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Agri-food innovation: study of the consumer's perception of economic value

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Introduction

The agri-food sector is one of the world's largest industries. It plays a strategic role in the global economy, affecting the lives of millions of people and contributing substantially to domestic and foreign trade (Moubarac et al., 2014).

This relevance makes it one of the systems most exposed to the challenges of globalization, population growth and the climate crisis, which in recent decades have imposed a profound rethinking of production and consumption models, directing the evolution of the sector towards innovation and sustainability. As highlighted by Alam et al. (2025), the role of the food industry in ensuring food sustainability, safety and protection is crucial for collective well-being, as process and product innovations can improve the preservation, safety and nutritional value of food, ensuring a stable supply even in the face of global challenges such as climate change and population growth (Lezoche et al., 2020; Schrettle et al., 2014).

Therefore, in this scenario, innovation represents a strategic lever to simultaneously respond to the needs of public health, environmental sustainability and economic resilience.

At the political and institutional level, the issue of transforming agri-food systems has been recognized as a global priority. The *FAO Science and Innovation Strategy* (FAO, 2022) highlights how science and innovation are key factors in promoting more efficient, inclusive, resilient and sustainable agri-food systems, fully in line with the 2030 Agenda for Sustainable Development. Innovation, understood not only as technological progress, but also as social, institutional and organizational change, is identified as a driver for systematically addressing today's complex challenges.

In line with this vision, the European Union has taken a leadership role in defining integrated research and innovation (R&I) strategies aimed at supporting the transition to sustainable food systems. As reiterated in the policy documents *Food 2030 – Pathways for Action 2.0 (2023)* and *Shaping the Future of Food Research and Innovation (2025)*, R&I is considered a key factor in addressing the environmental, social and economic challenges related to the transformation of the agri-food sector, considered not only a source of food but a strategic lever for achieving the Union's political priorities, including climate neutrality, food security and public health. The European Green Deal, the "Farm to Fork" strategy, the Biodiversity Strategy, the Bioeconomy Strategy, the Circular Economy Action Plan and the Common Agricultural Policy 2023–2027 are key tools of this integrated vision, recognising that only a coordinated approach between politics, science and society can generate solutions capable of addressing the complexity of the food challenges of the future.

The growing interest in more sustainable production and consumption models has stimulated the emergence of new areas of research and development, including that of novel foods. Mosikyan et al. (2024) highlight how these new products offer the opportunity to diversify protein sources, improve the efficiency of production systems and reduce the environmental impact of food consumption, paving the way for innovations capable of combining sustainability and social acceptability.

Simultaneously, Alam et al. (2025) show that the most recent transformations of the food industry are not limited to the product level, but affect the entire system, combining technological, nutritional and organizational innovations. Among the most relevant trends are the expansion of functional and clean label foods, the spread of digital and sensor solutions (AI, IoT, blockchain), the development of meal kits, ready-to-eat and healthy snacks, and the growth of smart packaging capable of improving safety and traceability. Overall, these trends outline an evolution of food innovation increasingly oriented towards integrating health, sustainability, convenience and transparency.

The evolution of this innovative framework has led academic research to progressively broaden its attention towards the intersections between innovation, sustainability and consumer behavior, recognizing that the success of innovations depends not only on their technical characteristics, but also

on the value perceived by consumers and their willingness to recognize it economically. As Dijksterhuis and Wallner (2025) observe, the consumer represents "the last judge of success" in the value chain: if a given innovation is not accepted, even the most advanced efforts in terms of sustainability or health risk fail (Bruhn, 2008; Spiller & Belogolova, 2017). In fact, the adoption of new technologies and sustainable practices is conditioned by a multiplicity of motivations, attitudes and values (van Trijp, 2013), and the diversity of makes it necessary to apply segmentation that takes into account not only socio-demographic data, but also motivations and interests related to health, sustainability and individual responsibility in consumption (Verain et al., 2020).

Therefore, understanding the economic and psychological determinants of this value has become a crucial objective to guide production, marketing and policy strategies sustainably and innovatively.

The state of the art: between acceptance and economic value

The international literature has extensively explored the issue of acceptance of food innovations.

The most recent systematic reviews confirm that consumers' openness to new foods and technologies depends on a complex set of cognitive, emotional and value factors, analyzed through a plurality of psychographic constructs employed in acceptance studies. Among the most recurrent are the *Food Neophobia Scale* and the measures of *novelty seeking* and *food involvement*, which describe the individual propensity to experiment or, on the contrary, the aversion to innovation (Mosikyan et al., 2024); trust in producers, institutions and technologies (Castellini et al., 2025; Alam et al., 2025); *health orientation* and *food literacy*, which influence the perception of usefulness and safety (Baker et al., 2022; Alsubhi et al., 2022); and the values of *environmental concern* and *pro-sustainability orientation*, associated with a higher level of acceptance and willingness to pay (Fu et al., 2024; Castellini et al., 2025). Taken together, these results confirm that trust in the system, the perception of health and environmental benefits, and food curiosity favour acceptance, while neophobia, disgust and risk perception hinder its spread.

In parallel, a large body of studies has measured willingness to pay (WTP) as a monetary indicator of acceptance, estimating the value that consumers place on product, process or system innovation attributes. The reviews and meta-analyses show that, despite adopting different methodologies — *Discrete Choice Experiments (DCE)*, *contingent valuation*, *hedonic pricing models (HPM)* or incentive auctions — the primary studies converge in finding an average positive WTP for agri-food innovation, with price premiums between 20% and 35% for sustainability, safety or traceability attributes (Abdu et al., 2021; Piracci et al., 2024; Mustapa & Kallas, 2025).

Despite the heterogeneity of contexts and methods, common trends emerge. Environmental attributes — such as sustainable production method, reduction of ecological impact or organic certifications — generate the highest price premiums on average (Piracci et al., 2024; Mustapa & Kallas, 2025). These are flanked by attributes related to local origin and traceability, which are also associated with a positive WTP but more variable depending on the product and geographical context (Vriezen et al., 2022). The social aspects, while appreciated, show a willingness to pay that tends to be lower (Abdu et al., 2021; Piracci et al., 2024).

Starting from this evidence, recent research has progressively brought the two perspectives — psychological and economic — closer together, giving rise to an integrated strand that analyzes how attitudes, values and beliefs directly influence the economic evaluation of innovation. This approach recognizes that the economic propensity of the consumer cannot be explained only by considerations of price or marginal utility, but reflects cognitive, emotional and value dispositions that shape the very perception of the innovative product (Onwezen et al., 2021). In fact, several studies have integrated psychographic constructs into econometric models of WTP, using either approaches inspired by the *Theory of Planned Behavior* or the *Technology Acceptance Model* (de-Magistris & Gracia, 2016; Hoek

et al., 2021), and validated scales such as the *Food Neophobia Scale*, the *Health Consciousness Scale* or measures of *trust* and *perceived naturalness* applied to *Discrete Choice Experiments* and mixed models (Asioli et al., 2017; Chen et al., 2025; Nazzaro et al., 2025; Rivaroli et al., 2026). The most recent meta-analytical syntheses confirm the robustness of this relationship, identifying attitudes, subjective norms and pro-sustainability values as significant predictors of WTP for innovative and sustainable products (Fu et al., 2024; Mustapa & Kallas, 2025; Alsubhi et al., 2022). Taken together, these contributions outline a theoretical and methodological framework that overcomes the distinction between acceptance and economic evaluation, interpreting the willingness to pay as a monetary expression of individual beliefs and values towards food innovation.

Research objectives and contribution

This thesis is part of this evolution, contributing to the consolidation of these lines of study by expanding the available evidence and applying consistent tools to different forms of food innovation. Specifically, it contributes to the current understanding of the relationship between innovation and consumer preferences by providing multi-case and cumulative evidence across heterogeneous innovation settings (nutritional, process-related, and digital), thereby helping to clarify recurring patterns and acceptance conditions that would be difficult to observe within a single case study.

The four central studies analyse how consumers value innovation. The first, *"Ready-to-Eat Innovative Legumes Snack: The Influence of Nutritional Ingredients and Labelling Claims in Italian Consumers' Choice and Willingness-to-Pay"*, represents the nutritional and health dimension of product innovation; the second, *"Breaking Bread" with Innovation: The Challenge of Product Differentiation through Alternative Flours, Fermentation, and Traceability Systems*, investigates preferences towards sustainable processes and alternative ingredients; the third, *"Consumers' Purchase Propensity for Pasta Tracked with Blockchain Technology and Labelled with Sustainable Credence Attributes"*, and the fourth, *"Credence in Code: Consumer Engagement and Responses to Blockchain-Enabled Sustainability in Tomato Purée"*, explore the role of blockchain technology as a guarantee of trust and transparency.

Through a quantitative framework that combines *Discrete Choice Experiments* (DCE), *Hedonic Pricing Models* (HPM) and *Partial Least Squares Structural Equation Modeling* (PLS-SEM), built on psychographic constructs and validated scales, the works produce economic estimates that show how factors such as knowledge, experience and attitude towards technology translate into willingness to pay.

Two further contributions broaden the reflection: the study on Primitivo wine, *"Sustainability and Quality in Wine Pricing: Insights from the Primitivo E-Commerce Market"*, analyzes the implicit value of quality and sustainability attributes; the study on rusks, *"Boosting Market Appeal: Exploring the Impact of Nutritional Claims on Popular Italian Dietary Cereal Product"*, explores the role of nutrition communication in the perception of quality and health.

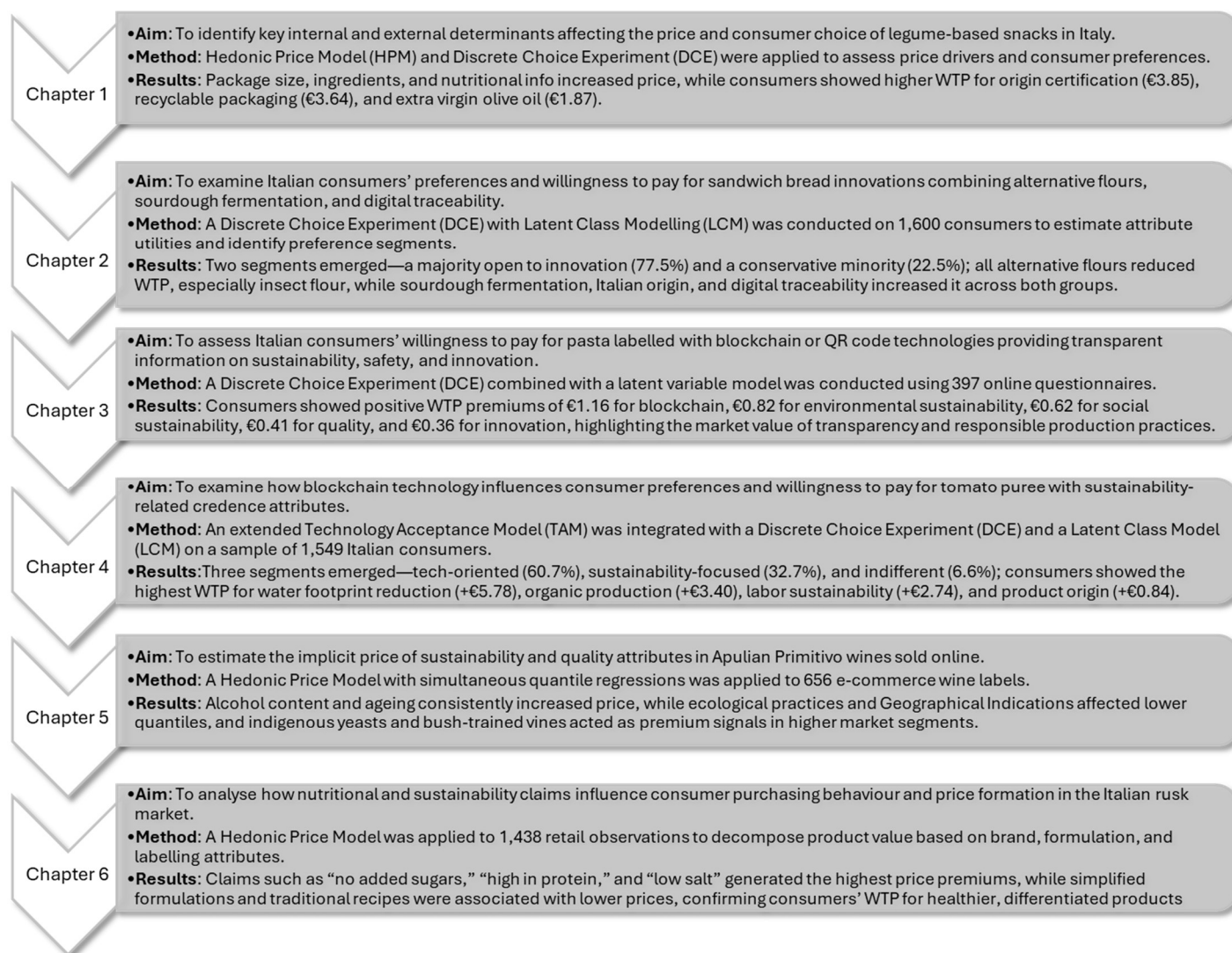
The articles included in this thesis share a unified objective: to deepen understanding of the relationship between agri-food innovation and consumer preferences. Specifically, the analysis of different forms of innovation and market contexts, together with the heterogeneity of the methodological approaches adopted, makes it possible to systematically observe whether and to what extent the value attributed to innovation varies with the nature of the product, the type of innovation and the type of information the consumer receives.

Structure and progression of articles

The thesis adopts the form of a collection of scientific articles, connected by a common thread but differentiated by methodological approach and field of application.

Each article contributes specifically to the understanding of the value of food innovation, addressing different types of innovation (product, process and system) and integrating, where appropriate, econometric and psychographic tools.

Figure 1 illustrates the flow of the thesis and the main objectives, methods and results of each work.



Each chapter contributes to building a cumulative view of the characteristics through which innovations generate economic value and willingness to pay. Specifically:

- **Chapter 1**, entitled *"Ready-to-Eat Innovative Legumes Snack: The Influence of Nutritional Ingredients and Labelling Claims in Italian Consumers' Choice and Willingness-to-Pay"* (Nutrients, 2023), opens the thesis by analyzing how nutritional and health information influence the evaluation of product innovation.

Through the combination of *the Hedonic Pricing Model* and *the Discrete Choice Experiment*, the chapter identifies the attributes that determine the willingness to pay for healthy and innovative snacks, highlighting the central role of labels and *labelling claims* in the formation of perceived value.

- **Chapter 2**, entitled *"'Breaking Bread' with Innovation: The Challenge of Product Differentiation through Alternative Flours, Fermentation, and Traceability Systems"*, (Future Food, 2025), delves into process and product innovation, analysing consumer preferences towards bread made with alternative flours and natural fermentation.
Through a *Discrete Choice Experiment* estimated with the *Latent Class Model*, the study identifies consumer segments more or less open to innovation and confirms the importance of naturalness and traceability as drivers of acceptability.
- **Chapter 3**, entitled *"Consumers' Purchase Propensity for Pasta Tracked with Blockchain Technology and Labelled with Sustainable Credence Attributes"* (Frontiers in Sustainable Food Systems, 2024), introduces the analysis of blockchain-related system innovations as a digital traceability tool.
The *Discrete Choice Experiment* model, estimated with the *Mixed Logit Model* and interactions between attributes and latent variables, makes it possible to estimate the willingness to pay for sustainability and transparency attributes, highlighting the influence of knowledge, experience and attitude towards technology on purchasing choices.
- **Chapter 4**, titled *"Credence in Code: Consumer Engagement and Responses to Blockchain-Enabled Sustainability in Tomato Purée"* (Cleaner and Responsible Consumption, 2025).
Combining *Partial Least Squares Structural Equation Modeling* (PLS-SEM) and a *Discrete Choice Experiment* estimated with *Latent Class Model*, the chapter jointly analyzes psychographic constructs (attitude, attribute orientation, *belief*, behavioral intention) and economic choices, identifying classes of consumers with different levels of sensitivity to sustainability and traceability.
- **Chapter 5**, titled *"Sustainability and Quality in Wine Pricing: Insights from the Primitivo E-Commerce Market"* (Sustainability, 2025), examines the implicit value of quality, reputation, and sustainability attributes in the Primitivo wine market.
Through a *Hedonic Pricing Model* applied to a large dataset of commercial labels, the chapter quantifies the price premiums associated with designation of origin, collective reputation and sustainable production practices.
- **Chapter 6**, entitled *"Boosting Market Appeal: Exploring the Impact of Nutritional Claims on Popular Italian Dietary Cereal Product"* (Journal of Agriculture and Food Research, 2025), expands the analysis by exploring the role of nutritional communication in the construction of perceived value.
Combining a *Hedonic Pricing Model* with an experimental survey, the chapter analyzes how *nutritional claims* influence the perception of healthiness and contribute to the competitive positioning of traditional breakfast products.

Together, these articles build a coherent path that goes from assessing the market value of innovations to understanding the psychological and perceptual motivations that determine their acceptance. The final chapters further broaden the perspective by investigating how quality, reputation and nutritional communication contribute to the construction of economic and perceived value in the Italian agri-food market.

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CHAPTER 1

Ready-to-Eat Innovative Legumes Snack: The Influence of Nutritional Ingredients and Labelling Claims in Italian Consumers’ Choice and Willingness-to-Pay

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Article

Ready-to-Eat Innovative Legumes Snack: The Influence of Nutritional Ingredients and Labelling Claims in Italian Consumers' Choice and Willingness-to-Pay

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Abstract: The global offer of legume-based snacks has sharply increased in recent years. However, to date, few studies have focused on the relationship between product supply and demand concerning the importance of attributes of such innovative foods. In this research, we identified the key internal and external determinants that affect legumes snack (LS) price and choice by Italian industries and consumers, respectively. In parallel, we investigated their preferences and perceptions towards these foods. We used the hedonic price model (HPM) and the discrete choice experiment (DCE) approach for these purposes, respectively. HPM revealed that the monetary value of LS was determined to greater significance by the: (i) size of the package; (ii) presence of rice, presence of lentils; (iii) presence of the nutritional information; and (iv) the discount shops as site of purchase. DCE revealed that the: (i) origin certification, (ii) recyclability of the package, and (iii) use of extra virgin olive oil of LS provided Italian consumers a high utility, for which they were willing to pay an average price premium of EUR 3.85, 3.64, and 1.87, respectively. On the contrary, the sunflower oil induced a decrease in their function utility. As such, this paper contributes to define potent market-segmentation strategies and to deliver effective private and public nutrition interventions for healthy eating.

Keywords: choice experiment; healthy eating; hedonic price; legumes snack choice determinants; legumes snack quality and preferences



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1. Introduction

1.1. Broad Context

In many countries around the world, improving food nutrition and, consequently, eating healthy is of greater importance on the political agenda. This increased emphasis on health has created a market for food products promoted as healthy or associated with wellness [1]. As such, food manufacturers reframe their labelling processed foods for healthier claims [2], affecting the consumers' perceptions of the healthiness of processed packed foods [3] and helping them to choose among these products, for which nutritional ingredients and labelling information should be unambiguous and comprehensible [4].

In this context, the concept of functional food has been developed based on successive advances in the process of elaboration and understanding of the relationship between nutrition and health, considering that their purpose does not end with the mere satisfaction of the need for hunger but intend to provide the human body with essential nutrients to prevent nutrition-related diseases and even improve physical and mental health [5]. Therefore, foods that naturally bring health benefits should be distinguished from those modified, enriched and fortified to be defined as functional. In recent decades, this last category of food is the one on which research has focused following the development of a multitude of new foods and beverages and favoring the acquisition of a significant

competitive advantage for companies owing to the demand for health foods has been stimulated by socio-economic changes, such as the lengthening of life expectancy, rising healthcare costs, the social costs of non-communicable diseases and the widespread desire for a better quality of life [6] and, because these foods can be distributed with nutritional and health claims, aiming to help consumers make well-informed choices at a glance [7–9], favoring a differentiation of foods that possess them.

Therefore, job roles, family organization, lifestyle and social changes [10] are making food intake more irregular, often without fixed mealtimes, leading to cardiometabolic consequences [11]. This irregularity can result in large time intervals between meals, while the human body requires a regular energy supply. Consumers often meet this energy need by eating snack products between meals, regularly outside the home and most frequently in the afternoon. As such, snacking becomes an important reward to consumers within modern eating behaviors [12].

Moreover, the consumption of snacks is motivated by biological factors (i.e., genetic profile, homeostasis), social factors (i.e., cultural, religion, education, beliefs, parental influences marketing, climate, food access, food availability), and hedonic factors (i.e., addiction, pleasure, sensory perceptions, emotions) [13–16]. In the market, there is a wide range of ready-to-eat (RTE) snacks on supermarket shelves with an extensive variety of sizes, shapes, colors and tastes designed to attract the consumer [Figure 1]. The major types of snacks are classified according to their ingredient composition and processing technology into first, second and third generation. The first category includes the simplest snacks such as chips, popcorn, etc. [17]; in the second category are those with direct expansion (puffed corn curls, onion rings, corn tortilla chips, etc.) which have a relatively low nutritional value [16]; finally, the third category includes snacks with indirect expansion, also called “pellets” which are first dried and then expanded by frying, hot air or microwave heating [18]. In general, the most used production techniques are baking, frying and extrusion.



Figure 1. Samples of Italian ready-to-eat snacks. (a) Mix of cereals and legumes snack (on the label, we can observe the following main claims: organic, non-fried); (b) red lentils snack (on the label, we can observe the following main claims: bio, vegan, natural source of fibers, rich in proteins and fibers, with Himalaya red salt); (c) mix of legumes and rice snack (on the label, we can observe the following main claims: snack with 90% chickpeas, beans, edamame, less than 3% in fat, rich in proteins and fibers, non-fried, gluten-free); (d) mix of corn, legumes and chili pepper (on the label, we can observe the following main claims: hot legumes, gluten-free, non-fried, less than 60% in fat). Source: photos provided by the co-author Antonella Labbate, 2022.

1.2. Aims and Significance

In this context, the present paper had two major purposes. The first was to evaluate the label information (i.e., intrinsic: percentage of legumes, cooking method, presence and

type of oil, use of organic ingredients, absence of gluten, etc., and extrinsic: packaging, claims, brand, etc.), as well as the place of the purchase in terms of their effect on a range of ready-to-eat snacks' prices, offered by Italian stores and whereby consumers maximize their utility and products' perceived quality. Additionally, this food category offered a range of innovation and healthiness which made it appropriate for the first purpose of this present research, for which we used the hedonic price model (HPM) that assumes that products consist of a set of intrinsic and extrinsic attributes valued by both manufacturers and consumers. In fact, a hedonic function represents the minimum price at which attributes can be given and the maximum price at which they will be purchased [19] in a long-run equilibrium. In parallel, the second purpose of this research was to explore, among a representative sample of Italian consumers in Apulia region (southeastern Italy, Figure 2; the total population and area are 4.06 million and 19.37 K km², respectively) [20], determinants allowing to understand the behavior, preferences and purchasing decisions of Italian consumers towards ready-to-eat snacks based on legumes and, to estimate their willingness-to-pay (WTP) for such products, qualified as healthy and innovative food, produced in Italy and sold in the Apulian food stores. For this second purpose, we used the discrete choice experiment (DCE) approach, by means of a multinomial logit model (MNL) and latent class model (LCM), for which data were collected through a social survey. Scrupulously, this second purpose of the study addressed three interlinked research sections: (i) What are Apulian consumers' habit and propensity towards consuming snack-based legumes? (ii) What is their WTP towards nutritional ingredients and labelling information for snack-based legumes? (iii) How does their socioeconomic profile affect their WTP? As such, this research contributes to the scientific literature through several features. First, there is a paucity of research that have used HPM for market analysis and/or DCE to investigate snack-based legumes consumers' habits and preferences as supported by the literature review, presented above (Section 1.2). Second, the Italian snacking market has never been focused on consumer behavior, preferences, and WTP towards ready-to-eat snacks and, particularly, snack-based legumes. Moreover, this paper provides new indications into Italian snacking consumption in terms of preferences utility, whereby an average of 38 and 30 over 100 individuals snack at least a few times a week in Italy and Apulia, respectively [20]. Third, the market analysis through the hedonic price and the econometric valuation analysis is essential for the prediction and positioning of market and innovation outreach strategies [21] by snacks manufacturers that would meet Italian consumers' expectations and, consequently, strengthen their competitiveness. Fourth, eliciting consumers' habits and preferences also has public health implications in terms of increasing healthy eating early in life [22] and enhancing communication about nutritional ingredients and labelling claims on snacks to affect the healthy consumption of snacks products such snack-based legumes. In fact, a matching of the results obtained from the two models applied here (HPM and DCE) allow us to assess whether supply and demand are aligned, to understand if what is already on the store shelves corresponds to what is expected by the consumer and to guide the food industry in the development of product combinations more in line with market preferences. The following section embarks on how HPM and DCE were mapped out.



Figure 2. Geographical location on Apulia region (southeastern Italy).

2. Materials and Methods

2.1. Hedonic Price Model (HPM)

2.1.1. Theoretical Background

To estimate the monetary value of product features, the HPM, which has its roots in microeconomic theory, was first proposed by Rosen in 1974 [23]. HPM considers a product as a set of characteristics/attributes, whereby the consumers purchase the product that comprises this set, maximizing their utility. Similarly, producers maximize their profits by determining the price of a product based on its attributes [23]. Therefore, differentiated goods can be considered as a set of various quality attributes that discriminate them from other similar goods, so that the equilibrium market price can be considered a function of the implicit prices of each attribute of the good [24]. Nevertheless, the price function should not be directly interpreted as general measures of the consumer's WTP for product attributes. In fact, a greater observed price for an attribute may be more influenced by the costs of production, rather than by the consumers' appreciation. Moreover, there is a possibility that only a small fraction of consumers purchase goods that contain such expensive attributes. As such, HPM is generally recognized as a relevant tool for assessing the price premium for "credence attributes" such as certification, indications of origin and other characteristics that cannot be observed by the consumer after purchase [23,24], making it difficult to assess its utility. Given that, the price "P" of a product "j" can be described as:

$$P_j = f(Z_j) \quad (1)$$

where: "Z" is a vector of characteristics belonging to the product "j" and "f(.)" is an unspecified functional form.

Equation (1) indicates that the price (P) that consumers pay for the product is a function of the monetary values of a set of attributes (j) incorporated in the product (Z) sold on the market, which can be dimensioned by partially differentiating with respect to each attribute [23,25]. Furthermore, since at market equilibrium the marginal price that a consumer pays for each attribute j corresponds to the marginal cost that the producer incurs to offer that attribute on the market, Equation (1) can be estimated using ordinary least

squares. Since variables with different scales can be selected, as well as dummy variables, it is necessary to find the optimal hedonic price model among the available forms, such as log-linear, double log-linear and linear log. In this study, a single equation approach was applied [26,27] to determine the effects that each snack characteristic causes on the price and a linear specification of the hedonic price equation were preferred. As such, the equation of the final model is given as follows:

$$P = \beta_0 + \beta_j Z_i + \beta_j X_{ij} + \varepsilon \quad (2)$$

where:

“P” is the price, “ β_0 ” is the constant, β_j is a parameter vector of product attributes, “Z” is the quantitative attribute “weight”, “X” is defined as a set of observable qualitative attributes of the product, “i” identifies an attribute ($i = 1, \dots, I$), “j” is the number of choices between different qualitative attributes ($j = 1, \dots, J$) and “ ε ” is residual.

2.1.2. Implementation and Statistical Data Analysis

To apply Equation (2), we collected data between May 2022 and July 2022 on 177 valid observations on all legume-based snacks as presented on the shelves and sold in Apulia retail stores (i.e., hypermarkets, supermarkets, minimarkets and discounters) and e-shops. Among this information (Table 1), on the one hand, the retail price (“P”, ranging from EUR 0.73 to 3.53 per pack of 100 g) and the weight (“Z”, ranging from 40 to 240 g) were considered as dependent and continuous variables, while on the other hand the other explanatory variables “X” was categorical and then converted into one or more fictitious variables. Consequently, we estimated “P” by a mean of statistical linear regression, whereby we derived the values of “ β_0 ” and “ β_j ”. Prior to the regression analysis, quantitative data (i.e., weight of the package) were normalized by Box-Cox power transformation to improve their conformity to normal distributions. The Shapiro–Wilk test was then used to test their normality.

Table 1. Description of variables used in our hedonic price model analysis.

Variable	Description	Category
Price	Dependent variable Sales price EUR/pack Explanatory variable	Continuous
Package size	Package contents in grams	Continuous
Organic certification	Organic = 1; Non-organic = 0	Dichotomous
Type of legumes	Lentils = 1; Other = 0	Dichotomous
	Peas = 1; Other = 0	Dichotomous
	Chickpeas = 1; Other = 0	Dichotomous
Presence of other flours/starches	Corn = 1; Other = 0	Dichotomous
	Rice = 1; Other = 0	Dichotomous
	Potatoes = 1; Other = 0	Dichotomous
	Wheat = 1; Other = 0	Dichotomous
Gluten-free	Gluten-free = 1; Non gluten-free = 0	Dichotomous
Fried	Fried = 1; Not fried = 0	Dichotomous
Spices	Spicy = 1; Unspicy = 0	Dichotomous
Oil	Absent = 1; Other = 0	Dichotomous
	Extra Virgin Oil = 1; Other = 0	Dichotomous
	Seeds = 1; Other = 0	Dichotomous
Claim—low fat	Present = 1; Absent = 0	Dichotomous
Claim—source of proteins	Present = 1; Absent = 0	Dichotomous
Claim—source of fibers	Present = 1; Absent = 0	Dichotomous

Table 1. Cont.

Variable	Description	Category
Claim—vegan	Present = 1; Absent = 0	Dichotomous
Pack	Recyclable = 1; Non-recyclable = 0	Dichotomous
Observation site	Neighborhood shop = 1; Other = 0	Dichotomous
	Supermarket = 1; Other = 0	Dichotomous
	Hypermarket = 1; Other = 0	Dichotomous
	Discount = 1; Other = 0	Dichotomous
	E-commerce = 1; Other = 0	Dichotomous

2.2. Discrete Choice Experiment (DCE)

2.2.1. Theoretical Background

The discrete choice experiment (DCE) constitutes a social survey-based approach, often used to estimate consumer preferences and behavior as well as their WTP. In line with Lancaster utility theory [28], DCE was introduced by Batsell and Lodish [29] and Louvière and Woodworth [30]. It simulates a purchase situation by presenting different products/alternatives to respondents and asking them to choose the product that, among all, best meets their requirements and expectations [21]. Generally, a constant alternative corresponding to non-buy is also presented to add more realism to the experiment. Concretely, a social survey-based approach is divided into sets of alternative possibilities consisting of at least two options and the no-buy choice (Table 2). The product is thus described by several attributes, further classified into levels. Consumers are invited to choose which product they would buy within each set of alternative options (choice sets) based on the description provided, revealing their preference for specific attributes or levels and their relative importance [31]. Thus, the consumer derives the marginal utility by examining the trade-off between the relevant attributes of a product to make certain purchasing decisions [32]. Over the years, the use of DCE has been extended to many disciplines, such as transport, environment, telecommunications, marketing and, recently, human health. Regarding agri-food products, the use of DCE has intensely increased in the last decade and has been applied for different themes such as, but not limited to, (i) wine consumption [21], (ii) enhancement of typical products [32], and (iii) local and organic foods [33].

Table 2. An example of a choice set used in our discrete choice experiment.

Option A (Product A)	Attribute	Option B (Product B)	Attribute	Option C (No-Buy)
	Certified organic (Bio)		Not certified organic (Bio)	
	Type of legumes: Chickpeas		Type of legumes: Lentils	
				
	Gluten-free		Non gluten-free	
				
	Presence of a nutritional claim		Absence of a nutritional claim	

Table 2. Cont.

Option A (Product A)	Attribute	Option B (Product B)	Attribute	Option C (No-Buy)
				
	Spiced	Not spiced		
				
	Presence of origin indication	Presence of origin indication		
				
	Recyclable package	Non-recyclable package		
				
	Type of oil: Sunflower	Type of oil: No added oil		
				
	Weight 100 g	Weight 100 g		
	Price per pack EUR 2.25	Price per pack EUR 5.70		
I will select: ☒	Option A ☐	Option B ☐	Option C ☐	

2.2.2. Implementation and Econometric Data Analysis

We implemented the DCE in 5 phases. First, we defined the attributes and related levels as depicted in Table 3 from the observational study during the survey conducted in the places of sale. Second, we determined the experimental design from the combination of nine selected attributes and their levels.

Consequently, we conducted a D-efficient Bayesian design [33–35], for which the D-error was low, equal to 0.214%, indicating a good efficiency of the design at extracting information from respondents in the DCE. Moreover, we used Equation (3), for which 4,145,760 possible profiles were created (i.e., $J_n = 3^2 \times 5 \times 2^6$, whereby two attributes have three levels; one attribute has five levels and six attributes present two levels as depicted in Table 3).

$$N = \frac{J_n \times (J_n - 1)}{2} \quad (3)$$

where: “J” corresponds to the number of levels and “n” to the number of attributes that have “J” levels.

Table 3. Attributes and levels used in our discrete choice experiment.

Attribute of the Snack		Levels	Brief Description
Organic certification		−1: Absence +1: Presence	An organic snack is produced without the use of synthetic chemicals and genetically modified organisms.
Type of legumes		−1: Chickpeas	The type of legume that constitutes the main constituent of the snack.
		0: Lentils	
		+1: Peas	
Gluten claim		−1: Non gluten-free +1: Gluten-free	Gluten is a cereal protein that causes intestinal inflammation for gluten intolerant consumers.
Nutritional or health claim		−1: Absence +1: Presence	The nutritional claim states, suggests or implies that the snack has beneficial nutritional properties, due to energy/substances contained. Similarly, the health claim states, suggests or implies the existence of a relationship between snack or one of its components and health.
Spices		−1: Not spiced +1: Spiced -	The use or not of spices for flavouring or colouring snacks.
Origin indication		−1: Absence +1: Presence	The origin indicates the country or region in which snacks were produced.
Recyclability of the pack		−1: Not recyclable +1: Recyclable -	
Type of oil		−1: Sunflower oil 0: No added oil +1: Extra virgin olive oil	The type of oil used or not as an ingredient.
Price		−2: EUR 1.10 −1: EUR 2.25 0: EUR 3.40 +1: EUR 4.55 +2: EUR 5.70	Set of prices to make the hypothetical market more realistic with prices that respondents see daily in stores.

As a result, we generated 48 reasonable profiles (i.e., set choices), consisting of 3 options (A, B and C), which were divided into two blocks consisting of eight set choices each (see Supplementary File S1—Experimental Design and Table 2 as an example), with a fixed order of presentation based on the previous experience of the focus group experts in Italian food consumption and preferences and the pilot survey. Each choice set consisted of 5 columns. The first two columns described the product A known as an option A, indicating a set of specific features available for consumers. The second two columns depicted the product B known as an option B, including another set of specific attributes of the legume snacks.

The last column had no attributes and referred to option C, indicating the possibility of the “no-buy” of legume snacks that could be chosen by respondents. The use of photographs, as a stimulus visual information reflecting the attribute under assessment [36], helped them to easily choose the option.

Third, we carried out a field survey through an online questionnaire, from July to December 2022, reaching a valid sample of 518 respondents mainly in Apulia region, taking into consideration the Apulian population’s age, gender distribution and annual household income (Table 4).

Table 4. Sampling of the respondents taking into consideration the age, gender and household income of the population in Apulia.

Variable	Category	Apulia %	Sample N.	Sample %
Age (year)	From 19 to 30	17.00%	105	20.27%
	Between 31 to 50	31.00%	150	28.96%
	Over 50	52.00%	263	50.77%
Gender	Male	49.00%	253	48.84%
	Female	51.00%	265	51.16%
Annual household income (in EUR 1000)	Less than 20	Average 31,156	296	57.14%
	Between 20 and 40		150	28.96%
	Over 40		72	13.90%

Source: Istat, 2021 [37].

As such, we organized the field questionnaire into three sections: the first section involved questions about the behavior and propensity to consume legume-based snacks in terms of general purchases, consumption and importance of legumes, knowledge and purchases of innovative legume snacks. Concretely, this section aimed to understand the level of knowledge of respondents of legume snacks. Specifically, we asked them to indicate: (i) the frequencies and places of purchase in general (i.e., neighborhood shops, neighborhood stores, hypermarkets, discounts, e-commerce), where they go most often to buy food products; (ii) the importance that they place with respect to certain product characteristics (i.e., label, brand, price, Bio, etc.), using a three-level staircase (i.e., not important, medium importance, very important); (iii) the type of diet, the type of snack and the number of meals during the day; (iv) the consumption and importance of legumes in the diet; and, (v) the knowledge, consumption and frequency of purchase of legume snacks. In the second section of the questionnaire, we engaged a hypothetical purchase situation of legume snacks, in which the blocks of eight sets of choice were presented to respondents as described above. Finally, in the third section, we collected the socio-economic and socio-demographic information of the respondents (i.e., age, income, residence, household income, etc.). Once data were collected, we based our econometric data analysis, using Nlogit software (version 5.0), on the Lancaster utility theory [28] as explored above. Here, we assumed that the consumer, by choosing between two products, A or B, will select the one with greater utility (Table 2). Therefore, the choice of the product is influenced by its attributes and the preferences that distinguish the consumers, conditioned by undetectable factors (for example habit or aversion), considered as random variables. As such, the utility function is described by a deterministic component (V), a function of observable attributes and a stochastic component (ε) that represents measurement errors with all unobservable attributes that influence the purchase choice. Thus, the utility function is determined as follows:

$$U_{nj} = V_{nj} + \varepsilon_{nj} \quad (4)$$

where: V_{nj} can be expressed by:

$$V_{nj} = \beta'x_{nj} = \alpha + \beta_1x_{1n} + \beta_2x_{2n} + \dots + \beta_mx_{mni} + \varepsilon_{nj} \quad (5)$$

“ x_{nj} ” indicates the attribute “ x ” of the alternative “ j ” selected by the individual “ n ”, with the coefficients “ β ”, whereby “ β_n ” represents the weight of the preference for each level of attribute, while the coefficient “ α ” incorporates the heterogeneities of the sample of consumers/respondents.

Since it is not possible to know with exact certainty which alternative “ j ” is most useful for the respondent, it is determined that the alternative “ j ” is more useful than the other alternatives considered. Therefore, the probability that the respondent “ i ” will choose the alternative “ j ” among the others is expressed as follows:

$$\begin{aligned} P_{ni} &= \text{Prob} (U_{ni} > U_{it} \ \forall j \neq i \text{ and} \\ &= \text{Prob} (U_{ni} > U_{nj} + \alpha_{000}) \ \forall j \neq i \\ &= \text{Prob} (\alpha_{000} < -U_{nj}) \ \forall j \neq i \end{aligned} \quad (6)$$

where: “ n ” is the single interviewee (i.e., consumer/respondent) and “ j ” is the alternative (i.e., Product A/Option A; Product B/Option B; No-buy/Option C as described above in Table 2).

Therefore, the overall average monetary value of each individual attribute reflects the “price premium” that the consumer would be willing to pay for a hypothetical product that possesses those characteristics. As such, we estimated this monetary value through a multinomial logit model (MNL) to which we applied an LCM to improve the likelihood of the model, segment the market and estimate a probable profile of the consumer of innovative snacks. Although the MNL provided the basis for the analysis of discrete choice modeling, its basic limitations, in particular the assumption of independence from irrelevant alternatives (IIA), motivated the researchers to consider specific alternatives, including the latent class model, as well as the approach used in this study to analyze the different behaviors among respondents. The LCM model allows us to group the consumers interviewed into a set of Q classes in relation to their purchasing choices. The initial sample is then divided into sub-samples, so that we no longer have a heterogeneous total sample, but a defined number of homogeneous sub-samples. Prior to selecting the most appropriate number of classes to improve the model statistical properties, the information criteria values for models with 1 to classes 4 has been elaborated (Table 5), in which a gradual process was conducted. As such, a model fit for statistics information criteria (IC: maximum log likelihood, minimum Bayesian information criteria/BIC and minimum Corrected Akaike Criteria/CAIC) is normally used for this purpose. By gradually adding the number of classes, the model presents the most optimum fit improvement in terms of stability, sensitivity and specificity [21,38,39]. Nevertheless, using AIC may risk overfitting the model by having too many classes and using BIC may risk underfitting the model by having too few classes [40]. Therefore, when determining the appropriate number of classes in an LCM, the researcher must consider the number of classes required to address the underlying research questions and the ease of interpretation of multiple classes when the number of classes is large [41]. For this reason, we decided to limit the LCM at two classes. The solution led to an improvement in the fit of the model compared to MNL, without incurring in a less stable convergence due to the increase in the class numbers.

Although the division of the sample through the LCM allows us to include from the beginning of the covariates, the characteristics of the respondents able to influence their purchasing behavior and optimize the subdivision based on socio-economic and/or physical peculiarities, given the exploratory nature of the survey it was decided to verify the significance of the covariates downstream of the segmentation. For this investigation, a decision-making process was carried out consisting of various test steps, with the aim of selecting several classes able to improve the statistical properties of the model considering the consistency of the classes in percentage terms, the significance attributes and the

likelihood of the model. As a result of the selection of alternative j in the various purchase sets, the probability of consumer “ i ” to fall into class q is expressed by:

$$\pi_{ij|q} = \frac{\exp(\beta'_q x_{ij})}{\sum_{q=1}^Q \exp(\beta'_q x_{ij})} \quad (7)$$

where: “ x_{ij} ” expresses a set of typical characteristics of the class; “ β_q ” are specific coefficients relative to the classes to be estimated. The conditional probability that consumers will choose alternative “ j ” is expressed:

$$\pi_{ij} = \sum_{q=1}^Q \pi_{iq} \pi_{ij|q} \quad (8)$$

Table 5. The information criteria values for models 1 to 4 classes.

