and one round number. The participant whose ID was drawn was considered the "winner" and received the option chosen in the drawn round (i.e., either 100 g of shelled Pistacchio Verde di Bronte PDO or receive the alternative cash amount).
7. Reward: all participants received a gift as a token of appreciation for their participation, consisting of a T-shirt and a cap featuring the logo of the CleanPistachio project, which funded this research. Finally, a questionnaire was administered, including socio-demographic questions about the participants in the experiment.

This procedure is incentive-compatible because participants knew from the outset that any round could be binding, and therefore had an incentive to reveal their true preferences in each round (Lusk and Shogren, 2007).

All the procedure was computer-based, in an experimental lab. Participants were seated at individual computer stations, physically separated from one another, and had no possibility to communicate with each other or to interact with the moderator during the survey. This arrangement was adopted to prevent any potential influence or bias in their responses.

Thus, each participant conducted a total of 16 rounds of the experimental auction using the MPL approach. In each of the 16 rounds, each participant had to make a real choice between the following two options:

- Option A: a 100-g bag of shelled Pistacchio Verde di Bronte PDO, produced according to IPM techniques;
- Option B: an amount of cash, with an increasing value (+€0.5 from one round to the next - from 4.5€ to 7.5€).

Each session (16 rounds) was divided into two groups (Group 1 and Group 2) with 8 rounds each. In each of the two groups, the participants received the same price list, as shown in Table 2.

In the first round of each group, respondents were asked if they wanted neither pistachios nor cash.

Before the first of the 16 scheduled rounds, the moderator explained the detailed information shown in Fig. 1 about the auctioned good that is i.e. a 100-g bag of Pistacchio Verde di Bronte PDO produced using IPM techniques. The IPM protocol details were read aloud by the moderator while participants followed the text on their individual computer screens. This procedure ensured that all participants received the same information and facilitated comprehension, while minimizing the risk of

**Table 2**  
Experimental design.

Group	Round	Option A	Option B
<b>Information provided to participants about shelled Pistacchio Verde di Bronte PDO, produced according to IPM farming practices</b>			
Group 1	1	Pistachio “Clean”, no money	NO pistachio “Clean”, no money
	2	Pistachio “Clean”, no money	NO pistachio “Clean”, 4.5 € cash
	3	Pistachio “Clean”, no money	NO pistachio “Clean”, 5.0 € cash
	4	Pistachio “Clean”, no money	NO pistachio “Clean”, 5.5 € cash
	5	Pistachio “Clean”, no money	NO pistachio “Clean”, 6.0 € cash
	6	Pistachio “Clean”, no money	NO pistachio “Clean”, 6.5 € cash
	7	Pistachio “Clean”, no money	NO pistachio “Clean”, 7.0 € cash
	8	Pistachio “Clean”, no money	NO pistachio “Clean”, 7.5 € cash
<b>Information about the cost incurred by farmers to adopt IPM farming practices</b>			
Group 2	9	Pistachio “Clean”, no money	NO pistachio “Clean”, no money
	10	Pistachio “Clean”, no money	NO pistachio “Clean”, 4.5 € cash
	11	Pistachio “Clean”, no money	NO pistachio “Clean”, 5.0 € cash
	12	Pistachio “Clean”, no money	NO pistachio “Clean”, 5.5 € cash
	13	Pistachio “Clean”, no money	NO pistachio “Clean”, 6.0 € cash
	14	Pistachio “Clean”, no money	NO pistachio “Clean”, 6.5 € cash
	15	Pistachio “Clean”, no money	NO pistachio “Clean”, 7.0 € cash
	16	Pistachio “Clean”, no money	NO pistachio “Clean”, 7.5 € cash

misinterpretation.

The participants also learned that the same IPM techniques had already been applied in some pilot farms as part of a larger research project funded by the European Commission and the Regional Government of Sicily entitled “CleanPistachio”.

After the first 8 rounds, participants were presented with the specific production costs incurred by farmers as a result of applying the protocol shown in Fig. 1. These costs (Table 3) were analytically determined through direct surveys in the partner farms of the “CleanPistachio” project that have implemented the above protocol.

After the presentation of the costs, the participants completed the remaining 8 rounds.

The order of the information treatments was not randomized: par-

chooses the 100-g packet of Pistacchio Verde di Bronte PDO and instead opts for cash reveals their price threshold and thus the limit of their WTP for the auctioned product.

**2.3. Statistical analysis**

The bidding data obtained from the MPL experiment were point, right-censored or interval data. For example, if a respondent chooses option B in the first round of a given group, their WTP is zero and it is point data. On the other hand, if a respondent chooses option B for the first time in the second round, their WTP is (0, 4.5] and is interval data. Furthermore, if a respondent does not choose option B until the end, his WTP is (7.5, +∞], which is right-censored data.

In addition, since data were obtained twice for each individual (group 1 and 2), the data were panel data. In panel data analysis, two common assumptions can be made regarding the individual-specific effect: the random effects assumption and the fixed effects assumption. The random effects assumption states that unobserved individual heterogeneity is uncorrelated with the independent variables, whereas the fixed effects assumption allows for correlation between the individual-specific effect and the independent variables. Moreover, if the random effects assumption holds, the random effects estimator is more efficient than the fixed effects model (Wooldridge, 2010). In this study, endogeneity is not expected to be an issue, as only exogenous Group2 dummy and demographic variables are used as independent variables.

Thus, following Wik et al. (2004) and Hörisch and Kirchkamp (2010), a random-effects interval-data regression model was applied, using Stata 17.0 software.

The equation considers the linear regression model with panel-level random effects:

$$Bid_{it} = \mathbf{x}_{it}\beta + v_i + \varepsilon_{it} \tag{1}$$

where  $Bid_{it}$  represents the bid amount for individual panel  $i$ , and information absence or presence at time  $t$ . The term  $\mathbf{x}_{it}$  denotes the  $1 \times K$  vector containing explanatory variables; while  $\beta$  represents their parameter vector. The term  $v_i$  captures random effects that account for individual-specific characteristics, and  $\varepsilon_{it}$  is the error term.

As mentioned above, the observed data in this study consist of pairs  $[Bid_{1it}, Bid_{2it}]$ , such that the only information available is  $Bid_{1it} \leq Bid_{it} \leq Bid_{2it}$ , where  $Bid_{2it}$  is possibly  $+\infty$  (StataCorp, 2021). In the case of  $Bid_{1it} = Bid_{2it} = Bid_{it}$ ,  $Bid_{it}$  is point data.

Assuming  $v_i \sim N(0, \sigma_v^2)$  and  $\varepsilon_{it} \sim N(0, \sigma_\varepsilon^2)$ , the likelihood function for individual  $i$  th is given by:

Speech during the presentation of the IPM protocol	IPM protocol adopted by the pistachio farms involved in the “CleanPistachio” project as presented to the participants of EA *
<p>A goal that is becoming increasingly relevant in pistachio tree management is the control of fungal pests that affect the root system and trunk of the pistachio plant.</p> <p>This can be achieved by adopting an innovative, low-impact control strategy that increases plant resistance by employing biological products and growth promoters (microelements, bio stimulants, and resistance inducers).</p> <p>This control strategy, in addition to reducing the amounts of copper used, makes it possible to:</p> <p>(a) prevent the occurrence of infections in the trunk and roots of the pistachio plant;</p> <p>(b) reduce the environmental impact of the production process and maintain the naturalness of the land;</p> <p>(c) produce a healthier end product because the products used are all zero residue;</p> <p>(d) to prevent the harmful effects of mycotoxigenic fungi that develop postharvest in processing environments.</p>	<p>IPM practices during the fall and winter period.</p> <ul style="list-style-type: none"> <li>- Root crown and root: AGILUS BIO (Mycorrhizal fungi of the species <i>Glomus</i> sp.), DECCO GROW (fluid seaweed extracts (<i>ascophyllum nodosum</i>), QA3 (adhesive).</li> <li>- Pruning cuts: REMEDIER (<i>Trichoderma asperellum</i> and <i>Trichiderma gamsii</i>).</li> <li>- Trunk and branches: AIRONE EXTRA (cupro fungicide)</li> </ul> <p>IPM practices during the spring and summer period.</p> <ul style="list-style-type: none"> <li>- Root crown and root: AGILUS BIO, DECCO GROW, QA3.</li> <li>- Trunk and branches: AIRONE EXTRA.</li> <li>- Foliage: REMEDIER, SYLIT (Micronized rock powder), AMYLO-X (<i>Bacillus amyloliquefaciens</i>, D747 strain).</li> <li>- Base of the plant: REMEDIER</li> </ul>

**Fig. 1.** Information provided to participants before round 1.

icipants first received the basic description of the treatment, followed by the cost information. This sequence was necessary because cost information would have not been meaningful without prior knowledge of the treatment itself. The aim of this MPL experimental auction was to determine the price at which each individual would switch from option A to option B. Indeed, the round in which an individual no longer

**Table 3**  
Estimated average costs of implementing IPM farming practices under the CleanPistachio project.

Item	Cost (Euro/ha)
Cost of technical equipment	1350.00
Cost of distribution	800.00
<b>Total cost</b>	<b>2150.00</b>

$$L_i = \int_{-\infty}^{\infty} \frac{e^{-v_i^2/2\sigma_v^2}}{\sqrt{2\pi\sigma_v}} \left\{ \prod_{t=1}^2 F(Bid_{1it}, Bid_{2it}, \mathbf{x}_{it}\beta + v_i) \right\} dv_i \tag{2}$$

where,

$$F(Bid_{1it}, Bid_{2it}, \mathbf{x}_{it}\beta + v_i) = \begin{cases} (\sqrt{2\pi\sigma_\epsilon})^{-1} e^{-(Bid_{1it} - \mathbf{x}_{it}\beta - v_{it})^2 / (2\sigma_\epsilon^2)} & \text{if } (Bid_{1it}, Bid_{2it}) \text{ is point data} \\ 1 - \Phi\left(\frac{Bid_{1it} - \mathbf{x}_{it}\beta - v_{it}}{\sigma_\epsilon}\right) & \text{if } (Bid_{1it}, Bid_{2it}) \text{ is right censored data} \\ \Phi\left(\frac{Bid_{2it} - \mathbf{x}_{it}\beta - v_{it}}{\sigma_\epsilon}\right) - \Phi\left(\frac{Bid_{1it} - \mathbf{x}_{it}\beta - v_{it}}{\sigma_\epsilon}\right) & \text{if } (Bid_{1it}, Bid_{2it}) \text{ is interval data} \end{cases} \tag{3}$$

where  $\Phi(\cdot)$  denotes the cumulative normal distribution function (Wik et al., 2004; StataCorp, 2021).