	Multinomial Logit	2-Class	3-Class	4-Class
Loglikelihood	−4340	−3792	−3620	−3483
K	10	21	32	43
Inf. CrAIC	8701	7226	7306	7053
AIC/K	2.10	1.84	1.76	1.70
BIC	−4257	−3617	−3353	−3125
N	4144	4144	4144	4144
Average			64.3%	57.5%
classes probabilities	100%	75.3%	20.9%	14.5%
		24.7%	14.7%	13.3%
				14.6%

To better explain the choices of consumers, the estimation of parameter values is carried out through the maximization of the log likelihood function:

$$nL = \sum_{i=1}^N \ln \left[\sum_{q=1}^Q \pi_{iq} \left(\prod_{t=1}^{T_i} \pi_{it|q} \right)^{y_{ij}} \right] \quad (9)$$

Regarding the estimation of WTP that reflects how much extra consumers are willing to pay as a price premium for a ready-to-eat legume-based snack with a specific characteristic, we used the following formula:

$$WTP_a = - \frac{\beta_a}{\beta_p} \quad (10)$$

where: “WTP_a” is the willingness-to-pay for attribute “ a ”; “ β_a ” and “ β_p ” are the estimated coefficients related to each attribute and price, respectively, according to the respondent’s membership in each class.

3. Results

3.1. Respondents’ Descriptive Statistics

This section comprises the main descriptive statistics related to the behavior and propensity of Apulian’s residents to purchase and consume legume-based snacks (i.e., part 1 of the field survey) and their socio-demographic and economic profiles (i.e., part 3 of the questionnaire). As such, supermarkets were the highest frequent purchase site for snacks (36.00%), followed by neighborhood shops (20.00%), hypermarkets (18.00%), grocery stores (16.00%), discount stores (10.00%) and E-commerce (1.00%), as shown in Table A3. Although around 53% of the respondents in this social survey accorded a high level of attention towards the expiry date of the products, followed by the type of ingredients, prices, nutrition facts and labels of snacks (Table A4). Regarding the type of snacks consumed among the sample (Table A5), few respondents (5.61%) selected the sandwich as a type of snack, but the majority (57.56%) of them opted for the fruits and vegetables (i.e., apple, banana, kiwi, peach, fennel, carrots, etc.). Furthermore, most

respondents (45.95%) consumed legume snacks a few times a month, while few of them (3.47%) consumed this food category upon the recommendation of a dietitian, as presented in Tables A6 and A7. Regarding their socio-demographic and economic profiles, on average, the respondents were similarly distributed between gender, since 48.80% were male, nearest to middle-age (46.12 years old), with an average of around 3 persons per family. In terms of academic level, the average number was almost 14 years of education. Furthermore, their total annual household income was distributed as follows: 57.10% (less than EUR 20,000), 29.00% (between EUR 20,000 and 40,000) and 13.90% (over EUR 40,000). Moreover, most of the respondents worked in the agriculture sector (16.22%), as depicted in Table 6.

Table 6. Respondents' socio-demographic and economic profiles.

Variable	Category	N.	Mean/%	Standard Deviation	Min	Max
Gender	Female	253	51.20%			
	Male	265	48.80%			
Age	Years		46.12	15.22	18	75
Family numbers	Number		3.19	1.12	1	5
Academic level	Years		13.94	3.85	0	21
Annual household income (in EUR 1000)	Less than 20	296	57.10%			
	Between 20 and 40	150	29.00%			
	Over 40	72	13.90%			
Sector of work	Agriculture	84	16.22%			
	Construction	34	6.56%			
	Culture and Art	21	4.05%			
	Finance	24	4.63%			
	Education	53	10.23%			
	Consultancy	58	11.20%			
	Industry and Transport	20	3.86%			
	Marketing and Communication	34	6.56%			
	Social Health	58	11.20%			
	Public Sector	18	3.47%			
	Tourism	40	7.72%			
	Students/not working	74	14.29%			

3.2. Hedonic Price Results

3.2.1. Descriptive Statistics and Analysis of Variance

Among the 177 valid observations (Table 7), 57.10% of snacks were organic certified. Chickpeas (65.00%) and corn (46.90%) were the most observed type of legumes and flour, respectively. Given the relative low observation of wheat flour (11.90%), most of the snacks were gluten-free (78.50%), not fried (61.00%), not spiced (87.00%) and formulated with sunflower oil (70.10%). In the same way, most of the items presented labels with at least one type of claim in order to enhance the snack consumption and encourage their potential purchase, such as: low fat (14.10%), source of proteins (65.00%) source of fiber (73.40%), vegan (25.40%). Additionally, most items (81.90%) indicated the recyclable symbol on their labels (Table 6). Moreover, snacks were widely observed in E-commerce (52.00%), followed by supermarkets (33.30%), neighborhood shops (5.60%), discount shops (5.60%) and hypermarkets (3.40%). Furthermore, the correlation between price (considered here as dependent variable) and these labels' attributes (considered here as independent variables) revealed that the minimum price of a pack of legume snacks is equal to EUR 0.73 per 100 g, while the maximum price was EUR 3.53 per 100 g. Therefore, the analysis of variance depicted that the attributes with a highly significant difference ($p < 0.001$) were: "package size", "lentils", "rice", "claim—low fat", "claim—vegan", "sunflower oil" and "without oil". Similarly, discount shops ($p < 0.001$) as a purchase site showed greater significance than other purchase places (Table 8).

Table 7. Descriptive statistics of snacks used in our hedonic price model analysis.

Variable	Description	Number of Observations (Snack)	%	Mean	Standard Deviation	Min	Max
Package size	Package contents in grams	177		95.06	45.61	40.00	200.00
Price	EUR per 100 g	177		2.08	0.62	0.73	3.53
Organic certification	Organic	177	57.10				
Type of legumes	Lentils	177	59.90				
	Peas	177	58.20				
	Chickpeas	177	65.00				
Presence of other flours/starches	Corn	177	46.90				
	Rice	177	33.90				
	Potatoes	177	17.50				
	Wheat	177	11.90				
Gluten-free	Gluten-free	177	78.50				
Fried	Fried	177	39.00				
Spices	Spicy	177	13.00				
Oil	Absent	177	21.50				
	Extra Virgin Oil	177	14.70				
	Sunflower	177	70.10				
Claim—low fat	Present	177	14.10				
Claim—source of proteins	Present	177	65.00				
Claim—source of fibers	Present	177	73.40				
Claim—vegan	Present	177	25.40				
Pack	Recyclable	177	81.90				
Observation site	Neighborhood shop	177	5.60				
	Supermarket	177	33.30				
	Hypermarket	177	3.40				
	Discount	177	5.60				
	E-commerce	177	52.00				

Table 8. Parameter estimates in our hedonic price model analysis.

Variable	Coefficient (b)	Significance	p-Value
Constant	120.660	***	<0.001
Package size (g)	−119.936	***	<0.001
Lentils	0.277	***	<0.001
Rice	0.340	***	<0.001
Potatoes	0.194	**	0.019
Claim—source of fibers	0.133	**	0.019
Claim—low fat	−1.388	***	<0.001
Claim—vegan	0.187	***	0.003
Sunflower oil	−0.580	***	<0.001
Without oil	0.327	***	0.010
Supermarket	−0.124	**	0.031
Discount	−0.503	***	<0.001
R ²	0.758		
Adjusted R ²	0.742		
F-statistic	47.005		

Note: ***, ** ==> Significance at 99%, 95%, level, respectively.

3.2.2. Linear Regression Analysis

The most frequently observed attributes were subsequently subjected to linear regression analysis. The empirical model showed a good overall significance ($F = 47.005$, $p < 0.001$) and a good ability to explain the variability of the dataset ($R^2 = 0.758$), as shown in Table 8. Hence, the empirical model can now be expressed according to the following expression:

$$\begin{aligned} \text{Price (EUR/100 g)} = & 120.660 + (-119.936 \times \text{"Package size"}) + (0.277 \times \text{"Lentils"}) + \\ & (0.340 \times \text{"Rice"}) + (0.194 \times \text{"Potatoes"}) + (0.133 \times \text{"Claim Source of fibers"}) + (-1.388 \times \\ & \text{"Claim Low fat"}) + (0.187 \times \text{Claim Vegan}) + (-0.124 \times \text{"Supermarket"}) + (-0.503 \times \\ & \text{"Discount"}) + (-0.580 \times \text{"Sunflower oil"}) + (0.327 \times \text{"Without oil"}). \end{aligned} \quad (11)$$

We considered 95 g per pack (an overall average of pack sizes) as a baseline value in the application of the hedonic price equation. Consequently, we assigned the values of 0 and 1 for variables presented in Tables 7 and 8, respectively, in Equation (11). As a result, we obtained an average price of EUR 1.99 per 100 g. Subsequently, we calculated other prices this time by assigning a value of 1 to the variables that were significant through the previous descriptive analysis. Thus, on the one hand, the prices of snacks based on "lentils", "rice flour", "no oil", "source of fibers", "potatoes starch" and "vegan" were increased to EUR 2.26, 2.33, 2.31, 2.12, 2.18 and 2.17, respectively. On the other hand, the prices of legume-based snacks bought at the supermarket or at a "discount shop", "with no fat" or "with sunflower oil" reduced to EUR 1.86, 1.48, 0.60 and 1.41, respectively, in comparison to the baseline price of EUR 1.99 per 100 g.

3.3. Econometric Results

3.3.1. Multinomial Logit Model (MNL) and Latent Class Analysis (LCA)

To assess consumer preferences for the nine selected attributes as described above (Table 3), we initially used the MNL which provided the basis for the analysis of DCE. Then, we applied LCA that made it possible to group the interviewed respondents into a set of classes in relation to their purchasing choices. As such, the MNL estimates are reported in Table 9, and most coefficients of the concerned attributes (i.e., organic certification, gluten-free, indication of origin, recyclable package, the use of extra virgin oil) presented positive signs, except for price, chickpeas as a type of legume, the use of spices and sunflower oil, and were highly significant, except for chickpeas, at the significance level of 99%. These findings denote that the attribute with positive coefficients estimates and high significance provided Apulian consumers with high utility and trust regarding, at least, the quality of the legume-based snacks. On the contrary, the ASC—No choice coefficient (i.e., no buy) was equal to 0.076 and not significant, indicating that the thesis that respondents would gain utility from Product A or Product B over Option No-buy is not statistically supported. With respect to the LCA model, the sample was divided into 2 classes with values of 75.28% and 24.72%, improving the log likelihood function by indicating better values compared to the MNL (Table 9). Specifically, both classes have a highly significant and negative price coefficient, which means that, for the whole sample of respondents, a small price variation lead to not buying the product. On the contrary, the attributes related to the origin indication, the recyclability of the package and the use of an extra virgin olive oil were highly appreciated by the entire sample, since their coefficients had positive value, but with different significance levels among the two classes, accepting the hypothesis of heterogeneous consumer preferences for legume-based snacks consumption. Specifically, the purchase decision of the respondents of class 2 was not influenced, using chickpeas as a type of legumes, the addition of spices, the gluten claim and the use of sunflower as seed oil, for which their coefficients estimates were not significant. On the contrary, the correspondent coefficients with negative and significant levels in class 1 imply that the respondents of this class accorded a high degree of importance when selecting between products. With respect to the non-purchase variable, the correspondent coefficient

was negative and highly significant for the first class, indicating that the respondents of this class were very inclined to purchase, while class 2 presented positive and significant coefficients, inducing a propensity not to buy, regardless of the type of attributes of the innovative legume-based snacks.

Table 9. Multinomial logit model (MNL) and latent class analysis (LCA) results.

Multinomial Logit Model (MNL)			Latent Class Analysis (LCA)			
100%			Class 1 75.28%		Class 2 24.72%	
Attribute	Coefficients		Coefficients		Coefficients	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Price	−0.13587 ***	0.000	−0.17553 ***	0.000	−0.14965 **	0.0248
Organic certification	0.42048 ***	0.000	0.55767 ***	0.000	−0.37660 **	0.0312
Type of legumes—chickpeas	−0.06728	0.268	−0.19830 ***	0.0066	0.18002	0.3411
Gluten claim—gluten-free	0.33102 ***	0.000	0.51665 ***	0.000	−0.22098	0.2116
Spices—spiced	−0.16627 ***	0.0002	−0.18565 ***	0.0002	−0.03238	0.865
Origin indication	0.35148 ***	0.000	0.38232 ***	0.000	0.84242 ***	0.000
Recyclability of the pack—recyclable	0.44088 ***	0.000	0.54381 ***	0.000	0.63196 ***	0.0006
Type of oil—sunflower	−0.42070 ***	0.000	−0.57562 ***	0.000	−0.30223	0.1393
Type of oil—extra virgin olive oil	0.29699 ***	0.000	0.24193 ***	0.0013	0.35899 *	0.0884
Opt-out (no choice)	0.07669	0.435	−0.96220 ***	0.000	2.22685 ***	0.000
Model statistics						
	MNL		LCA			
Log Likelihood (LL)	−4340.48		−3792.06			
Inf.Cr.AIC	8701.0		7626			
AIC/N	2.10		1.84			
Bayesian information criterion (BIC)	−4257		−3617			
Number of observations	4144		4144			
Total number of responses	518		518			
Number of variables (K)	10		21			

Note: ***, **, * ==> Significance at 99%, 95%, 90% level, respectively.

3.3.2. Willingness-to-Pay

As Figure 3 depicts, the WTP of respondents for the use of nutritional and claims information on the label of legume-based snacks tends to be heterogeneous across the two classes. In class 2, consumers are willing to pay the highest price premium (EUR 5.49) for labelling regarding the regional origin of this food category, followed by class 1 (EUR 2.22). With respect to recyclable package claims and the use of extra virgin oil, all members' classes are willing to pay a premium price range between EUR 3.11 and 4.18, and EUR 1.39 and 2.36, respectively. However, the WTP was negative for the use of spices, chickpeas as type of legumes and sunflower oil for members' class 1. In addition, respondents' from class 2 were not willing to pay a premium price for the organic certification of legume

snacks. This can be explained by the fact that they do not have enough awareness about the beneficial aspect of biological products.

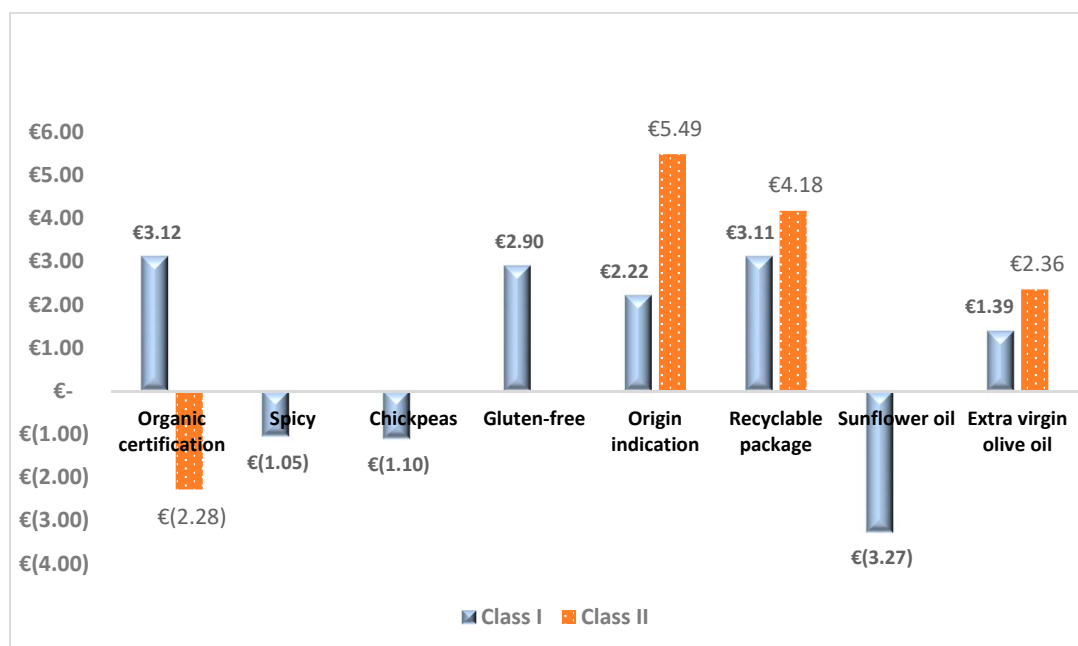


Figure 3. Willingness-to-pay for the use of nutritional ingredients and labelling claims on ready-to-eat legume-based snacks.

4. Discussion

4.1. Interpretation and Comparison of the Results

In this paper, ingredients, claims and certifications were the categories of determinants that may affect pricing and decisions on snacks purchase and consumptions by Italian to some extent. In terms of HDM, we found that not all intrinsic and extrinsic labelling information of the legume-based snacks were statistically significant. The presence of an organic certification, as widely observed, was considered not significant by the analysis of variance nor by the linear regression analysis. Moreover, on the one hand this factor and the peas as type of legumes did not influence the estimate of the hedonic price, while on the other hand, legume snacks based on lentils and chickpeas positively affected the hedonic price of the product. Above all determinants, the weight of the pack, slightly negative, presented a highly significant coefficient, indicating that larger packages would have a lower price (i.e., “family size” or “convenience format”). Similarly, the price was also negative and a highly significant coefficient. Moreover, the absence of oil and the presence of sunflower oil were considered as significant attributes but both negatively affect the estimate of the hedonic price, indicating that Italian consumers preferred or found greater utility from the presence of extra virgin olive oil and underlining the attention to eating health by the respondents. Furthermore, the substitution of wheat flour by rice flour and/or potato starch, traditionally gluten-free components and always used as substitutes for wheat flour in starchy foods and presenting positive and significant coefficients, was also greatly appreciated by Italian consumers. In addition, we found that there was a greater usefulness if lentils were added to the composition of the snack. On the contrary, the place of purchase (i.e., supermarkets and discount stores) presented negative coefficients, indicating a lower utility to the respondents. In terms of DCE, we found that the type of legumes, as a symbol of a healthy and eco-friendly product, was not so preferred by respondents, compared with its origin and certification. In fact, the results revealed that Italian consumers paid more attention to the presence of (i) an organic certification,

(ii) an indication of origin and (iii) a claim of gluten-free, attributes that should be more considered by snack industries to continuously increase the utility of this food category.

Previous papers have also assumed the importance of food ingredients, claims and certifications in pricing and decisions on food consumption, such as snacks. In line with our HPM analysis, previous studies show that the global offer of legume-based snacks has strongly increased in recent years [42], many still focused on improving the technology of production of these highly innovative products [43–46], but very few have focused on the consumer and their propensity to buy. Given this research gap, the possibility of comparing our results with those emerging from other studies relating to the snack world has been reduced to a single possibility that investigates Ethiopian consumer preference and willingness to pay for enriched snacks [47]. Labeling, taste and ingredients were found to be among the most significant attributes in the process of choosing and purchasing innovative snacks, for both studies. In fact, in our study the respondents of the first class do not derive utility from a snack with a spicy flavor and the second class is indifferent to it. Ahmed et al. [47] found that Ethiopian consumers also prefer to buy mango flavored snacks rather than a spicy tomato one. The other important aspect that influences consumers' decision to purchase snacks is the main ingredients: the sorghum-chickpea combination is much preferred over snacks with corn as the main ingredient, as consumers are aware that their blend has a better nutritional and/or health combination. So, this shows that consumers are more health conscious and choose protein-, fiber- and carbohydrate-enriched snacks over carbohydrate-enriched and protein-deficient snacks [47]. In the same way, our respondents are very attentive to the type of ingredients, nutritional indications and snack labeling, a constant that is also found in many other publications [48–50]. In fact, it is now established that consumers seek satisfaction in food, but at the same time they are increasingly aware of the fact that food contributes significantly to their health and well-being [51]. Health and well-being are sought not only in a careful evaluation of the main ingredients, but also of the minor constituents such as the type of oil used. In fact, the profiled consumers show a highly negative utility for the presence of sunflower oil (EUR −3.27 for the first class), as opposed to the willingness to pay a premium price for the presence of extra virgin oil (EUR 1.39 for first class and EUR 2.36 for the second class, respectively). Attention to health also emerges from the market analysis as, out of 100% of the observed products, 79% are gluten-free, 60% are not fried and each one has health and/or nutritional claims used by companies, both to highlight and enhance the beneficial effect of the product and because, in the wake of this trend, the consumer is more inclined to purchase. The importance of claims is seen both in the results of the DCE, which sees respondents more willing to pay for them, and in the study carried out in Ethiopia, which sees nutritional and/or health claims as the most influential attribute of fortified snacks. Although the presence of claims and the type of ingredients are attributes of ascertained importance for the consumer, to push companies to invest significantly in the promotion of these aspects, an even more influential attribute found to be significant in our study, is the presence of an indication of the origin of the raw materials constituting the snack. Although there is a different willingness to pay for this attribute, the purchase by both classes is strongly influenced by its presence, resulting in EUR 2.22 for the first class and EUR 5.49 for the second class. However, this interest is not reflected in the analysis of the hedonic price from which it emerges as only one Apulian producer (i.e., Cerealitalia) has presented on the label the indication of the geographical origin of the legumes used. Despite this lack of interest from companies, the literature appears to be in agreement with our result, showing how this attribute is already relevant for different types of products: plant-based beef meatballs [49], wine [21], sea urchins [52], oil [53] and legumes [54]. Depending on the social and cultural changes that have taken place, the needs and preferences expressed by consumers have changed, passing from the satisfaction of subjective needs and those related to the health of the individual, to ethical and environmental needs, paying attention to the community. Precisely in this context, attention to sustainability is growing, which takes the form of both the demand and the supply of innovative snacks with environmental

claims on the label; in fact, most of the references observed on the shelf have on the label a reference to the green objectives pursued by the companies, ranging from the use of renewable energy sources to the use of recyclable packaging, attributes for which consumers of both classes have expressed a willingness to pay (EUR 3.11 for the first class and EUR 4.18 for the second class, respectively). The environmental aspects also include organic certification, which, as demonstrated by Juhl et al. [55] and Loureiro et al. [56], makes food to be perceived as healthier, more eco-friendly, and tastier than conventional ones. Aware of these reasons, most manufacturing companies require organic certification, which in fact has been found on a large percentage of products observed. However, not all respondents in our sample rate this attribute uniformly. In fact, if the first class is positively influenced by it and is willing to pay EUR 3.12, for the second class it is an attribute that discourages the purchase of the snack with a WTP of EUR −2.28. This result is in line with previous studies that have analyzed the same attribute on other agri-food products, underlining that the premium price that consumers are willing to pay for organic products compared to conventional ones does not follow a precise pattern [57]: WTP awards differ widely across countries, consumer segments and behavior, and product types for which consumers tend to be less loyal to processed organic foods than fresh ones [58]. Yiridoe et al. [59] found that consumers are willing to pay less for organic products with a longer shelf life. Uddin et al. [60] showed that consumers have a disincentive to purchase a certified organic ready-to-eat meal. So, one might think that if the first class is highly sensitive to the motivations that drive organic certification, the second class might not be sensitive to these aspects or, since it is a processed food, as in the cases mentioned above, it does not derive any usefulness from it.

4.2. Importance and Implications of the Results

The results explored above give a clear idea of the role of nutritional facts and labelling information of ready-to-eat legume-based snacks on Italian consumers' habits, preferences and WTP. Here, we link the findings to the scientific literature and deduce private and public implications. Firstly, there is a dearth of research that has simultaneously implemented HPM and DCE to determine price and to elicit snacks consumers' behaviors and their WTP, respectively. Hence, this study enriches the scientific literature on the elicitation of key determinants that affect legume snack price and choice by Italian consumers. Additionally, it may be considered as the starting point to concord a dialogue between the concerned industries interested in differentiating their food products and Italian consumers interested in increasing their consumption utility, and thus toward a better offer of innovative and healthy legume-based snacks. Among these snack products, potato chips often dominate the snack industry, followed by corn chips. Moreover, most RTE snacks are based on ingredients that are high in starch (i.e., corn, wheat, rice, oats, potatoes), with low nutritional value in terms of vitamins, minor minerals, amino acids, and fibers (Table A1) [61]. Furthermore, many RTE snacks are considered energy-dense and nutrient-poor foods with high glycemic index values (Table A2) [62], which could contribute to the increased prevalence of obesity and diabetes [63–65]. Consequently, over the last decade consumers turned out to be more health conscious and require healthier and more nutritious snacks than previously available. As such, the extruded legume-based snacks, in which legume proteins represent up to 20–35% [65] depending on the type of raw material, constitute an innovative healthier alternative to prevent coronary heart disease, diabetes and metabolic syndrome [66], and a suitable alternative for people intolerant to gluten [67]. This means that the launch of innovative and healthful products such a legume-based snack necessitates a campaign of promotion and communication through labelling, which are considered as an indispensable source of information for the consumer and, very often, the main tool by which the latter can evaluate the attributes of the product that they would not otherwise be able to maximize, such as its purchase utility and the product's perceived quality [52]. On the one hand, these analyses have been widely applied to different products, such as lentils as such [54], processed tomatoes [68], ultra high temperature milk [27] and the yogurt market [26], but

on the other hand, not yet enough attention has been paid to legume snacks, which are considered to be an innovative food that have been increasingly widespread in recent years.

4.3. Limitations and Future Research Directions

Despite being a representative sample of consumers of the Apulia population in terms of gender and ages, this research did not explore new insights into Italian regional differences in snack-based legumes preferences utility. Moreover, the DCE, as a non-incentive compatible design relying on hypothetical situations and stochastic assumptions, cannot predict all determinants affecting Italian consumers' choice and WTP for ready-to-eat legume snacks. In addition, a randomized order of options in every choice set will be helpful to prevent an order bias and to ensure that the order in which options are presented to respondents will not influence the survey results. Therefore, we cannot definitively extrapolate our results to the overall Italian population in helping industries' snacks to adopt market segmentation strategies at national level. As such, these results need to be validated by a further important research effort by also eliciting any other attributes (i.e., such as environmental sustainability, social sustainability, use of blockchain QR code as tool of traceability, etc.) attached to snack-based legumes and not considered in this research and in other reference markets other than Apulian.

5. Conclusions

Modernization and globalization have changed Italian consumers' lifestyles and food choices. In some respects, ready-to-eat foods such snack-based legumes are progressively becoming more popular among them, owing to their convenience of consumption and ease of preparation and storage, inducing a substitution of the traditional meals to some extent. Hence, labeling information assists Italian consumers to purchase ready-to-eat snack-based legumes, for which they were willing to pay a premium price towards ingredients, nutritional claims, and certifications in terms of organic status and origin indication for adequate eating behavior. Henceforth, they mainly linked this food category to its nutritional benefits (i.e., high proteins and fiber contents, low fat, salt, and sugar content, gluten-free, rich in micronutrients and bioactive compounds) and its healthiest attributes (i.e., food alternatives that help to prevent coronary heart disease, diabetes, metabolic syndrome, etc.), but its ecological–environmental sustainability aspects (i.e., legumes as raw materials present favorable greenhouse gas emissions and water footprint compared with animal products, increase soil fertility and crop production by enriching the soil with the atmospheric nitrogen, decreasing the use of chemical fertilizers) remain partly known by consumers to some extent. This agro-ecological legumes feature may be relevant as an added value for snacks' industries interested in promoting their products. From this viewpoint, the obtained results provide some insinuations in which to orient healthy and eco-friendly snack products' enhancement policies and market strategies, based on consumer preferences.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/nu15071799/s1>, Table S1: Experiment Design.

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Appendix A

Table A1. Composition of selected ready-to-eat snacks.

	Starch (g/100 g)	Sugar (g/100 g)	Dietary Fiber (g/100 g)	Fat (g/100 g)	Protein (g/100 g)	Water (g/100 g)	Energy Values (Kcal/100 g)
Popcorn	15.5	62.1	4.5	20	2.1	2.6	480
Potato crisps	52.6	0.7	5.3	34.2	6.2	2.8	530
Tortilla chips	58.9	1.2	6	22.6	7.6	0.9	459
Breadstick	67.5	5	3.8	8.4	11.2	3.5	392
Cereal bar	28.3	27.6	4.8	22.2	10.4	2.6	468
Kit Kat	12.9	50.1	1.4	26	7.5	2	500
Crispbread	67.4	3.2	11.7	0.6	9.4	6.4	308
Rice Krispie	82.5	10.4	0.7	1	6.1	3	382
Corn Flakes	81.4	8.2	0.6	0.9	7.9	3	376

Source: Retrieved from Public Health England [61].

Table A2. Glycemic index values of selected ready-to-eat snacks.

	Glycemic Index (Glucose = 100)	Glycemic Index (Bread = 100)
All Bran	30	43
Bagel	72	103
Breakfast cereal bar	78	111
Cheerios	74	106
Corn chips	63	90
Cupcake	73	104
Mars bar	68	97
Pretzel	83	119
Puffed crisp bread	81	116
Puffed rice cake	91	128

Source: Elaborated from Foster-Powell and Brand-Miller [62].

Table A3. Purchase sites by frequency of food purchase (in % of respondents).

Purchase Site	Frequency (%)		
	Low	Medium	High
Grocery stores	21.00%	22.00%	16.00%
Neighborhood shops	15.00%	19.00%	20.00%
Supermarkets	51.00%	39.00%	36.00%
Hypermarkets	6.00%	2.00%	18.00%
Discount stores	6.00%	18.00%	10.00%
E-commerce	0.00%	0.00%	1.00%

Table A4. Self-level attention on the features of food among the sample (in % of respondents).

Features of Food	Number	%
Price	224	43.20%
Label	190	36.70%
Nutrition facts	208	40.20%
Type of ingredients	238	45.90%
Quality of ingredients	167	32.20%
Packaging	94	18.10%
Gluten-free	34	6.63%
Indication of the product origin	143	27.65%
Organic food	58	11.22%
Expiry date	275	53.10%

Table A5. Type of snacks consumed among the sample (in % of respondents).

Type of Snack	Number	%
Fruits and vegetables (i.e., apple, banana, kiwi, peach, fennel, carrots, etc.)	298	57.65%
Salt snack (i.e., chips, crackers, gall salty biscuits)	222	42.86%
Sweet (i.e., croissants, chocolat cake, tarte, etc.)	150	29.08%
Sweet snack (i.e., wafers, biscuits, chocolates, etc.)	116	22.45%
Energy bars (i.e., protein, chocolate, red fruits, etc.)	68	13.27%
Sandwich	29	5.61%
Yogurt	142	27.55%
Other	23	4.59%

Table A6. Frequency of consumption of legume-based snack (in % of respondents).

Frequency of Consumption of Legume Snacks	N.	%
Never	137	26.45%
Everyday	3	0.58%
Several times a week	48	9.27%
Several times a month	55	10.62%
Few times a month	238	45.95%
Once a week	37	7.14%

Table A7. Reason of purchase of legume-based snack (in % of respondents).

Reason for Purchase	n.	%
Flavour	177	34.17%
Healthy	332	64.09%
Upon a recommendation	71	13.71%
Upon the advice of the dietitian	18	3.47%

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CHAPTER 2

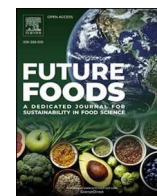
“Breaking Bread” with innovation: the challenge of product differentiation through alternative flours, fermentation, and traceability systems

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ABSTRACT

The growing demand for more sustainable and healthier foods has stimulated innovation in the food sector, particularly in the bakery industry. However, market differentiation for products such as sliced bread is limited by consumers' marked resistance to certain innovations, such as the introduction of innovative ingredients and processing methods. To this end, a robust Discrete Choice Experiment methodology was used on a nationally representative sample of nearly 1600 Italian consumers. A Latent Class Modelling revealed two distinct preference profiles: an innovation-oriented majority (77.5 %) and a more conservative segment (22.5 %). All unconventional flours were associated with negative WTP, particularly insect flour, although the aversion was less pronounced in the innovation-oriented group. Conversely, characteristics related to sourdough fermentation and digital traceability received positive ratings in both segments. The segmentation according to innovation and conservative-oriented consumers is insightful. Although the novelty of ingredients generates resistance reliable characteristics such as fermentation, traceability, and national origin are able to improve product acceptability, justifying its better positioning. Targeted marketing strategies can be outlined based on these different behaviour: consumers who are open to innovation respond to greater transparency and health-related signals, while conservative consumers require reassurances based on tradition and familiarity. These findings support the promotion of market differentiation that combines innovation and trust in the context of industrial baking.

1. Introduction

In the era of global progress in agri-food systems, there is an increasing need to adopt innovative production strategies aimed at creating a perfect synergy between environmental and nutritional sustainability (Cappelli et al., 2020). Bakery products represent a long-standing staple in the human diet and continue to hold a central role in modern food consumption patterns. The bakery sector is also responding to these developments, increasing the range of innovative products made with alternative flours, using sourdough or enriched with functional ingredients. Although these strategies have mainly been adopted in artisanal bakeries, there has recently been growing interest in the industrial sector as well. Sandwich bread, also known as packaged bread or pan carré, is a leading industrial category in the bakery sector, mainly due to changes in consumer habits, which appreciate its practicality, ease of use and long shelf life. However, its nutritional profile and sustainability is increasingly attracting the attention of manufacturers,

stimulating innovation in the use of new ingredients and the latest production methods, despite potential technological challenges or consumer acceptance issues related to cultural aspects or taste preferences.

Although marginal compared to artisan bread-making, the industrial bread segment constitutes a substantially significant part of the food market, even in traditional contexts such as Italy. According to ISTAT data (ISTAT, 2020), it represents approximately 2.63 % (€126 million) of the total value of the national bread market. The bread market is estimated at approximately €4.8 billion (Torazza, 2011) in 2020 with an increase in terms of value with respect to 10 years ago of about 28 %.

In the following paragraphs, we outline the main challenges currently affecting bread production in the global context, the innovative solutions adopted thus far in industrial baking, and the existing research gaps concerning consumer acceptability of these developments, as identified through a literature review.

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1.1. Challenges and trends in bread production in the global and Italian context

Faced with the escalation and convergence of global challenges, including climate change, indiscriminate consumption of natural resources, and increasing demographic pressure, it has become imperative to transform current food systems (Willett et al., 2019). Food production is considered responsible for a substantial share of greenhouse gas emissions and environmental degradation, making dietary changes a key lever for improving the health of the planet (Poore and Nemecek, 2018). In this context, the concept of sustainable diets, defined as those with low environmental impacts that contribute to food and nutrition security and healthy life for present and future generations, has gained increasing traction in both scientific and policy domains (FAO, 2010). A major component of this transformation is the protein transition, which encourages a shift away from resource-intensive animal proteins toward plant-based and alternative protein sources (Tso and Forde, 2021; Aiking and de Boer, 2020; IPCC, 2022).

European consumers' environmental knowledge and risk perception increase environmental concern (Saari et al. 2021), which strongly influences their behavioral intentions, and makes them more aware of the environmental and health implications of their choices, leading to a growing interest in sustainable alternatives. This is in line with values such as transparency, naturalness and ethical production (Siegrist and Hartmann, 2019). To satisfy these preferences, producers of bread and other cereal-based products are trying to reformulate accordingly. Another important novelty is the implementation of digital traceability systems, thanks to the implementation of available technologies such as blockchain and QR codes on packaging. These tools allow consumers to access detailed information about the origin, processing methods and sustainability characteristics of products (Chiaraluce et al., 2024). At the same time, they respond to the growing demand for transparency and trust in food production, particularly among younger, change-oriented consumers (Garaus and Treiblmaier, 2021) and those prioritizing environmental issues in their food choices (Pascucci et al., 2011). In addition to environmental concerns, the production of bread is challenged by high levels of waste. This is particularly evident in the retail and post-purchase domestic stages, due to overproduction and the limited shelf life of baked goods (Gustavsson et al., 2011; Beretta et al., 2013). Furthermore, the affordability of sustainable or enriched options remains a challenge that could reinforce socio-economic disparities in access to healthier and more sustainable foods of this type (de Bakker and Dagevos, 2012). At the production level, balancing standardization with innovation poses a major technical challenge, introducing differentiation that can hinder large-scale, uniform production (Cappelli et al., 2020). In parallel, regulatory barriers related to labeling, health claims, and traceability can further complicate product development and market positioning. Together, these challenges embody the birth of a new generation of food products that aim to balance environmental sustainability, health promotion, and consumer values. However, it remains unclear to what extent consumers are interested and willing to adopt and pay for these attributes, especially in the case of staple foods such as sandwich bread, an aspect that is crucial for the commercial success of such products.

1.2. Innovative solutions in global and Italian industrial baking

Building on the global shift toward sustainable diets and innovations in baking technology, the following section explores how these developments are being integrated into industrial bakery practices. Companies operating in this context adopt strategies aimed at enhancing those distinctive attributes such as innovation, sustainability and traceability (Nazzaro et al., 2019; Cappelli et al., 2020), which can influence purchasing decisions and justify the presence of a premium price. In particular, alternative flours derived from legumes, ancient grains, or food by-products offer a promising means to diversify sources

of plant-based nutrients while reducing reliance on conventional wheat, which is often linked to monoculture practices and high agrochemical input (Caporgno and Mathys, 2021; Danciu et al., 2023).

The enrichment with alternative matrices to wheat, such as those derived from legumes, pseudo-cereals (e.g., quinoa, amaranth, buckwheat), and insects, represents a promising approach due to their high fiber content of fibers, bioactive compounds, and high-quality proteins, thus combining health benefits with food safety (Gobbetti et al., 2020; Alejandro Ruiz et al., 2025). Moreover, diversifying raw material sources in the bakery supply chain reduces dependence on mono-varietal soft wheat crops, thereby enhancing ecosystem services and contributing to the sustainability of cropping systems (Liu et al., 2025). However, despite their potential environmental benefits, these alternative sources often face technological limitations, as well as bioactive compounds in non-bioavailable forms and anti-nutritional factors that can reduce digestibility.

At the industrial level, these challenges are typically addressed through physical pretreatments (hydrothermal processing, high-pressure treatments and extrusion cooking) as well as the use of chemical additives (modified starches, hydrocolloids and protein isolates). Although these solutions are technically effective, they can degrade nutritional components and do not reflect current demands for low-impact "green" processes (Naqash et al., 2017). As an alternative, sourdough fermentation offers an excellent biotechnological solution, and much research has demonstrated its ability to improve the structural properties, shelf life, and flavor complexity of bakery products, particularly those made with gluten-free or non-traditional flours (Moroni et al., 2011; Rizzello et al., 2014; Sayadi et al., 2025). In particular, certain strains of lactic acid bacteria (LAB), classified as 'Generally Recognized as Safe' (GRAS), are present in sourdough alongside yeasts and are capable of developing pro-technological traits that improve the functional, sensory, and microbiological safety characteristics of food products (Caporgno and Mathys, 2021; Wolter et al., 2014). Fermentation has served as an effective method of food preservation for millennia (Ross et al., 2002) and in the baking sector, sourdough fermentation has consistently been shown to enhance crumb structure, improve digestibility, produce health-promoting bioactive metabolites, and provide potential health benefits, including enhanced micronutrient bioavailability and reduced glycemic response (Poutanen et al., 2009). It also prolongs shelf-life, and in particular, enriches flavour complexity - even in gluten-free or composite breads produced with legume, pseudo-cereal or insect flours (Pontonio et al., 2019; Aksoy and Suleymanzade, 2025; Olojede et al., 2022). Collectively, it was confirmed that carefully tailored lactic fermentation is a robust strategy for sensory improvement when alternative flours are used, thereby broadening consumer appeal while supporting both nutritional and sustainability goals. Although technological and nutritional innovations in bakery products are progressing rapidly, sensory issues related to taste and texture, along with cultural and traditional factors, remain critical barriers to consumer acceptability and market uptake, requiring targeted strategies.

1.3. Consumer acceptability: literature review and research gap

Recent market analysis highlight a growing interest of consumers in baked goods with clean-label, transparent, and functionally enriched ingredients, particularly in established market (Europe and USA), with recent expansion to Latin American and Asian markets (Polachini et al., 2022). This trend reflects a broad shift in consumer attitudes and values, such as towards health, environmental sustainability and transparency in food production. Notably, the incorporation of non-traditional flours, such as those derived from legumes, pseudocereals, or even insects, offers significant nutritional and environmental advantages (Meyerding et al. 2018). The acceptance of those innovative ingredients is influenced by sensory factors (e.g., taste, texture, and appearance) (Gosine and McSweeney, 2019), as well as by cultural predispositions,

psychological factors, and food neophobia (Hartmann and Siegrist, 2017; Onwezen et al., 2021). While insect flour faces cultural barriers (La Barbera et al., 2018), recent work by Alejandro Ruiz et al. (2025) suggests that functional and sustainable ingredients may mitigate the aversion among innovation-oriented segments. For instance, insect-based flour, despite its demonstrated health benefits, though highly sustainable and protein-rich, faces resistance due to disgust or unfamiliarity, limiting its integration into markets (Alhujaili et al., 2023).

At the same time, traceability and transparency in the food supply chain have become increasingly important to consumers. Recent studies highlight the growing importance of factors such as origin, production methods, and digital traceability systems (e.g., QR codes, blockchain) in shaping consumer purchasing behavior. A systematic review by Reitano et al. (2024) confirms that blockchain-enabled traceability can strengthen consumer trust, enhance perceived quality, and boost willingness to pay (WTP) for food products. This effect has also been observed in the Italian staple food market: Boncinelli et al. (2024) found that digital traceability systems significantly increase WTP for bakery products, especially when combined with Italian origin claims. Similarly, Petrontino et al. (2024) confirm that consumers increasingly seek verifiable information on production processes and ingredient provenance, demonstrating a growing WTP for dried pasta accompanied by sustainability claims tracked via blockchain, thus highlighting the rising demand for transparency. Furthermore, Mustapa et al. (2025) demonstrated that consumers' acceptance of legume-based gnocchi was influenced by factors such as education and concern for environmental issues, also suggesting that product format may influence WTP.

Aligning with the rising demand for ethical and informed consumption, these tools allow consumers to verify product quality, safety, and sustainability. Similarly, an analysis of European consumers reveals that transparency, sustainability, and health are the key drivers behind the acceptance of blockchain-tracked foods, with many respondents willing to switch brands and pay a premium when credible provenance data are provided (Panghal et al., 2024; Li et al., 2025). Furthermore, this aligns with findings by Rossi et al. (2023), who identified an emerging niche market among younger Italian couples who demonstrate strong environmental commitment and a greater willingness to pay premium prices for sustainable bakery products. These studies suggest that while innovation acceptance remains segmented, combining traceability with familiar cues (e.g., local origin or traditional processing) may bridge the gap between traditional and sustainable bakery offerings, reflecting an increasing convergence between consumer values and market options.