Due to the limited sample size, we did not include a separate control group receiving only IPM information and no additional information

**Table 4**  
Socio-demographic characteristics of the interviewed sample.

Variable	n.	%
<i>Gender</i>		
Male	49	50.5 %
Female	48	49.5 %
<i>Age</i>		
18-30 y.o.	40	41.2 %
31-50 y.o.	43	44.3 %
>50 y.o.	14	14.4 %
<i>Educational level</i>		
Middle school	17	17.5 %
High school	58	59.8 %
Degree	20	20.6 %
Post-degree	2	2.1 %
<i>Annual household income</i>		
<20 k€	34	35.1 %
20-39,9 k€	42	43.3 %
40-59,9 k€	12	12.4 %
60-79,9 k€	4	4.1 %
>80 k€	5	5.2 %
<i>Number of underaged in the family</i>		
0	18	18.6 %
1	50	51.5 %
2	19	19.6 %
>2	10	10.3 %
<i>In the family, do you lead a fund cultivated with pistachios trees?</i>		
Yes	27	27.8 %
No	70	72.2 %
<i>Do you purchase products obtained using techniques with reduced environmental impact (e.g., organic farming, integrated farming, etc.), and if so, how often?</i>		
No	23	23.7 %
Yes, frequently (at least 1 time per week)	23	23.7 %
Yes, rarely (less than 1 time per week)	51	52.6 %

about costs. Instead, our analyses rely on within-subject comparisons, using participants' initial responses (prior to the cost-related information) as the baseline for the estimates.

This paper estimates two models: the main-effects model (hereafter referred to as the “basic model”) and the interaction-effects model

(hereafter referred to as the “extended model”). In the main-effects model, the explanatory variables include a constant term and dummy variables that provide information on the cost incurred by farmers to adopt the eco-sustainable defence plan. The interaction-effects model extends this by incorporating interactions between the variables from the main-effects model and individual characteristics. These characteristics include a female dummy, age group dummy, an annual household income, a pistachio farmer dummy, and a college graduate or higher dummy.

The selection of interaction terms in the extended model was guided by previous studies highlighting the moderating role of socio-demographic factors in sustainability-related preferences and willingness to pay (e.g., Grunert et al., 2014; Loureiro and Hine, 2002). Specifically, gender and income have been shown to influence both environmental attitudes and purchasing behavior, justifying their inclusion as moderators of the treatment effect. The inclusion of education and farming status dummies reflects evidence that knowledge and occupational experience may shape the perceived relevance or cost-benefit evaluation of eco-sustainable practices. Hence, these interactions were introduced to capture potential heterogeneity in marginal willingness to pay across distinct consumer profiles.

### 3. Results

#### 3.1. Socio-demographic

The sample of 97 respondents is fairly evenly distributed in terms of key characteristics, with a slight preponderance of certain age groups, education levels and average incomes (Table 4).

In terms of gender, the sample is balanced between men (50.5 %) and women (49.5 %), suggesting that the results of the WTP analysis are unlikely to be significantly affected by a preponderance of one gender over the other. In terms of age groups, the 31–50 age group is the most represented (44.3 %), followed by the younger group (18–30 years, 41.2 %), while participants over 50 make up 14.4 % of the sample.

**Table 5**  
Basic Model: effect of information about costs of IPM control on WTP.

	Coefficient	Std. err.	z	P > z	[95 % conf. Interval]	
Group2 dummy	0.582	0.143	4.06	0.000	0.301	0.862
_cons	529.651	0.218	24.30	0.000	4869.351	572.367
$\sigma_u$	1880.059	0.164	11.43	0.000	1557.808	220.231
$\sigma_\epsilon$	0.907	0.081	11.17	0.000	0.747	1065.811
rho	0.811	0.039			0.725	0.879
LR test of $\sigma_u = 0$ : chibar2(01) = 86.82			Prob >= chibar2 = 0.000			

The sample shows a generally high level of education, with a prevalence of high school and university graduates.

The annual household income distribution indicates that most respondents belong to lower and middle-income households, with relatively few in the higher income brackets.

Notably, 27.8 % of respondents operate a pistachio farm. This background may influence their familiarity with production processes, possibly leading to a different perception of product value and sustainability practices, which could affect their bidding behavior. While the remaining 72.2 % are not directly involved in pistachio production. This suggests that the sample is predominantly made up of consumers rather than producers, which is useful for evaluating the perception of sustainability from the perspective of end consumers.

An interesting aspect concerns the frequency with which environmentally friendly products are purchased. 52.6 % rarely buy them, which indicates a positive but not yet fully established inclination towards sustainability. 23.7 % buy them frequently, indicating a segment of consumers who are already loyal, while 23.7 % do not buy sustainable products at all, indicating the presence of barriers possibly related to the price or perceived added value of these products.

### 3.2. WTP results

The estimated basic model analyzed the effect of providing information on costs for implementing IPM farming practices (Group2 dummy variable) on consumers' WTP (Table 5). The results show that the coefficient of the Group2 dummy variable is 0.5817 with a p-value < 0.000, indicating that the information provided significantly increased the average WTP of the participants. The intragroup variance index ( $\rho = 0.8113$ ) indicates that a significant portion of the variability in WTP is explained by individual differences between participants. The likelihood ratio (LR) test on the variance of individual effects confirms that the use of a random effects model is appropriate ( $p < 0.000$ ).

Table 6 shows the average WTP values derived from the model's linear predictions. In the first group of 8 rounds, the average WTP for a 100-g packet of shelled Pistacchio Verde di Bronte PDO was €5.30, while in the second group this value increased to €5.88. These results indicate that providing detailed information about the costs associated with implementing sustainable pistachio pest control practices has a positive impact on participants' willingness to pay.

These findings help us answer the first research question (RQ1). The results of the baseline model show that providing such information on the costs of the IPM strategy adopted by pistachio growers significantly increases consumers' WTP, suggesting that sustainability is indeed perceived as an additional quality attribute that complements traditional indicators such as geographical origin and sensory characteristics. This confirms that sustainability represents an added value for many consumers in relation to high-quality agricultural and food products.

In order to answer the second research question (RQ2), an extended model was estimated that includes socio-demographic variables and their interactions with the Group2 dummy variable (Table 7). By conducting a LR test to compare the pooled model, emerged  $\rho = 0.805$ ,  $\bar{\chi}^2 = 83.64$ ,  $P\text{-value} = 0.000$ ; this confirms that it is appropriate to use a random effects model. In this model, some variables were statistically significant. The first significant variable is age. Participants between 40 and 50 years (s40) have a significantly higher WTP compared to other groups (coefficient = 1.476,  $p = 0.024$ ). Participants over 50 years (sm50) also have a higher WTP (coefficient = 1.429,  $p = 0.034$ ). In terms of education level, participants with a university or

**Table 6**  
WTP mean results.

	Mean	St. Dev.
WTP_Group1	5.30 €	0.21
WTP_Group2	5.88 €	0.21

postgraduate degree (over\_graduate) show a lower WTP than others (coefficient = -0.930,  $p = 0.077$ ). It seems that older consumers are willing to pay more than younger ones, while consumers with higher education levels are less inclined to increase their WTP even when they receive additional information about the costs of adopting sustainable pest control methods in pistachio orchards.

The interaction variable between income and information on the costs of adopting IPM farming practices (income\_averaged) has a negative and marginally significant coefficient (coefficient = -0.260,  $p = 0.079$ ), suggesting that higher income individuals tend to adjust their WTP less after receiving information on the additional costs of adopting IPM strategies for pistachios.

The other variables in the model were not significant. No significant effects emerge for the interactions between Group2 dummy and the age or income categories, indicating that the effect of the information on WTP is fairly consistent across groups.

In summary, these results confirm that information about costs for implementing IPM techniques plays an important role in influencing consumers' WTP for pistachios produced with reduced environmental impact from pest control operations. However, the degree of response varies based on socio-demographic characteristics.

## 4. Discussion

In general, the results of this study show that informing consumers about the IPM farming practices used in the production of Pistacchio Verde di Bronte PDO significantly increases the WTP compared to the value of traditional pistachio from Bronte PDO. These results confirm that consumers recognize an extra value to the environmental benefits of a luxury food by increasing its overall value.

With regard to the research questions investigated in this study, we can state the following.

The results suggest that sustainability is perceived as an additional quality attribute that complements traditional indicators such as geographical origin and sensory characteristics. This confirms that sustainability represents added value for many consumers in connection with high-quality agricultural and food products.

Interestingly, the effect occurs in a context strongly characterised by local identity, suggesting a layered decision-making process in which origin, tradition and sustainability interact. These results contribute to the literature on credence goods by showing that sustainability information can add value in niche markets for agricultural food and emphasize the need to disentangle the effects of local preference from sustainability per se in future research.

When socio-demographic characteristics are included in the Extended Model, the effect of information remains positive but becomes less pronounced, suggesting that the response to sustainability-related information differs according to consumer profile. In particular, older consumers show a higher WTP, possibly due to a stronger interest in the product or more traditional consumption values. In contrast, younger consumers show a lower responsiveness, which may be due to generational differences in the interpretation of quality signals.

The income effects also show a nuanced dynamic. Consumers with higher incomes tend to have a lower WTP, which could be due to a preference for alternative luxury food or the view that the PDO label alone stands for sufficient quality. Similarly, educated consumers show a lower impact of the information treatment, possibly because they evaluate claims about sustainability more critically or already have prior knowledge that makes new information less influential.