In this context, the key challenge lies in understanding how technological, nutritional and cultural factors intersect to shape consumer acceptance of bakery innovations. While previous paragraph has outlined how processing methods perceived as “natural,” such as sourdough fermentation, can improve perceptions of quality, authenticity, and healthfulness when compared to industrial pre-treatments (Pontonio et al., 2023). The combination of lactic fermentation, alternative flours and digital traceability thus holds promise not only for improving technical product quality but also for meeting the complex expectations of modern consumers, expectations that encompass sustainability, health, and transparency. These factors may, in turn, justify a market premium for such products, but they also raise questions about which attributes truly drive buying decisions.

Despite the increasing availability of sustainable sandwich bread alternatives, there is a lack of comprehensive evidence on how consumers evaluate the simultaneous presence of innovative ingredients, natural fermentation, and traceability technologies (Bandinelli et al., 2023; Garaus and Treiblmaier, 2021). Empirical evidence remains limited regarding how consumers value these combined attributes, especially in mass-consumed, standardized products, where differentiation is challenging, creating a critical knowledge gap. Most existing studies focus either on niche products or individual attributes, often

neglecting the interactions between ingredients, processing, and traceability in shaping consumer preferences and WTP (Petrontino et al., 2023a). Moreover, few studies have employed robust experimental designs, such as Discrete Choice Experiments (DCE), to quantify trade-offs and simulate real-world decision-making processes in this context. Without clear evidence on these trade-offs, producers risk misaligning innovation with consumer priorities and compromising market uptake.

This study addresses this gap by investigating Italian consumers' preferences for sliced bread made with alternative flours, fermented with natural sourdough, and equipped with a digital traceability system. Through a large-scale DCE involving a representative national sample of 1600 Italian participants, the research aims to provide novel insights into attribute valuation and consumer segmentation in the sustainable Italian bakery sector.

2. Materials and methods

Aligned with the research objectives, this study employed a structured online questionnaire administered to a representative sample of consumers. The questionnaire was structured into four main sections designed to capture multidimensional aspects of consumer behavior and preferences toward innovative sandwich bread products. The first section was designed to collect sociodemographic characteristics and verify representativeness of the sample. The second section focused on consumption and general purchase habits for bread alternative products. The third section, the central element of the questionnaire, was focused on a Discrete Choice Experiments (DCE), a well-established methodology for analyzing consumer decision-making and estimating willingness to pay, modeling products as combinations of attributes that determine the utility derived by consumers (Tria et al., 2025). The last section of the questionnaire included questions on the perceived importance and influence of credence attributes in food purchase choices, and the attitude toward innovative sandwich bread.

The analysis is grounded in McFadden's (1974) Random Utility Theory, which theorizes how individuals make choices among competing alternatives, each characterized by a set of attributes and associated levels, based on the utility they derive from them. The attributes and levels selected for this study reflect key trends in innovation and sustainability within the sandwich bread sector. In our study, through a careful review of the literature and an analysis of market and sector innovations, we identified four attributes (Fig. 1) used for the construction of the choice tasks in the DCE.

The first attribute chosen concerns raw materials. In order to allow meaningful comparisons among alternative or non-conventional flours, we considered flours derived from legumes, pseudo-cereals, and edible insects, selected due to their growing market interest and innovation potential. Wholemeal wheat flour was selected as the baseline, due to its widespread recognition and market prevalence, which results in minimal price variation across industrial baked products (Di Cosola et al., 2025). Moreover, its established association with healthfulness also helps prevent overestimating the impact of switching from a conventional to a novel product.

Other features investigated include production method and origin of ingredients. In particular, we compared bread produced using natural sourdough fermentation with bread made from thermally pre-treated flour. This choice reflects an environmental issue because, although heat treatment is often required for alternative flours, replacing it with natural fermentation can save energy and improve nutritional quality. In relation to ingredient origin, given the lack of a mandatory requirement for these products under Italian regulations - unlike for pasta, processed tomato, or dairy products - the attribute comprises three levels: “No indication”, “Italy”, or “Abroad”.

The study additionally examined consumer interest in digital traceability systems, designed to provide real-time information on the product regarding ingredient origin and transformation for reaching a farm-to-fork strategy. This attribute was represented in the DCE by a QR

Attributes	Levels			
	1	2	3	4
Types of alternative flours (used in the production of loaf bread with varying percentages)	Wholemeal flour from wheat 	Legumes Flour (e.g. chickpeas, peas) 	Insect Flour 	Pseudocereals flours (quinoa, amaranth, buckwheat, etc.) 
Production Method (concerns the method of pre-treatment of alternative flours)	with natural leaving (sourdough starter) 	with physical means (e.g. heating) 	-	-
Origin (indicating the country where the raw materials were sourced)	No indication	Italy 	Abroad 	-
Digital Traceability (the application of an advanced system to obtain information about the product/process)	Present (QR Code) 	Not present	-	-

Fig. 1. Attributes and levels used in the discrete choice experiment (DCE).

code logo, although participants were not shown underlying traceability data. Regarding the price attribute, five levels were considered. Starting from the average market price of a standard 500 g loaf of sliced bread in Italy (€2.05), incremental levels were calculated using increases of 25 %, 50 %, 75 %, and 100 %.

Data collection was carried out in January 2025 via a leading survey research company which administered a structured online questionnaire to a representative sample of 1600 Italian consumers. Statistical representativeness of the sample was ensured across key demographics, including age group, gender, and geographical distribution, in line with ISTAT national statistics on the Italian population (ISTAT, 2024). The questionnaire was designed to minimize potential biases in the DCE method. Before presenting the choice tasks, a cheap-talk script was included alongside Fig. 1, which explained the attributes and provided introductory instructions for the experiment, asking participants to make purchase decisions under their usual conditions and respond honestly. This approach aimed to prevent the overestimation of willingness to pay in hypothetical contexts (Tria et al. 2025). Additionally, the nutritional and environmental benefits of alternative flours, sourdough fermentation, and digital traceability were deliberately not explained to participants, with the goal of avoiding conditioning effects from information or nudging bias (Ntoumanis et al., 2022). Finally, the fourth section was administered after the DCE to further mitigate potential bias in the choice experiments, exploring consumer attention to specific product characteristics, such as those perceived to influence price and those that might motivate the purchase of innovative sliced bread. At the end, the entire dataset was checked and cleaned of any incomplete or inconsistent responses, such as identical choices across questions and choice sets, choosing the price-dominated alternative repeatedly or straight-lining patterns suggesting inattentiveness. The experimental design for the DCE was generated using a modified

Fedorov algorithm (Zwerina et al., 1996), selecting the design with the highest D-efficiency value (1.05). A total of 12 purchase scenarios were generated and split into two statistically balanced blocks, using a pseudo-random design, each consisting of six choice sets. In each set, respondents were asked to choose between two multi-attribute bread alternatives (A and B) and a no-purchase option C (optout) (Fig. 2).

The data collected were analysed using a Conditional Logit Model (CLM) to estimate the average preferences of the entire sample. Subsequently, a Latent Class Model (LCM) was applied in order to capture the unobserved heterogeneity in preferences among respondents. Finally, a Multinomial Logistic Regression (MLR) was conducted to identify the socio-demographic and psychographic factors associated with belonging to different classes.

The use of these econometric models made it possible to quantify the trade-offs made by consumers between different product characteristics and to estimate their willingness to pay (WTP) for each attribute.

In the context of CLM, the utility (U_{nj}) that individual n assigns to alternative j is modelled as follows:

$$U_{nj} = \text{No buy} + \beta X_{nj} + \text{price } \lambda j + \varepsilon_{nj} \quad (1)$$

Where:

- “No buy” is a constant specific to the ‘no purchase’ option.
- X_j is a vector of dummy-coded attributes for the alternative j .
- β represents the estimated coefficients for each attribute.
- λ is the negative marginal effect of price on utility.
- ε_{nj} is the unobserved error, distributed according to an extremely independent and identically distributed value.

To consider the influence of individual characteristics (e.g., attitudes or values), interactions between product attributes and latent variables

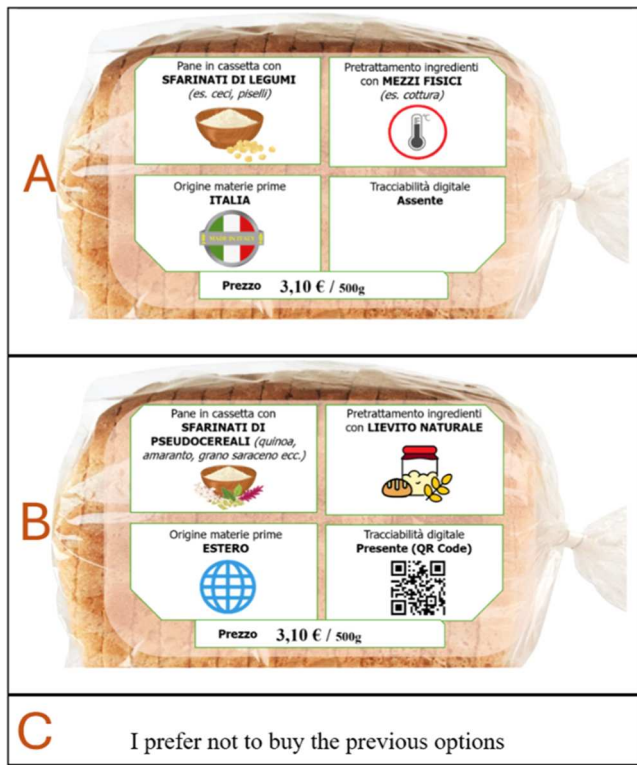


Fig. 2. Example of a choice set (the choice set is in Italian).

can be included:

$$U_{nj} = \text{No buy} + \beta X_{nj} + \text{price} \lambda_j + \gamma X_{nj} Z_n + \varepsilon_{nj} \quad (2)$$

Where Z_n is a vector of latent trait scores for respondent n and γ captures how these traits moderate preferences. The latent traits Z_n are estimated through a measurement model based on reflective indicators

$$I_{kn} : I_{kn} = \delta I_k + \zeta I_k Z_n + v_{kn} \quad (3)$$

Where: δI_k is a constant for the k -th indicator, ζI_k is the estimated effect of the latent variable Z_n on this indicator, and v_{kn} is a disturbance term, assumed to be normally distributed.

In order to segment different consumer groups, we employed a Latent Class Model (LCM). LCM assumes that the studied population is divided into a finite number of classes or segments coherent with the choice patterns. Each group has its own set of parameters, providing a straightforward interpretation of the group's characteristics and preferences (Magidson and Vermunt, 2004).

In the context of a DCE, the probability that a respondent will choose alternative i is a function that includes the attribute levels of alternative i and the attribute levels of all other alternatives presented in Table 2 and becomes as follows:

$$\text{Prob}(\text{choice} = i) = \frac{\exp^{V(\beta, X_i)}}{\sum_j \exp^{V(\beta, X_j)}} \quad (4)$$

where $V(\beta, X_i)$ is the observed component of the utility function for alternative i and j is a set of alternatives. Furthermore, the choice probability (Eq. (4)) within a class q becomes as follows:

$$\text{Prob}(\text{choice} = i / \beta q) = \frac{\exp^{V(\beta q, X_i)}}{\sum_j \exp^{V(\beta q, X_j)}} \quad (5)$$

Lastly, Willingness to Pay (WTP) for any given attribute x_k is derived by dividing the marginal utility of that attribute by the negative marginal utility of price:

$$\text{WTP}_k = -\beta_k / \beta_p \quad (6)$$

3. Results

Over the 1600 administered questionnaires, the sample resulted in 1537 valid respondents, as reported in Annex A. Considering the main statistics of the Italian population, demographic representativeness was guaranteed with a sample of consumers over 18 years old who are responsible for food purchases, balanced by gender and geographical area. Descriptive statistic on socio-economic characteristics - including education, employment status, income, age, and gender - collected in the first section of the questionnaire reveals that the sample closely matched the Italian population in terms of age and geographical distribution (ISTAT, 2024). In addition, while most respondents were Italian citizens (97.4 %), had a high school level education (53.35 %), and held a job (34.29 %), only 11.32 % of them earned more than EUR 60000 per year.

Annex B shows the statistics of our sample related to consumption and purchase habits, including weekly food expenditure, purchase frequency and channels for bread alternatives, as well as the level of consumer attention toward specific product characteristics. In particular, the results reveal that 46.84 % of respondents purchase sliced bread most frequently in supermarkets and 45.35 % of respondents spend between EUR 101 and 150 on food per week.

Furthermore, regarding the questions in the fourth section on attention to credence attributes, respondents allocated the greatest focus on country of origin (59.85 % rated high or extreme), health claims (50.01 %), and certifications (49.12 %) among sliced bread characteristics, while alternative proteins attracted the least attention (17.11 %). The raw material origin (63.5 % high/extreme) and ingredient quality (68.64 %) were identified as the strongest influences on bread price. Finally, when considering purchase intentions, respondents prioritize health benefit information (70.98 %), origin details (74.11 %), and sustainability information (64.87 %), suggesting a clear openness to innovation, especially when linked to health and environmental benefits.

Regarding the elaboration of choice task with LCM, the comparison of models with increasing numbers of latent classes, based on AIC and BIC information criteria, showed lower values for the 3-class model, suggesting a better overall fit (Table 1). However, the intercept of the second class was not statistically significant ($p = 0.101$), indicating that is a priori probability did not differ from the reference class. As a result, a 2-class model was selected for its clearer segmentation and higher interpretability.

The analysis identified two distinct consumer segments of consumers in terms of their preferences for innovative sandwich bread. The estimated class membership coefficient (1.265***) was positive and significant, with Class 1 representing the majority of respondents (77.5 %) and Class 2 the remaining 22.5 %. A direct comparison of coefficients across the two classes revealed substantial differences in how product attributes are valued (Table 2), also in comparison to CLM results. While the Class 2 exhibited stronger resistance to unconventional flours, the first class was characterized by being less closed to innovation.

Alternative flours had a negative impact on product choice in both classes, with stronger rejection observed in Class 2. In general, legume and pseudocereal flours were viewed less negatively than insect flour, which faced pronounced aversion, likely due to deep-rooted cultural factors. This aversion, however, appeared significantly attenuated in Class 1 (insect flour: 1.412*** in Class 1 vs -3.219*** in Class 2).

Table 1
Godness of fit of LCM.

Classes of the Model	Log-Likelihood	df	AIC	BIC
1	-13449.84	9	26917.69	26991.74
2	-7796.40	24	15640.80	15838.27
3	-7679.06	29	15416.11	15654.73

Table 2
Latent class model results.

Variable	CLM	Std. Err.	Class 1	Std. Err.	Class 2	Std. Err.
FL_leg	−0.3937***	0.0399	−0.150***	0.0436	−1.153***	0.1189
FL_ins	−1.293***	0.0497	−1.412***	0.0838	−3.219***	0.2034
FL_pse	−0.9378***	0.0429	−0.479***	0.0480	−1.309***	0.1309
TR_bio	−0.2282***	0.032	+0.266***	0.0493	+0.511***	0.1060
OR_I	0.1995***	0.0438	+0.739***	0.0817	+1.680***	0.1454
OR_es	−0.3413***	0.0377	−0.055	0.0360	−0.054	0.1214
DT_yes	0.0709**	0.0333	+0.406***	0.0481	+0.377***	0.0974
Opt Out	−2.6332***	0.088	−3.204***	0.1297	+0.130	0.2834
PRICE	−0.1697***	0.0216	−0.130***	0.0220	−0.223***	0.0703

Notes: FL_leg = legume flour; FL_ins = insect flour; FL_pse = pseudocereal flour; TR_bio = pre-treatment with natural yeast; OR_I = Italian origin; OR_es = foreign origin; DT_yes = digital traceability.

(*) $p < 0.10$, (**) $p < 0.05$, (***) $p < 0.01$.

Nonetheless, these variations were not sufficient to make any alternative flour preferable to wholemeal wheat flour, which remained the most positively perceived baseline. WTP estimates for all alternative flours were negative, particularly so in Class 2, confirming strong resistance among a substantial share of consumers.

Conversely, process-related attributes such as natural sourdough fermentation and digital traceability received positive and significant coefficients in both classes. Both segments appreciate characteristics linked to naturalness and transparency, regardless of their openness to innovative ingredients. Italian origin had a positive effect in both classes, more marked in Class 2 (+1.680*** vs +0.739***), suggesting that more sceptical consumers value national origin more as a guarantee of quality and familiarity. Conversely, foreign origin did not significantly differ from the absence of information in either class. As expected, price had a negative effect on choice in both segments, with greater sensitivity in Class 2 (−0.223*** vs −0.130***). The main difference between the groups concerns the opt-out constant: strongly negative in Class 1 (−3.204***), it indicates a high propensity to purchase the product in general, while it is not significant in Class 2, suggesting a weaker preference.

WTP estimates (Table 3 and Fig. 3), derived from the attribute coefficients relative to price, confirmed the trends observed in the latent class model.

Finally, the multinomial logistic regression (MLR) analysis (Table 4), based on the most likely latent class membership, identified the socio-demographic and psychographic determinants associated with class allocation.

Consumers more likely to belong to Class 1, i.e., more open to innovation, were those who purchased sandwich bread more frequently (RRR = 1.39***), were male (RRR = 1.28***), younger (Under_45: RRR = 2.14***), and had middle to high income (Inc2: RRR = 1.17***). Psychographic traits linked to Class 1 included stronger attention to health claims, alternative proteins, traceability, and production process innovation. In contrast, price sensitivity and preference for ingredient origin were more pronounced among Class 2 respondents. Moreover,

Table 3
WTP estimated per Class.

Variable	Class 1 WTP	Std. Err.	Class 2 WTP	Std. Err.
FL_leg	−1.158***	0.3924	−5.169***	0.1718
FL_ins	−10.881***	0.1781	−14.433***	0.4686
FL_pse	−3.688***	0.7470	−5.869***	0.1954
TR_bio	+2.049***	0.4637	+2.293**	0.9516
OR_I	+5.691***	0.9879	+7.531***	0.2637
OR_es	−0.422	0.2874	−0.243	0.5245
DT_yes	+3.125***	0.5476	+1.689**	0.6635
Opt Out	−24.686***	0.3905	+0.581	0.1433

Notes: FL_leg = legume flour; FL_ins = insect flour; FL_pse = pseudocereal flour; TR_bio = pre-treatment with natural yeast; OR_I = Italian origin; OR_es = foreign origin; DT_yes = digital traceability.

(*) $p < 0.10$, (**) $p < 0.05$, (***) $p < 0.01$.

lower education levels were negatively associated with membership in Class 1, suggesting that consumers with higher education were more open to product innovation.

4. Discussion

The results offer valuable insights into how consumers perceive innovation in industrial bakery products. In general terms, while there is clear resistance to insect-derived flours, and to a lesser extent to legumes and pseudocereals, other attributes related to processes and transparency are welcome. In fact, fermentation with sourdough emerges as a universally recognized and appreciated characteristic, presumably because of its connection with tradition, naturalness and digestibility. Furthermore, the study highlights considerable heterogeneity in consumer preferences regarding product innovation. The use of a Latent Class Model allowed us to identify two distinct segments of Italian consumers: a majority class (Class 1) characterized by openness to innovation and a smaller, more conservative class (Class 2) marked by stronger resistance to change.

The negative utility in both classes of non-conventional flours confirms prior findings on the impact of food neophobia and cultural acceptance on consumer choices (Grahl et al., 2020; Herbert and Beaumont, 2021). Consistently, legume aversion found in our results further supports this interpretation, and in contrasts with a recent study in which, among a smaller sample of Spanish consumers, the majority of participants exhibited a high level of trust toward legume-based gnocchi, although this trust was influenced by socio-demographic factors such as education level, income, financial situation and environmental concerns of the respondents (Mustapa et al., 2025). Insect flour, in particular, showed the strongest aversion, especially in Class 2 (WTP:14.43€), aligning with studies that associate insect consumption with disgust and unfamiliarity (La Barbera et al., 2018). While Class 1 showed more moderate responses (e.g., WTP for insect flour:10.88€), wholemeal wheat flour remained the dominant baseline, suggesting that familiarity and perceived healthiness still drive consumer choices in this category. Although selecting wholemeal flour as the baseline reinforces its leading position in the baked-goods market, it may also amplify negative preferences toward less familiar flours, thereby widening the perceived gap with white flour.

In contrast with the aversion to ingredient innovation, attributes related to natural processing and transparency were positively evaluated across both segments. The use of sourdough fermentation improved perceived utility and WTP (around +2€ for both classes), reflecting a wider trend of consumer preference for "natural" and "clean label" food processes (Asioli et al., 2017; Poutanen et al., 2009).

The positive response to digital traceability supports studies already conducted (Boncinelli et al., 2024; Petrontino et al., 2024). This suggests that even if the product is not particularly engaging, consumers appreciate mechanisms that guarantee transparency and verification of origin. This implies that technological solutions (Blockchain, QR codes and

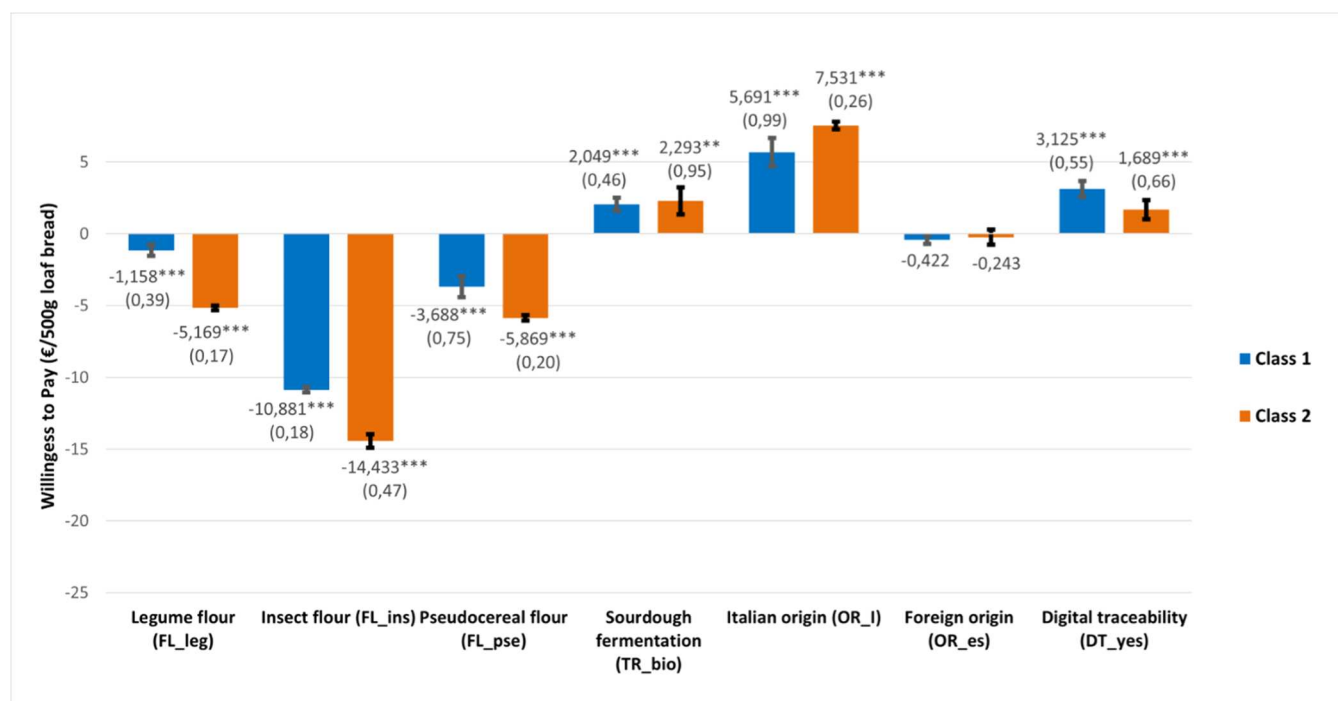


Fig. 3. Estimated willingness to pay (WTP) for Class 1 and Class 2. Asterisks denote statistical significance levels (as in Table 3), and error bars represent standard errors (values in parentheses).

Table 4
Determinants of class membership.

Variabile	Coeff.	Std. Err.	RRR	Std. Err.
P_Freq	+0.326***	0.0167	1.386***	0.0231
At_Price	−0.205***	0.0185	0.815***	0.0151
At_Claim	+0.094***	0.0236	1.099***	0.0260
At_ProDiv	+0.275***	0.0197	1.316***	0.0259
At_BioStart	−0.067**	0.0248	0.936**	0.0232
At_Cert	−0.030	0.0253	0.971	0.0246
At_Or	−0.418***	0.0235	0.659***	0.0155
At_Trace	+0.091***	0.0233	1.095***	0.0255
Int_Var	+0.302***	0.0251	1.353***	0.0340
Int_Health	+0.041	0.0272	1.042	0.0283
Int_Brand	+0.037*	0.0222	1.037*	0.0230
Int_Or	−0.101***	0.0277	0.904***	0.0250
Int_Proc	+0.107***	0.0258	1.113***	0.0287
low_education	−0.100**	0.0452	0.905**	0.0410
Male	+0.247***	0.0311	1.280***	0.0399
Under_45	+0.760***	0.0363	2.138***	0.0777
Inc1	−0.181***	0.0560	0.834***	0.0467
Inc2	+0.157***	0.0516	1.170***	0.0604

Notes: RRR, Relative Risk Ratio; P_Freq = frequency of bread box purchase; At_ = attention when purchasing; Price = price; Claim = health claims; ProDiv = alternative protein; BioStart = natural yeast; Cert = certifications; Or = origin; Trace = traceability; Int_ = intention to purchase an innovative bread in the presence of specific conditions; Var = variability of supply in the market; Health = health; Brand = knowledge of the brand offering the innovation; Proc = information on the production process; low_education = elementary or average education compared to high_education, degree or post_graduate; Male = men; Inc1 = income less than 20000 €/year; Inc2 = income between 20000 and 60000 €/year.

(*) $p < 0.10$, (**) $p < 0.05$, (***) $p < 0.01$.

smart labels) can help from a logistical point of view but also as a marketing lever to increase consumer confidence. QR codes for real-time verification of ingredient origin generated significant positive responses (WTP: +3.13€ in Class 1; +1.69€ in Class 2), supporting literature that emphasizes the role of traceability in fostering trust and purchase intent (Chiaraluce et al., 2024; Lin et al., 2021). The origin had a significant

effect in both classes. Italian origin was associated with the highest WTP in Class 2 (+7.53€), reinforcing its role as a signal of quality and safety among more conservative consumers. In contrast, foreign origin did not significantly differ from a lack of information. This aligns with findings that "local" or national sourcing is a key heuristic used by consumers when evaluating food authenticity and safety (Nocella et al., 2012).

Price was negatively associated with product choice in both segments, with stronger sensitivity in Class 2 (−0.22 vs −0.13). Class 1 respondents also showed a significantly negative constant for the opt-out alternative (Opt Out = −3.20), suggesting that, overall, they perceived the new product options as superior to the default. In contrast, Class 2 respondents did not systematically reject the opt-out, indicating lower overall willingness to adopt new bread formats under uncertainty or innovation fatigue (Siegrist and Hartmann, 2020). Importantly, the dual segmentation identified through LCM confirms the heterogeneity in consumer openness toward innovation. The large share of Class 1 suggests a market segment willing to engage with moderate innovation, especially when it aligns with perceived health and sustainability benefits. On the contrary, respondents belonging to the class 2 demonstrated the need for improved consumer education, in terms of safety, nutritional value, and environmental implications of alternative flours. Respondents belonging to the class 1, younger, male, and with higher incomes and education levels, tend to regular and affordable slices bread consumers. This group of respondents cared more about health claims, alternative flours, digital traceability, and new production methods as also depicted by Asioli et al. 2017. On the contrary, Class 2 was more price-sensitive and focused on origin, sticking to familiar, budget-friendly options. As such, this study suggests for the bakery industry the following: (i) Alternative flours have clear health and environmental perks, but people need convincing mainly for insect flours (Onwezen et al., 2021; La Barbera et al., 2018). Packaging, labels, and in-store info should focus on these attributes (Asioli et al., 2017); (ii) Sourdough fermentation could be a smart move, helping bridge the gap between old and new; and (iii) Digital tools (QR codes, blockchain) can boost trust, especially for skeptics (Bandinelli et al., 2023). In addition, research shows that when paired with sustainability claims, these tech features make products seem more credible and transparent.

The indication of Italian origin, a proxy for authenticity and safety, also plays a crucial role, especially for consumers with higher neophobia or conservative preferences. As already found by previous studies on food products (Petrontino et al., 2023b), origin is often perceived as a guarantee of familiarity and local quality, and it can compensate for hesitation toward other less familiar product innovations. This suggests that explicitly communicating national origin can be a strategic positioning tool, particularly when introducing sustainable or novel ingredients in mass-market products.

Consumer behaviour towards food innovation depends on socio-demographic, and psychological factors, inducing customized marketing strategies. As such, our study has some main limitations, primarily related to method used. The DCE approach does not fully capture real-world consumer acceptance and engagement. The stated-choice nature of DCEs can introduce hypothetical biases that may overestimate willingness to pay and purchase intentions compared to actual market behavior. This occurs because self-report methods such as surveys and questionnaires are prone to socially desirable responses, which is the tendency for participants to provide answers that present themselves in a favorable light or "stretch the truth" to make a good impression (Martin and Nagao, 1989). Although we used a "cheap talk" script to mitigate this tendency, its effectiveness cannot be guaranteed, and residual biases may remain. The cheap talk script was useful for enhancing attribute comprehension and information provision, but these were deliberately limited to capture the current state of consumer preferences while minimizing nudging effects. Despite this approach, and although no formal filter questions were used to verify attribute comprehension, the consistency of attribute interpretation across participants is confirmed by the differentiated responses observed in the choice sets. Additional limitations concern the point-in-time nature of DCE preference elicitation, which does not account for how consumer attitudes might shift as novel ingredients become more familiar through market exposure and educational efforts. Moreover, the absence of sensory evaluation can represent another constraint, since sensory properties play a crucial role in food purchase decisions, particularly for novel products. Finally, focusing on the Italian market, limits the broader applicability of these findings to other cultural and geographical contexts. Consequently, future research should integrate multiple methodological approaches, including sensory testing, and cross-cultural comparisons, as well as longitudinal studies tracking preferences evolution. Testing different communication and labeling strategies may also boost consumer acceptance of new food products.

5. Conclusion

This study examined Italian consumers' preferences and willingness to pay (WTP) for innovations in sandwich bread, particularly those related to the use of alternative flours, sourdough fermentation and digital traceability systems. To this end, a large-scale discrete choice experiment was conducted involving a representative sample of 1600 participants. The results showed marked heterogeneity in preferences, distinguishing two consumer profiles: the majority (77.5 %) were open to innovative features, while a minority (22.5 %) maintained a more conservative attitude.

While all unconventional flours (based on legumes, pseudocereals and insects) were detrimental to product choice, this was significantly more pronounced among conservative consumers. Insect flour, in particular, aroused the strongest aversion, confirming the persistent role of cultural and psychological barriers.

Both sourdough fermentation and digital traceability were appreciated in both segments, indicating that natural processes and transparency are widely accepted and useful in promoting the adoption of more radical innovations. Italian origin also reinforced the perceived value of the product, especially among consumers less inclined to change. These results suggest that the development and marketing of innovative products should integrate new elements within a context of

familiar and reliable attributes, such as naturalness and provenance. In parallel, food companies should adopt targeted segmentation strategies: using storytelling and value-based communication for innovation-friendly consumers, and emphasising re-assurance, tradition and national origin for more conservative segments.

The use of stated preferences, typical of the DCE approach, may not fully reflect actual purchasing behaviour, and the focus on Italian consumers limits its generalisability. Future studies should integrate self-reported and observational methods with sensory analysis, explore different cultural contexts, and evaluate the effectiveness of communication strategies in promoting the acceptance of sustainable innovations.

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Ethical statement

Participants were informed with the following statement at the beginning of the questionnaire: "The survey, conducted exclusively for research purposes, is aimed at collecting consumer preferences regarding the purchase of sliced bread in Italy. Any information communicated for the survey will be treated in compliance with Regulation (EU) 2016/679, ensuring the utmost confidentiality. The data controller is DISSPA – Department of Soil, Plant and Food Sciences of the University of Bari "Aldo Moro".

Moreover, they gave informed consent via the statement "I am aware that my responses are confidential, and I agree to participate in this survey", where an affirmative reply was required to enter the survey. They were able to withdraw from the survey at any time without giving a reason.

CRediT authorship contribution statement

Alessandro Petrontino: Writing – review & editing, Writing – original draft, Visualization, Supervision, Conceptualization. **Emanuela Tria:** Writing – review & editing, Methodology, Formal analysis. **Michel Frem:** Writing – review & editing, Methodology. **Francesco Di Cosola:** Writing – review & editing, Validation, Investigation, Data curation. **Simona Carbone:** Writing – original draft, Conceptualization. **Erica Pontonio:** Supervision, Funding acquisition. **Francesco Bozzo:** Resources, Project administration, Funding acquisition.

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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Supplementary materials

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Data availability

Data will be made available on request.

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CHAPTER 3

Consumers' purchase propensity for pasta tracked with blockchain technology and labelled with sustainable credence attributes

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Consumers' purchase propensity for pasta tracked with blockchain technology and labelled with sustainable credence attributes

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Introduction: Pasta is a key product in Italy's agri-food industry, consumed due to its ease of preparation, nutritional richness, and cultural importance. Evolving consumer awareness has prompted adaptations in the pasta market, to address concerns about social, environmental, quality, and food safety issues. This study examines Italian consumers' willingness to pay (WTP) for pasta in local markets, analysing their behaviours and preferences.

Methods: For this purpose, we used a discrete choice experiment (DCE) technique combined with a latent variable model. We also collected 397 valid online questionnaires.

Results and Discussion: The results reveal an interest utility among all respondents to pay a price premium of €1.16, €0.82, €0.62, €0.41, and €0.36 for 500 g of pasta, for the use of blockchain/QR code (BC) technology on the label, providing data on credence attributes such as safety, environmental and social sustainability as well as business innovative practices, respectively. As such, this research has private and public implications. On one hand, this research may bridge the scarcity in studies regarding consumer preferences and WTP for BC in the pasta value chain, preventing agricultural frauds, ensuring the sustainability and quality of agri-food products like pasta, and protecting and educating consumers through clear and transparent information. On the other hand, this research may incentivise pasta businesses to meet social and environmental consumers' demands while simultaneously enhancing their financial performance.

KEYWORDS

blockchain technology, choice behaviour, food innovation, food safety and quality, food sustainability, food traceability information, willingness to pay (WTP)

1 Introduction

Pasta value chain constitutes a strategic Italian agri-food sector. With an average of 23 kg/capita/year, Italy is the universal leading country in pasta consumption in 2022 and has the first worldwide position in pasta production which is estimated near to 4 million tonnes in 2021 as depicted in [Tables 1, 2](#). Furthermore, Italy holds a share of 28.3% of the global dried pasta export, generating an export value of this category of foods of approximately 4 billion euro in 2022. In addition, Italy produces 3.8 million tonnes of durum wheat from 1.24 million

TABLE 1 Leading countries in pasta consumption in 2022 (kg per capita).

Country	Average consumption (kg/capita/year)
Italy	23
Tunisia	17
Venezuela	15
Greece	12.2
Peru	9.9
Chile	9.6
United States of America	8.8
Turkey	8.7
Iran	8.5
France	8.3
Germany	7.9

Source: www.statista.com/statistics/1379424/per-capita-consumption-pasta-by-country (accessed on 07/11/2023).

TABLE 2 Leading countries in pasta production in 2021 (Tonnes).

Country	Production (Tonnes)
Italy	3,890,467
United States of America	2,000,000
Turkey	1,902,423
Egypt	1,200,000
Brazil	1,182,000
Russia	1,096,912
Nigeria	700,000
Iran	560,000
Argentina	407,336

Source: www.statista.com/statistics/1378224/leading-countries-worldwide-in-pasta-production (accessed on 07/11/2023).

hectares, mostly located in Apulia and Sicily regions (southern Italy), representing approximately 28 and 21% of the total cultivated area in durum wheat, respectively. Despite, it is important to spotlight how the country cannot meet the growing national demand. Thereby, Italy imports pasta and derivatives, with a total of 40.1 thousand tonnes, especially from China and Germany as presented in Table 3 (Statista, 2023). Consumed on a daily based in Italy, dried pasta and similar substances are considered as easy-to-cook, convenient, nutritious, and affordable food category items. However, their relative high carbohydrate contents may cause a barrier for their market growth, mainly for consumers over 50 years old (Pounis et al., 2016). In this direction, to attract and satisfy consumers, a wide variety of pasta is evolving, integrating different ingredients (i.e., carrots, herbs, beet, and legumes), and including innovative production processes such as organic, gluten-free, and vegan. However, the rising of environmental and social sustainability issues, the food frauds, the food quality and safety, and the impact of innovative technologies constitute continuously the major consumer concerns in the developed countries such Italy. As a result, all economical actors are joining their efforts to satisfy this increasing aware of consumers' requirements toward more traceable, sustainable, innovative, safe, and high-quality Italian pasta

products, inducing a greater consumer willingness to pay (WTP) (Rossi et al., 2023). On the contrary, a lower WTP to them may occur if they have modest information and awareness about safety and healthy features of pasta (Altamore et al., 2017). Thus, there is a need for new research to explore these consumers' requirements toward as well as their consumption of pasta.

In this direction, many studies have looked at food traceability, sustainability, innovation, and safety from a consumer behaviour perspective. Regarding the traceability issues, several research studies have explored the consumers' acceptability of blockchain traceability system (BT) as an innovative digital tracking food. Since 2008, the concept of the Internet of Things (IoT) was applied, to become a reality the application of electronic and real-time information sharing (Qian et al., 2020). Consumers' purchasing behaviour toward traceable food could change according to their perception of these technologies. In their studies, Spence et al. (2018), Yeh et al. (2019), and Lin et al. (2021) analysed consumers' intention to adopt BT toward the traceability of organic food products, indicating that BT influences positively and significantly their purchase decision. Therefore, BT is considered an important aspect in our research. In terms of sustainability issues, the determinants of consumer behaviour toward environmental and social sustainable pasta production were relatively less addressed in the literature review. In their study, Altamore et al. (2017) assessed consumers' preferences and opinions toward environmental issues associated with pasta in Sicily, in which the participants, evaluated very interesting the absence of toxins, related to climate conditions in Sicily. This could, therefore, be considered as an ecosystem service that would be useful to evaluate the adoption of sustainable and healthy agricultural models, as suggested by Mediterranean diet. Furthermore, it is crucial to inform consumers how the food traceability system works to gain consumers' trust in food safety and to build their confidence in it. This consideration was also exposed by Bandinelli et al. (2023), who considered that BT can constitute an important tool, but the mechanism that regulates it must be correctly communicated, so that the consumers can understand its effectiveness in guaranteeing transparency and accountability. Practically, the use of IoT sensors gathers both field and meteorological information about durum wheat production and uploads them into Hyperledger Fabric (Fiore et al., 2023, 2024). An edge computing unit is responsible of converting this huge amount of data into valuable information; then, it uploads the output of the processing to Ethereum. Growers also upload some information about the wheat production (i.e., where it is produced and how it is transported from the field to the cooperative). A consumer, looking at the pasta package in a supermarket, decides to know more about this food. He may open the web app and scans the QR code that he finds on the pasta label. He then retrieves all relevant information about a lot of pasta product, at different stages of the value chain (Galvez et al., 2018), such as: stage of production (i.e., gathering information on but not limited to: varieties, agricultural practices such as the use of the pesticides, fertilisers, or any other agricultural practices that have been applied during the cultivation process, timing, production area, and working conditions); stage of processing (i.e., gathering data on but not limited to: operations conditions, packaging, process of fabrication, safety, and quality assurance); stage of storage (i.e., retrieving data on but not limited to: the quantity, temperature, and humidity); and stage of distribution (i.e., getting data on real-time environmental data of transport and storage, location of the distribution vehicles,

TABLE 3 Leading suppliers of Italy's imports of pasta in 2022 (million euros).

Country	Importation (million euros)
China	14.83
Germany	12.76
Belgium	12.34
Poland	9.89
France	7.63
Netherlands	6.89
Greece	4.61
Austria	4.48
South Korea	4.41
Serbia	4.05

Source: www.statista.com/statistics/1027841/leading-suppliers-of-italy-s-imports-of-pasta (accessed on 07/11/2023).

transportation timing, and quality control). Consequently, the advantages that the application of BT in a food supply such pasta value chain can bring are many and involve both consumers and producers in terms of: transparency and authenticity of data; security, as the problem of fraud is kept under control; decentralisation; automation and consequent reduction of administrative costs and bureaucratic practices; recognition of goods that do not comply with safety standards and consequent withdrawal of goods from the market; and identification of the true origin of the products as well as the reduction of counterfeiting and falsification of pasta products. In addition, the use of BT technology implements the social sustainability of the pasta, emerging many social elements. In fact, the social sustainability encompasses a series of manoeuvres that aim mainly to ensure a comfortable and dignified life for workers without any distinction between them. In this direction, the social sustainability of pasta products will involve a significant commitment on the part of agricultural households, especially in terms of enhancing human capital through carrying out professional and extra-professional training activities for workers as well as transparency toward illegal work and fair retribution. Furthermore, other potential elements may emerge through this sustainability dimension in terms of: (i) occupational safety, leading to personnel safety training activities, controls, and certifications; (ii) health insurance, prevention, and assistance services; (iii) potential pension funds and insurance policies for workers; (iv) initiatives for the reconciliation of work with personal needs such as leave and flexibility of hours, support for parents for the management of children, facilitations for meals, transport, and accommodation; and (v) initiatives to support immigrant workers for housing facilities, bureaucratic facilitations, and language training.

With respect to innovation issues, numerous scientific studies have addressed the determinants that affect consumers' perception and estimated the WTP by type of pasta toward this attribute. To examine whether increased vegetable variety enhances healthy food choices and improves meal composition, [Bucher et al. \(2011\)](#) have used a randomised experiment, in which participants tend to select an assortment of pasta and vegetables, inducing a balance meal and improving their food selection. In their studies, [Foschia et al. \(2014\)](#) explored the variation in the preparation processes of pasta made by durum wheat pasta (as a control) and pasta made with durum wheat

semolina and pea flour combinations, to assess the quality and to identify the best predictive *in vitro* glycaemic response in terms of starch degradation. Based on WTP, [Pappalardo et al. \(2017\)](#) have evaluated the economic feasibility of high heat treatments, a physical eco-friendly method for pest control in industrial plants that produce pasta in Sicily (Italy), increasing the factory's turnover and reducing the environmental impact. In their research, [Pasdar et al. \(2017\)](#) elucidated the compliance between information presented in food labelling of widely consumed foods such as pasta and their true values, inducing misleading effects on food choice and leading to public unhealthy eating. In addition, [Predieri et al. \(2018\)](#) explored the Italian older adults' consumers toward the development of innovative and healthy pasta sauces. [Van der Stricht et al. \(2023\)](#) studied WTP for front-of-pack labels on microalgae protein pulps. In their studies, [Stasi and Baino \(2023\)](#) assessed consumers' desires and willingness to purchase five frozen gnocchi formulations, while [Palmieri et al. \(2021\)](#) analysed consumers' WTP for a novel functional pasta based on *Opuntia Ficus Indica*. Furthermore, a small number of studies have looked at consumer preferences for the characteristics of pasta as it is. In this direction, [Cavallo et al. \(2014\)](#) conducted a real-world choice experiment considering 10 main intrinsic and extrinsic attributes (i.e., local origin, labelling, organic certification, and branding) of pasta. Finally, [Castellini et al. \(2022\)](#) stated that the acceptance of new food traceability technologies has shown that individual factors are the ones that most influence acceptability.

In this context, the present study will explore the behaviour, preferences, and purchasing decisions of Italian consumers and estimate their WTP toward pasta sold in the Italian markets. Precisely, this research focussed on dried pasta and aimed to answer to the following scientific questions: (i) What are Italian consumers' attitude and propensity toward consuming dried pasta? (ii) What are their WTP for the presence of the blockchain technology/QR code (hereafter, BC) on the pasta label as an implemented digital tool of traceability? (iii) What are their WTP toward the provision of additional labelling information associated to the environmental sustainability conditions (hereafter, IE), social sustainability issues (hereafter, IS), quality, and safety aspects (hereafter, IQ), and to the innovation business practices (hereafter, IN) used to produce pasta in Italy? (iv) How do their beliefs on food traceability and attention to credence food attributes such pasta, influence their consumption behaviour and purchase decision?

In summary, the originality and relevance of this research might be envisaged in different dimensions. First, there is a dearth of research that have explored the Italian consumer behaviour, propensity, and WTP toward the concerned attributes associated with pasta among the most internationally traded food products, as synthesised in [Table 3](#). For these purposes, we used simultaneously a discrete choice experiment (DCE) approach by means of a mixed logit model (MXL), and a latent variable model estimated within the structural equation model ([Ali et al., 2021; Figure 1](#)). Therefore, the remainder of the study is structured into six sections. The next section provides a brief outline of the econometric conceptual framework used for pasta choice. The subsequent section describes the DCE, MXL, and SEM models, in which the choice variables and the data collection survey are also stressed. The results are presented in section four and are followed by the discussion and limitations of the research in section 5. The concluding remarks are highlighted in the final section.

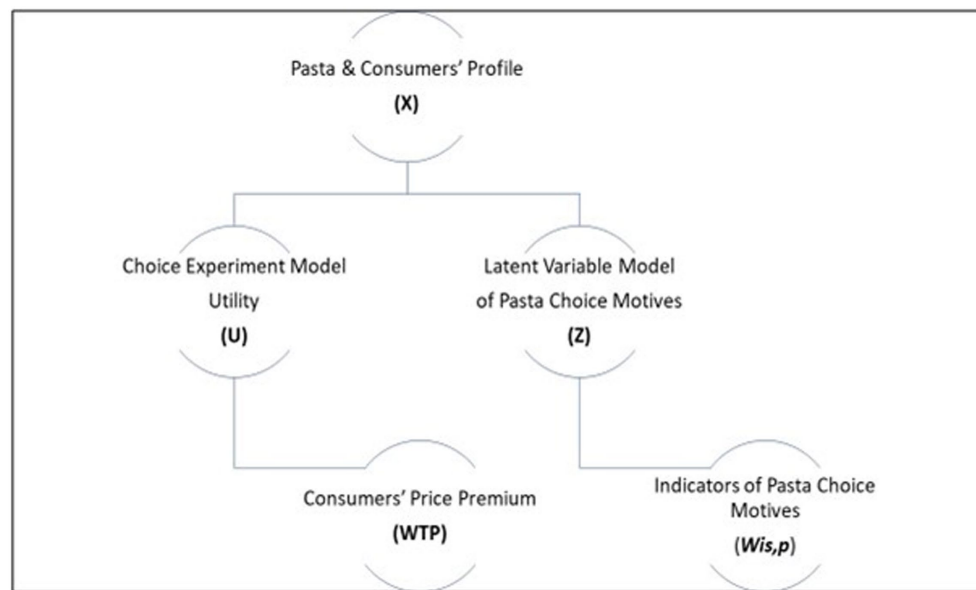


FIGURE 1
Conceptual framework used in the analysis based on Ali et al. (2021).

2 Materials and methods

2.1 Choice experiment model: consumers' utility

The DCE is commonly applied to (i) explore decision choices in economy (Friedel et al., 2022), (ii) elicit consumers' preferences in marketing research, and (iii) estimate their WTP toward food product characteristics (Petrontino et al., 2022). DCE has also been adequately used in the literature in different contexts to explore pasta consumption. The DCE model involves the following stages: (i) selection of the attributes and the assignment of levels, (ii) experimental design and construction of choice sets, (iii) elaboration of a social questionnaire, (iv) sampling of respondents and survey, (v) econometric data analysis and estimation of the WTP, as described below. Furthermore, the DCE is based on the random utility maximisation (McFadden, 1974), assuming that a consumer would gain a utility from (Equation 1) a food product such as pasta. As such, the utility (U_{nj}) is modelled as follows:

$$U_{nj} = \text{No buy} + \beta X_{nj} + \text{price } \lambda_j + \varepsilon_{nj} \quad (1)$$

where "No buy" is an alternative specific constant (ASC) representing the no-purchase option, X_j denotes the vector for each alternative j , containing different attributes (BC, IE, IS, IQ, IN) coded as dummy variables, β is a vector of the coefficients associated with each attribute, price is the price vector, and λ is the effect of price on utility (Equation 2). The ε_{nj} is the unobserved error term. Heterogeneity in preferences can be considered in the choice model including interaction terms representing the attitudes and beliefs of the consumers as latent variables.

$$U_{nj} = \text{No buy} + \beta X_{nj} + \text{price } \lambda_j + \gamma X_{nj} Z_n + \varepsilon_{nj} \quad (2)$$

where Z_n is the vector of the latent variables scores of n -th respondent, and γ is the effect of this characteristic on the utility function.

2.2 Latent variable model: heterogeneity of consumers' preferences

Assuming that utility function is individually determined and that psychographic variables are determinants in the behaviour of each respondent, a structural equation model (SEM) was structured to test the relationships between "closeness to blockchain technology" and the psychographic consumers' latent variables, namely, "attention to credence attributes" and "beliefs on traceability" (Rungie et al., 2012). SEM comprises a system of linear equations that concurrently assess the connections between observable variables, which are measurable items, and the unobservable constructs evaluated by these items. An essential practical benefit of employing SEM for data analysis is its capability to unveil relationships between latent variables that remain unobservable but can be deduced from observable variables. In this direction, the main underlying hypothesis is that the latent constructs of opinion and beliefs can explain the differences in preferences across respondents, resulting in a more efficient and parsimonious model. Since the latent characteristics are not directly observed, a set of k responses to the questions (items) are functions of the latent variables. Z_n scores are then estimated through a measurement model that implies the weights of the single items contributing to the latent variables, according to the set of equations where the values of the I_{kn} indicators (Equation 3) are dependent on the value of the related latent variable:

$$I_{kn} = \delta I_k + \zeta I_k Z_n + u_{kn} \tag{3}$$

where δI_k is a constant for the k -th indicator, ζI_k is the estimated effect of the latent variable Z_n on this indicator, and u_{kn} is a disturbance term that is assumed to be normally distributed.

2.3 Choice variables: attributes and levels

In the DCE approach, attributes are referred to as choice variables, factors, or features used by scientists to describe adequately the consumer’s decision outcome in a hypothetical situation (Friedel et al., 2022). Within each choice attribute, a few numbers of levels are assigned that could be qualitative or quantitative. In our DCE, we choose six attributes (i.e., BC, IE, IS, IQ, IN with 2 levels each, and Price with 3 levels as depicted in Table 4), using a focus group of technical experts, and considering their importance and negligence in terms of traceability for Italian consumers (Petrontino et al., 2023a). In fact, the traceability was often analysed with respect to the food safety and security issues and is considered relatively decisive in marketing strategies that may help to improve the performance of the pasta market. Regarding the social sustainability, we also considered that this attribute is often neglected compared to environmental sustainability and business innovation practices and could influence consumers’ purchase decision and their WTP. The price was considered in this study as discrete variable (Petrontino et al.,

2022), and its levels were assigned to cover the current different retail selling prices of the most popular Italian pasta packs of 500 g.

2.4 Designing choice sets and data collection: experimental design and social questionnaire

A combination of levels for each attribute (Table 5) is presented to each respondent. Given the excessive number of combinations (i.e., $2^5 \cdot 3^1 = 96$ alternatives), a D-efficient optimal design has been implemented, resulting in 2 blocks with 6 choice sets and 2 alternatives. Accordingly, we elaborated and divided the questionnaire into three different sections. The first section explored respondents’ attitudes and propensity toward the consumption and purchase of pasta, along with 9 questions such as the following: “What is your frequency of pasta purchase? (i.e., once a day; more than once a week; once a week; more than once a month; once a month; less than once a month; never)” (Q1); “Where do you habitually purchase dried pasta? (i.e., hypermarkets, supermarkets, discount shops, pasta factories, local shops, online (e-commerce), other)” (Q2); “When purchasing dried pasta, how much attention (low, medium, and high) do you pay for the following features: price, information labelling, nutritional facts, brand, presence of organic certification, presence of origin certification, and mode of packaging” (Q3); “According to your personal experience, how much (high, medium, or low) of the following characteristics affect the price of dried pasta: origin,

TABLE 4 Attributes and levels assigned in our discrete choice experiment for pasta.

Attribute	Level
Blockchain Technology (Code: BC) 	1 Presence 2 Absence
Information on the environmental sustainabilityCode: IE 	1 Presence 2 Absence
Information on the social sustainability Code: IS 	1 Presence 2 Absence
Information on the quality & safety Code: IQ 	1 Presence 2 Absence
Information on the innovation Code: IN 	1 Presence 2 Absence
Price Code: Price	1 EUR 1.20 2 EUR 2.40 3 EUR 3.00

TABLE 5 Example of a set choice shown to respondent.

Dried pasta	Attribute & Code	Option "A" Alternative "A"	Option "B" Alternative "B"	Option "C" Alternative "C" (No option/No buy)
	Blockchain Tecnology Code: BC	Present 	Absent	Neither "A" nor "B"
	Information on the environmental sustainability Code: IE	Absent	Present 	
	Information on the social sustainability Code: IS	Present 	Absent	
	Information on the quality & safety Code: IQ	Absent	Present 	
	Information on the innovation Code: IN	Absent	Present 	
	Price Code: Price	3,00€	1,50€	
Which option/alternative do you select?		☐	☐	☐

purchase site, promotion strategy, qualitative characteristics of the product and characteristics related to the process of production" (Q4); "Which of the following sentences identifies better your behaviour in relation to the purchase of dried pasta: I am willing to buy a larger amount of pasta if the price is low; I am willing to pay a price premium if the pasta is safe and certified; I prefer an adequate quality/price, without caring about the safety of the product" (Q5); Express your level of consent (Strongly disagree; disagree; neither agree nor disagree; agree; strongly agree) related to the transparency of operations along the pasta value chain such a greater transparency of operations along the pasta value chain offer: a guarantee on the quality of the product; social benefits (i.e., respect of the job contract, undeclared work, reduction of labour exploitation, etc.); Environmental benefits (i.e., reduction of gas emissions, better efficiency in the use of water and energy, reduction of food waste, etc.); Benefits in terms of traceability of the production and food safety; An increase of innovation in the agricultural sector (i.e., use of sensors IoT, GPS, drones, etc.), offering benefits in terms of food security" (Q6); "Have you heard about the blockchain technology?" (Q7). "Are you aware (not all; a little, enough; a lot; very much) about blockchain technology associated to agri-food products?" (Q8); "What is your frequency (not all; a little, enough; a lot; very much) of agri-food purchase tracked with the blockchain technology?" (Q9).

The second section of the questionnaire was introduced by a chip talk scripts (Tonsor and Shupp, 2011; Van Loo et al., 2011; Dahlhausen et al., 2018; Jürkenbeck, 2023) describing the selected attributes and providing an example of a set choice (Table 4) to help the respondent in his decision process. Consequently, we presented an adequate number of 6 purchase simulations (i.e., set choice/task choice, Table 4) to prevent respondent fatigue (Hess et al., 2012; Dahlhausen et al., 2018; Petrontino et al., 2023b) and in which each respondent had to select between 2 alternatives (A, B) among each task choice that differed in the presence or absence on the label of the studied product the following: (i) QR code that reflects the blockchain technology, (ii) information on the environmental sustainability issues associated with the production of dried pasta, (iii) information on the social sustainability conditions associated with the production of dried pasta, (iv) information on the quality and safety production, (v) information of the innovation process of dried pasta production, and (vi) price. In addition, the set choice included a no buy option (C) in which we used pictograms reflecting the presence of the concerned attributes (Petrontino et al., 2023a).

The third section revealed the socio-demographic and economic profile of the respondents (i.e., gender, age, residence, civil status, family composition, level of education, work position, work sector, and annual household income).

2.5 Sampling: participants' survey

We carried out an online survey (Survey Monkey, 2023), from June to September 2023, covering the population living in Italy, and engaging 397 valid pasta respondents, considering the Italian population age, gender repartition, and annual household income, in which the sample was in a similar range to the main statistics of Italian population (Istituto Nazionale di Statistica – ISTAT, 2023) as reported in Table 6. Thus, the respondents in the survey were the main responsible for shopping for food for household consumption. For this purpose, we used the Equation 4 considering a margin of error 5%, and a confidence level of 95%, in which we calculated a sample size of 384 respondents and then we decided to increase this value to 400, and finally, we retained 397 valid respondents. Furthermore, the data collected through the online questionnaire were used exclusively for statistical purposes and for this study. They will not be disclosed to third parties or used for private interests, own or others, according to Regulation (EU) 2016/679 on the protection of individuals regarding the processing of personal data. The acquired information was exclusively used in an aggregate way, thus guaranteeing the most complete anonymity of the respondent. Furthermore, the consent from the participants was requested, at the beginning of the survey, to participate in this study in accordance with the national legislation and the institutional requirements.

$$n = \frac{\frac{z^2 * p(1-p)}{e^2}}{1 + \left(\frac{z^2 * p(1-p)}{e^2 N} \right)} = \frac{\frac{1.96^2 * 0.5(1-0.5)}{(0.05)^2}}{1 + \left(\frac{1.96^2 * 0.5(1-0.5)}{(0.05)^2 * 48\,021\,983} \right)} \quad (4)$$

$$= \frac{384.16}{1.00008} = 384$$

Where n is the sample size, N is the population size over 18 years old ($N = 48,021,983$ in the first of January 2023 based on ISTAT 2023), e is the margin of error (percentage in decimal form: 5%), z is the z -score ($z = 1.96$ for a desired confidence level of 95%), and p is the standard deviation ($p = 0.5$).

2.6 Data analysis: statistical and econometric analysis

On the one hand, DCE was analysed with the econometric software Nlogit version 5, and Krinsky-Robb method with 500 draws has been utilised to estimate the WTP for each attributes according to their coefficients obtained in MXL model. The weights and the standard deviation of the items belonging to the respective latent variables contributed to calculate the scores to be used in the MXL model as interaction terms with the attributes of DCE. On the other hand, SEM was analysed using the partial least square structural equation modelling tool of the software JASP version 0.17.1.0. The latent variable “closeness to blockchain technology” (BLO) has been putted in relation with the following two latent variables “attention to credence attributes” (ATT) and “beliefs on traceability” (TRA), assuming that BLO is influenced by TRA and ATT while TRA is also influenced by ATT as shown in the Figure 2. After an accurate analysis

TABLE 6 Sample of Italian respondents used in our discrete choice experiment for pasta.

Variable	Category	Italian population	Sample	
			Number	%
Age (year)	18 ≤ Age ≤ 44	29.74%	159	40.05
	45 ≤ Age ≤ 64	30.84%	171	43.07
	> 64	23.80%	67	16.88
Gender	Male	48	183	46.10
	Female	52	214	53.90
Annual household income in EUR	Income ≤20.000	31,600	92	23.17
	20.000 > Income ≤40.000		207	52.14
	Income >40.000		98	24.69
Total – Sampling size			397	100.00

Source: Our elaboration and ISTAT, 2023.

of the model fit indexes, internal and external reliability, and significance of the settled relations, the composition of the latent construct has been defined as follows. BLO latent variable comprises the two items derived from the question Q7 and Q9. ATT latent variable comprises the four items derived from the question Q3, namely, the presence of organic certification (A_Organic), the presence of origin certification (A_Origin), nutritional facts (A_Nutrition), and information labelling (A_label). TRA latent variable comprises the three items derived from the question Q6, namely, benefits in terms of traceability of the production and food safety (T_Trace), social benefits (T_Social), and an increase of innovation in the agricultural sector (T_innovation).

3 Results

3.1 Descriptive results: respondents' attitudes and propensity

This section presents the main descriptive statistics results related to the parts 1 and 2 of the online questionnaire survey toward the respondents' attitudes and propensity to purchase food such as dried pasta as well as their socio-economic profile. As a result, supermarkets were the most popular places of purchase of such category of food (28.72%), followed by hypermarkets (19.40%) and discount markets (11.59%), more than once a week as depicted in Table 7. Moreover, approximately 50% of the respondents in this survey conferred a high self-level of attention toward the price of the products and the importance of labelling information, nutritional facts, a medium self-level of attention regarding the nutritional facts, the presence of the origin certification, and the mode of packaging, which indicates that their purchase behaviour was mainly influenced by these product attributes as illustrated in Table 8. With respect to their self-level of experience with the level of influence of pasta features on its purchase price (Table 9), 34.26% of the respondents believed that the aspect of this food category influenced its purchase price, but approximately 10% of them were convinced that the purchase site or the promotional strategy presented relatively a low level of influence on its purchase price. In addition, most of respondents were willing to pay a “price

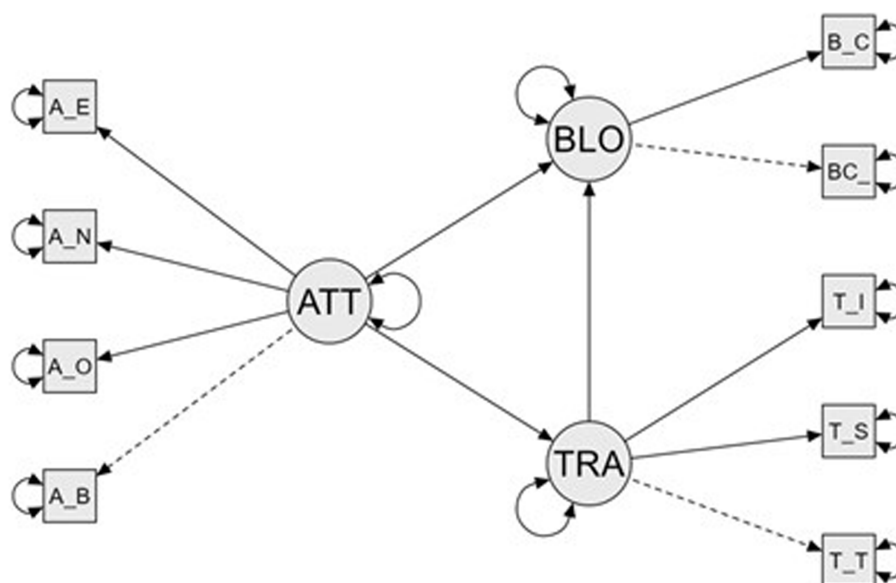


FIGURE 2

Relation between the latent variable “closeness to blockchain technology” (BLO) and the two latent variables “Attention to credence attributes” (ATT) and “Beliefs on traceability” (TRA).

TABLE 7 Purchase sites by frequency of pasta purchase (in number N and % of respondents).

Place of purchase	Frequency of purchase (number of purchase)													
	Once a day		More than once a week		Once a week		More than once a month		Once a month		Less than once a month		Never	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Hypermarkets	20	5.04	77	19.40	27	6.80	2	0.50	0	0	0	0	0	0
Supermarkets	23	5.79	114	28.72	41	10.33	1	0.25	0	0	0	0	0	0
Discount shops	8	2.02	46	11.59	17	4.28	2	0.50	0	0	0	0	0	0
Pasta factories	1	0.25	4	1.01	0	0.00	0	0.00	0	0	0	0	0	0
Local shops	4	1.01	3	0.76	1	0.25	0	0.00	0	0	0	0	0	0
Online (e-commerce)	3	0.76	1	0.25	0	0.00	0	0.00	0	0	0	0	0	0
Other	0	0.00	1	0.25	1	0.25	0	0.00	0	0	0	0	0	0

premium” if the dried pasta was safe and certified, followed sequentially by its other attributes, such as its adequate quality/price report, and its relative lower price as revealed in Table 10. The research was also explored into Italian consumer awareness and purchase frequency of agri-food tracked with BC, adopting a five-point Likert scale range, with 1 representing “not at all” or “never” and 5 “very much” or “always” as illustrated in Tables 10, 11. Consequently, very few respondents were very much (3.53%) or a lot (9.57%) aware about blockchain technology and were always (1.26%) or often (8.56%) purchased agri-food products tracked with digital BC as depicted in Tables 11, 12.

Despite these results, most of respondents agreed that a greater transparency of operations along the value chain, through the use of BC, offered the following: (i) a guarantee on the quality of the product such as dried pasta (52.14% of respondents), (ii) social benefits in terms of the respect of the job contract, undeclared work, and

reduction of labour abuse (54.66% of respondents), (iii) environmental benefits in terms of reduction of gas emissions, a better efficiency in the use of water and energy, reduction of food waste, etc. (51.89% of respondents), (iv) benefits in terms of traceability of the production and food safety (56.68% of respondents), and (v) an increase of innovation within the agriculture sector, offering more benefits in terms of food security (48.61% of respondents). For this issue, we also adopted a five-point Likert scale range, with 1 representing “not at all” or “never” and 5 “very much” or “always” as depicted in Table 13.

3.2 Latent construct: reliability and validity

The latent construct settled to produce the interaction terms to be used in the econometric model as resulted in the following paragraphs has been preliminarily verified in terms of internal

TABLE 8 Respondents' self-level attention on the characteristics of pasta (in number N and % of respondents).

Pasta feature	Level of attention					
	Low		Medium		High	
	N	%	N	%	N	%
Price	8	2.02	190	47.86	199	50.13
Information labelling	28	7.05	182	45.84	187	47.10
Nutritional facts	50	12.59	199	50.13	148	37.28
Brand	41	10.33	176	44.33	180	45.34
Presence of organic certification	82	20.65	209	52.64	106	26.70
Presence of origin certification	69	17.38	185	46.60	143	36.02
Mode of packaging	79	19.90	208	52.39	110	27.71

TABLE 9 Respondents' self-level experience with the level of influence of pasta features on its purchase price (in number N and % of respondents).

Pasta feature	Respondents	
	N	%
Origin of the pasta	95	23.93
Purchase site	40	10.08
Promotion strategy (publicity, flyers)	43	10.83
Qualitative characteristics of the product	136	34.26
Characteristics related to the process	82	20.65
Total	396	100.00

consistency, reliability, and discriminant validity (Table 14). Factor loadings and average variance extracted (AVE) values show a satisfactory convergent validity of the items used in the construct. In addition, the reliability of the construct, as shown in Table 15, is high.

3.3 Econometric results

3.3.1 Pasta consumers' preferences

The estimation results from the multinomial logit model (MNL), MXL model, and MXL model including interaction with psychographic terms are reported in Table 16. MXL model with interactions looks to be the more adequate model to explain the consumer choices because it shows improvements in terms of likelihood and information criterion. The coefficient for the price is both negative and statistically significant in all the elaborations, mirroring a discernible impact on consumer choice. Similarly, the no buy option exhibits a noteworthy negative coefficient. Furthermore,

TABLE 10 Respondents' behaviour related to pasta purchasing (in number N and % of respondents).

Pasta feature	Respondents	
	N	%
I am willing to buy a larger amount of pasta if the price is low	39	9.82
I am willing to pay a price premium if the pasta is safe and certified	218	54.91
I prefer an adequate quality/price. Without caring about the safety of the product	140	35.26
Total	396	100.00

TABLE 11 Respondents' awareness about blockchain technology (in number N and % of respondents).

Level	Respondents	
	N	%
Not at all	107	26.95
A little	143	36.02
Enough	95	23.93
A lot	38	9.57
Very much	14	3.53
Total	396	100.00

the estimated standard deviations for all attributes markedly differ from zero, signifying substantial heterogeneity in consumer preferences for blockchain technology, alongside information pertaining to the environment, social factors, quality, and innovation. The attributes related to blockchain technology and information on pasta production have always positive and significant coefficients, meaning that consumers retrieve utility from this kind of information. The most appreciated attribute is IQ letting believe that consumers are interested mostly in quality information on the food product. The effect of "attention to credence attributes" and "beliefs on traceability" on consumer preferences for all the attributes is included by interaction terms. Looking at the results that come from the interaction between MXL model attributes and the scores of the latent construct, it looks that those consumers that have a stronger belief on benefits of traceability show a greater preference for blockchain technology and the information on environment and quality of pasta. On the contrary, those consumers that pay more attention to credence attributes have a greater preference for social information and innovation of production.

3.3.2 Pasta consumers' willingness to pay

Table 16 summarises the consumer's WTP per attribute type, in which respondents are willing to pay extra EUR 1.16, 0.82, 0.62, 0.41, and 0.36 per 500 g of pasta for a complete information of pasta safety, environmental sustainability, blockchain technology/QR code, innovation business, and social sustainability, respectively. As

such, the highest WTP is determined by the “food safety” attribute (average price premium of EUR 1.16/500 g), while the least WTP is determined by the “social sustainability information” (average price premium of EUR 0.36/500 g), indicating that food safety appears to be the most critical consumers’ concerns among the concerned attributes. However, these WTP differences across pasta attributes and consumers are statistically significant as depicted in Table 17.

TABLE 12 Respondents’ purchase frequency of agri-food products tracked with the blockchain technology (in number N and % of respondents).

Level	Respondents	
	N	%
Not at all	147	37.03
A little	95	23.93
Enough	116	29.22
A lot	34	8.56
Very much	5	1.26
Total	396	100.00

4 Discussion

4.1 Comparison and interpretation

In this study, we applied and extended the DCE model to explore the influence of a set of attributes (BC, IE, IS, IQ, IN) toward consumers’ purchase propensity for pasta in Italy. As such, we estimated the preferences of respondents through MXL where attributes of the product were interacted with latent variables that proved significant interactions with respect to “behaviour” related to blockchain technology in food choice. Regarding the BC technology for pasta, our results are in line with Contò et al. (2016), who stated that when simulating a pasta buying process through CE, consumers seemed likely to choose products characterised by credibility attributes such as the origin of the wheat, for which they were also willing to pay a premium price. This certainly reflects that the application of a traceability system, through BC, on pasta would positively influence consumer purchasing behaviour, indicating that consumers are willing to pay a premium for the traceability of products. However, digital transformation process could stimulate the innovation in the agri-food sector too. In fact, the technology 4.0 can offer the agri-food companies to create new opportunities for success and gain competitive benefits. In addition, in this context, it is crucial consumer orientation as core competencies in dynamic

TABLE 13 Respondents’ consent related to the transparency of operations along the pasta value chain (in number N and % of respondents).

A greater transparency of operations along the pasta value chain offer:	Level of consent									
	Strongly disagree		Disagree		Neither agree nor disagree		Agree		Strongly agree	
	N	%	N	%	N	%	N	%	N	%
A guarantee on the quality of the product	10	2.52	9	2.27	56	14.11	207	52.14	115	28.97
Social benefits (i.e., respect of the job contract, undeclared work, reduction of labour exploitation, etc.)	10	2.52	6	1.51	85	21.41	217	54.66	79	19.90
Environmental benefits (i.e., reduction of gas emissions, better efficiency in the use of water and energy, reduction of food waste, etc.)	4	1.01	13	3.27	63	15.87	206	51.89	111	27.96
Benefits in terms of traceability of the production and food safety	8	2.02	4	1.01	43	10.83	225	56.68	117	29.47
An increase of innovation in the agricultural sector (i.e., use of sensors IoT, GPS, drones, etc.), offering benefits in terms of food security	6	1.51	14	3.53	113	28.46	193	48.61	71	17.88

TABLE 14 Psychographic latent variable composition.

Latent	Items	Weights	Standard deviation	Factor loadings
ATT	A_Organic	0.322	0.687	0.702
	A_Origin	0.344	0.705	0.794
	A_Nutrition	0.293	0.664	0.676
	A_Label	0.290	0.623	0.669
TRA	T_Trace	0.346	0.797	0.627
	T_Social	0.362	0.829	0.656
	T_Innovation	0.494	0.844	0.894

Source: our elaboration.

TABLE 15 Reliability measures.

Latent	AVE	Cronbach's α	Jöreskog's ρ	Dijkstra-Henseler's ρ
ATT	0.503	0.811	0.813	0.817
TRA	0.568	0.771	0.774	0.803
BLO	0.706	0.754	0.759	0.768

Source: our elaboration. The latent variable "closeness to blockchain technology" (BLO) has been putted in relation with the following two latent variables "attention to credence attributes" (ATT) and "beliefs on traceability" (TRA), assuming that BLO is influenced by TRA and ATT while TRA is also influenced by ATT. Comparative fit index (CFI): 0.973; goodness of fit index (GFI): 0.967; root mean square error of approximation (RMSEA): 0.057; standardised root mean square residual (SRMR): 0.029.

market environments. Among others industry 4.0 technology, BC represents an innovative voluntary certification system that can improve efficiency, security, safety, and transparency even in food supply chains (Galvez et al., 2018). In addition, Chen et al. (2021) demonstrated that Chinese utility can benefit from both the application of blockchain technology and traditional traceability technologies, and consumers are more inclined to buy ecological agricultural products that use blockchain technology than those that use traditional traceability technologies. In this context, Bandinelli et al. (2023) also evaluated the consumers' interest in buying a package of ancient wheat pasta that includes all the information about its origin and processing methods. Their results highlighted the importance of the construct "perceived security," corresponding to "a threat that creates a circumstance, condition, or event with the potential to cause economic hardship in the form of destruction, disclosure, modification of data, fraud, waste, and abuse."

With respect to the safety and environmental sustainability of the pasta, these issues prevail for Italian consumers, reflecting their concern regarding the food safety information and the sustainable conditions of harvesting and processing, as well as antifraud issues related to pasta. This result is consistent with Altamore et al. (2019), who found that more than 90% of the sample wanted information on the healthiness of pasta or how it is produced, the origin of the raw material, and the absence of elements potentially harmful to human health, confirming the importance of labelling on purchasing choices. In addition, they found that health and origin are characteristics that consumers consider the most important in purchasing choices. Therefore, information and communication on the identity

characteristics of pasta seem to play an important role in building consumer awareness and thus influencing the purchase decision (Neuninger et al., 2017). In fact, more informed consumers are more likely to improve preferences for locally grown wheat and local pasta production. Moreover, since a traceability system can become a guarantee for the end user of the purchase of a sustainable product, the results produced by Defrancesco et al. (2017), which tested consumer preferences for the environmental attitudes of pasta, can be considered relevant for the research hypothesis presented. However, they found that, overall, consumers were not only unwilling to pay more for pasta products with beneficial environmental attributes and, to a lesser extent, health effects, but they firmly preferred traditional pasta. Similarly, Rossi et al. (2023) evaluated the WTP of Italian consumers for pasta from sustainable agriculture and the drivers that determine this WTP, but they arrived at more moderate results: Consumers recognised a higher WTP for sustainable pasta, but this value was influenced by drivers such as purchasing habits, personal characteristics, and environmental attitudes. In addition, our findings are consistent with Bandinelli et al. (2023), who reported that consumers are becoming more sceptical of the degree to which information reported on labels matches the actual product (Profeta et al., 2008; Sodano et al., 2008).

In addition, Wang and Scrimgeour (2023) determined that the product origin, quality control, food safety information, hygienic conditions, and scarcity management are the key features of blockchain food traceability that consumers considered to be crucial. Regarding the social sustainability information, our findings are more or less consistent with Nayal et al. (2023) and Kamilaris et al. (2019), who found that BC contributed to social sustainability, helping small farmers in insurance programmes, promoting smart contracts to protect labour from exploitation, and ensuring fairness in payments and taxation. However, our results are less consistent with Rana and Paul (2017), who found that consumers were willing to pay more for socially responsible products. In terms of innovation business, our results are less consistent with Basarir and Dayan (2022), who investigated on how innovative food products are perceived by consumers in United Arab Emirates, and how that perception affects their perceived risk and uncertainty, perceived cost/benefit, and attitude strengths toward the innovations. Moreover, Nazzaro et al. (2019) found that consumers were willing to pay higher price levels for the innovative product rather than for the traditional one. They also found a broad correlation between the innovative product attributes and the psychographic characteristics of consumers in two of the three consumer groups that were identified (i.e., rational adopters and pro-innovation), indicating the existence of many potential consumers. Moreover, as reported by Nazzaro et al. (2019), innovation in the agri-food sector is a tool for addressing the consumer-citizen's needs (Capitanio et al., 2012) and growing societal issues (Roucan-Kane et al., 2011). In fact it needs to be consider closely social and environmental changes too (Earle, 1997), contrary to the prevalent notion that innovation is primarily a technological process. For these reasons, academic and business attention in food innovations has increased, with a focus on the drivers that could guide consumer acceptance of innovation. In fact, for food firms to succeed in the food market, consumer perceptions of food innovations and their willingness to adopt or adapt them are crucial (Siegrist, 2008).

TABLE 16 Multinomial logit model, mixed logit model, and mixed logit model with interaction with psychographic terms.

Variable	MNL		MXL		MXL with interactions	
	Coefficients	Standard Error	Coefficients	Standard Error	Coefficients	Standard Error
BC	0.29465***	0.0628	0.43819***	0.12226	0.41831***	0.1152
IE	0.35557***	0.0585	0.59338***	0.09718	0.55040***	0.094
IQ	0.43043***	0.0636	0.78451***	0.11742	0.77677***	0.1164
IS	0.15692*	0.0801	0.28614**	0.13726	0.24272*	0.1358
IN	0.22692***	0.0632	0.32828***	0.11232	0.27616**	0.1087
			(non-random parameters)			
OPTOUT	−1.56844***	0.1074	−2.42456***	0.16347	−2.41887***	0.1601
PRICE	−0.38988***	0.0591	−0.70929***	0.08829	−0.66895***	0.0858
Interaction terms						
BC: ATT					0.11059	0.1146
BC: TRA					0.55770***	0.1177
IE: ATT					0.0579	0.0869
IE:TRA					0.30539***	0.0877
IQ: ATT					0.06529	0.1063
IQ: TRA					0.31611***	0.1058
IS: ATT					0.29065***	0.1117
IS: TRA					0.11454	0.1078
IN: ATT					0.40513***	0.1018
IN: TRA					0.01848	0.0981
Standard deviation						
SD_BC			1.64613***	0.1592	1.39691***	0.1424
SD_IE			1.10565***	0.1131	1.04743***	0.1118
SD_IQ			1.47876***	0.1318	1.41667***	0.1361
SD_IS			1.17994***	0.1565	1.12018***	0.1564
SD_IN			1.23945***	0.1231	1.21040***	0.1274
***, **, and * ==>significance at 1, 5, and 10% level.						
Log likelihood function	−2249.66		−2065.7		−2017.87	
Inf.Cr.AIC	4513.3		4155.4		4079.7	
AIC/N	1.895		1.745		1.713	
K	7		12		22	

4.2 Implications, limitations, and future research

The obtained findings induce here public and private implications. In fact, this research contributes to the scientific literature by exploring new insights into Italian consumption in pasta preferences utility. Third, the current econometric exploration is primordial to set up market outreach strategies by pasta industrials that would meet Italian consumers' expectations and, consequently, enhance their financial performances. Fourth, examining consumers' attitudes and propensity toward the selected attributes has also public implications in terms of protecting and informing the consumer through clear and transparent

information, preventing the problem of agri-frauds, permitting to obtain continuous monitoring of the production processes to guarantee the sustainability and quality of the agri-food products such pasta, and providing added services to the consumers. However, the research does not verify spatial variability in consumers' preferences among Italian regions for the concerned pasta attributes. In this direction, we suggest an extension on examining Italian consumer needs regarding pasta in each region of the country through a face-to-face field social survey and including all species of pasta. In addition, we may allow for extending the research of the consumer segmentation between communities and different socio-demographic and psycho-variables classes.

TABLE 17 WTP calculation based on a Krinsky-Robb method with 500.

Attribute	WTP	Standard error
BC	0.62533***	0.17432
IE	0.82278***	0.14604
IQ	1.16119***	0.18301
IS	0.36284**	0.17611
IN	0.41283***	0.14095

***, **, and * ==>significance at 1, 5, and 10% level.

5 Conclusion

The analysis conducted revealed, among others, a particularly significant element with respect to the impact of BC on the pasta market. The consumer was willing to pay a price premium toward the guarantee of purchasing a safe product, in terms of the quality and safety, and that was traceable in relation to all the links in its value chain. Meanwhile, studies on consumer preferences and willingness to pay for blockchain technology in agri-food supply chain are limited, and academic research studies investigating supply chain of pasta are rare. In this context, our study aimed to fill this research gap regarding the WTP of consumers for food such as pasta traced through BC, encouraging consumers to make knowledgeable decisions and to take a proactive approach to achieving the goals of social and environmental sustainability as well as public health. In this direction, BC appears to support green practices contributing to achieve environmental targets and can give more benefits for the society. Italian consumers' preferences may push companies to achieve environmental sustainability and increase demands related to social issues by providing authentic product feedback. All these issues enhance consumers' environmental and social awareness and improve sustainable performance of the pasta supply chain. Moreover, BC pasta traceability system could overcome the problematic nature of traditional food traceability systems and will reduce the chances of food adulteration and frauds, ensuring that the information on products' labels is adherence. These capabilities can improve consumers' awareness in terms of assurance of quality, real-time tracking, safety along the food chain, healthy, and chain clarity. At the same time, BC can be used by stakeholders to promote consumer loyalty, enhance the product's reputation, and draw in new clients.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The data collected through the online questionnaire were used exclusively for statistical purposes and for this study. They will not be disclosed to third parties or used for private interests, own or

others, according to Regulation (EU) 2016/679 on the protection of individuals regarding the processing of personal data. The acquired information was exclusively used in an aggregate way, thus guaranteeing the most complete anonymity of the respondent. Furthermore, the consent from the participants was requested, at the beginning of the survey, to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

AP: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing, Visualization. MF: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing, Visualization. VF: Conceptualization, Supervision, Validation, Writing – review & editing. ET: Data curation, Writing – original draft. AC: Data curation, Writing – original draft. FB: Conceptualization, Funding acquisition, Project administration, Writing – review & editing.

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Conflict of interest

MF was employed by Sinagri S.r.l.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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CHAPTER 4

Credence in code: Consumer engagement and responses to blockchain-enabled sustainability in tomato Purée

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Credence in code: Consumer engagement and responses to blockchain-enabled sustainability in tomato Purée

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ABSTRACT

Understanding how digital technologies can support more transparent food choices is essential for driving sustainability in agri-food systems. In this context, this study explores the role of blockchain technology (BCT) in shaping consumer preferences for tomato puree featuring credence attributes. An integrated approach that combines the Technology Acceptance Model (TAM) with a choice modelling framework has been used for this purpose. The originality of this research lies in extending the TAM framework by examining how consumer sensitivity to environmental, social, and economic sustainability attributes influences behavioral intention to adopt blockchain-traced food products. Based on a representative sample of 1549 Italian respondents collected through an online survey, a Discrete Choice Experiment (DCE) and a Latent Class Model (LCM) were additionally applied to identify three distinct consumer segments according to their attitudes toward blockchain and sensitivity to credence attributes. The results reveal that a small group of respondents (6.6 %) presents low interest in both aspects, while 32.7 % prioritize sustainability-related attributes. The largest segment (60.7 %) values blockchain for ensuring authenticity and transparency. With respect to a bottle of baseline tomato puree (700 mL), differences in willingness to pay among respondents reveal that sustainability-engaged consumers value information on water footprint reduction (+5.78 EUR) and product origin (+0.84 EUR) conveyed through BCT, while those more inclined toward technology prioritize information related to organic production methods (+3.40 EUR) and labor-related sustainability (+2.74 EUR). The results provide valuable insights for producers and policymakers aiming to promote more responsible consumption and enhance sustainability communication through technological innovation.