Overall, the results show that cost-based sustainability information can act as an additional quality signal that complements the PDO label in consumer evaluation. This suggests that even for premium and traditional products, sustainability claims can reduce information asymmetry and influence evaluation, which is consistent with signaling theory. In the Basic Model, the additional information results in a higher WTP, supporting the idea that transparency regarding production costs can

**Table 7**  
Extended model with socio-demographic variables.

Variable *	Coefficient	Std. err.	z	P > z	[95 % conf. Interval]
Female	-0.813	0.430	-1.89	0.059	-1.656 0.0297
Age_20s	1.181	0.684	1.73	0.084	-0.1603 2.522
Age_30s	1.136	0.690	1.65	0.100	-0.217 2.489
Age_40s	1.476	0.653	2.26	0.024	0.197 2.755
Age_More than 50s	1.429	0.673	2.12	0.034	0.111 2.748
Annual household income	0.054	0.211	0.25	0.800	-0.360 0.467
Pistachio farmer	0.195	0.476	0.41	0.682	-0.738 1.128
Over_graduate	-0.930	0.526	-1.77	0.077	-1.960 0.101
Group2 dummy	0.807	0.475	1.70	0.090	-0.124 1.738
Female*Group2 dummy	0.277	0.288	0.96	0.337	-0.288 0.842
Age_20s*Group2 dummy	-0.088	0.460	-0.19	0.848	-0.990 0.814
Age_30s*Group2 dummy	-0.220	0.464	-0.47	0.635	-1.132 0.691
Age_40s*Group2 dummy	-0.437	0.443	0.99	0.325	-0.432 1.306
Age_More than 50s*Group2 dummy	-0.086	0.452	0.19	0.849	-0.800 0.972
Annual household income*Group2 dummy	-0.260	0.148	-1.76	0.079	-0.551 0.030
Pistachio_farmer*Group2 dummy	-0.224	0.326	0.69	0.492	-0.415 0.863
Over_graduate*Group2 dummy	0.084	0.352	0.24	0.812	-0.607 0.775
_cons	4.721	0.702	6.72	0.000	3.345 6.097
$\sigma_u$	1.757	0.154	11.44	0.000	1.456 2.059
$\sigma_e$	0.865	0.078	11.03	0.000	0.712 1.019
$\rho$	0.804	0.041			0.715 0.875
LR test of $\sigma_u = 0$ : chibar2(01) = 83.64				Prob >= chibar2 = 0.000	

raise consumer awareness and positively shape perceptions of value. These results are in line with the signaling theory (Spence, 1973), since information contributes to reducing information asymmetry and increasing trust in the environmental credentials of the product (Darby and Karni, 1973; Akerlof, 1970). To illustrate, our results provide new insights into how transparent sustainability information interacts with established quality signals, such as PDO certification. Signalling theory suggests that consumers in premium product markets rely on credible cues to infer unobservable product attributes. In this context, PDO labels already serve as a strong quality signal associated with origin and tradition. However, our results show that cost-based sustainability information, when added, acts as an additional layer of signalling, reducing information asymmetry and further influencing consumer evaluation. This multi-layered effect makes it clear that sustainability cannot replace existing signals, but can complement them. From a theoretical perspective, this underpins the idea that in complex markets, multiple credible signals can co-exist and interact, with cumulative effects on willingness to pay. In this case, cost transparency reinforces the perceived authenticity of the PDO product and strengthens trust.

However, in the Extended Model, the heterogeneous nature of consumer responses becomes clearer. Older consumers are particularly receptive to the communication of production costs. Similarly, lower-income consumers appear to place additional value on sustainability when they are aware of the economic impact on farmers and may interpret the additional cost as justification for a premium price. When luxury goods, often favored by high-income consumers, are paired with additional attributes such as sustainable cultivation, these attributes may resonate even more strongly with low-income groups. This insight could have important implications for strategies aimed at communicating sustainability in the luxury sector. In particular, providing sustainability-related information might prove especially effective in engaging lower-income consumers.

Conversely, consumers with higher levels of education are more skeptical, either doubting the need for a higher price or relying on pre-existing knowledge that mitigates the impact of the information. This result can be interpreted as a kind of “information saturation” or “credibility filtering” that is consumers with a high level of education often process information with a greater degree of attention and may already have in-depth knowledge of sustainability issues. As a result, additional information on sustainability, particularly when presented in relation to costs or included in marketing communications, may be perceived as redundant or even strategically motivated, resulting in

lower responsiveness. Furthermore, this group may apply a more analytical decision-making style and be more resistant to affective or normative cues (Grunert, 2011). As a result, the marginal effect of new sustainability information on their willingness to pay may be smaller than for less informed segments that perceive the same information as new or confidence-enhancing. This finding highlights the need for differentiated communication strategies, tailored not only to values but also to levels of cognitive engagement.

Nevertheless, it remains unclear whether a better tailored or more detailed narrative could change the perception of these segments. This suggests a promising direction for future research on how the design, depth or form of message delivery might influence the perceived value of sustainable practices among different consumer types.

The results of this study contribute to the scientific debate on the economic theory of consumer behavior, particularly in relation to luxury agri-food products. The first research question investigated whether information on organic-sustainable farming practices influences consumers' willingness to pay for Pistachio Verde di Bronte PDO. The results confirm that sustainability information does have a positive impact on WTP, although the magnitude of this effect varies across consumer profiles. This aligns with the Theory of Perceived Quality of Food Products (Steenkamp, 1990; Snoj et al., 2004), which suggests that consumers assess product quality through both intrinsic and extrinsic attributes. Our study contributes to this framework by highlighting how transparency regarding the economic costs of sustainability practices can become a relevant extrinsic attribute, thereby influencing the consumer's perception of quality and increasing WTP.

Moreover, the results confirm Akerlof's (1970) and Spence (1973) theories. In the absence of sustainability-related information, consumers are likely to undervalue the product, leading to potential market inefficiencies or adverse selection. However, once transparency is created, especially through clear and detailed communication about sustainable practices, consumer WTP increases. This effect supports the notion that reducing information asymmetry through signals can enhance the market value of sustainable luxury foods. Our results also point to a phenomenon we call ‘selective information asymmetry’, where consumers, even when evenly informed, are segmented according to their knowledge or sensitivity to sustainability issues. In other words, some consumers respond strongly to sustainability signals, while others rely primarily on traditional cues such as geographical origin. This finding is particularly relevant to the second research question and shows that the heterogeneity of consumer responses is not only due to demographic

factors, but also to how information is perceived and processed.

In light of the Theory of Segmentation (Barry and Weinstein, 2009), our results underscore the need to move beyond standard demographic or behavioral segmentation.

Sensitivity to sustainability proves to be a powerful segmentation criterion, indicating that consumer groups interpret and respond to sustainability signals in different ways. This interpretation strengthens the implications of our findings for the design of communication strategies and supports the idea that the effectiveness of sustainability-related information depends on how it is tailored to different segments. Thus, our findings support the view that transparency plays a strategic role in shaping consumers' perceived value, which is consistent with the broader implications of the second research question.

Finally, in the light of price discrimination theory (Besanko and Braeutigam, 2020), this study offers a new contribution by showing how the perception of sustainability can function as a segmentation lever in its own right. The high price of Pistacchio Verde di Bronte PDO is not only justified by the origin of the product, but also by the consumers' awareness of the producers' sustainability efforts. These results show that willingness to pay can be influenced by communication strategies that emphasize certain aspects such as the cost of IPM farming practices, thus adding a new value-based dimension to the classic price discrimination framework.

In summary, the study refines and extends existing economic theories by showing that willingness to pay for sustainability is a multi-layered and segmented phenomenon.

## 5. Conclusions

This study examined how sustainability influences the perceived value of luxury agri-food products, using Pistacchio Verde di Bronte PDO as a case study. In particular, it was investigated whether information on environmentally sustainable farming practices, such as IPM, can influence consumers' willingness to pay and whether there is heterogeneity between consumer segments in their response to such information. The results confirm that while PDO certification remains a strong and widely recognized indicator of quality, transparent communication about sustainable production methods can act as a complementary signal that increases perceived value, especially among more informed or sustainability-sensitive consumers. Furthermore, the study contributes to the literature on quality characteristics in premium markets. While previous research has mainly focussed on food in general, our findings suggest that transparent sustainability communication also remains relevant in premium, tradition-oriented markets.

From a theoretical perspective, the study provides new insights into how perceived quality is constructed through both intrinsic and extrinsic attributes and how addressing information asymmetries through clear and targeted communication can change consumer behavior. The findings also highlight the importance of consumer segmentation in developing effective marketing strategies, particularly in luxury markets where sustainability can serve as a basis for differentiation and even selective price discrimination.

However, the study has some limitations. Since both the product and the sample are local, the willingness to pay may reflect a preference for local products. This potential effect points to the need for future research in non-local contexts to isolate the effect of sustainability cues.

Moreover, it focused on a single PDO product and investigated a sample limited to consumers from one Italian region, which may limit the generalizability of the results.

Future research conducted in different contexts could validate and extend our findings by including different PDO products and a larger consumer group to minimize possible selection biases and strengthen the robustness of the results.

In conclusion, this research contributes to a deeper understanding of how sustainability can enhance perceived quality and economic value in luxury agri-food markets. It offers valuable implications for producers,

retailers, and policymakers interested in leveraging sustainability as both a competitive advantage and a pathway to more informed and responsible consumption.

## 6. Practical implications

The results of this study have important implications for producers and policy makers: communication strategies should not only focus on origin or traditional quality characteristics, but also emphasize the environmental and ethical dimensions of the production process. To illustrate, the evidence that transparent, cost-based information about sustainable practices increases willingness to pay suggests that producers could integrate explicit and verifiable information about production costs and practices into their marketing strategies. This type of information goes beyond general claims such as "sustainably produced" and instead provides concrete, credible evidence capable of differentiating products. Secondly, these results show that it is possible for PDO consortia to combine origin-based certification with detailed sustainability disclosure. Transparent cost information on labels, brochures or in direct sales channels could increase the value of PDO labels by recognizing the growing consumer interest in sustainable production.