1. Introduction

1.1. Sustainability challenges in the Italian tomato supply chain

In today's globalized and complex agri-food landscape, strategic sectors of the Italian economy are confronting critical challenges. Among these, the processing tomato supply chain stands out as an emblematic case. As a strategic pillar of the national agri-food economy (Annex A), it plays a central role in both domestic consumption and international exports. However, the Italian industrial tomato supply chain faces growing challenges that threaten its economic, social, and environmental sustainability throughout its life cycle: from resource-intensive agricultural practices to vulnerabilities in social and economic conditions (ISMEA, 2024).

The increase in Chinese production, which in 2024 recorded a +31 % compared to 2023 and a +68 % compared to 2022 (ANICAV, 2024), consolidates China's role as an increasingly strong competitor in exports. This development contributes to a more competitive international market context, potentially affecting price dynamics and the strategic positioning of producers operating under different regulatory, quality, and sustainability frameworks. From an environmental perspective, the intensification of the water crisis in 2024 significantly impacted agricultural yield and production capacity, especially in the Northern basin, highlighting the urgency of promoting sustainable practices in the tomato sector. Recent studies indicate that water consumption per ton of product can reach high levels, with significant environmental implications and increased operating costs (Eslami et al., 2023), making the tomato processing chain a high-intensity user of water and energy

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resources. Moreover, from a social perspective, the heavy reliance on seasonal labour, often under precarious conditions, raises ongoing concerns about fairness, transparency, and ethical responsibility along the chain.

The persistence of these critical issues along the supply chain is not always perceived by consumers, who often have access to limited information on production practices. As a result, even when they are motivated to make responsible choices, the lack of transparency can hinder them from recognizing and rewarding the most virtuous producers, thus discouraging investment in sustainable practices. Such information asymmetries, therefore, limit the ability of demand to drive meaningful change along the entire food supply chain (Jia et al., 2024).

1.2. Transparency as a prerequisite for food choices

Transparency becomes a fundamental prerequisite for enabling informed and responsible food choices (Pozelli Sabio and Spers, 2022; Marty et al., 2022). In fact, the growing consumer focus on sustainability and quality presents a strategic opportunity to differentiate products in international markets and promote more responsible and innovative practices. This shift could enhance the competitiveness of the agri-food sector while addressing broader economic, environmental, and social expectations. In an increasingly globalized market, authenticity is recognized as a crucial quality criterion by consumers, producers, and regulatory bodies (Galvez et al., 2018). Consumers seek reassurance about the origin and content of food products, hoping for high conformity with the information provided on labels. Issues related to sustainability, quality, and food safety are major concerns for consumers in developed countries. They are increasingly preferring food products that offer concrete proof of sustainability, perceived as safer and healthier, and which guarantee environmental benefits (Vázquez Meléndez et al., 2025). This growing awareness is driving supply chain actors to collaborate in offering more traceable, safe, innovative, and sustainable products, fostering a greater willingness to pay for such guarantees (Petrontino et al., 2024). Greater transparency regarding the origin and production stages of products not only reduces health risks but also enhances consumers' ability to evaluate product attributes (Sepe, 2024). Despite the interest, information asymmetries remain a significant challenge in global food trade, preventing consumers from making informed choices and undermining confidence in food safety (Lin et al., 2021). To overcome these issues, consumers often rely on third parties to verify the credibility of the provided information (Théolier et al., 2021). Labelling regulations aim to reduce these disparities through certifications that ensure the truthfulness of the information. However, it remains essential to reassure consumers about the correspondence between the qualitative attributes of the products and what is declared, especially regarding environmental and social sustainability (Galvez et al., 2018; Mol, 2015; Tian, 2017). Such information falls within the concept of credence attributes, which cannot be checked by consumers to verify independently, even after purchase.

1.3. Blockchain for sustainable agri-food systems: opportunities and challenges

In response to these challenges, it is crucial to adopt innovative approaches in managing the food supply chain. In particular, blockchain technology emerges as a promising solution.

Originally conceived in the context of Bitcoin, blockchain can be defined as "a linked list of immutable and tamper-proof blocks, stored on every participating node" (Bandinelli et al., 2023). Essentially, a blockchain is a system made up of linked blocks, where each block contains data and a reference to the previous block through the hash value of that block. When new data needs to be recorded, a new block is added to the end of the chain, containing both the new data and the hash of the previous block. If any changes are made to the data or to the connections between blocks, the chain would be broken. Therefore, the

integrity of the chain becomes the proof that the data has not been altered or tampered with. Once the blockchain is established or updated, it is distributed across a peer-to-peer network, enabling shared access to the data (Pakseresht et al., 2023). Hence, Blockchain technology is characterized by four key features: (i) immutability, since the recorded data cannot be altered, ensuring a highly reliable environment. (ii) decentralization, since each node in the network participates in the validation and conservation of information, eliminating the need for a central authority. (iii) openness, through a consensus mechanism that makes information accessible to network participants, increasing mutual trust, and (iv) anonymity, protecting the privacy of participants (Lin et al., 2021).

Today, blockchain application extends to multiple domains, including the agri-food sector, where it can contribute to ensuring quality, traceability, and security along the entire supply chain (Fiore et al., 2024; Tian, 2017). Indeed, the blockchain architecture admits the collection and preservation of immutable and tamper-proof information at every stage, from raw material procurement to final distribution, reducing information asymmetries and enhancing transparency (Wünsche and Fernqvist, 2022). Building on these features, blockchain applications in the food supply chain grant timely monitoring of products and processes, making it possible to identify the responsibilities of different actors (Lin et al., 2021) and to provide consumers with access to the history of the product (Shahzad et al., 2023) by scanning a QR code present on the label. While the quality of the information still depends on the accuracy of the data entered, the blockchain infrastructure helps produce auditable records along the supply chain, making environmental, social, and economic impacts more concrete and visible, offering a more reliable perspective on sustainability indicators and supporting more informed decisions by producers and consumers (Thanasi-Boçe and Hoxha, 2025). For this reason, it admits multiple potentials such as identifying inefficiencies, reducing the industry's carbon footprint, and incorporating smart contracts and sensors (Contini et al., 2023), becoming a valid and promising tool to enable the transformation of credential-type attributes into search-type attributes (Bandinelli et al., 2023), in a condition of complete transparency. Blockchain also represents a significant opportunity to support sustainability across multiple dimensions (Khan et al., 2025). Specifically, it contributes to the achievement of several UN Sustainable Development Goals: SDG 2 (Zero Hunger), by enabling transparent food chains and combating fraud; SDG 8 (Decent Work and Economic Growth), by supporting fair labour practices through traceable and verifiable employment conditions; SDG 12 (Responsible Consumption and Production), by improving supply chain efficiency and reducing waste; and SDG 16 (Peace, Justice, and Strong Institutions), by enhancing transparency and accountability in agri-food governance.

While Blockchain offers a promising technological infrastructure to promote transparency, trust, and sustainability across agri-food systems, its effectiveness depends on a broad set of factors involving all stakeholders along the supply chain – including governments, producers, processors, distributors, and consumers. Previous studies have highlighted persistent barriers such as those of coordination and collaboration among supply chain actors which manifest themselves both on a technical level (e.g. scalability, digital literacy gaps, and interoperability problems) (Kumar et al., 2024; Sakthivel et al., 2024), at the operational level concerning real certainty of data reliability (the "Garbage In, Garbage Out" effect) (Katsikouli et al., 2021) as well as at the relational and organizational level (mutual distrust, cultural resistance, low stakeholder involvement) (Gerasimova, 2024; Essien et al., 2024; Virmani and Singh, 2024). In addition to these critical issues, there are further constraints of a structural nature, related to the lack of harmonized regulations and reference standards (Katsikouli et al., 2021; Martínez-Castañeda and Feijoo, 2023) as well as to diverse investment decisions and significant cost and implementation challenges faced particularly by SMEs (Mangla et al., 2022; Katsikouli et al., 2021). These challenges cannot be addressed directly through consumer-oriented

studies. However, demonstrating that consumers are willing to pay a premium price for blockchain-enabled traceability can act as an indirect lever, encouraging upstream actors to engage more actively, validate technological solutions, and invest to overcome those structural and cultural barriers.

1.4. Related work on consumer preference for blockchain: gaps, objectives, and originality of the study

In blockchain-based traceability systems, consumers are granted “read-only” access to additional information through a QR code on the product, which redirects them to the entire product journey (Dionysis et al., 2022). Tran et al. (2024) showed that willingness to pay (WTP) is higher for traceable food products, but only when QR codes provide focused and relevant information; generic or overly detailed content discourages consumer engagement. Therefore, although there are objective and widely studied conditions to define blockchain technology as a revolutionary tool, the simple introduction of an advanced technology is not enough to guarantee its success. As underlined by Duong et al. (2024), understanding consumer expectations, through the collection of empirical data, is critical to guide companies towards informed strategic decisions about blockchain adoption in specific markets, to ensure that blockchain-based traceability systems are not only technically robust but also socially acceptable and responsive to the values and decision-making processes of end users. In detail, in the food sectors like the tomato processing industry, where many sustainability-related features such as environmental impact or social fairness are not directly observable, blockchain-based traceability can help reduce information asymmetries by making such credence attributes more visible and verifiable to consumers.

However, the potential of this technology to foster informed and responsible food choices depends on how consumers perceive and react to this new layer of information. In particular, individual attention to such attributes, as well as broader attitudes toward the enabling technology, may shape both the intention to adopt traceability systems and the willingness to pay for products that incorporate them. Indeed, a recent study on blockchain-based food production highlighted that consumers who tend to seek product information highly value food traceability (Tran et al., 2025). Moreover, a recent systematic review by Reitano et al. (2024) has mapped the evolving landscape of research on consumer acceptance of blockchain-based food traceability, identifying key variables such as trust, perceived risk and safety, traceability, certification reliability, and WTP. The vast majority of empirical studies to date have relied either on consumer utility theory, using discrete choice experiments (DCE) to estimate WTP for blockchain-related food attributes (e.g., Chen et al., 2021; Lin et al., 2022; Shew et al. 2022; Yang et al., 2021), or on autonomous psychological models, such as variations of the Technology Acceptance Model or structural equation models exploring constructs like perceived usefulness, trust, or risk (e.g., Bandinelli et al., 2023; Maesano et al., 2025; Liu et al., 2023).

Only a few studies have attempted to combine psychological dimensions with choice modelling, typically by including limited sets of belief-based variables within choice experiments, without relying on an integrated cognitive framework. For example, Contini et al. (2023) combined SEM and DCE to assess trust in certification and sustainability; Petrontino et al. (2024) explored selected attitudinal factors alongside economic preferences; while Rao et al. (2023) examined the moderating role of consumer knowledge on WTP, further highlighting the importance of cognitive antecedents. However, none of these studies has, to date, adopted a comprehensive behavioural model in conjunction with a DCE design to jointly estimate the psychological drivers of acceptance and the economic trade-offs expressed through consumer engagement.

This study aims to fill a significant gap in the literature by analysing how individual perceptions and attitudes influence consumer engagement and willingness to pay for credence attributes conveyed through blockchain technology in the tomato sector. Building on the hybrid

model proposed by Califano et al. (2024), the research adopts an integrated approach that combines a Discrete Choice Experiment (DCE) focused on sustainability-related attributes with an extended Technology Acceptance Model (TAM). Among the psychological drivers of consumer adoption, Petrontino et al. (2024) demonstrated that attention to sustainability-related belief attributes plays a particularly relevant role in the context of blockchain-enabled traceability. They empirically validated a structural relationship in which attention to belief attributes influences both beliefs about traceability and closeness to blockchain technology. Therefore, the present study extends the Technology Acceptance Model (TAM) by including such attention as a psychological antecedent of the behavioural intention to adopt blockchain-based traceability. By combining behavioural and economic models, this approach offers a more complete framework to analyze the complexities of consumer engagement in the context of sustainable consumption, and it provides a more holistic and policy-relevant understanding of consumer engagement with blockchain-enabled food traceability and sustainability. In other words, taking into consideration the evidence from a common Italian food product, this study seeks to answer the following research question: *How does the use of blockchain in food traceability shape the evaluation of sustainability attributes, depending on the psychological drivers of consumer engagement with this technology?*

The remainder of this article is organized into six sections. The next section provides a brief overview of the theoretical framework and the hypothesis of the research. The third section describes the methods adopted, including the DCE and the PLS-SEM analysis. The results are discussed in the fourth section, followed by conclusions, implications, and reflections on the limitations of the research in the final section.

2. Theoretical framework

In agro-food systems, consumer preferences drive purchasing and consumption behaviour. Random Utility Theory (RUT), widely used to elicit such preferences, offers a solid framework for analysing individual choices (McFadden, 1974). Indeed, RUT enables estimation of how product features, such as transparency and sustainability characteristics, shape consumer choices. It models decisions based on these observable attributes (Lancaster, 1966) and a random component capturing unobserved factors like habits, attitudes, and behaviour. In the past decades, numerous models have been formalised to understand the behavioural patterns that condition the consumer engagement on themes like sustainability, product quality and novel technology. These models include, but are not limited to: (i) Technology Acceptance Model (TAM) (Davis, 1989); (ii) Theory of Reasoned Action (Fishbein and Ajzen, 1975); (iii) Theory of Planned Behavior (Ajzen, 1991); Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003). Among these models, TAM was identified as relevant for the study, as it is a fundamental theoretical tool to understand the factors that influence blockchain adoption by consumers, as shown by previous studies (Bandinelli et al., 2023; Martinelli and De Canio, 2024; Sepe, 2024). In line with the example of Bandinelli et al. (2023), the proposed model follows Davis' approach in his “Technology Acceptance Model” study, analyzing how perceived usefulness (PU), perceived ease of use (PEOU) and attitude towards use (ATT) influence the behavioral intention (BI) toward blockchain solutions, adopted to access information on the quality and sustainability of products in the tomato puree supply chain.

As stated by Martinelli and De Canio (2024), the PU of blockchain during food purchases relates to the ability to determine the status and quality of a food product, verifying all aspects related to traceability and verification of quality and origin. This opportunity, considered useful and desirable for consumers, is hypothesized to positively influence the attitude towards adopting blockchain during food purchases. PEOU generally represents how simple and pleasant a new technology is perceived to be (Martinelli and De Canio, 2024). The hypothesis is that it positively influences the PU, because when a system is easy to use, it is perceived as more useful (Kumar et al., 2022), and, at the same time, it

influences the attitude towards the adoption of blockchain. Regarding attitude, as stated by Kumar et al. (2022), it can be defined as an internal predisposition that pushes an individual to act favorably or unfavorably towards a system. Factors such as PEOU and PU are believed to have a direct influence on attitude, which, in turn, affects the intention to adopt new technologies, increasing the probability of their use. Finally, considering the focus on credence attributes, the study uses an extended version of the TAM, enriched by the construct “Attention to Credence Attributes”, (CRE) whose internal reliability and relationship with proximity to blockchain technology have been demonstrated by Petrontino et al. (2024) (Fig. 1).

In this study, the inclusion of psychological constructs, derived from the TAM, allows us to explore how purchasing behavior for products with sustainability and quality attributes conveyed through the implementation of a blockchain traceability system is influenced by variables such as attitudes and attention (Fig. 1). As reported by Califano et al. (2024), although discrete choice experiments (DCE) are powerful tools for investigating how consumers evaluate multi-attribute product alternatives, the literature recognizes that individual preferences are influenced by a wide range of factors, including psychological constructs (Caracciolo et al., 2016; Ortega et al., 2011). Demographic and socio-economic characteristics, traditionally used in consumer studies, show limited explanatory power in understanding preference heterogeneity (Dagevos, 2005; Nocella et al., 2012). The introduction of psychographic variables allows us to represent decision-making behavior not only through social factors but also through individual attitudes, motivations, and preferences, offering a more realistic description of decision-making processes (Ben-Akiva et al., 2002).

3. Materials and methods

In this study, we consulted a representative sample of consumers using an online survey. The analysis followed a mixed-method approach that included: (1) a segmentation of the sample based on the choices made among the DCE alternatives, through a latent class model (LCM) that accounts for the factors explored within the extended TAM framework; (2) the assessment of the relationships among the TAM constructs via partial least squares structural equation modelling (PLS-SEM); and (3) the profiling of the typical consumer who values blockchain-based traceability (BCT), to inform targeted marketing strategies and

promote this innovation as a competitive advantage, using a multinomial logistic regression (MLR).

3.1. Social survey

In November 2024, a leading survey research company administered an online questionnaire (Annex B) to a representative sample of 1549 Italian consumers in charge of household food purchases. Statistical representativeness was guaranteed for individuals over 18 years of age, by gender, and by geographical distribution, considering the main statistics of the Italian population (ISTAT, 2024) as reported in Table 1. Before completing the questionnaire, participants were informed of the confidentiality of data collection in compliance with Regulation (EU) 2016/679.

The questionnaire was divided into four main sections (Suppl. Material A). The first section focused on consumption habits, including weekly food expenditure, purchase channels for tomato puree, purchase frequency, and familiarity with blockchain-based agri-food products. Additional questions explored the frequency of buying blockchain-

Table 1
Sampling of the respondents taking into account the age, gender and geographical area of residence of the Italian population.

Variable	Italy (in %) 2024 ^a	Sample	
		N	%
Age (year)			
From 18 to 29	15	234	15.1
From 30 to 44	21	333	21.5
From 45 to 60	31	488	31.5
Over 60	33	494	31.9
Gender			
Male	49	753	48.6
Female	51	796	51.4
Geographical area of residence (Italy)			
North West	27	420	27.1
North East	20	311	20.1
Center	22	342	22.1
South	20	304	19.6
Islands	11	172	11.1
Total – Sampling size		1549	100

^a Based on ISTAT, 2024.

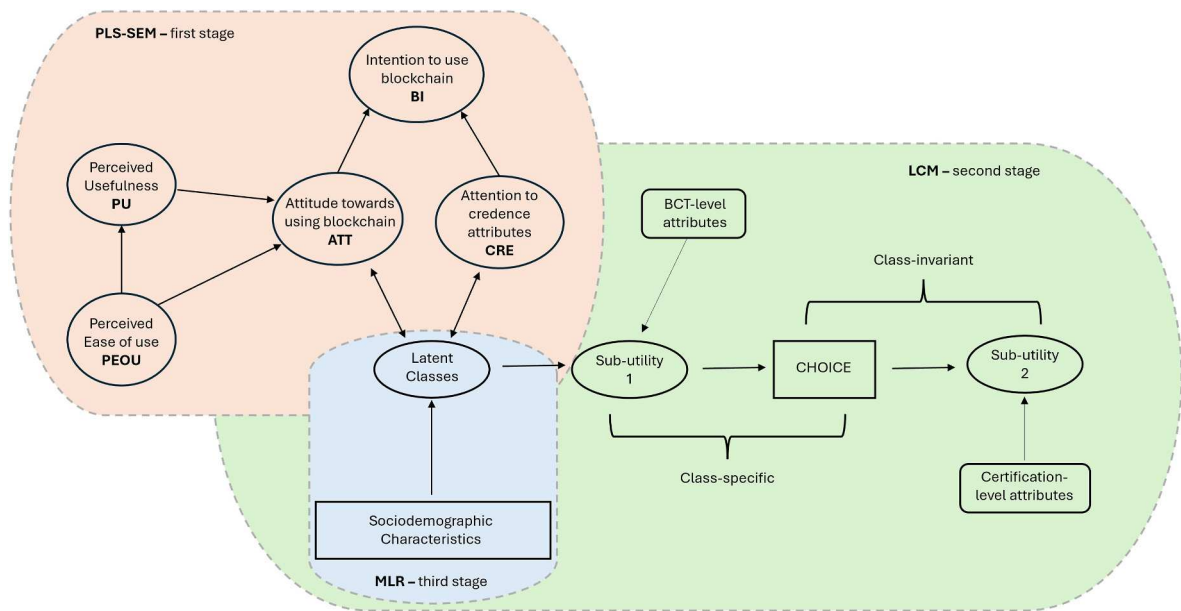


Fig. 1. Conceptual framework integrating TAM and DCE.
Note: PLS-SEM = partial least squares structural equation model; LCM = latent class model; MLR = multinomial logistic regression (see section 3).

tracked products and the reasons for non-purchase. The second section collected respondents' socio-economic characteristics such as education, employment, income, age, and gender. The third section included the set of choice tasks, detailed within the experimental design in Section 3.2.

The final section included items to measure the extended TAM constructs, adapted from Bandinelli et al. (2023) and Petrontino et al. (2024). Their operationalization and role within the structural model are discussed in Section 3.3. For each item, a five-point Likert scale was used to measure the degree of relevance that these elements have for the respondent.

To minimize missing values, most of the questions had a mandatory response. However, the items responsible for measuring the extended TAM constructs were left optional, resulting in a small incidence of missing data.

3.2. Discrete choice experiment (DCE)

Discrete Choice Experiment (DCE) is a well-established and widely used methodology to analyze consumer decision-making behavior and estimate their WTP for specific product attributes (Petrontino et al., 2023 a). DCE considers products as sets of attributes that determine the utility derived by consumers. As explained by Califano and Spence (2024), this approach allows for the simulation of a realistic decision-making environment, where participants choose between alternatives described by systematic combinations of attributes and levels, designed according to a rigorous experimental design. Through the choices declared by the interviewees, it is possible to infer the values attributed to each attribute, even when these are not consciously perceived by consumers.

In this study, DCE was adopted to evaluate the preferences of Italian consumers for a tomato puree with credence-type attributes, linked to sustainability and quality aspects, guaranteed through an innovative traceability tool, such as blockchain. As stated by Vázquez Meléndez et al. (2025), blockchain-tracked food products are not widely available to consumers at this stage of technology adoption. DCE can estimate preferences and WTP, even for products not yet widespread on the market, making it particularly effective for investigating these aspects in a complex and evolving food context.

The experimental design was developed in Stata 15.1 using the modified Fedorov algorithm (Carlsson and Martinsson, 2003; Zwerina et al., 1996) following a pilot study conducted with 50 respondents, designed to estimate the prior coefficients to be included in the efficient design. After selecting the design that provided the highest D-efficiency value (0.85), we organized 10 choice sets. To reduce respondent fatigue, each participant completed 5 choice sets created through a division into 2 statistically balanced blocks, generated using a pseudo-random design. In each of them, respondents expressed their preference between 2 multi-attribute alternatives (A and B) and a no-purchase alternative (Hensher et al., 2015). The selected attributes were identified through a careful review of the literature and are designed to capture key credence-type information, which can be certified either through traditional systems or via advanced blockchain-based traceability. As shown in Tables 1 and in the choice screens, the Blockchain level was indicated only by the presence of a QR code on the label (icon + "blockchain traceability" label), the information accessible via the QR was not displayed; the Certification level appeared as a third-party claim (icon/label), whereas the No information level included neither. This operationalization was intended to isolate the effect of the information source (distributed ledger vs. third-party certification) from potential confounders related to format and level of detail. Accordingly, we examined consumer response to the mode of information provision rather than to specific batch-level data. However, participants were informed in the introductory instructions that the QR provides farm-to-fork information: "The use of technology translates into the use of sensors and IoT (Internet of Things) technologies to collect production data and a QR code placed on the label. The presence of the code on the

product allows consumers to access information about the food, from field to fork, to highlight the characteristics of the goods and the sustainable and innovative practices implemented by the manufacturing companies." The attributes chosen reflect the main pillars of sustainability from a life cycle perspective: the origin of raw materials (OR) represents economic sustainability and the enhancement of local value chains; the reduction of water use (Water Footprint, WF) and the elimination of chemical inputs (BIO) address environmental concerns; while respect for workers and workplace safety (SS) embodies the social dimension of sustainable production. Price was also included to serve as a benchmark for estimating consumers' willingness to pay (Table 2).

Regarding the country of origin, specifying this attribute is mandatory in Italy for tomato derivatives, as established by the Interministerial Decree of November 16, 2017. Moreover, WTP for this attribute has been widely investigated (Latino et al., 2023; Petrontino et al., 2023 b), showing a general preference for paying a premium price for local products. This factor becomes even more significant considering the increasing production of imported goods, particularly from countries like China, which creates significant pressure on domestic producers, necessitating a greater consumer awareness.

Since food production plays a key role in environmental sustainability, contributing significantly to issues such as water scarcity and resource depletion (Groth et al., 2023), this study aimed to examine the importance of these aspects from the consumer's perspective, focusing on two key attributes: the reduction of water consumption and the reduction or elimination of chemicals in production. These attributes

Table 2
Attributes and attribute levels considered in our DCE.

Attribute	Level	Missing Information*	Information being present through certification**	Information being present in the blockchain system and obtainable with a QR code***
Water consumption: Reduction of water consumption in production (i.e., Water Footprint)	–			
Use of chemicals: Reduction or elimination of phytosanitary treatments with chemicals	–			
Origin: Origin indication of raw material «tomato»	–			
Social aspects: Respect for workers and safety in the workplace	–			
Price: EUR for a bottle of 700 mL	1.10 2.20 3.50 4.70			

Note: * No information is provided regarding the specific attribute; ** The attribute is verified by an established third-party organization of either public or private origin (i.e., organic certification or zero residue); *** A QR code can be used to get information about a particular attribute; blockchain technology ensures data validity and authenticity.

represent distinct dimensions of environmental sustainability: the former is associated with environmental protection, while the latter has a health connotation. In particular, the choice to consider the Water Footprint was driven both by the challenges the tomato processing industry faces in optimizing water resource efficiency and by Life Cycle Assessment (LCA) studies on tomato product production, particularly tomato puree (Manfredi and Vignali, 2014; Del Borghi et al., 2014), which highlight that water is the most extensively used non-renewable environmental resource in production, with usage ranging from 50 to 75 kg per kg of finished product.

The analysis also extended to social sustainability, focusing on the health and safety conditions of workers, in light of the “gangmaster” phenomenon historically affecting the tomato harvesting phase. The “gangmaster” phenomenon, also known as “caporalato” in Italian, refers to the illicit intermediation of workers. This system involves intermediaries, often linked to organized crime, who recruit and manage labor for employers. These gangmasters exploit vulnerable workers, including migrants, by subjecting them to poor working conditions, low wages, and sometimes even physical and mental abuse. The phenomenon is particularly prevalent in the agricultural sector, where gangmasters control the recruitment and employment of seasonal workers. Migrants, due to their economic and legal vulnerability, are often the primary targets of this exploitation. The gangmasters maintain a state of existential subordination, keeping workers in a cycle of dependency and exploitation. Efforts to combat this phenomenon include stricter legislation and enforcement, as well as initiatives to regularize the status of migrant workers to reduce their vulnerability (www.infomigrants.net).

Finally, regarding price levels, they were identified through surveys by the Prices and Tariffs Observatory of the Ministry of Enterprise (<https://osservaprezzi.mise.gov.it/>), estimating an average value for each of the main Italian markets, each representing a geographical sub-area. The levels considered, ranging from EUR 1.10 to EUR 4.70 for 700 mL

of product, were chosen to cover the high variability of prices between the north and south of the country.

Within the questionnaire (see Annex B and Table 2), the section of the Discrete Choice Experiment (DCE) was introduced through a cheap-talk script (Petrontino et al., 2024), which presented the selected attributes and levels and provided an illustrative example (Fig. 2) of a choice set to help the respondents in their decision process. As highlighted by Cummings and Taylor (1999), this tool was created to reduce hypothetical bias, i.e., the tendency of respondents to overestimate their willingness to pay in hypothetical contexts. Cheap talk informs participants of the existence of this bias and invites them to formulate their choices as if they were real purchasing decisions (Tonsor and Shupp, 2011).

3.3. PLS-SEM

The elaboration of TAM derives from a partial least squares structural equation model (PLS-SEM) was implemented exploring the role of the latent variable (BI) of the extended Technology Acceptance Model (TAM), related to the perception of ease of use and usefulness of blockchain technology, attitude towards using blockchain, and attention to credence attributes in choice behavior (Fig. 2). This approach is particularly relevant as it allows for the identification of relationships between dependent variables and their unobservable drivers, known as latent variables (LVs), which can be inferred from measurable indicators, commonly referred to as manifest variables (MVs).

Table 3 reports constructs (LVs), definitions about TAM and the items, linked to each construct, included into the questionnaire.

3.4. Integration of DCE and TAM

Following the approach taken by Califano et al. (2024), the

INFORMATION ABOUT:	OPTION A	OPTION B
		
WATER CONSUMPTION		
USE OF CHEMICALS		
ORIGIN		-
SOCIAL ASPECTS		
PRICE	4,70 €	2,20 €

I will opt for: ☐ Option A ☐ Option B ☐ Option C (No Purchase)

Fig. 2. Example of a choice set as administered to the respondents.

Table 3
Latent variables, Definition and Items of extended TAM.

Latent variables (LVs)	LV code	Definition	Reference	Items ^a
Perceived Usefulness	PU	The subjective probability, for potential users, that the use of a specific application system will enhance work performance within an organizational context.	Bandinelli et al. (2023); Davis (1989); Davis et al. (1989)	Using this system is useful (disagree – agree) By using this system, I can quickly know where what I purchase comes from (disagree – agree) Using this system simplifies my decision-making process when purchasing (disagree – agree)
Perceived Ease of Use	PEOU	The degree to which the potential user expects the system to be effortless to use	Bandinelli et al. (2023); Davis (1989); Davis et al. (1989)	Learning to use the system would be (easy - difficult) Using the system is (easy - difficult) Interacting with the system requires (a lot of mental effort - little mental effort)
Attitude Toward Use	ATT	Attitude toward a particular technology	Bandinelli et al. (2023); Davis (1989); Bandinelli et al. (2023); Venkatesh et al. (2003)	I think using the system is a (good - bad) idea The idea of using blockchain intrigues me I think using blockchain is a waste of time
Behavioral Intention	BI	Willingness to actually use the system	Bandinelli et al. (2023); Venkatesh et al. (2003)	I intend to use the system in the future (disagree – agree) I plan to use the system in the future (disagree – agree) I would like to use the system in the future (disagree – agree)
Attention to Credence Attributes	CRE	Importance attributed to quality and sustainability information of the credence type reported on the label during the purchasing process.	Petrontino et al. (2024)	When purchasing tomato sauce, how much attention do I pay to the country of production or the product's place of origin? When purchasing tomato sauce, how much attention do I pay to the product's production characteristics (variety, technology, etc.)? When purchasing tomato sauce, how much attention do I pay to the presence of environmental or social certifications? When purchasing tomato sauce, how much attention do I pay to nutritional information (table, ingredients, and claims)?

^a See Annex B.

integration of the TAM and DCE models was achieved by implementing a LCM, where preferences are considered to be discretely distributed in clusters and class-specific parameters can be estimated in each segment (Fu, 2021). As demonstrated by previous studies (Califano et al., 2024; Contini et al., 2023; Fantechi et al., 2022; Nocella et al., 2012; Petrontino et al., 2024), the integration of latent variables improves the explanatory power of the models, allowing for more accurate market segmentation and a more realistic representation of consumer choices. The diagram illustrated in Fig. 1 graphically represents the conceptual framework through which TAM and DCE have been integrated in the present study.

The latent variables resulting from the TAM through the PLS-SEM are integrated into the econometric model to explain differences in individual preferences (Petrontino et al., 2022, 2024; Sepe, 2024). To link the TAM to the second stage of the analysis, the latent scores predicted for attitude toward blockchain (ATT) and attention to credence attributes (CRE) were used as covariates in a Latent Class Model (LCM). This approach enables the segmentation of the sample based on unobserved heterogeneity in choice patterns. As explained in Mauracher et al. (2013), LCMs are well suited to marketing studies because they capture individual differences through probabilistic class membership based on observed and latent predictors.

In this study, the decision to include ATT and CRE in the class membership model is grounded in the structure of the extended TAM, which conceptualizes these constructs as key antecedents of behavioral intention (BI). Since BI reflects the propensity to adopt blockchain-based traceability and is theoretically influenced by both ATT and CRE, it is reasonable to expect that differences in these latent variables correspond to broader differences in consumer preferences. Therefore, ATT and CRE are used as psychographic variables to explain class membership within the LCM framework, in line with previous studies that have integrated psychological constructs into discrete segmentation models (Patel et al., 2023; Califano et al., 2024; Yeh and Hartmann, 2021).

Consistent with this theoretical structure, only the coefficients related to BCT were set as class-specific in the utility function.

Conversely, the coefficients associated with certification-level attributes were modeled as class-invariant, under the rationale that official certifications represent standardized information cues, less likely to interact with individual differences in ATT and CRE. This dual structure of the utility function (as depicted in Fig. 2) allows for a more accurate representation of how heterogeneity in psychological constructs translates into differentiated preferences only for blockchain-enabled features.

As in Califano et al. (2024), After estimating the LCM, the marginal value of attributes (MVA) in monetary terms was determined by dividing the coefficient of the non-monetary attribute by the price coefficient and multiplying the result by negative one.

In the final stage, a multinomial logistic regression (MLR) was performed to explore how sociodemographic and economic characteristics predict consumers' likelihood of belonging to each latent class. As in Califano et al. (2024), class membership was assigned based on posterior probabilities estimated from the latent class model. While this three-step approach does not fully correct for classification uncertainty, it provides a practical and interpretable framework for segmenting and profiling consumers. The methodological risks associated with misclassification are acknowledged, as highlighted by Bakk et al. (2014) and Vermunt (2010).

4. Results

4.1. Respondents' attention to credence attributes

Table 4 shows the levels of attention declared by Italian consumers towards different characteristics of tomato puree, highlighting a clear variability in the interest dedicated to the various attributes. The origin of the product (country or place of origin) is confirmed as a key factor in purchasing choices, with 35.77 % of the interviewees declaring to pay “fair attention” and 26.99 % “high attention.” In total, over 60 % of consumers assigned significant importance to this aspect. Environmental information also attracts interest, with 34.58 % assigning a fair level of attention and 13.57 % a high level, suggesting a growing

Table 4

Level of attention to credence attributes during the purchase phase (in number N and % of respondents).

Tomato puree product features	Level of attention (in %)									
	None		Low		Moderate		Fair		High	
	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
Country or place of origin	41	2.65	184	11.88	352	22.72	554	35.77	418	26.99
Production characteristics	57	3.69	243	15.73	504	32.62	560	36.25	181	11.72
Environmental information	65	4.20	247	15.97	490	31.67	535	34.58	210	13.57
Social information	139	8.99	365	23.61	504	32.60	402	26.00	136	8.80
Nutritional information	79	5.11	206	13.32	392	25.34	561	36.26	309	19.97

awareness towards sustainability issues. Production characteristics attract slightly more distributed attention, with 36.25 % of respondents declaring fair attention and 11.72 % high attention, while a further 32.62 % assigned a moderate level, indicating a widespread but less intense sensitivity than the origin.

Interest in the social aspects related to production is more moderate, with 26.00 % declaring fair attention and 8.80 % high attention, while over 30 % assign a moderate level, demonstrating that, although it is a less relevant topic, it is not completely neglected. Finally, nutritional information emerges as a particularly relevant attribute, with 36.26 % of interviewees declaring fair attention and almost 20 % declaring high attention, bringing the total of those who consider nutritional information an important element in choosing tomato puree to over 55 %.

Furthermore, Annex C provides a summary of the main descriptive results from sections 1 and 2 of the online questionnaire, relating to the purchasing behaviour of food products such as tomato puree and respondents' socio-economic characteristics.

4.2. PLS-SEM and LCM results

Fig. 3 presents the results of the TAM with standardized direct effects between the considered constructs. All path coefficients were significant and showed the expected signs.

Table 5 shows the results of the use of the Latent Class Model with increasing numbers of classes. The Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) for model selection identified three consumer segments as the best clustering solution (Weller et al., 2020).

Table 5

Latent classes' goodness of fit.

Classes	df	LL	AIC	BIC
1	10	−9999.64	20019.29	20019.7
2	17	−6386.76	12807.52	12944.22
3	24	−6245.51	12539.02	12732.01

Note: Estimates from 22,950 observations. The model failed to converge beyond the 3-class solution. Abbreviations: AIC, Akaike information criterion; BIC, Bayesian information criterion; DF, degrees of freedom; LL, log-likelihood.

The results in Table 6 describe the influence of attitude towards blockchain technology and attention to credence attributes, predicted by the extended TAM, on the probability that an individual is assigned to Class 1 or Class 2, both with respect to Class 3.

Lower levels of technology aptitude are associated with lower

Table 6

Class membership model, with Class 3 being the reference.

	Class 1		Class 2	
	Estimated	Std. Err.	Estimated	Std. Err.
z_ATT	−0.6308***	0.1366	−0.1628**	0.0743
z_CRE	−0.3305**	0.1217	0.1936**	0.0750
_cons	−2.4225***	0.1672	−0.7222***	0.1349

Note: z_ATT: attitude towards the use of BC technology, as predicted by the PLS-SEM results. z_CRE: attention to credence attributes, as predicted by the PLS-SEM. ***p < 0.001, **p < 0.05, *p < 0.10.

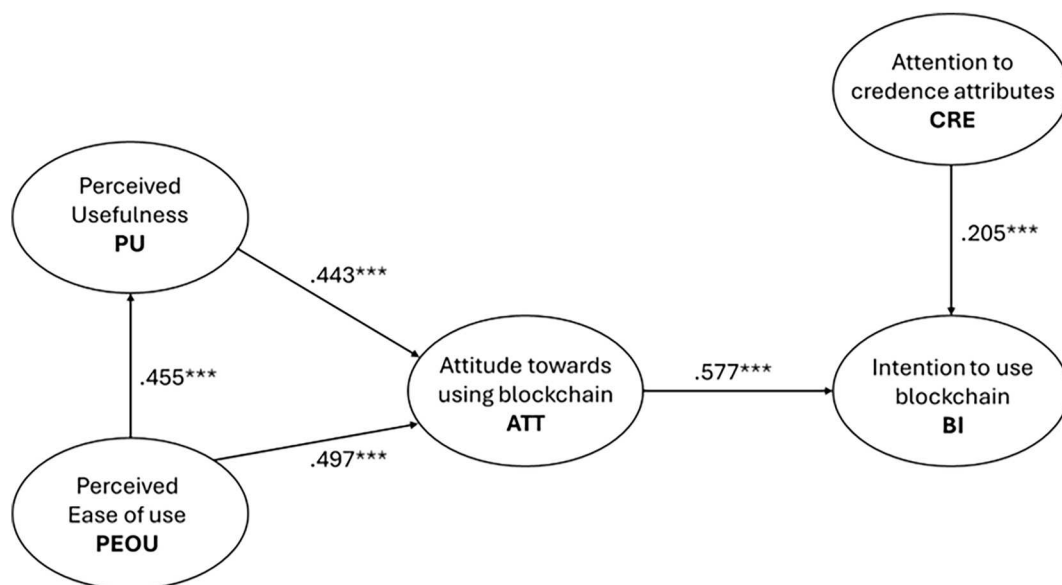


Fig. 3. Path coefficient values of the structural model, based on: (i) factor loadings, Cronbach's α , Rho A of the measurement model; (ii) Discriminant validity with the Fornell-Larcker Criterion; (iii) Multicollinearity check for the structural model (Variance Inflated Factors-VIFs) as depicted in Annex D.

Note: ***p < 0.01.

probabilities of being assigned to both Class 1 (6.60 %) and Class 2 (32.68 %), compared to the largest segment, Class 3, which represents 60.72 % of respondents. Conversely, a high attention to credence attributes reduces the probability of being assigned to Class 1 and increases the probability of falling into Class 2. Therefore, Class 1 includes those who show low aptitude for blockchain and little interest in quality and sustainability attributes. Class 2 includes consumers who are less inclined to blockchain but more attentive to credence attributes. Finally, Class 3 is composed of individuals with a greater predisposition to the use of blockchain technology and who pay moderate attention to quality and sustainability attributes of products at the time of purchase.

Table 7 presents the results of the choice models for each latent class. Invariant coefficients across classes show that both price and opt-out have negative effects, while attributes conveyed through certification have positive coefficients.

Regarding class-specific estimates for attributes conveyed through BCT technology, Class 1 (low attention and low attitude) shows a total disinterest in this regard, with negative WTP values. Class 2 is willing to pay a significant premium price for the WF attribute conveyed with BCT followed by OR, while it does not recognize added value for the BIO attribute. Finally, Class 3 is generally willing to pay for all attributes conveyed with blockchain, except for WF (Table 8). The marginal value results for blockchain-enabled attributes are visually summarized in Fig. 4, which clearly illustrates the heterogeneity of preferences: while Class 1 associates negative values with all blockchain attributes, Class 2 rewards Water Footprint and, to a lesser extent, Origin, and Class 3 consistently values blockchain for BIO, Social Sustainability, and Origin.

4.3. MLR results

For a more in-depth analysis of the latent class profiles, MLR was employed, adopting a three-step ML approach (Table 9). Compared to Class 3 (high aptitude/low attention), Class 1 and Class 2 are more likely to be female, older than forty-five, with a lower level of education and little or no previous experience in purchasing products tracked through BC technology. Furthermore, Class 1 (low aptitude/low attention) is more likely to allocate less than 100 euros per week for food shopping and have no awareness of what BCT is applied to the agri-food sector. Differently, Class 2 (low aptitude/high attention) is more likely to know about blockchain although they have not experimented with it and tend to allocate a larger budget to weekly food shopping.

5. Discussion

5.1. Interpretation of consumer sensitivity to innovation, origin, and sustainability attributes

Regarding the psychological aspects shaping behavioral intention

(BI) towards blockchain adoption, the results confirm the effectiveness of the TAM model, where perceived ease of use (PEOU) and perceived usefulness (PU) affect BI, through attitude (ATT), in line with previous studies on consumer behavior toward technological innovations (Bandinelli et al., 2023; Martinelli and De Canio, 2024). A key insight emerges from the confirmation of attention about credence attributes (CRE) that strongly correlate with BI, suggesting that consumers who value authenticity, quality, traceability, and sustainability are more inclined to adopt blockchain-traced foods (Petronino et al., 2024).

The Latent Class Model (LCM) provided further insights into explaining how consumer preferences and willingness to pay for blockchain-conveyed sustainability attributes vary as a function of psychological profiles. The three emergent classes exhibit distinct profiles in both psychological orientation and valuation of credence attributes conveyed by BCT.