In addition, policy makers and producer organizations could consider developing certification schemes that include elements of cost transparency, especially for high-value niche products. This can support stronger product positioning and justify premium prices for sustainability-conscious consumer segments.

Finally, these results show that a market value for sustainability can be created without major structural changes, simply by reducing information asymmetries. This can be particularly important when producers have low profit margins and cannot afford expensive certification procedures but can credibly present their efforts to consumers.

## CRediT authorship contribution statement

**R. Selvaggi:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **K. Yagi:** Writing – review & editing, Writing – original draft, Software, Methodology, Data curation. **G. Maesano:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **C. Ting:** Writing – review & editing, Software, Data curation. **G. Pappalardo:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Funding acquisition, 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.

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## Data availability

Data will be made available on request.

## References

- Akerlof, G.A., 1970. The market for 'Lemons': quality uncertainty and the market mechanism. *Q. J. Econ.* 84 (3), 488–500.

- Arena, E., Campisi, S., Fallico, B., Maccarone, E., 2007. Distribution of fatty acids and phytosterols as a criterion to discriminate geographic origin of pistachio seeds. *Food Chem.* 104, 403–408.
- Athwal, N., Wells, V.K., Carrigan, M., Henninger, C.E., 2019. Sustainable luxury marketing: a synthesis and research agenda. *Int. J. Manag. Rev.* 21, 405–426.
- Barzman, M., Bärberi, P., Birch, A.N.E., Boonekamp, P., Dachbrodt-Saaydeh, S., Graf, B., et al., 2015. Eight principles of integrated pest management. *Agron. Sustain. Dev.* 35 (4), 1199–1215.
- Barry, J., Weinstein, A., 2009. Business psychographics revisited: from segmentation theory to successful marketing practice. *J. Market. Manag.* 25 (3–4), 315–340.
- Besanko, D., Braeutigam, R., 2020. *Microeconomics, sixth ed.* Wiley. Retrieved from <https://www.perlego.com/book/3866182/microeconomics-pdf>.
- Blackwell, R., D'Souza, C., Taghian, M., Miniard, P., Engel, J., 2006. *Consumer Behaviour: an Asia Pacific Approach.* Deakin University.
- Canavari, M., Drichoutis, A.C., Lusk, J.L., Nayga Jr, R.M., 2019. How to run an experimental auction: a review of recent advances. *Eur. Rev. Agric. Econ.* 46 (5), 862–922.
- Darby, M.R., Karni, E., 1973. Free competition and the optimal amount of fraud. *J. Law Econ.* 16, 67–88.
- Drichoutis, A.C., Lusk, J.L., 2016. What can multiple price lists really tell us about risk preferences? *J. Risk Uncertain.* 53, 89–106.
- Gil, J.M., Gracia, A., Sanchez, M., 2000. Market segmentation and willingness to pay for organic products in Spain. *Int. Food Agribus. Manag. Rev.* 3 (2), 207–226.
- Grunert, K.G., 2011. Sustainability in the food sector: a consumer behaviour perspective. *Int. J. Food Syst. Dynam.* 2 (3), 207–218.
- Grunert, K.G., Hieke, S., Wills, J., 2014. Sustainability labels on food products: consumer motivation, understanding and use. *Food Policy* 44, 177–189.
- Gusella, G., López-Moral, A., Antón-Domínguez, B.I., Trapero, C., Polizzi, G., Trapero, A., Michailides, T.J., Agustí-Brisach, C., 2024. Current status of pistachio diseases in countries of the Mediterranean Basin. *Plant Pathol.* 73, 2005–2029.
- Han, P., Rodriguez-Saona, C., Zalucki, M.P., Liu, S., Desneux, N., 2024. A theoretical framework to improve the adoption of green integrated Pest management tactics. *Commun. Biol.* 7, 337.
- Hartmann, L.H., Nitzko, S., Spiller, A., 2016. The significance of definitional dimensions of luxury food. *Br. Food J.* 118 (8), 1976–1998.
- Hennigs, N., Wiedmann, K.P., Klarmann, C., Behrens, S., 2013. Sustainability as part of the luxury essence: delivering value through social and environmental excellence. *J. Corp. Citizen.* (52), 25–35.
- Hörisch, H., Kirchkamp, O., 2010. Less fighting than expected: experiments with wars of attrition and all-pay auctions. *Public Choice* 144, 347–367.
- Jaeger, S.R., Harker, F.R., Ares, G., 2023. Consumer insights about sustainable and 'beyond organic' agriculture: a study of biodynamics in the United Kingdom, Australia, Singapore, and Germany. *J. Clean. Prod.* 401, 136744.