These results confirm that consumer heterogeneity in WTP for blockchain-enabled sustainability claims is not only driven by socio-demographic factors or product characteristics, but also by deeper psychological predispositions, validating the importance of integrating attitudinal and value-based dimensions into segmentation models.

The analysis of preferences for individual attributes highlights a consistent pattern across classes, particularly concerning the origin of raw materials. This finding confirms a widely supported thesis in the literature: Cammarelle et al. (2024) highlight that these are the attributes most selected by Italian consumers when purchasing processed tomato products. Similar evidence is provided by Meyerding (2016), who identifies strong preferences for locally grown products, alongside price and organic labels. Further studies reinforce the role of origin in guiding purchasing decisions for fresh and processed tomatoes (De Daverio et al., 2021; De Meo et al., 2022; Samoggia et al., 2021), as a marker for quality and sustainability (Menéndez i Molist et al., 2024), extending the relevance of origin across a wide range of Italian agri-food products (Mauracher et al., 2013; Bimbo et al., 2022; Migliore et al., 2015).

The value placed on the origin of raw materials, especially when made more credible through blockchain, emerges as a strategic lever to support sustainable consumption choices and enhance the resilience of local supply chains. This aspect has become even more important in light of the recent scandals surrounding fraudulent practices that have involved Italian agri-food products, particularly in comparison with low-cost imports from abroad. Episodes of counterfeiting or fraud, not only in the processed tomato sector, have raised serious concerns, undermining consumer confidence in “Made in Italy” products and threatening the reputation of entire supply chains (Bonaiuto et al., 2021). In such a context, blockchain-based traceability systems can serve as a strategic tool to authenticate provenance, restore consumer trust, and safeguard fair competition against unfair practices. By making the transparency and verifiability of origin more accessible, blockchain

Table 7
Choice model results, with class-specific and class-invariant estimates.

Attributes	Class 1 (Low attitude to BCT and low sustainability focus)		Class2 (Low attitude to BCT but high sustainability focus)		Class 3 (High attitude to BCT but moderate sustainability focus)	
	Estimated	Std.Err.	Estimated	Std.Err.	Estimated	Std.Err.
WFb	−2.167***	0.279	2.360***	0.254	−0.212**	0.069
BIOb	−1.071***	0.264	−0.778***	0.220	1.388***	0.081
ORb	−2.087***	0.222	0.343**	0.113	0.786***	0.058
SSb	−1.159***	0.301	−0.118	0.155	1.119***	0.071
Fix_WFc	0.490***	0.046	0.490***	0.046	0.490***	0.046
Fix_BIOc	1.119***	0.078	1.119***	0.078	1.119***	0.078
Fix_OrC	1.004***	0.080	1.004***	0.080	1.004***	0.080
Fix_SSc	0.665***	0.049	0.665***	0.049	0.665***	0.049
Fix_PRICE	−0.408***	0.022	−0.408***	0.022	−0.408***	0.022
Fix_asc	−1.540***	0.105	−1.540***	0.105	−1.540***	0.105

Note: WF = Water Footprint, BIO = Reduction or Elimination of Chemicals, OR = Origin, SS = Social Sustainability. The suffix c = guaranteed by certification, while b = guaranteed by blockchain. Fix = estimates that remain constant across classes. *p < 0.10; **p < 0.05; ***p < 0.01.

Table 8

Marginal value of the attributes (MVA) in monetary terms.

Attributes	Class 1 (Low attitude to BCT and low sustainability focus)		Class2 (Low attitude to BCT but high sustainability focus)		Class 3 (High attitude to BCT but moderate sustainability focus)	
	Estimated	Std.Err.	Estimated	Std.Err.	Estimated	Std.Err.
WFb	−5.308***	0.747	5.780***	0.649	−0.520**	0.173
BIOb	−2.624***	0.664	−1.907***	0.538	3.400***	0.221
ORb	−5.110***	0.599	0.841**	0.284	1.925***	0.166
SSb	−2.840***	0.766	−0.291	0.383	2.741***	0.172
Fix_asc	−3.772***	0.266	−3.772***	0.266	−3.772***	0.266
Fix_WFc	1.201***	0.121	1.201***	0.121	1.201***	0.121
Fix_BIOc	2.742***	0.200	2.742***	0.200	2.742***	0.200
Fix_Orc	2.461***	0.205	2.461***	0.205	2.461***	0.205
Fix_SSc	1.631***	0.144	1.631***	0.144	1.631***	0.144

Note: WF = Water Footprint, BIO = Reduction or Elimination of Chemicals, OR = Origin, SS = Social Sustainability. The suffix c = guaranteed by certification, while b = guaranteed by blockchain. Fix = estimates that remain constant across classes. *p < 0.10; **p < 0.05; ***p < 0.01.

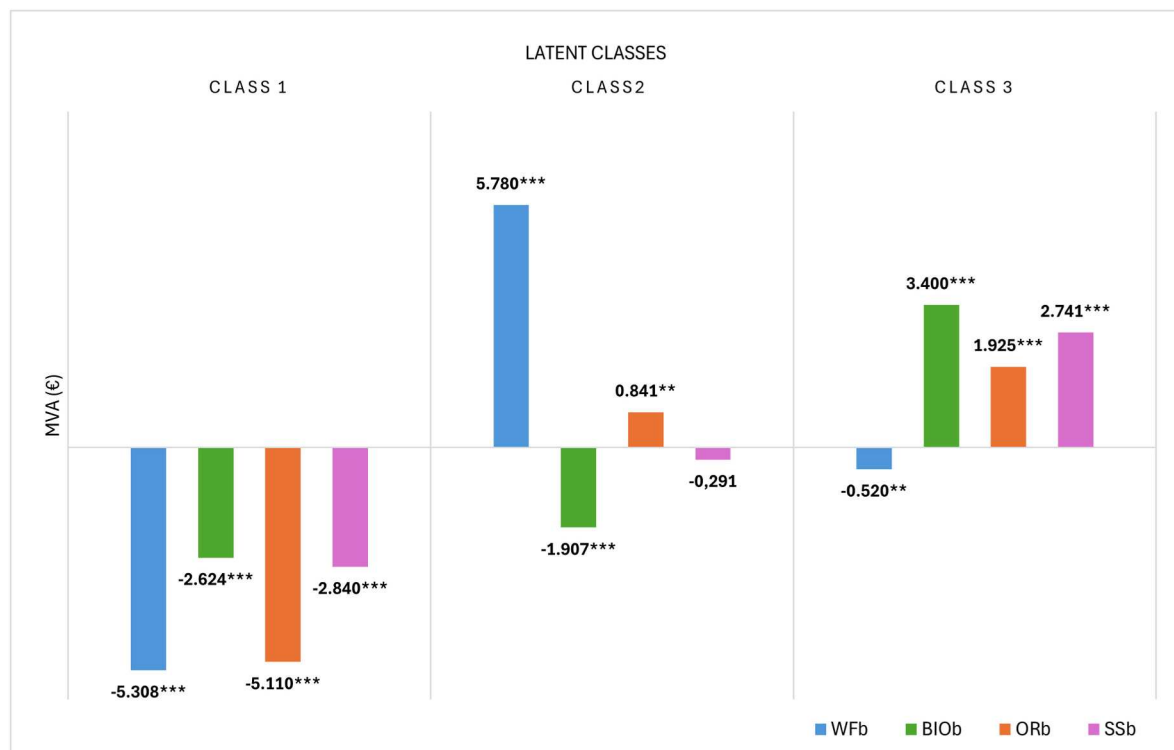


Fig. 4. Marginal Value of Attributes (MVA, €) by latent class for blockchain-enabled levels. Bars report class-specific WTP (asterisks denote significance as in Table 8). Positive values indicate premiums; negative values indicate discounts.

not only strengthens fairness in trade dynamics but also safeguards Italian supply chains, supporting their economic sustainability through a fairer alignment of production costs and sales prices and greater protection against imports that weaken competitiveness (Safer and Pulvento, 2024).

Among the different product attributes and in contrast to the preference shown for origin, the information on the Water Footprint (WF) stands out as less immediate and intuitive for most consumers. Appreciation of this label appears limited to a consumer segment that is particularly sensitive to environmental issues (Class 2). This difficulty of understanding has already been highlighted in the literature on environmental labels, as Meyerding (2016) highlights that, despite the general interest in sustainability, more complex or less intuitive labels, such as those related to carbon footprint, tend to obtain negative partial utilities compared to products without such labels. At the same time, the growing demand for quantitative, reliable, and verifiable data, especially from well-informed consumers, demonstrates a significantly higher willingness to pay among environmentally attentive buyers for

detailed water footprint information. In this scenario, blockchain technology, by integrating farm-to-fork traceability, can enable granular monitoring of water consumption throughout the product life cycle, which is particularly valuable in water-stressed sectors such as tomato processing. Furthermore, if implemented rigorously, blockchain can serve as an effective tool to mitigate the threat of greenwashing, protecting the supply of environmentally friendly products and providing data that strengthens trust between stakeholders and consumers (Nygaard and Silkoset, 2022).

The Organic attribute (BIO) shows an opposite trend compared to the WF attribute. Consumers in Class 3 (High attitude to BCT) appreciate it most, while Class 2 does not show any willingness to pay for it. This difference could be explained by the fact that, for consumers who pay attention to credence attributes (Class 2), traditional organic certifications already provide information considered exhaustive in terms of quality and transparency. However, blockchain, when supplemented with data information on production systems, could serve as a “transparency amplifier” for existing organic certifications rather than

Table 9

Multinomial logistic regression results, with Class 3 (High attitude to BCT/Low attention to credence attributes/High WTP for BCT attributes) as reference.

	Coeff. (Class 1 vs 3)	RRR (Class 1 vs 3)	Coeff. (Class 2 vs 3)	RRR (Class 2 vs 3)
Food weekly expense up to 100 €	0.3994***	1.491	−0.1112***	0.895
Food weekly expense over 150 €	−0.2335***	0.792	0.0220	1.022
Knowledge about BCT	−0.1402***	0.869	0.0685***	1.071
Previous BCT experience	−0.5574***	0.573	−0.0507***	0.951
Yearly household income	−0.0420	0.959	0.0098	1.010
Male	−0.3950***	0.674	−0.0998***	0.905
Age up to 45 years	−0.8271***	0.437	−0.0727**	0.930
High education	−0.2214***	0.801	−0.3716***	0.690
Constant	−0.2355**	0.790	−0.4412***	0.643

Note: RRR, Relative Risk Ratio; “Previous BCT experience”: frequency of purchasing food tracked with BCT. “Knowledge about BCT”: self-evaluation of blockchain awareness in the agri-food sector. Yearly household income was treated as an ordinal predictor coded: 1 = < €20,000; 2 = €20,000–€60,000; 3 = > €60,000. *p < 0.10; **p < 0.05; ***p < 0.01.

replacing them. Even though the objective of this study was to compare traditional certifications and blockchain technology as substitute options, the results, consistent with the cases identified by Köhler et al. (2022), could point out the potential for a synergistic interaction.

This integration creates a hybrid system where traditional certification bodies maintain their established credibility and consumer trust, while blockchain technology enhances the verification process by providing granular, immutable traceability throughout the supply chain. This model allows both blockchain to engage digitally savvy consumers who value technological innovation (Class 3) and conventional organic labels to preserve the confidence that they have built over decades (Class 2), thereby expanding the market reach for organic products.

Another relevant aspect concerns the value attributed to information on social sustainability by the main segment of the sample. The interest in this attribute, closely linked to the attention towards respecting decent working conditions in production and distribution chains, suggests the opportunity to deepen the role of blockchain as a tool for guaranteeing transparency for such information. Blockchain technology could thus be explored as a mechanism to enhance the traceability of social sustainability practices, offering more reliable information on working conditions and helping to address persistent issues such as labour exploitation in agricultural value chains. In this line, the study by Thiermann et al. (2024) showed that consumers give particular importance to specific elements, such as minimum wages, weekly working hours, access to social security insurance, improvements in housing conditions, and bonuses for working on holidays and Sundays. In this context, blockchain could represent a key tool to convey this information in a detailed way, offering consumers greater transparency and assurance compared to traditional certification logos such as “fair trade,” “fair labour,” or “no-cap.”

To operationalise the implications of these findings, Table 10 provides a summary of attribute-specific recommendations addressed to relevant stakeholders. The table highlights how regulators, producers, and communicators may act upon the revealed preferences to strengthen the uptake and effectiveness of blockchain-supported traceability and sustainability signalling.

Beyond these high-level recommendations, from a practical standpoint, these findings offer concrete guidance for tomato puree labelling and pricing strategies. For labelling, producers should prioritize

Table 10
Recommendations by attribute and target stakeholder.

Attribute	Key insight from results	Recommended action	Stakeholder
Origin	Strong and consistent WTP across Class 2 (+0.84€) and Class 3 (+1.92€) showing fair-to-high attention levels	Promote the adoption of blockchain-based origin certification to restore fairness in trade dynamics, ensure economic sustainability for domestic producers, and reinforce the “Made in Italy” claim after recent fraud scandals.	Producers and Policy makers
Water Footprint	High WTP only in (Class 2); negative in Class 3. Highly polarized preferences: Class 2 (sustainability-focused consumers) shows high positive WTP (+5.78€), while Class 3 shows negative utility (−0.52€).	Acknowledge that current certification systems fall short on water footprint; support the development of clear, intuitive blockchain-based communication to reach both sustainability-minded and blockchain trust-driven consumers.	Certification bodies, blockchain developers, and Communicators
Organic Production	Opposite trend between classes: strongly valued by Class 3 (+3.40€), but penalized by Class 2 (−1.90€).	Integrate blockchain rather than replace existing organic certifications.	Producers and Certification bodies
Social Sustainability	Highest WTP in Class 3 (+2.74€), showing strong potential for improving transparency about labour exploitation issues in tomato supply chains	Develop frameworks that reconcile blockchain transparency with privacy, enabling detailed labour info.	Regulators and policymakers

blockchain-enabled origin information. QR codes linking to blockchain verification can serve as effective tools to communicate authentic provenance while differentiating products from cheaper imports. For water footprint labelling, a tiered approach is recommended: easier and more intuitive for mainstream consumers, and detailed quantitative data for environmentally focused buyers willing to pay premium prices. It is therefore necessary to understand how information is communicated from a technical and graphic point of view in order to achieve the best possible results in line with those obtained in this study. Regarding pricing implications, the uneven valuation of the organic attribute across consumer segments and the benefits of a hybrid certification model suggest that firms should retain existing organic price premiums while layering on modest blockchain verification fees, rather than fully replacing traditional certification costs.

Building on these tactical guidelines, targeted implementation of blockchain in sectors where information asymmetry remains high, such as environmental and ethical dimensions of food production, could enhance consumer trust, promote responsible consumption, and indirectly pressure supply chains to improve sustainability standards. Beyond its traceability functions, blockchain can also contribute to operational and environmental performance by increasing resource efficiency, reducing waste, and enabling real-time monitoring across the value chain. In fact, blockchain can play a pivotal role in supporting circular economy strategies within the agri-food sector. According to [Pakseresht et al. \(2023\)](#), blockchain's contribution to circularity can be framed in three main areas: (1) preventive effects, such as the reduction of information asymmetries and the promotion of optimized eco-efficiency; (2) valorisation of waste and by-products, including improved recycling processes and ex-post traceability for secondary resources; and (3) enabling of regenerative strategies, particularly through ex-ante traceability mechanisms that facilitate resource regeneration and closed-loop systems. As demonstrated by [Khan et al. \(2025\)](#) in the food and logistics sectors, its integration supports eco-efficiency and process transparency, improves coordination among stakeholders, and fosters accountability in labour practices and environmental impact reporting. Furthermore, as shown by [Compagnucci et al. \(2022\)](#), Blockchain adoption in agri-food SMEs enhances internal digitalization processes, facilitates real-time, bidirectional communication with consumers, and creates new channels for strategic engagement, particularly in contexts where transparency and authenticity are critical, such as the "Made in Italy" sector. The technology's role, therefore, extends well beyond data tracking: it becomes a systemic enabler of sustainable transitions, linking technological innovation with consumer expectations and production system resilience.

In the third and final phase of the analysis, the MLR results highlighted that direct, prior experience with blockchain-traced products shapes preferences more than awareness. Unlike recent studies ([Tran et al., 2024](#)), which identify the lack of awareness of the functioning and value of BCT as a limit to its diffusion, the results of this study highlight how direct experience plays a decisive role in orienting preferences towards its use. This suggests that knowledge of the technology alone is not sufficient to determine its preference. Therefore, in addition to the importance of clearly communicating how BCT works to ensure understanding and recognize its effectiveness in promoting transparency and responsibility ([Bandinelli et al., 2023](#)), it is necessary to invest in the availability of such references which, as approximately 30 % of the sample claimed, are difficult to find as they are not yet widely available on the market.

5.2. Limitations of the study and future directions

Regarding the limitations of the study, for a further optimization of the understanding of the determinants that influence the attitude towards BCT, the TAM model could have included predictor constructs related to trust or knowledge of BCT as in previous studies. In particular, some researches have extended the model by integrating: the Perceived

Product Transparency (PPT) ([Sepe, 2024](#)), the Perceived Trust (TR) ([Bandinelli et al., 2023](#); [Sepe, 2024](#)), Perceived Security or Perceived Privacy ([Bandinelli et al., 2023](#)) or Technology Principles Knowledge (TPK), ([Martinelli and De Canio, 2024](#)). However, the choice not to include these constructs was mainly dictated by the need to limit the length of the questionnaire during administration. Since the questionnaire included sections dedicated to measuring the TAM and five choice sets for the DCE, the inclusion of additional questions to extend this scale could have increased the cognitive load of the respondents, with the risk of introducing biases related to survey fatigue or satisficing response behaviour ([Galesic and Bosnjak, 2009](#); [Krosnick, 1991](#)). However, self-report methods such as surveys and questionnaires are prone to socially desirable responses, which is the tendency for participants to provide answers that present themselves in a favorable light or "stretch the truth" to make a good impression ([Martin and Nagao, 1989](#)), which is therefore an intrinsic limitation of the method that should be mentioned. Likewise, the stated-choice nature of DCEs can introduce hypothetical biases that can influence estimated preferences and WTP; although we used a "cheap talk" script to mitigate this tendency, its effectiveness cannot be guaranteed, and residual biases may remain.

Furthermore, the methodological decision to specify the attributes guaranteed by the BCT in a distinct way from those conveyed by traditional certifications has allowed to isolate the contribution of technology, thus responding to the study's needs to specifically evaluate the perceived value of the BCT. Although this choice may have influenced the direct comparison between the two guarantee systems, with a possible effect on the estimates of willingness to pay, it represents a conscious methodological compromise, aimed at ensuring a more targeted evaluation of technological attributes.

A further limitation of this study lies in its exclusive focus on the potential benefits of blockchain for sustainability, without considering the environmental costs associated with the technology's implementation. As highlighted by [Khan et al. \(2025\)](#), some blockchain infrastructures, particularly those based on proof-of-work consensus mechanisms, are associated with high energy consumption, potential e-waste generation, and significant carbon footprints. Future research should therefore evaluate the overall sustainability balance of blockchain adoption in agri-food supply chains, by comparing the environmental and social benefits of enhanced traceability against the ecological costs of the enabling infrastructure. This would include assessing energy use, emissions, and the potential advantages of transitioning to more efficient systems, such as proof-of-stake models or the integration of renewable energy sources.

Finally, the exclusive focus on the Italian market represents a constraint, given the crucial role of exports in the tomato products sector. In-depth analysis of the perception of BCT in destination markets could provide valuable insights for a more effective marketing strategy at an international level. In particular, the value of Made in Italy and compliance with specific production criteria could be even more relevant in those foreign markets where Italian products are more exposed to unfair competition from third countries. An extension of the analysis to these contexts would allow us to better understand the role of BCT as a tool for product protection and differentiation, contributing to strengthening the competitiveness of the sector on international markets.

6. Conclusions

The results of this study contribute significantly to the existing literature by highlighting the substantial potential of blockchain technology (BCT) in engaging consumer segments that are sensitive to sustainability and innovation. By applying a DCE model to investigate the propensity to purchase tomato puree with credence attributes (WF, OR, BIO, SS) guaranteed by blockchain traceability and using an LCM model to estimate the preferences of interviewees, this research offers meaningful insights into the agri-food marketing sector. The assessment of

sample heterogeneity based on scores predicted by the extended TAM model for attitudes towards technology and attention to credence attributes provides valuable implications for positioning and communication strategies of blockchain-tracked tomato products.

With respect to the consumer segmentation and potential for BCT adoption, the analysis identifies three distinct segments of consumers with varying attitudes towards BCT and credence attributes (i) Class 1 (i.e., Low involvement with BCT and credence attributes): is the smallest segment, which shows a concrete difficulty in engaging with the credence attributes conveyed by BCT; (ii) Class 2 (i.e., High value on credence attributes, low inclination towards BCT), despite not being inclined towards BCT, this segment places a high value on specific credence information. This suggests that targeted communication focusing on these attributes can increase the involvement of this consumer category; and (iii) Class 3 (i.e., High propensity to adopt BCT), representing approximately 60 % of the sample, this majority class demonstrates a strong propensity to adopt BCT almost independently of the specific attribute. This indicates that BCT is perceived as a guarantee of authenticity and reliability.

These findings point to broader implications for sustainable agri-food systems and public policy. (I) They support the recommendation to develop labelling standards that integrate blockchain-based traceability as a tool to enhance consumer trust in sustainability claims. Such standards could ensure greater transparency and verification of environmental and social attributes across the supply chain. (II) Moreover, the findings suggest that blockchain technology could be strategically aligned with broader policy initiatives, such as the EU Farm-to-Fork Strategy or Italy's National Recover and Resilience Plan (PNRR) and the National Digitalization Strategy, to promote low-impact, resilient, and ethically responsible food systems. In this context, (III) increasing the availability and accessibility of blockchain-traced products on the market remains essential, as many consumers reported difficulty in finding such options, despite being positively predisposed to their adoption. Furthermore, from a production perspective, firms should articulate the added value of blockchain by emphasizing its ability to certify sustainability claims, increase traceability, and reduce information asymmetries.

Overall, the study confirms that blockchain, when aligned with consumer expectations for sustainability, can act as a powerful lever to promote more transparent and resilient agri-food value chains (Bandinelli et al., 2023; Tran et al., 2024). By making attribute information verifiable, it may enable better-informed purchasing decisions and reinforce the link between production practices and consumption behavior, thereby supporting progress toward economically viable, environmentally responsible, and socially inclusive food systems (Khan et al., 2025; Compagnucci et al., 2022).

CRedit authorship contribution statement

Emanuela Tria: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Francesco Di Cosola:** Writing – original draft, Data curation. **Alessandro Petrontino:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Formal analysis, Conceptualization. **Michel Frem:** Writing – review & editing, Writing – original draft, Investigation. **Francesco Bozzo:** Validation, Supervision, Project administration, Funding acquisition, Conceptualization.

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responsible for them.

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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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.clrc.2025.100339>.

Data availability

Data will be made available on request.

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CHAPTER 5

Sustainability and Quality in Wine Pricing: Insights from the Primitivo E-Commerce Market

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Article

Sustainability and Quality in Wine Pricing: Insights from the Primitivo E-Commerce Market

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Abstract

The wine sector faces urgent challenges related to climate change, resource constraints, rising energy costs, and shifting consumption patterns. In this context, sustainability represents a lever of competitiveness and resilience, enabling producers to differentiate themselves through their connection with the territory and the preservation of artisanal practices. This is particularly evident for native varieties, such as the Apulian Primitivo, whose market repositioning is based on production choices that combine sustainability and craftsmanship, generating wines with distinctive organoleptic characteristics while also contributing to the environmental, economic, and social protection of the production areas. At the same time, the spread of e-commerce offers new opportunities to enhance these characteristics: online descriptions enrich the communication of details compared to the physical label, reducing information asymmetries and making signs of quality and sustainability more visible. Therefore, this study applies a hedonic model to estimate the implicit price of such practices, analyzing 656 Primitivo labels through simultaneous quantile regressions. The results show that sensory characteristics, such as alcohol content and ageing, determine the price throughout distribution, while identity and sustainable attributes have heterogeneous effects: ecological practices and Geographical Indications affect the lower quantiles, while indigenous yeasts and sapling vines are configured as premium signals in the upper segments.

Keywords: winemaking; local grape; hedonic price model; quantile regression; digital market; product differentiation



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1. Introduction

In recent years, sustainability has emerged as a key strategic lever in agri-food systems, becoming increasingly relevant in business and public policy. Food systems are currently at the crossroads of global challenges such as resource depletion, climate change, and socioeconomic inequality, as noted by El Bilali et al. (2024) [1]. These issues have a significant impact on the production, distribution, and consumption of food. In this context, agri-food markets are intricate, dynamic systems whose operations have a direct impact on social, economic, and environmental balances [2].

They are strategic hubs to address global tensions and to implement the principles of the 2030 Agenda, promoting sustainable practices along the entire supply chain. Addressing these challenges implies a systemic reconfiguration of production and distribution models

and requires a transdisciplinary approach to identify which system functions should be phased out, supported or redesigned, while building a shared agenda of research, policies and actions.

Borsellino et al. (2020) [2] underline that the transformation underway represents both a challenge and an opportunity: creating effective, inclusive, and nutrient-conscious marketplaces that can reduce environmental externalities, promote collaborative governance models throughout the supply chain, and value low-impact agricultural approaches (integrated, organic, and precision farming) is essential. However, the literature shows that the transition to sustainable production models encounters numerous barriers, which vary according to firm size, sector, and adopted technologies. In the case of small and medium-sized enterprises, for example, the most recurrent constraints concern the lack of resources, high initial capital costs, and the lack of managerial and technical skills [3] (Álvarez Jaramillo et al., 2019). The systematic review by Campuzano et al. (2023) [4], which focuses precisely on identifying barriers to sustainable innovation in the agricultural sector, highlights the persistence of both internal (financial resources, skills, organizational mindset) and external barriers, including the lack of favourable policies and regulations and the scarcity of skilled labour.

Despite these constraints, innovation remains an essential tool to face the challenges of the transition. According to Cecchini et al. (2018) [5], the “sustainability-oriented innovation” paradigm integrates social, environmental, and economic objectives going beyond the traditional linear research-development logic. Precision technologies, conservative agriculture, process and product eco-innovations, but also organizational solutions and multi-stakeholder collaborative models design paths to reduce chemical inputs, save water, cut emissions and enhance biodiversity. From this perspective, innovation extends beyond the technological aspect; it also includes supply chain management, governance practices, and consumer communication in an effort to influence their perception of value and their willingness to pay for sustainable products. As sustainability in the food sector is increasingly conceptualized as a multidimensional construct, which consumers perceive and hierarchize differently, from “protection of natural resources” to “accessibility to healthy food” to “decent working conditions” [6], it becomes crucial to understand how these meanings influence purchasing behaviours. Consequently, assessing consumers’ propensity to change their eating habits and to recognize the added value of sustainable products becomes a priority not only to guide supply, but also to promote more responsible and equitable eating patterns [2].

As reported by Cecchini et al. (2018) [5], the post-modern consumer is more informed and inclined to consider ethical, social, and environmental values when making purchases, rather than being driven by price or taste. Multiple studies provide evidence of this behavioural shift, showing that sustainability labels (e.g., organic, fair-trade, reduced carbon impact, Geographical Indications, etc.) have become significant drivers of purchasing decisions [7,8]. However, experimental research indicates that consumers are willing to pay a substantial premium for “responsible” products, only when both informational transparency and sensory quality are ensured. Without these conditions, the search for sensory enjoyment is prioritized over sustainable awareness, highlighting the need to combine taste performance with value-driven content [9,10].

This ambivalence of demand is reflected in the challenges of supply: if consumers reward sustainability only when it is accompanied by transparency and quality, companies are called upon to innovate without neglecting efficiency and sensory performance. The tensions between innovation drives, implementation limits and consumer expectations find an emblematic example in the wine supply, which, to regenerate ecosystems, reduce emissions, and ensure social equity, must address five key challenges along the entire value

chain: the impact of climate change and adaptation strategies; reducing emissions and creating carbon sinks; the responsible use of inputs in the vineyard; innovation in packaging; and the social and economic sustainability of producing communities [11] (Wagner et al., 2023). As Golicic (2022) [12] shows, many companies follow an evolutionary path, starting with environmental aspects, then moving on to economic balance, and finally integrating the social dimension. This gradual process reflects the structural difficulties of the transition, as “green” approaches can lead to higher labour requirements, temporary drops in yield, and increased unit costs, generating tension between reduced inputs, production targets, and profit margins.

At the same time, several studies have shown that the transition from conventional practices to lower-impact solutions can, under specific soil and climate conditions, strengthen economic margins by combining yield stability with improved product quality. Research conducted in Italian wine contexts has shown that the adoption of integrated approaches makes it possible to combine environmental and economic sustainability, albeit with some trade-offs related to yields [13]. Similarly, low-input regimes increase operational complexity and short-term risks but, under specific yield profiles and pedoclimatic conditions, allow for the joint achievement of environmental and economic performance [14,15].

In the vineyard, the answers to the challenges of sustainability, aimed at reducing the use of chemicals, water and energy, are realized through three main guidelines: the adoption of traditional low-yield training systems, which have demonstrated significant physiological and microclimatic benefits in conditions of increasing climatic stress, helping to limit water loss and protect the bunches during heat waves [16]; the use of resilient native grape varieties, which offer a concrete solution for the reduction in pesticide use and for the promotion of more sustainable viticulture, in line with the objectives of the European Green Deal [17]; and the progressive extension of vineyard areas conducted with sustainable methods, in particular organic and biodynamic, which is recorded in both traditional and emerging producing countries [18].

In the winery, practices that focus on sustainability and quality are being explored. This includes using local yeasts, spontaneous fermentations, limited sulphites, ageing in low-impact materials, and reducing fining and filtration.

The use of indigenous yeasts has proved to be an effective strategy to strengthen the authenticity of the wine, enhancing the sensory characteristics linked to the microflora of the territory [19]. Spontaneous fermentation, which is based precisely on these yeasts naturally present on the grapes and in the vineyards, makes it possible to obtain unique wines, with a strong regional identity, while requiring careful management to ensure their quality and stability.

The use of sulphites is also the subject of attention: although they are commonly used as antioxidants and antimicrobials, their use raises growing health concerns. For this reason, alternative solutions are being experimented with, such as natural extracts rich in phenolic compounds, which make it possible to significantly reduce the sulphur dioxide content in wines, offering concrete answers to the growing demand for more natural and healthy products [20].

In parallel, research is exploring natural fining agents that are more sustainable than traditional ones: among these, pomace has been shown to be effective in removing tannins and anthocyanins, with equal or superior performance compared to commercial agents [21].

Finally, the refining materials are also evolving. Several wood species, in addition to oak, are being studied for their unique chemical compositions and their effects on wine quality [22]. In addition, ceramic and cementitious materials are emerging as alternatives to wood and stainless steel. These alternative ageing materials offer winemakers new tools to improve wine quality, reduce costs, and improve the sustainability of the industry.

These choices, along with lightweight packaging and short-chain logistics, lead to product features that appear on wineries' labels and stories. They play an increasing role in consumer buying decisions and act as strategic tools for strengthening market competitiveness.

1.1. Recent Dynamics of the Wine Market

The wine industry is one of the agricultural sectors with the highest added and symbolic value, where quality, sustainability, and territorial identity are all closely interconnected. However, the industry is undergoing a deeper restructuring process on a global scale. According to ISMEA (2025) [23], global wine production in 2024 reached its lowest level in the last ten years, standing at around 221 million hectolitres. Europe maintains its leadership, but its weight has dropped to 64% of the total, while international trade has stabilized at around 36 million hectolitres and 36 billion euros. Italy keeps playing a major role in this scenario: in 2024, it reclaimed the top spot as the world's largest producer, reaching 44 million hectolitres—a 15% rise compared to 2023. It also confirmed its position as the top exporter by volume (21.7 million hectolitres) and second by value (8.1 billion euros) [23]. With 529 recognized PDO and PGI designations, the industry is valued at over €14 billion, equal to 10% of the national agri-food turnover. Even on the national market, wine remains a cornerstone of Italian food culture, with consumption stable at around 22 million hectolitres, corresponding to approximately 37.8 litres per capita.

Apulian Viticulture: The Case of Primitivo

Apulia is the leading Italian wine-producing region by volume, with over 90,000 hectares of vineyards and more than 1.4 million hectolitres of wine produced in 2024 (ISTAT, 2024). The region includes 29 DOC, 4 DOCG, and 6 IGT that protect native grape varieties. Among these, Primitivo stands out and has gained growing attention in both national and international markets.

Originally from Dalmatia, the Primitivo grape arrived in Apulia more than two thousand years ago. It found its ideal growing conditions in the Manduria area and, by the 1990s, became the ninth most planted grape variety in Italy [24]. For many years, Primitivo was mainly used for blending. However, lower yields and better winemaking methods helped to reposition it as a red wine with strong character, appreciated again by the wider public [24]. Its commercial revival also coincides with efforts to strengthen local identity. "Primitivo di Manduria" received DOC status in 1974 and was later awarded DOCG recognition in its "Dolce Naturale" version in 2011. The production area includes 18 towns in the provinces of Taranto and Brindisi, covering more than 5000 hectares. Many of the vineyards still use the traditional bush-trained vines method, which fits well with the Ionian-Salento climate [25].

According to Circana data processed for Vinitaly [26], Primitivo saw a 12.3% increase in value in 2024 compared to the year before, reaching €40.6 million in sales in large-scale retail, with about 7.5 million litres sold and an average price of €6.20 per bottle. Over the 2019–2024 period, it recorded the second-highest annual growth rate (+10%), just behind Vermentino (+11%). Primitivo is also among the top five red wines by average price per litre, ahead of Barbera, Nero d'Avola, and Montepulciano.

This combination of strong regional roots and growing interest in native, resilient grape varieties make Primitivo a good case for exploring whether the market recognizes a premium for quality and sustainability attributes shown on labels. To study this, the literature often uses hedonic pricing models, which are common in wine research to estimate how product features affect prices.

1.2. Bibliographic Review: The Hedonic Price Applied to Wine

Martínez-Navarro et al. (2024) [27] describe how the literature on wine marketing has evolved through three distinct periods: a first phase of emergence (1990–2009), followed by a phase of growth (2010–2016), and more recently, a phase of rapid expansion (2017–2022). Among the common topics across all these stages, the relationship between quality and price has remained central, only overtaken in impact by themes concerning communication and promotion. Early studies mainly aimed to identify the elements that influence wine prices and to understand how pricing affects consumer choices. In recent phases, the discussion on quality has gone beyond purely economic factors. Researchers have begun to investigate which attributes affect how consumers and experts perceive quality and how these perceptions translate into a willingness to pay a premium price.

In this context, the hedonic approach has been used a lot to investigate how different product features affect wine prices. A recent systematic review of hedonic pricing models applied to wine [28] showed that attribute selection, market definition, data sources, and econometric methods have a significant impact on the explanatory capacity of these models. In fact, selecting the variables to be included in the hedonic function is one of the main empirical challenges [29]. Núñez et al. (2024) [28] propose a detailed hierarchical-deductive classification, which builds on a common distinction in the literature [30,31] between: (I) objective attributes, (II) quality and reputation, and (III) those related to production, consumption, and the economic environment. Each of these categories includes multiple layers. Among objective features, a further distinction is made between observable intrinsic attributes, such as wine type and colour, and attributes not directly observable but shown on the label, including vintage, grape variety, ageing, alcohol content, and environmental certifications. Based on an international sample of more than nine thousand wines sold online in France, Italy, Germany, and Australia, Gonçalves et al. (2021) [32] confirm that vintage and alcohol content are key price drivers across countries and market segments. They also find differentiated effects for colour, blend, bottle closure type, and awards, revealing notable heterogeneity in price determinants across national markets.

The second major category (quality and reputation) is composed mostly of subjective attributes. It includes both wine quality indicators, observable (e.g., brand, quantity produced) or non-observable (expert evaluations, awards, aggregate judgments), and company reputation indicators, which are also distinguished between observable (size or age of the winery) and non-observable (overall rating), up to forms of collective reputation, such as membership in associations or designation of origin. Several studies confirm the relevance of such indicators. Benfratello et al. (2009) [30], Cacchiarelli et al. (2014) [33], Di Vita et al. (2015) [34] and Caracciolo & Furno (2020) [35] show that geographic designations like DOCG, DOC, and IGP are solid price drivers, although their effects differ depending on the market and product segment. Caracciolo & Furno (2020) [35], for example, note that the same attribute may hold different meanings for different consumer groups, while Di Vita et al. (2015) [34] show that certifications tend to generate higher premiums in upper price tiers and are less relevant in the lower end of the market.

As regards non-observable quality indicators, several contributions [31,33] show that expert scores, awards, and recognition contribute positively to price formation, particularly in the mid-to-high segments. However, the role of reputation is broader and more layered: Benfratello et al. (2009) [30] highlight that, in contexts of imperfect information, the reputation consolidated over time can be a more reliable signal than isolated recognitions. Moreover, Boatto et al. (2011) [31] show that the signalling effectiveness of these attributes depends on the distribution channel, being more marked in contexts frequented by less experienced consumers.

Finally, the third group of attributes refers to production, consumption, and the economic environment. It includes factors such as farming and winemaking practices, packaging, conditions of consumption (time, place, pairing), and consumer habits like brand loyalty or deeper motivations linked to place and socio-economic context. In this area, environmental and organic certifications have been frequently investigated, but with controversial results. While environmental certification alone tends to generate a price premium, visible environmental labelling can sometimes negatively affect the product, especially in the presence of low consumer environmental literacy [36]. Abraben et al. (2017) [37] note that the premium for organic is concentrated in the mid-range segments, while in high-end wines it can also translate into a discount.

Despite the emerging focus on sustainability and process quality, as noted by Núñez et al. (2024) [28], the characteristics associated with the production process are still little explored in hedonic models. Often, these practices reduce production yields and require greater labour intensity. Still, they can contribute to the sensory distinctiveness and identity of the product play. They can play a crucial role in the enhancement of the oenological heritage, in the conservation of the rural landscape, and in the promotion of the environmental, economic, and social sustainability of the production areas. The influence of these practices was investigated with respect of the cost or sensory profile of the wine [38,39], but no one, so far, has evaluated the implicit value attributed to the communication of the adoption of cultivation and winemaking practices that strengthen the link between wine and territory. This overlooked dimension offers a promising avenue for further investigation, which the present study aims to address.

1.3. Research Objective

In recent years, attention to sustainable production practices has grown significantly, but the literature still shows important gaps. Few studies systematically analyze how these practices translate into price changes, and even fewer focus on native varieties undergoing repositioning. Contributing to this gap is the difficulty of finding such detailed information through wine labels in traditional distribution channels.

However, the expansion of e-commerce offers an opportunity to fill these gaps, as product sheets and online descriptions make not only traditional quality signals (appellation, vintage, alcohol content) accessible and comparable, but also elements related to sustainability and craftsmanship. As demonstrated by Lynch and Ariely (2000) [40], the reduction in search costs and the greater transparency of information in digital markets systematically influence consumer choices: direct access to credence attributes favours more quality-oriented decisions and reduces price sensitivity.

The choice of Apulian Primitivo as the reference market offers a singular and significant context to examine how attributes related to sustainability and tradition translate into economic recognition. It is, in fact, an autochthonous grape variety, once relegated to blending and now at the centre of a process of qualitative enhancement. Moreover, the structure of its supply chain, composed largely of small and medium-sized enterprises, makes strategies based on such practices particularly relevant, which can represent a more accessible and distinctive way to differentiate oneself on the market compared to solutions that require substantial investments and economies of scale. For these practices to effectively contribute to the sustainable transition of the wine sector, however, they must also be valued by consumers. This remains a fundamental step, since the transition from process sustainability to perceived sustainability is anything but linear: not all attributes are equally recognized, nor do they generate the same impact in terms of willingness to pay.

Considering this evidence, the present study aims to answer the following research questions:

RQ1. To what extent do artisanal and sustainable practices (e.g., low-yield farming systems, use of indigenous yeasts, environmental sustainability mentions, and Geographical Indications) affect the price of Primitivo wine in the e-commerce market?

RQ2. What is the relative weight of these practices in the different market segments, from the mass market to the premium market?

To answer these questions, the study applies a hedonic pricing model to the online marketplace. More specifically, the adoption of quantile regression in an e-commerce context represents a significant methodological innovation, as it allows not only the modelling of average market effects, as in previous hedonic studies, but also the analysis of distributional tails, while exploiting the richness of digital marketplace information, where standardized descriptions reduce information asymmetries. This approach delivers a threefold contribution to the literature: theoretical, by extending wine hedonic models to incorporate previously unexplored sustainability dimensions; methodological, through the application of quantile regression in this field; and practical, because quantifying the economic contribution of individual sustainability and quality practices to the formation of the final price, can provide strategic guidance to producers on investments, denomination policies, and digital communication, as well as policy recommendations for valorising native varieties and supporting the sustainable transition of the entire supply chain.

2. Materials and Methods

As reported by Petrontino et al. (2023) [41], taking up previous studies [42,43], the hedonic pricing model (HPM) considers a product as a set of characteristics/attributes, whereby consumers buy the product that includes this set, maximizing their utility. Similarly, manufacturers maximize their profits by determining the price of a product based on its attributes. Thus, differentiated goods can be considered as a set of various quality attributes that distinguish them from other similar goods, so that the market equilibrium price can be considered a function of the implied prices of each attribute of the good.

However, this theoretical framework is based on robust assumptions: (i) perfect identification of the relevant market; (ii) independence of attributes or related implicit marginal prices; (iii) perfectly competitive markets in long-term equilibrium; (iv) perfect and symmetrical information between consumers and producers [29].

In the wine-growing context, Miller et al. (2007) [44] highlight how these conditions are difficult to achieve. Furthermore, as pointed out by Unwin (1999) [29], Rosen's framework [42], does not provide operational indications on the functional specification of the price function nor on the selection of the relevant attributes, exposing the analysis to econometric criticalities such as multicollinearity, endogeneity and sample representativeness problems.

Despite these limitations, HPM has established itself as a reference methodology in wine sector studies, by virtue of its ability to estimate the economic value of quality and sustainability attributes incorporated in wines [45]. The literature reports a wide variety of methodological approaches used for the estimation of hedonic price functions. Ordinary least squares (OLS) regression is the most widely used technique, used in 93% of studies and 85% of estimates [28], thanks to the simplicity of interpretation of the coefficients and the availability of correctives for heteroskedasticity and autocorrelation (51% of studies).

The functional form used is another important methodological issue. According to Núñez et al. (2024) [28], 76% of the studies adopt a semi-logarithmic specification, allowing the coefficients to be interpreted as semi-elasticity. Less frequent is the use of the pure logarithmic form (7%) or mixed log-linear models (7%). More complex functional shapes, such as Box–Cox transformations, are residual, mainly used to improve the fit of the model in the presence of strongly asymmetric distributions.

However, the increasing focus on market segmentation and consumer heterogeneity has raised questions about the adequacy of conventional conditional averaging models. As Amédée-Manesme et al. (2020) [46] point out, traditional hedonic models assume homogeneous market behaviour, assuming that the relationship between price and attributes remains constant throughout the price distribution. This assumption risks hiding differentiated dynamics between market segments, generating partial or distorted estimates. In response to these critical issues, quantile regression (QR) is an alternative approach capable of capturing changes in price premiums associated with attributes along the different percentiles of the distribution [34].

Unlike OLS regression, which estimates the average effect of attributes on price, QR allows these effects to be analyzed at different points in the conditional price distribution, explicitly modelling the tails and intermediate segments of the market. The QR is based on minimizing weighted absolute deviations and estimating conditional quantile functions for each percentile $q \in (0,1)$, by means of linear programming algorithms [47]. The objective function is represented by:

$$Q(\beta q) = \sum_{i: y \geq x'_i \beta q} q |y_i - x'_i \beta q| + \sum_{i: y < x'_i \beta q} (1 - q) |y_i - x'_i \beta q| \quad (1)$$

where βq represents the estimated coefficients for each quantile [34]. As a semi-parametric estimate, QR is robust compared to heteroskedasticity and outliers, offering more flexibility in analyzing segmented markets [48]. Although the application of QR to the wine sector is still relatively limited, it has proven effective in analyzing reputation awards and market segmentations, as evidenced in previous studies [34,49].

Consistent with this evidence, the present study adopts a quantile regression model to estimate the hedonic price function, in order to quantify the marginal contribution of sustainability and quality attributes in the pricing of Primitivo wine sold online.

2.1. Data Collection and Dataset Construction

The dataset was built through systematic web scraping conducted between September and November 2024 using Web Scraper, a browser-based tool for extracting structured data from e-commerce platforms.

The collection involved exclusively the main pure players in Italian wine e-commerce: Tannico, Vino.com, Callmewine, Xtrawine, and Bernabei. The decision to focus on these specialized platforms responds to a twofold need. On the one hand, these are direct sales channels that play an important role in the Italian market. According to the most recent Mediobanca report [50], pure players represent a market share close to that of producers' direct sites, with an overall sales growth of +8% in 2024 compared to the previous year. Tannico confirmed its position as market leader (€29 million in revenues), followed by Bernabei (€28.5 million), Vino.com (€27 million), Callmewine (€13.6 million), and Xtrawine (€9.1 million). On the other hand, the choice of the online channel allows access to detailed and standardized product information, reducing informational asymmetries and allowing a homogeneous detection of the technical and commercial characteristics of the wines.

The focus of the survey concerned the labels marketed as Apulian Primitivo. At the end of the collection, comments without essential information (e.g., price) were excluded from the sample, as well as sweet wines (known as "Passito") or other special versions, as they were associated with specific production practices that could significantly affect the typological reference.

The final dataset includes 656 distinct labels. Table 1 shows the 15 variables identified, divided into four main macro-categories: company information, production characteristics, attributes of product, and awards and recognitions.

Table 1. Description of variables used in our hedonic price model analysis.

Variable	Category	Description	Code
Score Winery	Dichotomous	$3.4 \leq \text{score} \leq 3, 7 = 1$; otherwise = 0	Score_A
		$3.8 \leq \text{score} \leq 4, 0 = 1$; otherwise = 0	Score_B
		$4.1 \leq \text{score} \leq 4, 3 = 1$; otherwise = 0	Score_C
Winery Site	Dichotomous	Apulia = 1; otherwise = 0	CA_PU
Price_75	Continuous	Final price of wine (euro/ 75 cL)	Price per 75 cl
Years	Dichotomous	$0 \leq \text{years} \leq 3 = 1$; otherwise = 0	Y0_3
		$4 \leq \text{years} \leq 6 = 1$; otherwise = 0	Y4_6
		more than six years = 1; otherwise = 0	Ymore_6
Denomination	Dichotomous	IG = 1; otherwise = 0	IG
		DO = 1; otherwise = 0	DO
Grape Variety	Dichotomous	Primitivo 100% = 1; otherwise = 0	MONO_V
Alcohol	Dichotomous	$\text{Alcohol} \leq 14\% = 1$; otherwise = 0	ALC%14
		$14\% < \text{alcohol} \leq 15.5\% = 1$; otherwise = 0	ALC%14–15.5
		$\text{Alcohol} > 15.5\% = 1$; otherwise = 0	ALC%15.5
Type	Dichotomous	red = 1; otherwise = 0	RED
		rosè = 1; otherwise = 0	ROSE
Overripening	Dichotomous	overripening = 1; otherwise = 0	TARD
Planting	Dichotomous	apulian bush-trained vine = 1; otherwise = 0	ALB
		other planting system = 1; otherwise = 0	Imp_oth
		not present = 1; otherwise = 0	Imp_no
Refinement	Dichotomous	wood = 1; otherwise = 0	AF_LE
		steel = 1; otherwise = 0	AF_AC
		other material = 1; otherwise = 0	AF_oth
		not present = 1; otherwise = 0	AF_no
Packaging	Dichotomous	product sold in a wooden case or box = 1; otherwise = 0	Pack_ast_cass
Philosophies	Dichotomous	indigenous yeasts = 1; otherwise = 0	IND
		old vines and vines over 25 years old = 1; otherwise = 0	OLDV
Eco_Practices	Dichotomous	Presence of at least one environmental practice (organic, biodynamic, synergic) = 1; otherwise = 0	Eco_Practices
Awards	Dichotomous	Single reward > 95 = 1; otherwise = 0	AW_U95
		Multiple rewards, mean > 95, SD < 2.5 = 1; otherwise = 0	AW_M95_LSD
		Single reward 90 < score < 95 = 1; otherwise = 0	AW_U90_95
		Multiple rewards, mean 90–95, SD < 2.5 = 1; otherwise = 0	AW_M90_95_LSD
		Multiple rewards, mean 90–95, SD > 2.5 = 1; otherwise = 0	AW_M90_95_HSD
		Single reward < 90 = 1; otherwise = 0	AW_U90
		Multiple rewards, mean < 90, SD < 2.5 = 1; otherwise = 0	AW_M90_LSD
		Multiple rewards, mean < 90, SD > 2.5 = 1; otherwise = 0	AW_M90_HSD

The company information includes the score attributed to the winery (based on user evaluations) and the geographical location of the production site, distinguishing between companies located in Apulian region and outside the region. The information relating to production characteristics includes the planting system (bush-trained vines, other forms or undeclared), the method of refinement (wood, steel, other materials or undeclared),

the adoption of certified or declared environmental practices (organic, biodynamic or synergistic agriculture), the use of indigenous yeasts, the use of old vines and the possible application of over-ripening techniques of the grapes. The product information concerns the type of wine (red or rosé), the varietal purity (Primitivo 100% or blend), the alcohol content (classified into three categories), the presence of a Geographical Indications (DOCG/DOC or IGT), the year of production and the retail price for a standard 75 cl bottle.

Finally, about the awards and recognitions, the scores assigned by sector guides (e.g., Gambero Rosso, Bibenda, Vitae AIS, VITIS Vitae, Wine Spectator, Mundus Vini) and by experts of international importance (e.g., Parker, Maroni, Suckling), each operating with different evaluation scales and criteria, were considered. In order to harmonize the data, all scores were traced back to a common scale on a basis of 100. For each label, the number of awards received (single or multiple) was recorded. In the presence of multiple scores attributed to the same label, mean and standard deviation were calculated as indicators of consistency between the evaluations from different sources.

2.2. Specifying the Quantile Regression Model

In line with the methodological approach illustrated, the present study applies a quantile regression model aimed at analyzing the contribution of sustainability, quality, and reputation attributes to the determination of the price of Primitivo Pugliese wine in the different market segments. The analysis, in fact, was conducted through the use of the STATA 15 software, on the 10th, 25th, 50th, 75th, and 90th percentiles, in order to capture any differences in the price premiums associated with the attributes along the distribution. The dependent variable is represented by the natural logarithm of the price per 75 cl ($\ln_Price75$). Functional specification by the Box–Cox test suggested a value of $\lambda \approx -0.71$. However, the corresponding transformation implies an excessive compression of the variability at the extremes of the distribution (Table 2), with the risk of distortion precisely in the upper tail, which is central to our analysis. As Cacchiarelli et al. (2014) [33] point out, in the wine market, the extremes of the price distribution should not be considered mere outliers, but relevant observations that reflect market segmentation and deserve to be analyzed. For this reason, instead of adopting transformations that compress these values, it was considered more appropriate to apply quantile regressions, which make it possible to capture the effects of explanatory variables across the entire conditional distribution of prices, while avoiding parametric assumptions on the distribution of errors. In line with established practice in hedonic wine studies, the logarithmic transformation of the price was therefore adopted, as it ensures econometric robustness, guarantees comparability with the reference literature [34,35,46,51], and does not compromise the consistency of the estimators. On the other hand, all the independent variables, corresponding to the attributes shown in Table 1, have been encoded as dummy variables, assigning a value of 1 in the presence of the attribute and 0 in the case of absence. As reported in the correlation matrix in Supplementary Material (Table S1), no significant correlations were detected among the variables, ensuring that the estimates are not affected by collinearity issues.

The coefficients estimated in the model, therefore, must be interpreted as approximate percentage changes in the price per 75 cl, associated with the presence of the attribute with respect to the reference category. Therefore, for each percentile of the conditional price distribution, the coefficient of a dummy variable represents the percentage increase (or decrease) of the price associated with the presence of the attribute considered, all other characteristics being equal.

Table 2. Comparison of price distributions (€/75 cl).

Statistic	Price_75	ln_Price75	Boxcox_Price75
Mean	19.1	2.75	1.19
Std. deviation	17.09	0.57	0.07
Minimum	4.9	1.59	0.95
1st quartile (Q25)	10.3	2.33	1.14
Median (Q50)	13.63	2.61	1.18
3rd quartile (Q75)	22.59	3.12	1.25
Maximum	187.88	5.24	1.37
Variance	292.18	0.32	0.01
Skewness	4.43	1.13	0.08
Kurtosis	30.87	4.54	2.58

3. Results

3.1. Descriptive Statistics

As shown in Table 3, the dataset analyses 656 Primitivo wine labels available online. The average price is €19.10/75 cl, but with considerable variability: it ranges from a minimum of €4.90 to a maximum of €187.88, highlighting a highly heterogeneous commercial offer. Almost all of the wines examined are made up of reds (97.4%) and produced from a single grape variety (97.3%), confirming the monovarietal vocation of this market segment.

The producing companies are mainly located in the Apulian region (97.4%); however, a residual share of Primitivo wines, while declaring itself Apulian, comes from wineries based in other regions. As for online reputation, 94.1% of companies have evaluation scores between 3.8 and 4 out of 5.

Considering the variable ageing time, it emerges that Primitivo with more than six years of ageing represents a commercial niche (9.5%), while labels with ages between zero and three years and between four and six years are almost equally distributed (49.2% and 41.3%, respectively). The alcohol content is also distributed in a similar way: 43.8% of the wines have an alcohol content of less than 14%, while 46.2% are between 14% and 15.5%; only a marginal share (10.6%) exceeds this threshold.

From the point of view of certifications, about 56% of wines fall into the I.G. category, while 44% have a D.O. certification. Ageing in wood is the most common practice (47%), while steel (26%) and other ageing techniques (17%) are less common. However, information on refinement is not always available. In general, the presence of elements about quality or sustainability practices is rather limited: only 12% of labels report environmental practices, and even more limited is the widespread use of indigenous yeasts (8%), the use of grapes from vineyards over 25 years old (18%), or late harvesting (5%).

Training techniques also show a certain variability: about 30% of wines declare the use of the Apulian bush-trained system, while in most cases (54%) the planting system is not specified. Regarding quality awards, 44% of wines are without awards, while the remaining labels report heterogeneous and fragmented awards. Finally, packaging in wooden cases or crates affects just 5% of wines, suggesting that this choice remains limited to a very small market share.

Table 3. Descriptive statistics.

Variable	<i>n</i>	%	Mean	Std. Dev.	Min	Max
Price per 75 cl (€)	–	–	19.10	17.09	4.90	187.88
Score_A	20	3.0	0.03	0.17	0	1
Score_B	617	94.1	0.94	0.24	0	1
Score_C	19	2.9	0.03	0.17	0	1
CA_PU	639	97.4	0.97	0.16	0	1
Y0_3	323	49.2	0.49	0.50	0	1
Y4_6	271	41.3	0.41	0.49	0	1
Ymore_6	62	9.5	0.09	0.29	0	1
IG	367	55.9	0.56	0.50	0	1
DO	289	44.1	0.44	0.50	0	1
MONO_V	638	97.3	0.97	0.16	0	1
ALC%14	287	43.8	0.44	0.50	0	1
ALC%14–15.5	303	46.2	0.46	0.50	0	1
ALC%15.5	66	10.06	0.10	0.30	0	1
RED	639	97.4	0.97	0.16	0	1
ROSE	17	2.6	0.03	0.16	0	1
Eco_Practices	81	12.3	0.12	0.33	0	1
TARD	33	5.0	0.05	0.22	0	1
Imp_no	357	54.4	0.54	0.50	0	1
Imp_oth	104	15.9	0.16	0.37	0	1
Imp_ALB	195	29.7	0.30	0.46	0	1
AF_LE	308	46.9	0.47	0.50	0	1
AF_AC	172	26.2	0.26	0.44	0	1
AF_oth	112	17.1	0.17	0.38	0	1
AF_no	64	9.8	0.10	0.30	0	1
IND	53	8.1	0.08	0.27	0	1
OLDV	117	17.8	0.18	0.38	0	1
Pack_no	624	95.1	0.95	0.22	0	1
Pack_ast_cass	32	4.9	0.05	0.22	0	1
No_award	287	43.8	0.44	0.50	0	1
AW_U95	51	7.8	0.08	0.27	0	1
AW_M95_LSD	42	6.4	0.06	0.24	0	1
AW_U90_95	45	6.9	0.07	0.25	0	1
AW_M90_95_LSD	21	3.2	0.03	0.18	0	1
AW_M90_95_HSD	70	10.7	0.11	0.31	0	1
AW_U90	34	5.2	0.05	0.22	0	1
AW_M90_LSD	45	6.9	0.07	0.25	0	1
AW_M90_HSD	61	9.3	0.09	0.29	0	1

3.2. Quantile Regression Results

This section presents the results of the estimated simultaneous quantile regressions on five quantiles of the price function (Q10, Q25, Q50, Q75, Q90) for 656 labels of Primitivo wine, with the OLS regression used for comparative purposes. The analysis, as can be seen in Table 4, allows us to examine how observable attributes, relating to winery, production, product, and premiums, differentially influence the price in different market segments. The heterogeneity of effects along the distribution was further verified through the Wald tests on the equality of coefficients (Table S2), which confirm significant differences for some key variables, supporting the validity of the quantile approach.

Table 4. Results of Quantile regression and OLS.

Variable	Q10		Q25		Q50		Q75		Q90		OLS	
	Coeff.	^a Std. Err.	Coeff.	^a Std. Err.	Coeff.	^a Std. Err.	Coeff.	^a Std. Err.	Coeff.	^a Std. Err.	Coeff.	^b Std. Err.
Score_A	−0.1530	0.1137	−0.1218	0.0994	−0.0165	0.1193	0.0056	0.1634	−0.0876	0.2014	−0.0742	0.0865
Score_C	0.1499	0.10248	0.0908	0.1558	0.2709 **	0.1293	0.2992 **	0.1221	0.1944	0.1412	0.1492 *	0.0914
CA_PU	0.0229	0.0927	0.0437	0.0911	0.0955	0.0958	0.0549	0.1567	0.1120	0.2180	0.0824	0.0796
Y0_3	−0.1389 ***	0.0382	−0.1398 ***	0.0410	−0.2083 ***	0.0404	−0.2333 ***	0.0535	−0.2447 ***	0.0710	−0.2150 ***	0.0334
Ymore_6	0.2756 ***	0.0724	0.2878 ***	0.0956	0.3840 ***	0.1030	0.4746 ***	0.1159	0.4949 ***	0.1462	0.3946 ***	0.0693
DO	0.1120 ***	0.0389	0.0591	0.0410	−0.0094	0.0382	−0.0582	0.0558	−0.0264	0.0719	−0.0367	0.0356
Mono_V	−0.1065	0.0798	−0.0953	0.0728	0.0427	0.1002	−0.0289	0.1364	0.0053	0.1259	0.0035	0.0607
ALC%14	−0.2073 ***	0.0359	−0.2358 ***	0.0408	−0.2704 ***	0.0419	−0.2878 ***	0.0489	−0.3391 ***	0.0730	−0.2877 ***	0.0337
ALC%15.5	0.3715 ***	0.1044	0.3538 ***	0.0877	0.4358 ***	0.1051	0.6279 ***	0.1306	0.7352 ***	0.1622	0.5086 ***	0.0713
Red	−0.1529	0.1072	−0.0266	0.0824	−0.0435	0.0996	−0.0269	0.1166	−0.0359	0.1674	0.0100	0.0656
Eco_Practices	0.1461 ***	0.0545	0.0557	0.0493	0.0127	0.0493	−0.0233	0.0643	−0.0405	0.0961	−0.0283	0.0384
TARD	−0.0270	0.0849	−0.0344	0.0917	0.0021	0.0722	0.0222	0.0887	−0.1153	0.1180	−0.0174	0.0719
ALB	−0.0130	0.0484	0.0291	0.0487	~0.0000	0.0426	0.1420 **	0.0674	0.1475 *	0.0841	0.0722 *	0.0421
Imp_oth	−0.0157	0.0520	−0.0112	0.0517	−0.0176	0.0513	−0.0214	0.0537	−0.0683	0.0818	−0.0430	0.0391
AF_LE	0.1192 **	0.0579	0.2151 ***	0.0682	0.1396 *	0.0755	0.0729	0.0821	0.0870	0.1038	0.1606 ***	0.0562
AF_AC	−0.0240	0.0669	0.0582	0.0711	−0.0668	0.0745	−0.1289	0.0882	−0.0387	0.1053	−0.0066	0.0569
AF_oth	0.0871	0.0649	0.1709 **	0.0674	−0.0266	0.0746	−0.0497	0.0963	−0.0130	0.1195	0.0723	0.0596
IND	0.0934	0.0606	0.0635	0.0683	0.0517	0.0924	0.2522 ***	0.0848	0.1990 **	0.0911	0.1067 **	0.0537
OLDV	0.1407 **	0.0543	0.0488	0.0632	0.0411	0.0510	0.0583	0.0848	0.1621 *	0.0851	0.0392	0.0520
Pack_ast_cass	0.0257	0.0941	0.0856	0.1134	0.1623	0.1523	0.3614 **	0.1716	0.3738	0.3177	0.2726 **	0.1088
AW_U95	−0.0697	0.0657	−0.0862	0.0573	−0.0807	0.0573	−0.2296 ***	0.0791	−0.0386	0.1629	−0.1161 **	0.0525
AW_M95_LSD	0.1785 *	0.0950	0.3304 **	0.1350	0.3159 ***	0.0751	0.2423 **	0.1190	0.2128	0.2254	0.3201 ***	0.0807
AW_U90_95	−0.0466	0.0944	0.0138	0.0897	−0.0258	0.0586	−0.0852	0.0826	0.0698	0.1310	−0.0393	0.0616
AW_M90_95_LSD	0.0399	0.1133	0.0882	0.1274	0.0124	0.1292	0.2221	0.2565	0.7359 **	0.3685	0.1753	0.1265
AW_M90_95_HSD	0.0019	0.0648	0.0250	0.0612	0.0603	0.0713	0.0776	0.0898	−0.0356	0.0839	0.0291	0.0503
AW_U90	−0.0401	0.0996	0.0088	0.0716	−0.0689	0.0719	−0.1811 **	0.0770	−0.1928 **	0.0896	−0.0943	0.0606
AW_M90_LSD	−0.0445	0.0599	−0.0046	0.0681	−0.0829	0.0681	−0.1156	0.0747	−0.1235	0.0911	−0.0921 *	0.0540
AW_M90_HSD	0.0921 *	0.0547	0.0794	0.0623	0.1255 **	0.0576	0.0702	0.0737	0.0287	0.0948	0.0858 *	0.0490
_cons	2.5107 ***	0.1684	2.4359 ***	0.1689	2.6741 ***	0.1922	3.0398 ***	0.2765	3.1491 ***	0.3240	2.6741 ***	0.1331
Observations	656											
Pseudo R ²	0.3145		0.3231		0.3853		0.4362		0.4646			
R ²	0.5980											

Note: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. ^a Bootstrap standard errors in parentheses; Replications = 1000. ^b Robust standard errors in parentheses; OLS = ordinary least squares, included as reference. Confidence intervals are based on the Stata default 95% confidence level. Random samples were drawn using seed 54321 to ensure full reproducibility of the results.

In relation to the attributes associated with the winery, it should be noted that the geographical location in the Puglia region does not represent a discriminating element in the determination of the price. In contrast, the Score_C shows positive significance from the median (0.2709 **) and upper (0.2992 **) quantiles, as well as in the OLS (0.1492 *). This result highlights how the perceived reputation of the manufacturer is not a uniform factor but emerges above all in the intermediate and upper segments of distribution, while an OLS analysis would have returned a positive average effect without capturing this heterogeneity.

As far as product characteristics are concerned, the vintage and the alcohol content emerge as systematic discriminating variables throughout the price distribution. The most recent vintages (Y0_3) and the lowest alcohol content (ALC% < 14%) show a significantly negative effect in all quantiles, with increasing coefficients along the distribution, while the OLS confirms the negative direction but returns only an average estimate of the effect (−0.2150 *** and −0.2877 ***). On the contrary, prolonged ageing (Y_more6) and high alcohol content (ALC% > 15.5%) are associated with a positive effect, which is also increasing in the different market segments, with consistent results also in OLS (0.3946 *** and 0.5086 ***). These results suggest that regardless of price range, the consumer perceives value in attributes that relate to greater wine structure and complexity.

As regards the focus of our analysis, the results show a differentiated improvement in information regarding production practices, which integrate sustainability, quality and product characterization objectives, along the price distribution. The environmental practices of organic, synergistic and biodynamic farming are significant and positively associated with price only in the first quantile (0.1461 ***), while the OLS does not detect any effect. Similarly, information on the use of wood as a refining material is valued in the medium–low segment (Q10–Q50) and OLS (0.1606 ***), indicating a positive effect that is attenuated in the premium segments. On the contrary, more technical information, such as the adoption of the sapling training system in the vineyard (ALB, significant at Q75 and OLS) and the use of indigenous yeasts for the initiation of fermentations (IND, significant at Q75–Q90 and in OLS), show a significant effect especially in the medium–high segments, indicating that these aspects are perceived as distinctive by more experienced consumers. Finally, the communication relating to the use of old vines has a non-linear effect: it is valued both in entry-level wines (Q10 = 0.1407 **) and in the premium segments (Q90 = 0.1621 *), while the OLS returns a positive but not significant coefficient, confirming the greater sensitivity of quantile regression to grasp these effects.

Finally, with regard to awards, the results show that the possession of multiple awards with high scores (>95), when shared by multiple sources (AW_M95_LSD), represents the main price driver, being significantly associated with a positive effect in the lower-middle and intermediate segments (Q25–Q75) and also in the OLS (0.3201 ***), while it loses relevance in the premium segment (Q90). In the higher segments of distribution, a positive effect emerges for wines awarded scores between 90 and 95 and low disagreement (AW_M90_95_LSD), significant only at Q90 (0.7359 **), suggesting that even lower scores, if shared by multiple sources, can constitute a signal of value in high-end products.

Single premiums, both with high (AW_U95) and medium (AW_U90) scores, do not represent added value, showing significantly negative effects in the medium–high and premium segments (Q75 and Q90), a result also confirmed by the OLS for AW_U95 (−0.1161 **). This evidence indicates that the market rewards the presence of multiple prizes shared between different evaluation sources, which are considered more reliable signals than the assignment of a single prize, even if prestigious.

4. Discussion

The present study analyzed the role of several observable attributes in the determination of the price of Apulian Primitivo wine marketed online, highlighting how the effect of these attributes varies significantly along the price distribution. Simultaneous quantile regressions made it possible to grasp the different sensitivity of consumers to quality signals depending on the market segment. Product attributes, such as high alcohol content and prolonged ageing, are confirmed as price drivers throughout distribution, valued across the board by consumers. The elements related to the winery affect the intermediate segments of the market, where the perceived reputation of the producer acts as a signal of reliability for consumers. Production choices show a differentiated valorization: green practices and Geographical Indications emerge as strategic elements only in the lower segments, while the information related to the adoption of more technical and identity practices (bush-trained system and indigenous yeasts) is rewarded in the medium–high and premium segments. Finally, among the awards, only multiple awards shared between multiple sources are confirmed as price drivers.

With regard to the product characteristics, the results of the analysis are confirmed in the study by Gonçalves et al. (2021) [32], which reveal a systematic appreciation of vintage and alcohol as price determinants for all ranges and markets analyzed (France, Germany, Italy, and Australia). A higher alcohol content and prolonged ageing are rewarding attributes throughout the price distribution, consistent with the peculiarities of Primitivo, a grape variety historically appreciated to produce full-bodied and structured wines, for which a high alcohol content is a consistent indicator of perceived quality.

A second element of interest concerns the reputation of the winery, measured through the score attributed by online users. The result shows a positive and significant effect in the intermediate price segments (Q50 and Q75), suggesting that in these ranges the perceived reputation of the manufacturer represents a trustworthy signal for consumers. Unlike the findings of Di Vita et al. (2015) [34], who emphasized the role of producers' reputation in the lower market segments, our results indicate that this attribute is valued primarily in the middle range, while losing relevance in the premium tier.

An interesting result concerns the role of Geographical Indications. The results obtained differ from what has emerged in much of the previous literature. Di Vita et al. (2015) [34] show that origin certifications determine an increase in price premiums in the high segments of the market, acting as signals of perceived quality. Chandra and Moschini (2022) [52] confirm their relevance also for New World wines, where the indication of the grape variety has always been considered more influential. Instead, in our case, the designation of origin is valued exclusively in the entry-level segments, while it does not emerge as a discriminating factor in the medium–high price ranges. It can be hypothesized that this result is linked to the specific context of the Apulian Primitivo. Being the subject of a relatively recent phase of re-evaluation and repositioning, it is possible that the DOC does not yet represent, in consumer perception, a signal of sufficient quality to justify a premium price in the higher segments. This result appears consistent with the observation by Panzone & Simões (2009) [53], according to which the ability of Geographical Indications to generate a surcharge depends to a significant extent on the established reputation of the production region. It follows that, to amplify their effects and foster sustainability practices, “bottom-up” actions are needed, embedded in product specifications and governed at the local level [54].

In the case of Primitivo, it can therefore be assumed that the DOC, although formally consolidated, mainly performs a function of guaranteeing minimum quality, enhanced in the lower segments, but not yet recognized as a distinctive element in the premium segments.

Similarly, environmental sustainability practices (organic, biodynamic and synergistic farming) are also valued exclusively in the entry-level segment, thus acting as basic signals rather than differentiating factors in the premium segments. This result differs from Fanasch & Frick (2020) [51], according to which these certifications constitute credible signals, capable of generating price premiums; however, it is confirmed by the Abraben et al. (2017) [38] results, which note that the premium price associated with organic practices and certification tends to decrease in the higher quality segments, where such information appears to be overwhelmed by attributes perceived as more qualifying. Consistently, while the organic label enjoys basic recognizability, consumers display limited trust and a lack of awareness regarding the production method [55], making evidence-based communication essential to effectively engage premium segments.

Furthermore, according to Vecchio et al. (2023) [56], consumers' limited knowledge about sustainable practices, especially biodynamic and natural, can contribute to limiting their signalling effectiveness, especially in markets where there is no clear and standardized communication. The result relating to the enhancement of selected production practices, such as the use of wood in ageing, the sapling system, and indigenous yeasts, associated with a premium price in the medium-high and premium segments, deserves relevance. To our knowledge, no previous hedonic study has specifically analyzed the value attributed to the communication of such practices, despite the fact that Nunez et al. (2024) [28] highlight that elements related to the production process are progressively entering among the attributes considered in the definition of price functions. Yet, as the authors themselves point out, these techniques are generally considered in their function as objective determinants of cost or sensory quality, without attention to their enhancement as communicative tools. Our results suggest that, when properly communicated, the adoption of identity practices, such as the bush-trained planting typical of the Apulian territory or the use of indigenous yeasts, takes on a discriminating role in the higher market segments, probably by their ability to suggest an image of authenticity, traditional craftsmanship and a strong connection to the territory. This market recognition could be an incentive for the continuation and enhancement of traditional production practices, characterized by lower yields but capable of contributing to the conservation of the rural landscape, the protection of biodiversity, and the enhancement of the link between grape variety and terroir. This consideration is consistent with the findings of Petrontino et al. (2022) [57], who analyzed Italian consumers' preferences for an innovative Apulian wine made with native cultivars and enriched with nutritional information on the label. They confirm that consumers tend to connect the importance of native cultivars to the evocative appeal of the wine-growing landscape. The promotion of typical varieties, accompanied by additional quality information on the label, therefore represents a concrete opportunity for the Apulian wine sector, both in terms of competitive positioning and local income generation. In this perspective, a clearer and more standardized communication of these practices could represent a strategic lever to strengthen the positioning of Primitivo wines in the premium segments, highlighting both the identity value and the sustainable dimension of these production choices. Moreover, as emphasized by Chaminade (2020) [58], place-based actions are paramount to accelerating sustainability transformations, making them a strategic priority for the Apulian wine sector and the premium positioning of Primitivo wines.

Finally, quality awards selectively influence pricing. Only multiple awards, awarded from multiple sources and with high ratings (AW_M95_LSD), represent significant distributed drivers, except for premium wines for which the value of shared awards prevails over more moderate scores (AW_M90_95_LSD). On the contrary, a single award or recognition, even with high scores, is penalizing in the higher segments. This evidence helps to explain the variability of the empirical results observed in the literature, where the impact of

expert evaluations on prices is positive but not unequivocal. Even if meta-analyses [48,49] confirm an average positive effect of quality assessments, several studies have shown heterogeneous effects, more marked in red wines, in “primeur” products or in the presence of consensus opinions by several experts [59]. Increasing heterogeneity in assessment methods, sensory paradigms, and scoring scales could contribute to the variability of observed empirical results [28]. In this context, our results confirm the importance of consistency between evaluation sources as an element of strengthening the signal of perceived quality.

In conclusion, the results suggest that in the online market for Apulian Primitivo, the enhancement of observable attributes follows a stratified logic: in premium segments, specialized and reputational signals are prioritized, while in lower segments, more standardized communicative attributes prevail. Communication strategies operate as key signals convert technical attributes into perceived value and purchase intention across distinct market segments, reinforcing the promotion of sustainability and quality. In particular, potential solutions include the adoption of Quality Assurance Programs (QAP) [60], which—if effectively communicated—can establish recognizable cues that amplify the value of sustainability, especially among price-sensitive segments and for attributes that are otherwise difficult to interpret. Alternatively, brand-building and e-commerce co-creation initiatives [61] can leverage digital storytelling to elevate the visibility and appeal of identity- and reputation-based practices in premium segments, thereby consolidating the layered segmentation logic observed.

Limitations and Future Research

This study presents some limitations that may offer directions for future research. First, it focuses exclusively on Apulian Primitivo labels sold through e-commerce, excluding traditional mass-market channels and specialized wine shops. A future extension of the sample to include different sales channels could not only enhance the representativeness of the analysis but also enable comparisons between value dynamics across distribution contexts.

Secondly, unlike surveys that use historical data series [37,46,51], the cross-sectional nature of the dataset does not allow for capturing any changes over time in the perception of the analyzed attributes. Considering that Primitivo is going through a phase of commercial repositioning, it would be interesting to understand if and how the value attributed to practices such as identity or sustainable practices may change over time.

A third consideration can be developed regarding the attributes considered in the model. Although they cover important aspects related to intrinsic quality, sustainability, and reputation, they cannot include some dimensions of perceived value already recognized in the literature. As also highlighted by recent review about wine hedonic pricing studies [28], several extrinsic and intrinsic variables have been identified as price determinants in the hedonic models applied to wine and, among these, there are characteristics not included in the data collection of the present survey, such as: the sensory and chemical aspects of the product, the climatic and pedological conditions of the territory of origin, the exclusivity of the reference (e.g., reserves or limited editions), the quantity produced, the context and occasion of consumption, and the size of the company.

Finally, although the hedonic approach is useful in analyzing the relationship between observable attributes and price, it does not allow for direct investigation of individual preferences and cognitive processes underlying purchasing decisions, especially considering that some sustainability variables introduced as dummies have not yet been certified or validated through direct comparison with consumers. In this regard, integrating stated preference method, such as choice experiments or willingness-to-pay (WTP) analysis, could

provide a more comprehensive understanding of the value consumers attribute to different production and communication practices.

5. Conclusions

This study examined how quality, sustainability, and winemaking identity influence the price of Apulian Primitivo wine sold online. The application of a quantile hedonic model made it possible to analyze market segmentation, revealing how the value attributed to the various aspects examined changes along the price distribution.

The results provide a joint answer to the two research questions. They show that artisanal and sustainable practices affect the price of Primitivo wines marketed online (RQ1), but that their relative weight varies depending on the market segment (RQ2). In detail, traditional product attributes, such as alcohol content and ageing, are universally recognized signs of quality. On the other hand, environmental practices and Geographical Indications serve as basic signals, reassuring consumers in the cheaper segments, but fail to differentiate the product in premium markets. It is precisely in these segments that the distinctive value of identity attributes is noticed, such as bush-trained system farming and the use of indigenous yeasts, which represent a local production tradition perceived as a sign of authenticity and craftsmanship.

From a strategic point of view, the Apulian Primitivo seems to have a communication that is still too focused on certifications and generic sustainability statements. Producers could instead give greater prominence to identity practices as a lever of differentiation in high-spending segments, also through a clearer and more standardized narrative of artisanal practices. In addition, strengthening the collective reputation of DOC Primitivo could help consolidate the appellation's role as a premium brand.

To conclude, this work contributes to expanding hedonic models on wine by introducing variables related to sustainability and production identity, and it demonstrates the usefulness of quantile regression to analyze the heterogeneity of the online market. More generally, the results also offer insights into the role of the digital economy in sustainable development, showing how the greater transparency of information in e-commerce channels can affect the enhancement of production practices and, indirectly, purchasing behaviour.

The results suggest that sustainability, if not linked to a recognizable territorial identity, risks being seen as a basic requirement rather than a distinguishing factor. The real competitive key for Primitivo lies in the ability to combine sustainability and territorial identity in a cohesive narrative, capable of attracting the most experienced and quality-conscious consumers.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su17188094/s1>, Table S1: Correlation matrix of independent variables. Table S2: Wald tests for coefficient equality across quantiles.

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CHAPTER 6

Boosting market appeal: Exploring the impact of nutritional claims on popular Italian dietary cereal product

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Boosting market appeal: Exploring the impact of nutritional claims on popular Italian dietary cereal product

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ABSTRACT

This study examines the intricate interplay between nutritional claims and consumer purchasing behaviour in the Italian rusk market. Rusks, obtained by double baking sliced loaf bread, are a staple of the Italian breakfast, generating annual revenues of EUR 225 million. With the growing focus on more health-conscious food choices, especially after COVID-19, health-related claims on food labels have a greater impact on consumers. Utilizing the hedonic pricing method, the study decomposed rusk market value based on specific product characteristics, revealing how quality attributes and nutritional aspect influence price. Data collected from major retail chains yielded 1438 observations, showing a positive correlation between price and factors such as brand, format, ingredients formulations and nutritional or sustainability claims. Results show that among analyzed regulated nutritional claims: "no added sugars," "high in protein," and "low salt content" exhibit the highest premium price, highlighting consumers' willingness to pay more for products perceived as healthy, as well as for enriched products or those made with alternative flours. Conversely, in a very heterogeneous context and a highly competitive market, reduced ingredient formulations and traditional recipes result in discount prices. The research demonstrates that clear and transparent health-related communication promotes informed purchases. This study suggests that producers adopting differentiation strategies focused on nutritional quality and the use of food claims can enhance product appeal and positively influence consumer purchasing decisions, thereby increasing their market share in a dynamic market.

1. Introduction

1.1. Background information

The relationship between nutrition and health has been long recognized, dating back to the ancient Greek philosopher Hippocrates, who famously stated, "Let food be the medicine and medicine be the food." This concept has recently gained renewed attention due to the Global Nutrition Report, which highlights the prevalence of malnutrition-related diseases such as diabetes and obesity in both low-and high-income countries. Initiatives like the Food As Medicine (FAM) program in the USA aim to promote healthier dietary choices to improve overall health outcomes [1,2].

In terms of market context and consumer behaviour, the contemporary food market is characterized by pronounced product heterogeneity. This is evident in the overwhelming variety of items on store

shelves, including numerous offerings within the same product category that display diverse and distinct attributes. This competitive landscape necessitates food companies to adopt differentiation strategies by emphasizing unique features such as nutritional quality, source of raw material, and sustainability. These strategies aim to capture consumer attention and position brands more effectively in the market. The extensive product heterogeneity influences consumer perceptions in terms of utility and usability, often introducing disadvantages associated with increased product complexity, but which sees in the hedonic price method a quantitative approach to evaluate multiple product attributes and how this complexity can deter purchasing decisions [3,4].

However, the food market is also marked by significant information asymmetry, how formalized in economics terms by George A. Akerlof in 1970. Sellers often possess more knowledge about product information than buyers, who are at a disadvantage position, particularly concerning "credence" attributes, i.e. qualities that cannot be verified by consumer

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even after purchase and thus rely on trust in product labelling [5]. This imbalance amplifies the influence of marketing, which plays a critical role in shaping purchasing decisions. Unfortunately, these decisions are often driven by emotional factors, which can lead to outcomes that are unsustainable from a health perspective [6–8].

With respect consumer awareness, recent studies, particularly following the COVID-19 pandemic, show growing consumer attention to food product labels with claims on health [9,10]. As an example of this phenomenon, the rusks market experienced significant growth during the pandemic, with an increase in consumption linked to home breakfasts. An Italian sector report of 2021 highlighted that generic rusks saw a 2.8 % increase in volume and a 3.4 % increase in value respect previous year, representing 36.9 % of the market value. In contrast, whole wheat rusks remained stable, indicating a preference for classic and enriched variants. Enriched rusks experienced a 13.4 % growth in volume and a 33.4 % increase in value, with their average price rising by 17.6 % [11]. This segmentation is crucial to understand how quality attributes influence consumer choices and, consequently, market prices. This increased interest is driven by the desire to make more informed choices and focus on health prevention [12,13]. Nutritional claims on food products play a crucial role in this context, influencing consumer purchasing decisions and willingness to pay for products perceived as healthier. Despite the challenges of information asymmetry and the potential for misinterpretation, health and nutritional claims remain valuable tools for both consumers and producers. For producers, these claims can enhance product appeal and financial performance, while for consumers, they are essential in making healthier and more informed food choices.

Despite the growing awareness of the healing power of food, consumers often face confusion due to the variability of claims made by food products. In this context, institutional oversight of health claims on food is crucial to ensure that they are supported by scientific evidence, thereby preventing consumers from being misled and undermine their ability to make informed and healthier decisions [14,15]. In Europe, health and nutritional claims are regulated by EU Regulation 1924/2006 for guarantee that authorized claims are clear, evidence-based and not misleading to consumers, careful supervision is the responsibility of EFSA and the European Commission [16,17]. In according to article 2, paragraph 2 of EU Reg. 1924/2006, nutritional claims highlight a food's beneficial properties related to its energy content or the content of specific nutrients or other substances, such as “low fat” or “no added sugars”. In contrast, health claims imply a relationship between a category of food and health, highlighting the beneficial effects of the product on health, for example, “helps maintain normal cholesterol levels” [18].

1.2. Existing literature and impact on consumer behaviour

The effect of health and nutritional claims on food market has been analyzed in the literature, where research has shown that they significantly impact consumer purchasing decision. For [19] nutrition and health claims were considered the most relevant information on packaging, a priority for 87 % of consumers. These preferences however may be modified for specific product categories, or for product-extrinsic features such as brand, price, and communication strategy [20]. Food choices are driven primarily by sensory functions, but familiarity, nutritional knowledge and use influences healthier food choices [21]. Studies like [22,23] demonstrate that claims can positively influence purchasing attitudes, particularly when linked to innovative functional ingredients or products with less appealing sensory characteristics. Conversely [24], research on protein bars indicates that nutritional or health claims do not significantly affect product acceptance in terms of sensory or emotional appeal, with taste, flavour, and texture being the primary preference drivers, especially among younger consumers. This inconsistency highlights a major issue: the understanding of these claims. If not presented uniformly and clearly, nutritional or health

claims can confuse less experienced consumers who might misinterpret the information [25–27]. Despite these challenges, a greater consistency in nutritional information and an easier information of them, could improve public health, addressing issues like obesity, particularly childhood obesity [28]. While some consumers may make healthier choices based on nutrition claims, others may misinterpret these claims, potentially increasing overall food consumption and energy intake, thus counteracting obesity prevention efforts [29]. The support of nutritional expert, who knowing FAM definition, they can help consumers to make healthier choices and avoid being tricked by marketing tools [30]. However, claims on label remain valuable tools for both consumers and producers. Producers use them strategically to enhance product appeal and financial performance [31]. On the consumer side, health claims are a crucial aspect of food choice values (FCVs), influencing purchasing choices and willingness to pay for healthier and safety foods, a trend intensified by the COVID-19 pandemic [32–34].