- Jaworski, C.C., Thomine, E., Rusch, A., Lavoie, A.V., Wang, S., Desneux, N., 2023. Crop diversification to promote arthropod pest management: a review. *Agric. Commun.* 1 (1), 100004.
- Kapferer, J.-N., Michaut, A., 2015. Luxury and sustainability: a common future? The match depends on how consumers define luxury. *Luxury Res. J.* 1 (1), 3–17.
- Kihlberg, I., Risvik, E., 2007. Consumers of organic foods—value segments and liking of bread. *Food Qual. Prefer.* 18 (3), 471–481.
- Lee, S., 2025. Consumer attitudes and purchase intentions toward eco-friendly agricultural and food packaging: a case study in Chungnam Province, South Korea. *J. Environ. Earth Sci.* 7 (3).
- Lefebvre, M., Langrell, S.R.H., Gomez-y-Paloma, S., 2015. Incentives and policies for integrated pest management in Europe: a review. *Agron. Sustain. Dev.* 35 (1), 27–45.
- Loureiro, M.L., Hine, S., 2002. Discovering niche markets: a comparison of consumer willingness to pay for local (Colorado grown), organic, and GMO-free products. *J. Agric. Appl. Econ.* 34 (3), 477–487.
- Loureiro, M.L., Umberger, W.J., 2003. Estimating consumer willingness to pay for country-of-origin labeling. *J. Agric. Resour. Econ.* 28 (2), 287–301.
- Lusk, J.L., Shogren, J.F., 2007. *Experimental Auctions: Methods and Applications in Economic and Marketing Research.* Cambridge University Press.
- Mellièche, W., Casini, G., Gallo, M., D'Onghia, A.M., Colelli, G., Ricelli, A., 2024. First Report of *Aspergillus* Species in Green Pistachio of Bronte. *Phytopathologia Mediterranea*, pp. 103–110.
- Nestorowicz, R., 2013. The asymmetry of information on food market and consumers' preferences—some aspects. *Zesz. Nauk Szkoł Gospod. Wiej. W. Warszawie Polityki Eur. Finanse Mark.* 10, 506–513.
- Piracci, G., Lamonaca, E., Santeramo, F.G., Boncinelli, F., Casini, L., 2024. On the willingness to pay for food sustainability labelling: a meta-analysis. *Agric. Econ.* 55 (2), 329–345.
- Sánchez-Bravo, P., Chambers, E.V., Noguera-Artiaga, L., Sendra, E., Chambers, IV Edgar, Carbonell-Barrachina, Á.A., 2021. Consumer understanding of sustainability concept in agricultural products. *Food Qual. Prefer.* 89, 104136.
- Selvaggi, R., Lusk, J.L., Pappalardo, G., 2025. Eliciting dairy farmers' willingness to pay for digital devices for precision livestock farming. *J. Rural Stud.* 119, 103772.
- Sigurdsson, V., Larsen, N.M., Pálsdóttir, R.G., Polwaczny, M., Menon, R.V., Fagerström, A., 2022. Increasing the effectiveness of ecological food signaling: comparing sustainability tags with eco-labels. *J. Bus. Res.* 139, 1099–1110.
- Snoj, B., Pismanik Korda, A., Mumel, D., 2004. The relationships among perceived quality, perceived risk and perceived product value. *J. Prod. Brand Manag.* 13 (3), 156–167.
- Spence, M., 1973. Job market signaling. *Q. J. Econ.* 87 (3), 355–374.
- StataCorp, 2021. *Stata Longitudinal Data/Panel Data Reference Manual Release 17.* StataCorp LLC, College Station, TX.
- Steenkamp, Jan-Benedict E.M., 1990. Conceptual model of the quality perception process. *J. Bus. Res.* 21 (4), 309–333.
- Van der Veen, M., 2003. When is food a luxury? *World Archaeol.* 34 (3), 405–427.
- Van Loo, E.J., Caputo, V., Nayga, R.M., Meullenet, J.F., Ricke, S.C., 2011. Consumers' willingness to pay for organic chicken breast: evidence from choice experiment. *Food Qual. Prefer.* 22 (7), 603–613.
- Wik, M., Aragie Kebede, T., Bergland, O., Holden, S.T., 2004. On the measurement of risk aversion from experimental data. *Appl. Econ.* 36 (21), 2443–2451.
- Wilson, J.S., Petino, G., Knudsen, D.C., 2018. Geographic context of the green pistachio of bronte, a protected designation of origin product. *J. Maps* 14 (2), 144–150.
- Wooldridge, J.M., 2010. *Econometric Analysis of Cross Section and Panel Data.* MIT press.
- Yang, Q., Jaworski, C.C., Wen, Z., Desneux, N., Ouyang, F., Dai, X., Wang, L., Jia, J., Zheng, H., 2025. Crop heterogeneity may not enhance biological control of rice pests in landscapes rich in semi-natural habitats. *Agric. Ecosyst. Environ.* 379, 109354.
- Young, J.C., Calla, S., Lécuyer, L., 2023. Just and sustainable transformed agricultural landscapes: an analysis based on local food actors' ideal visions of agriculture. *Agric. Ecosyst. Environ.* 342, 108236.
- Yue, C., Alfnes, F., Jensen, H.H., 2009. Discounting spotted apples: investigating consumers' willingness to accept cosmetic damage in an organic product. *J. Agric. Appl. Econ.* 41 (1), 29–46.
- Zhou, J., Hu, W., 2023. Consumer preferences for eco-labeled agricultural products in China: evidence from a choice experiment. *J. Clean. Prod.* 293, 126–137.