1.3. Objectives and significance

Although there are studies that recognize nutritional claims among the attributes that influence the demand and WTP of food products in different countries [35,36] and how they can also influence the supply side, as measured in Spanish and Chinese dairy sector [37,38] or fruit beverages products in Italy [39]. Instead, no research examines the effects of nutritional or health claims on the price market for baked-cereal products in Italy. Cereal products are the basis of global nutrition and improving their nutritional quality could enhance public health, considering their role in healthier and more sustainable dietary patterns [40]. This study aims to fill this gap by analysing the impact of nutritional claims on consumer purchasing behaviour, particularly in the context of the Italian market for rusks, a cereal-based product generally recognized as dietary and healthy. Due to the nutraceutical potential of cereal-based products rich in bioactive compounds, such as fiber and antioxidants, these products play a significant role in reducing cardiovascular risks, improving gastrointestinal health, and preventing chronic diseases, which aligns with consumer demand for minimally processed and health-promoting foods [41,42].

Rusks is a popular Italian dietary cereal product obtained by double baking sliced loaf bread, which explains the etymology of the Italian term “fette biscottate”. In Italy, rusks are a staple of the Italian breakfast, often consumed with hot beverages and alongside other cereal-based products. The rusk market generates annual revenue of EUR 225 million [43]. Recent growth in the rusk market is driven by socio-economic factors and trends favouring long-shelf-life, easy-to-prepare, and health-oriented products, including organic, whole grain, and enriched options [36,44,45]. In response, large-scale retail (GDO) has expanded its offerings with specific characteristics to meet diverse consumer needs. Established brands and artisanal producers have increased their rusk production, focusing on selected ingredients and traditional processes. Competition has intensified, with private labels offering similar products at lower prices, achieving positive quality results and increasing market share [46,47].

Various studies have used rusks as basis for fortified products with high nutritional value, indicating a significant market presence across various cultures. These products, made with ingredients like flax seeds, finger millet, chia seeds, black rice, and proso flour, become exceptionally healthy due to their low glycemic index, high fiber content, and reduced levels of fats and sugars [48–54]. Moreover, when enriched with zinc, iron, calcium, vitamins A, D, B12, thiamine, riboflavin, niacin, and folic acid, they can become functional therapeutic products, useful for supporting malnourished children in the world's poorest areas [55].

In our study, we hypothesize that the presence of regulated nutritional claims significantly influences consumer preferences and market prices. We also aim to identify the most effective marketing strategies employed by leading brands in this sector. Specifically, this research aims to evaluate the monetary value associated with the presence of

quality attributes and nutritional aspects communicated through claims. It is well established that, in a perfectly competitive market for food products, the selling price is influenced by the price-quality relationship, which is important for both raw materials and processed products [56, 57]. Therefore, the hedonic pricing method is an appropriate methodology for achieving this goal, as it helps us understand how different product characteristics, such as brand, format, ingredients, and nutritional claims, influence selling prices and perceived consumer value. Given that rusks are often perceived as a diet food, attributes such as nutritional features are expected to significantly impact product prices. In other words, the goal of this approach is to determine the extent to which consumers are willing to pay a premium for health-related attributes. In this perspective, this research is significant as it addresses the gap in understanding how claims affect both consumer behaviour and market dynamics in the Italian rusk market. Additionally, this study contributes to the broader discourse on nutrition and public health by highlighting the importance of clear and evidence-based health claims.

The article is structured as follows: the next section will detail the methodology employed in the study, including the hedonic pricing analysis used to assess the impact of nutritional claims on market prices. Following this, we will present the results of our analysis, discussing the implications for both consumers and producers. Finally, we will conclude with recommendations for future research and practical applications of our findings in the Italian bread industry.

2. Methods and materials

2.1. Basic theory and functioning

The hedonic pricing method theory, developed by Lancaster and Rosen [58,59], is an econometric technique that estimates the market value of specific characteristics or services associated with a complex good by breaking it down into individual attributes. In our study, we applied this method to assess the market value of specific characteristics in food products, relying on market transactions involving differentiated goods. This approach infers the value consumers assign to each characteristic from observable market transactions, such as selling prices [60]. The method is highly adaptable to various market contexts and product categories due to its regression analysis flexibility. Originally applied to durable goods like housing, it has been extended to other sectors, proving effective in decomposing the values of complex goods [61,62]. Numerous studies, including our own, have applied the hedonic method to food products to determine the monetary trade-offs individuals are willing to make for specific characteristics, particularly in terms of quality and sustainability [37–39,56,63–65]. By incorporating this method in our research, we gained valuable insights into how different attributes of food products influence consumer preferences and market values, aiding future innovations in food design and processing.

According to the economic theory, the price of a good is a function of its characteristics. In a context of perfect competition from differentiated products, the market price is the sum of the implicit prices of each attribute. The hedonic method uses multivariate regression to isolate the effect of each characteristic on the price, where the coefficients represent the marginal value assigned by consumers. The hedonic price function is:

$$\text{Price} = f(C) + \epsilon \quad (1)$$

Where: “C” represents product characteristics, and “ ϵ ” captures the unexplained price variation not explained by the characteristics included in the model. To improve the precision of the estimate, choosing the appropriate functional form is necessary to adopt the form that can evaluating better the characteristics of food goods. In this term among five possible options: linear, logarithmic, log-linear, Box-Cox or other transformations; the log-linear transformation, appears to be the most suitable choice [66]. The log-linear form is particularly effective as it

enhances adherence to the normality assumption, which is crucial for the validity of regression models. By transforming the dependent variable (price) into its logarithmic form, this approach helps mitigate issues such as skewness and extreme values, making the distribution of the residuals closer to a normal distribution, a key assumption for the proper application of the regression model. As a result, the log-linear form enhances the robustness of the regression analysis, improves precision by interpreting coefficients as percentage changes in price, reduces the influence of outliers, controls for heteroscedasticity, and generally boosts the quality and reliability of the estimates. The model is specified as follows, where $\ln P$ represents the logarithm of the price:

$$\ln \text{Price} = f(C) + \epsilon \quad (2)$$

However, the method requires a large, representative data sample and careful selection of variables to address challenges like endogeneity and collinearity, ensuring valid and interpretable results in the context of food markets.

2.2. Data gathering

Between June and July 2024, we collected detailed data on brand, format, ingredients, health claims, and prices of rusks available in the Italian GDO. The choice of this product was made due to its characteristics as a dietary item, where nutritional and health aspects are considered crucial for both consumers and producers. Thus, we selected the main rusk-producing companies in Italy based on 2022 and 2023 revenue data. These companies generally fall under ATECO codes 10.72 and 10.73, covering bakery products and cereal-based foods as depicted in Table 1 [67]. ATECO stands for “Attività Economiche”, which is Italian for “Economic Activities”. It is a classification system used in Italy to categorize different types of economic activities for statistical and administrative purposes. The ATECO codes are similar to the NACE “Nomenclature of Economic Activities” codes used in other European countries.

The Italian rusk market is dominated by major national and international brands with annual revenues close to or exceeding EUR 100 million (1st to 6th in market share), alongside numerous companies, including private labels, that intensify the competitiveness of the sector. Based on the revenue factor, the brand attributes within the sample were categorized into four distinct variables. The first variable, designated as

Table 1
List of rusks producers in Italy by revenue (top 11)

Producer Companies	Product line brand	Revenue (million euro/year)	ATECO Code	Reference year
Barilla S.p.A.	<i>Mulino Bianco</i>	3.400	10.73	2023
Newlat Food Group S.p.A.	<i>Delverde</i>	730	10.61	2022
San Carlo Gruppo Alimentare S.p.A.	<i>San Carlo</i>	343	46.38	2023
Galbusera S.p.A.	<i>Galbusera</i>	278	10.72	2022
Colussi S.p.A.	<i>Misura</i>	263	10.72	2023
Grissin Bon S.p.A.	<i>Grissin Bon</i>	95	10.72	2023
Pastificio F.lli Cellino S.p.A.	<i>F.lli Cellino</i>	71	10.73	2023
Monviso Group S.r.l.	<i>Monviso</i>	57	10.72	2023
Probios Spa società benefit	<i>Probios</i>	27	46.21	2023
Biscotti P. Gentilini S.r.l.	<i>Gentilini</i>	23	10.72	2023
Brioche Pasquier Italie S.r.l.	<i>Brioche Pasquier</i>	20	10.72	2023

Source: Gathered from <https://www.ufficiocamerale.it/> (last accessed on November 14, 2024).

“Main Leader”, corresponds to the entity holding the 1st force within the sector. The second variable, labeled “Other Leaders” encompasses companies positioned between the 2nd and 6th force. The third category referred to “Other Brands” pertains to other companies that falls beyond the 6th. Finally, the fourth variable “Private Labels”, is defined to include product that are identifiable within this classification [68].

To ensure representative data for the entire national context, data collection was conducted on the e-commerce platforms of 15 Italian distribution chains, covering the country's five main geographical areas: North-East, North-West, Central, South, and Islands [69,70]. The choice to use e-commerce platforms is due to their offer of easy and free access to a large volume of data, overcoming the logistical challenges associated with in-store data collection. The selected chains have virtual stores with assortments and prices comparable to their physical counterparts, and the data collection focused on products only available for in-store pickup to avoid delivery costs. Data were collected by simulating purchases in cities within these macro-areas. In addition, to ensure a comprehensive and significant representation, both high-density (like Milan and Naples) and low-density provinces (like Belluno and Nuoro) were included in each macro-area as summarized in Table 2. This approach allows for broad and representative coverage of the entire Italian territory. For allowing to the best representation of the country's food market, the chains were selected based the distribution among cities according to geographic presence and sales formats, including hypermarkets, supermarkets, convenience local stores, and discount stores.

2.3. Dataset and econometric model

The dataset includes 1438 observations of rusks, providing detailed information on prices and product characteristics, primarily gathered through label analysis. Key attributes reported include brand, sales format, packaging material, type of flour, use of sourdough, organic or Italian wheat, and nutritional claims such as “Source of Fiber,” “Source of Protein,” and “Palm Oil Free.” These attributes selected on product features can be easily gathered by reading product labels, as they involve information that is easily accessible and understandable, even by

Table 2
Italian provinces and the distribution chains selected.

Geographical Area	Provinces	Population density (inhabitant/km ²)	Distribution chain
Nord East	Venice	348	Conad, Coop, Lidl, Gruppo Selex
	Belluno	53	Carrefour, Coop, Lidl, Others
Nord west	Milan	2067	Carrefour, Coop, Esselunga, Eurospin, Lidl, Gruppo Vegè
	Verbano-Cusio-Ossola	77	Carrefour, Conad, Coop, Esselunga, Lidl
Centre	Rome	807	Carrefour, Conad, Coop, Esselunga, Eurospin, Lidl, Gruppo Selex, Gruppo Vegè
	Rieti	72	Carrefour, Conad, Coop, Eurospin, Lidl, Gruppo Selex
Sud	Naples	2672	Conad, Eurospin, Lidl, Gruppo Selex, Gruppo Vegè
	Isernia	69	Conad, Coop, Eurospin, Gruppo Vegè, Others
Islands	Palermo	257	Conad, Eurospin, Lidl, Gruppo Selex, Others
	Nuoro	39	Conad, Coop, Eurospin, Gruppo Vegè, Others

Source: ISTAT, 2023 – Gathered from <https://demo.istat.it/app/?l=it&a=2023&i=POS> (last accessed on November 14, 2024).

reading the product's ingredient list. Among these, some have been widely used in applications of the hedonic price method to food products where the price dynamics in relation to product features has been demonstrated [37–39,56,63–65]. In dataset the inclusion of products involved only industrial rusk, with toast-like form and double baked, long shelf-life and sold in packaging with a descriptive label. Gluten-free products were excluded in dataset to avoid data dispersion, due to their generally higher price and more different product characteristics. Other attributes include are environmental sustainability claims and enrichment with ingredients like cereal flour, seeds, chocolate and fruit (Table 3). This comprehensive dataset enables detailed market analysis of rusks, evaluating the impact of each attribute on price and consumer willingness to pay. Based on Table 3, equation (2) becomes:

Table 3
Attributes and variables description.

Attribute	Variable	Typology	Description
Dependant variable			
Unit price		Continuous	Unit price expressed in EUR per kg
Independent variables			
Sales brand		Categorical	
	Private Labels	Dummy	Yes = 1; No = 0
	Main Leader	Dummy	Yes = 1; No = 0
	Other Leaders	Dummy	Yes = 1; No = 0
	Other Brands	Dummy	Yes = 1; No = 0
Sales format		Categorical	
	Greater than 400 g	Dummy	Yes = 1; No = 0
	Less than 400 g	Dummy	Yes = 1; No = 0
Packaging multipack (single-serve)		Dummy	Yes = 1; No = 0
Packaging material		Categorical	
	Paper	Dummy	Yes = 1; No = 0
	Plastic	Dummy	Yes = 1; No = 0
Type of flour		Categorical	
	Soft wheat >50 %	Dummy	Yes = 1; No = 0
	Whole grain flour >50 %	Dummy	Yes = 1; No = 0
	Other cereal flours >50 %	Dummy	Yes = 1; No = 0
Sourdough	Use of sourdough	Dummy	Yes = 1; No = 0
	Use of organic wheat	Dummy	Yes = 1; No = 0
Italian wheat	Use of Italian wheat	Dummy	Yes = 1; No = 0
(EU Reg. 1924/2006)	Rich in fiber/High in fiber	Dummy	Yes = 1; No = 0
	Source of fiber	Dummy	Yes = 1; No = 0
	No-added sugar	Dummy	Yes = 1; No = 0
	Lactose-free	Dummy	Yes = 1; No = 0
	Source of proteins	Dummy	Yes = 1; No = 0
	Source of vitamins or minerals	Dummy	Yes = 1; No = 0
	Lower fat content	Dummy	Yes = 1; No = 0
	Lower salt content	Dummy	Yes = 1; No = 0
	With extra virgin oil	Dummy	Yes = 1; No = 0
	Without palm oil	Dummy	Yes = 1; No = 0
	Certified “Okay Vegan” or alike	Dummy	Yes = 1; No = 0
	100 % plant-based ingredients	Dummy	Yes = 1; No = 0
	Sustainable Packaging	Dummy	Yes = 1; No = 0
	Sustainable Production	Dummy	Yes = 1; No = 0
	Other grain flours <50 %	Dummy	Yes = 1; No = 0
	Whole grains or seeds	Dummy	Yes = 1; No = 0
	Fruit or chocolate	Dummy	Yes = 1; No = 0

$$\begin{aligned}
\ln P = & \alpha + \beta_1(\text{sales brand}) + \beta_2(\text{sales format}) + \beta_3(\text{single-serve}) \\
& + \beta_4(\text{packaging material}) + \beta_5(\text{type of flour}) \\
& + \beta_6(\text{sourdough}) + \beta_7(\text{organic wheat}) + \beta_8(\text{Italian wheat}) \\
& + \beta_9(\text{nutritional claims}) + \beta_{10}(\text{other claims}) \\
& + \beta_{11}(\text{vegan product}) + \beta_{12}(\text{sustainability claims}) \\
& + \beta_{13}(\text{enriched product}) + \epsilon
\end{aligned}
\tag{3}$$

Regarding the estimation methodology, the econometric model was constructed and estimated using the Ordinary Least Squares (OLS) method with STATA software. This method is suitable for our case because it is widely used in econometrics to estimate the relationships between variables while minimizing the sum of squared residuals (the differences between observed and predicted values). By doing so, OLS provides optimal and robust estimates with reduced collinearity and variance, if the key assumptions (such as linearity, independence, and homoscedasticity) hold. Additionally, OLS is particularly effective in addressing potential multicollinearity issues in models with multiple predictors, as often applied in the context of food markets [3,66]. After estimating the β coefficients obtained through the OLS regression, it is necessary to apply the adjustments in accordance with the methodologies proposed by Halvorsen and Palmquist (1980) and Kennedy (1981) to accurately measure the marginal prices of each attribute in percentage terms and the implicit prices. These adjustments are critical to account for the non-linear relationships in the log-linear model and to ensure consistent and unbiased estimation of the price effects, particularly when dealing with both continuous and categorical variables [71, 72]. In particular, Kennedy approach provides a correction to estimate the percentage impact (PI) of a dummy variable on the dependent variable (e.g., prices) by considering the estimated variance of the associated coefficient β_i as expressed in equation (4)

$$PI = 100 \cdot \left(e^{\left(\beta_i - \frac{1}{2} \text{var}(\beta_i) \right)} - 1 \right)
\tag{4}$$

Therefore, the application of these adjustments is essential for an accurate assessment of implicit prices and marginal effects in a hedonic price analysis context, allowing appropriate implications of the results to be made in the market under consideration as done in other work as [39,73].

3. Results

3.1. Descriptive statistics

The analysis of the descriptive statistics for the 1438 observations in the rusk dataset highlights significant price variability associated with the analyzed attributes (Table 3). As shown in Fig. 1, the distribution is strongly skewed, with many products concentrated in the 4–6 EUR/kg range, below the average price of 8.18 EUR/kg. Other observations are present in the peak between 15 and 18 EUR/kg, while products priced above 20 EUR/kg are less frequent, reaching a maximum of 33,25 EUR/kg. The high standard deviation indicates a wide price distribution, as confirmed by the asymmetry of the histogram, with a predominance of more affordable and standard products, as expected for this product category.

Significant results of price variability associated with the analyzed attributes (Table 4) are observed, particularly in relation to nutritional claims, sustainability, and the use of alternative flours or enriched products, which emerge as the main drivers of premium pricing. These findings provide a solid foundation for hedonic price analysis, allowing for the quantification of the implicit value attributed to each characteristic.

Regarding the brand, private labels present lower average prices

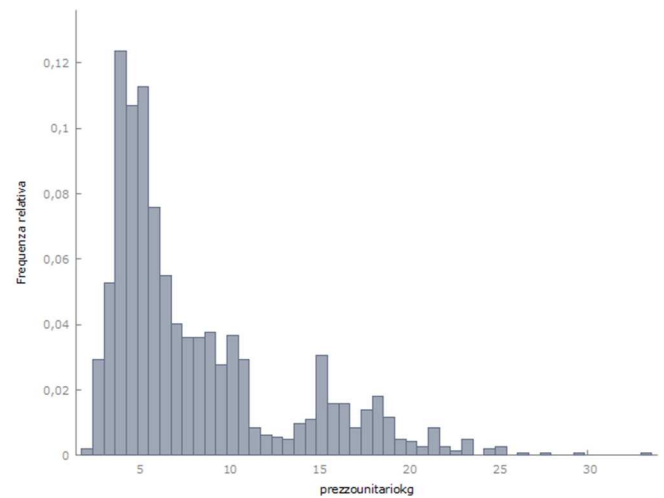


Fig. 1. Relative frequency distribution of the unit price EUR/kg
Source: Our Elaboration – Unit price (“prezzounitariokg”) in relative frequency distribution (“Frequenza relativa”).

with smaller standard deviations compared to other brands and market leaders, which show greater variability. Interestingly, it is the other brands that have higher average prices. These findings provide valuable insights into the competitive structure of the market and the strategic positioning choices adopted by various players. Market leaders enjoy a strong competitive advantage, capable of influencing purchasing decisions, particularly in the food sector, where segment leaders—such as in pasta, coffee, and baked goods—have a significant impact. In the baked goods and bread substitutes sector, the influence of the leading brand in Italy is particularly strong, holding a quarter of the market’s offerings and exerting a substantial impact on national consumer culture [74,75]. Regarding the format, as expected, products with larger formats present a significantly lower average price compared to smaller formats, while the presence of single-serving packs does not seem to entail the expected surcharge for better convenience and longer shelf life. About packaging materials, distinguishing between paper and plastic, reflects the growing consumer focus on environmental sustainability and the increasing preference for more ecological and recyclable packaging [76,77]. In our dataset, paper packaging has a higher average price (EUR 9.62/kg) compared to plastic (EUR 7.37/kg), likely due to the perceived greater environmental sustainability associated with paper. Despite having significantly different distribution percentages, soft wheat flour and whole wheat flour do not show major price differences, at difference to use of alternative flours to wheat, such as spelt and rye, or specific wheat cultivars like Senatore Cappelli and Kamut. For these products, the minimum price significantly increases to EUR 6.97/kg, raising the average to EUR 13.25/kg, almost double that of the sample. This difference may be attributed to the more difficulty in the supply of raw materials, as well as the high nutritional value recognized to products with these alternative flours. Products with sourdough show a lower average price (EUR 6.58/kg), while those with Italian wheat are above the general average (EUR 10.27/kg), reflecting a possible added value perceived by consumers, followed by organic products (EUR 9.46/kg). Both attributes seem to be linked to a premium pricing position recognized in other products. Regarding the nutritional claims recognized by the European regulations and have been found on the labels of rusks sample, among them, claim “no added sugars” (EUR 10.42/kg) or “reduced fat content” (EUR 11.27/kg) show a propensity for higher prices compared to those with generic claims like “source of fiber” (EUR 7.65/kg) or “lactose-free” (EUR 5.82/kg). Attributes like “lower salt content” and “High in fiber” or “Source of proteins” are positioned in between. This could indicate a greater willingness to pay for attributes perceived as directly linked to health. Products with the

Table 4

Descriptive statistics of attributes and corresponding variables.

Attribute & Variables	Number of observations	Price (EUR per kg)			
		Minimum	Maximum	Average	Standard deviation
Whole sample	1438	2.16	33.25	8.18	5.04
Sales format					
Greater than 400 g	251	2.16	10.98	4.33	1.86
Less than 400 g	1187	3.32	33.25	9.00	5.12
Packaging material					
Paper	518	3.74	24.92	9.62	4.38
Plastic	920	2.16	33.25	7.37	5.20
Packaging multipack (single-serve)					
No	922	2.16	26.67	7.82	4.42
Yes	516	2.73	33.25	8.83	5.93
Brand					
Private Labels	311	2.16	23.25	5.26	3.68
Main	371	3.17	26.67	8.27	5.72
Leader					
Other	445	3.32	18.45	8.21	4.45
Leaders					
Other	311	2.72	33.25	10.98	4.48
Brands					
Type of flour					
Soft wheat >50 %	1090	2.16	33.25	8.37	4.89
Whole grain flour >50 %	299	2.95	26.67	6.66	4.96
Other cereal flours >50 %	49	6.97	24.92	13.25	4.77
Organic wheat					
No	1332	2.16	33.25	8.08	5.12
Yes	106	4.91	21.48	9.46	3.58
Sourdough					
No	1342	2.16	33.25	8.30	5.05
Yes	96	2.91	20.36	6.58	4.60
Italian wheat					
No	1113	2.16	33.25	7.57	4.91
Yes	325	2.95	24.92	10.27	4.91
Nutritional claims (EU Reg. 1924/2006)					
Rich in fiber/High in fiber	528	2.95	33.25	8.76	5.76
Source of fiber	142	3.32	21.48	7.65	4.30
No-added sugar	97	4.81	33.25	10.42	5.16
Lactose-free	130	3.32	14.95	5.82	2.05
Source of proteins	142	4.53	33.25	7.89	4.82
Source of vitamins or minerals	219	3.07	14.30	5.96	2.50
Lower fat content	235	4.17	33.25	11.27	5.87
Lower salt content	56	4.03	20.36	8.33	4.32
Vegan product					
Certified “Okay Vegan” or alike	1095	2.16	33.25	6.93	4.59
100 % plant-based ingredients	101	7.83	33.25	11.44	4.21
Other claims					
With extra virgin oil	869	2.58	33.25	7.86	4.91
Without palm oil	83	4.97	23.25	11.19	5.14
Sustainability claims					
Sustainable Packaging	448	3.74	18.45	9.33	4.11

Table 4 (continued)

Attribute & Variables	Number of observations	Price (EUR per kg)			
		Minimum	Maximum	Average	Standard deviation
Sustainable Production	293	3.17	14.86	6.34	1.67
Enriched product					
Other grain flours <50 %	331	2.58	33.25	11.28	5.87
Whole grains or seeds	342	3.74	26.67	10.84	5.79
Fruit or chocolate	229	7.83	26.67	16.28	3.86

certified claim "Vegan Okay" or alike reach an average price of EUR 11.44/kg, higher than products with 100 % plant-based ingredients recipes (EUR 6.93/kg). Vegan-friendly recipes were carefully verified on the sample by reading the mandatory ingredient list present on product. This gap to the benefit of more active communication of information reflects the impact of certification presence or targeted branding activities. Other descriptive results show that products without palm oil represent 60 % of the references, a common characteristic with little influence on the average price. The 6 % that contains extra virgin olive oil shows a significantly higher average price (EUR 11.19/kg) despite a higher standard deviation. Products with sustainable packaging show an average price of EUR 9.33/kg, higher than the general average, confirming the importance of sustainability in consumers' value perception. Products enriched with fruit or chocolate reach the highest average price among enrichments (EUR 16.28/kg), doubling the overall sample average price. A similar trend, though with a reduced impact, is seen for enrichment with other flours, seeds, and cereals.

3.2. Ordinary Least Squares (OLS)

Following the sample analysis for the estimation of the hedonic price, the OLS model was applied through the log-linear regression described in section 2.3, with the encoding of the variables as shown in Table 3. This includes almost all dummy variables, which helps reduce multicollinearity in the model. The regression yielded excellent model performance values as depicted in Table 5. Specifically, the R^2 index of 0.82 indicates that the econometric model is statistically valid for explain the variance in the sample.

In Table 6 are presents the results of the econometric model estimation, where many explanatory variables are statistically significative. Main results shows that brand, sales format, raw material, nutritional or health claims and enrichment of products generate a significant premium price.

Table 5
OLS model.

Statistic	Value	Statistic	Value
Mean of dependent variable	1944	Sum of squared deviations of dependent variable	0,543
Sum of squared residuals	74,226	Standard Error of regression	0,229
R^2	0,824	Adjusted R-squared	0,821
F (28, 1408)	236,759	P-value (F)	0,000
Log-likelihood	90,041	Akaike criterion	-122,082
Schwarz criterion	30,756	Hannan-Quinn criterion	-65,021

Note: Dependent variable: log_Unit Price Robust standard errors adjusted for heteroscedasticity.

Table 6

Estimation results of the econometric model.

	Coefficient (p-value)	Standard Error	T-Ratio	Marginal effect ^a	Elasticity PI (%) ^b	Implicit price (€/kg) ^c
Constant	1740 (***)	0,046	37,525	–	–	–
Brand						
Other Leader	Baseline					
Private Labels	–0.134 (***)	0.036	–3.740	–12.58	–12.64	–1.04
Brand Leader	0.310 (***)	0.040	7.826	36.40	36.29	2.97
Other Brands	0.343 (***)	0.033	10.523	40.91	40.84	3.34
Sales format						
Greater than 400 g	Baseline					
Less than 400 g	0.303 (***)	0.019	16.221	35.45	35.42	2.90
Packaging material						
Plastic	Baseline					
Paper	–0.113 (***)	0.035	–3.182	–10.66	–10.72	–0.88
Multipack (single-serve)						
No	Baseline					
Yes	–0.014 (0.544)	0.023	–0.608	–	–	–
Type of flour						
Soft wheat >50 %	Baseline					
Whole grain flour >50 %	0.041 (*)	0.025	1.628	4.21	4.18	0.34
Other cereal flours >50 %	0.575 (***)	0.044	13.027	77.71	77.55	6.34
Organic wheat						
No	Baseline					
Yes	0.072 (*)	0.040	1.813	7.46	7.37	0.60
Use Sourdough						
No	Baseline					
Yes	–0.125 (***)	0.030	–4.201	–11.75	–11.83	–0.97
Use Italian wheat						
No	Baseline					
Yes	–0.097 (***)	0.027	–3.565	9.24	–9.28	–0.76
Nutritional Claims						
Rich in fiber/High in fiber	0.007 (0.767)	0.025	0.296	–	–	–
Source of fiber	0.080 (**)	0.027	2.999	8.27	8.24	0.67
No-added sugar	0.138 (***)	0.034	4.084	14.84	14.77	1.21
Lactose-free	–0.118 (***)	0.036	–3.300	11.17	–11.22	–0.92
Source of proteins	0.388 (***)	0.037	10.387	47.37	47.27	3.87
Source of vitamins or minerals	0.013 (0.581)	0.023	0.552	–	–	–
Lower fat content	–0.043 (0.243)	0.037	–1.167	–	–	–
Lower salt content	0.234 (***)	0.039	6.062	26.41	26.32	2.15
Vegan product						
Certified “Okay Vegan”	0.060 (*)	0.040	1.503	6.20	6.11	0.50
100 % plant-based	–0.389 (***)	0.021	–18.748	–32.26	–32.27	–2.64
Other claims						
With extra virgin oil	0.268 (***)	0.039	6.809	30.79	30.68	2.52
Without palm oil	–0.098 (***)	0.020	–4.778	–9.32	–9.34	–0.76
Sustainability claims						
Sustainable Packaging	0.106 (***)	0.030	3.559	11.19	11.14	0.91
Sustainable Production	–0.217 (***)	0.024	–9.021	–19.47	–19.49	–1.60
Enriched product						
Other grain flours <50 %	0.154 (***)	0.021	7.429	16.59	16.57	1.35
Whole grains or seeds	0.095 (***)	0.020	4.739	9.92	9.90	0.81
Fruit or chocolate	0.684 (***)	0.023	29.914	98.18	98.13	8.03

Note: Dependent variable = Log Unit Price; Significance: *** (p-value ≤0,01); ** (p-value ≤0,05); * (p-value ≤0,1).^{a b c} are shown only if the coefficients have significance.^a According to Halvorsen and Palmquist (1980) marginal effect is calculated as $100 \times (e^{\beta} - 1)$.^b According to Kennedy (1981) percentage impact (PI) is calculated as $100 \times (e^{\beta - 0.5 \text{var}\beta} - 1)$.^c Implicit price is calculated as average price of 8.18 €/kg and the price effect according to Kennedy's approach.

4. Discussion

4.1. Interpretation and comparison of the results

The results of the hedonic price regression highlight several significant factors influencing the unit price of the analyzed food products. The regression, performed using the OLS method and considering the logarithmic transformation of the price, identified numerous price-related attributes. Now, analyzing the results individually expressed with the Percentage of Impact (PI) on Table 6, we can highlight how the effect of the presence/absence of an attribute in the rusk market can be quantified. Respect to brand, using Other Leader (from 2nd to 6th forces in market share) as baseline: the “Brand Leader” and “Other Brands” exhibits a percentage premium price, of 36.29 % and 40.84 % respectively. This is likely because, compared to the mass market, the main brand benefits

from strong territorial presence and its commercial and consumers impact, while smaller brands focus on offering higher product quality that is recognized in price. Private labels have confirmed their competitive position, as measured by the descriptive statistics and predicted by literature, with a discount price of –12.64 %. Other relevant factors are format and material of packaging where as expected, smaller formats command a premium price (35.42 %), while the use of more packaging through single-serving portions of 4 slices or fewer does not lead to a significant price shift (not significant). Unlike the use of paper material, which generates a discount price (10.72 %) contrary to expectations and findings from studies on consumers' willingness to pay for green packaging [76,77] the rusk market does not appear to attribute significant economic value to the sustainability of the material.

Among the most influential variables, the use of alternative cereal flours (77.55 %), likely due to the difficulty in sourcing these flours

(spelt, rye, Kamut, etc.) and their recognized nutritional importance, allowing consumers to pay a premium price. The difference between whole wheat flour and soft wheat was not that large (4,18 %), likely due to the widespread market presence of whole wheat products, which has reduced the price difference over the years. Interestingly, the use of sourdough shows a discount price (−11.83) despite being recognized as an added value by the market. This trend is probably due to the recipe's simplification, similar to the 100 % plant-based recipe, which leads to a discount price of −32.27. These products exclude eggs, milk, powdered milk, and butter, resulting in a real cost difference between plant-based and animal-based raw materials. The minimal processing of these products, combined with their perception as simpler and more authentic, likely contributes to this price difference. In this context, the importance of communication activities is evident, as the use of a vegan-friendly claim, such as Vegan Okay, a third-party certification, commands a premium price (+6.11 %). Towards the health-related attributes, the presence of nutritional claims regulated by EU 1924/2006 of "No added sugars", "Source of proteins" and "Lower salt content" have the highest premium prices of 14.77 %, 47.27 % and 26.32 % respectively, suggesting the perceived value of these characteristics from consumer that influence their daily assumption. However, not all variables considered significantly impact the price. For example, the claim "lower fat content" and the indication "source of vitamins and minerals" do not show significant effects, with coefficients close to zero and non-significant p-values. Similar situation regarding the nutritional claims "high in fiber" and "source of fiber." Specifically, the claim "high in fiber" appears non-significant, with an effect close to zero, while the claim "source of fiber" is associated with a premium price of 8 %. This difference, even though the "high in fiber" claim requires a minimum fiber content of 6 g per 100 g compared to 3 g per 100 g for the "source of fiber" claim, can be explained by several factors. First, the presence of fiber, particularly for bread-like products, is well-known to consumers. Over time, this familiarity may have diluted the premium price effect of the "high in fiber" claim, similar to what has been observed for whole-grain products, which naturally contain fiber. Additionally, products labeled "source of fiber" may offer producers more versatility in creating a wider variety of products. This flexibility in product design could allow producers to better meet consumer preferences for taste and innovation. Lastly, an analysis of descriptive statistics suggests a possible reduced supply elasticity for "high in fiber" products, which may already be positioned in a premium segment. This positioning is often linked to other distinctive attributes, such as enrichment with specific ingredients, which may have mitigated the direct impact of the claim on the premium price. These findings can open the way for further research to explore the role of consumer behavior and marketing strategies in determining the economic value of these specific nutritional claims also in different baked products. For other our outcomes we point out that the Italian origin of the wheat and the use of organic wheat affect the price in opposite verse: positive for organic (+7.37) and negative for Italian wheat (−9.28).

Overall, the results confirm the importance of perceived quality and sustainability attributes, such as the use of Extra Virgin Olive oil (EVO), the enrichment of product (with chocolate or fruit) and sustainable packaging, which are positively associated with the price by 30.68 %, 98.13 % and 11.14 % respectively. In this direction, our results resonate with findings from various studies in literature. While health-related claims play a crucial role in influencing consumer decisions, the effectiveness can vary based on sensory attributes and the clarity of information presented. To draw comparisons with similar articles [22,23], suggests that these claims positively influence purchasing attitudes, particularly when connected to innovative ingredients. This is supported by Refs. [34,78] that indicate how COVID-19 pandemic has prompted consumers to prioritize health-oriented foods, thus increasing demand for products with claims. In this line [14,79], found that consumers exhibit a strong preference for products labeled with specific health claims, implying that these claims can significantly enhance product

appeal. However [24], noted that health claims might not significantly affect acceptance for products primarily driven by sensory characteristics, such as flavor and texture, especially among younger consumers. This inconsistency shows that while health-related claims can be persuasive, their effectiveness can vary with consumer demographics and product types. This indicates that while health-related claims can drive interest, producers must also consider sensory characteristics to appeal to a broad audience. Moreover, our findings also underscore the challenges associated with consumer understanding these claims. Misinterpretation of information due to inconsistent presentations can lead to confusion and impact dietary choices negatively. This is echoed in literature indicating that clearer nutritional information could help mitigate issues like obesity and assist consumers in making healthier choices [25–28]. Also, the inconsistent labeling and varied regulations across countries can lead to consumer confusion, mirroring the issues pointed out in this study. This supports the notion that clearer, standardized claim regulations can help consumers make more informed dietary choices and potentially reduce miscommunication.

4.2. Private and public implications

The hedonic price analysis conducted in this study could offer useful suggestions for both private companies and public policymakers. Through market price analysis, this research suggest how certain product attributes significantly influence the selling price, which in turn, may reflects the dynamic equilibrium between supply and demand. By understanding these attributes, producers can better tailor their marketing strategies and align new product development initiatives with consumer preferences, especially those of a growing segment that prioritizes health and quality. However, consumer behaviour is also influenced by company actions and marketing strategies, creating a continuous cycle of mutual influence that requires careful consideration. This study highlights how sustainable and health-related attributes of cereal products can make a difference in capturing consumer preferences and willingness to pay. For example, the strong positive impact of claims like "source of proteins" or the use of other cereal flours suggests opportunities for brands to match specific dietary trends, such as high-protein or alternative grain-based diets, which are gaining traction in modern markets.

Beyond marketing, the results encourage the integration of these claims with innovative technologies, such as blockchain to enables more secure and transparent communication, as confirmed by industry studies [80,81]. Attributes like "use of Italian wheat" or "sustainable production", which carry strong price premiums, could be further validated and communicated through blockchain systems. Additionally, the pressure of agri-food sector due to the increasing world population and demand for sufficient, safe, and high-quality food products can be facilitated by blockchain technology. This technology enhances supply chains efficiency by ensuring higher quality products with complete traceability from farm to table, while enabling the creation of immutable records of product origins and production methods, which fosters greater consumer trust [82]. However, implementing such systems comes with challenges [83,84]. Food producers, particularly small and medium enterprises (SMEs), often face high costs and logistical hurdles when adapting their technological infrastructure to blockchain systems. Additionally, there exists a significant knowledge gap among consumers regarding the benefits of these technologies, which may limit their perceived value [85,86]. To address these barriers, partnerships between private companies and public institutions could be instrumental. For instance, governments could provide financial incentives or grants to support the adoption of blockchain systems while simultaneously launching awareness campaigns to educate consumers on the added value of traceable and transparent food systems.

From a public perspective, the findings emphasize the importance of fostering policies that encourage sustainable and health-conscious food production. Claims related to sustainability, health or territorial

typicality enhancing market competitiveness and through specific food policies could lead to public health benefits. The use of certifications or clear claims regarding nutritional aspect can serve as a valuable tool. In the case of the vegan products in this study, an uncommunicated vegan recipe may lead to a discounted price; however, communicating the same product with certification can change the pricing trend. Addressing these gaps, public objectives could be further advanced not only through certifications but also by supporting private projects that promote sustainability, transparency, and health-oriented innovation. For example, governments and institutions could support solutions or programs that encourage the adoption of healthy practices, combined with clear communication strategies. These efforts would create a strong framework where public and private initiatives work together to meet consumer demands and achieve global sustainability goals. By leveraging insights from hedonic price analysis, stakeholders can address current challenges and capitalize on emerging opportunities to meet the evolving needs of modern food systems. The collaboration between private initiatives and public policies can foster a virtuous cycle of innovation, sustainability, and consumer satisfaction.

4.3. Future research directions

Further research should expand beyond the attributes analyzed in this study, evaluating product labels sold in Italy, exploring them in more detail to understand the presence of some "anti-nutritional" additives, consumer awareness of these aspects when making their purchases, and their economic impact on the market. Only through a comprehensive understanding of these factors can marketing and production strategies be directed towards healthier, more conscious offerings that meet the needs of an increasingly health-conscious public. Despite the specific focus on the Italian rusks market, this study can offer insights for the international cereal sector, applicable to products like crackers, toast, and other bread substitutes. Among these, for example, the investigation could be expanded to include the gluten-free product segment, considering its significant growth and increasing consumer demand in recent years. This would provide valuable insights into the evolving preferences of health-conscious consumers and the impact of gluten-free options on market dynamics and pricing trends, like [87,88]. Also, future research should continue to explore the nuanced effects of nutritional claims and health claims as established by EU Regulation 1924/2006 in the European context, across different food categories and consumer demographics, facilitating a more holistic understanding of how health messaging impact purchasing dynamics.

5. Conclusion

The key aspect of food market is product diversification. Each brand tries to differentiate itself through specific product attributes that can vary from the type of flour used (refined, whole, organic, etc.), the presence of additional ingredients (flax seeds, bran, ancient grains), to nutritional claims such as "no added sugars" or "rich in fiber". This segmentation is crucial to understand how quality attributes influence consumer choices and, consequently, market prices. Understanding market dynamics and consumer preferences will be essential for producers aiming to successfully position themselves in this segment.

The results of this research provide a crucial overview of the factors determining the price variability of food products in our sample, highlighting the influence of quality, health, and sustainability factors. This study highlights the critical role of quality, sustainable and nutritional aspect in shaping consumer behaviour within the Italian rusk market, revealing substantial implications for both consumers and producers. As the increasing prevalence of dietary-related health issues amplifies consumer interest in nutrition, the ability of food products to communicate their health benefits effectively becomes paramount. The findings demonstrate that nutritional claims not only enhance product appeal but also significantly influence consumer willingness to pay, suggesting that

companies can leverage this information strategically to optimize their market performance. Different studies have demonstrated the significant role of nutritional claims includes their positioning on label packaging. Research suggests that clear and easily identifiable claims enhance product appeal and consumer trust, influencing purchasing decisions. Additionally, these can create a psychological "halo effect," where a single positive attribute leads consumers to assume other desirable qualities, such as better taste or higher quality. This effect is particularly strong in functional or fortified products, where perceived health benefits may outweigh considerations like price or brand loyalty [89–91]. In our study the robustness of the model, confirmed by the statistical significance of the coefficients and the consistency of the results with theoretical expectations, suggests that the regression model used is a valid representation of price dynamics in the food sector. Additionally, the label analysis revealed a significant presence of ingredients not traditionally used in rusk preparation but employed for technological reasons, such as powdered milk, egg products, sweeteners, emulsifiers, and additives with antioxidant or preservative functions. These ingredients, often associated with ultra-processed products, raise questions about the nutritional quality of these foods. Their growing prevalence in the food market, both in Italy and worldwide, has sparked concerns about potential health impacts, including obesity, diabetes, and cardiovascular diseases. The presence of such ingredients in rusks could compromise the nutritional benefits of the product described and analyzed in this study regarding health and nutritional claims. Although rusks may seem like a light dietary option, it is essential to read labels carefully to identify potentially harmful ingredients. Ingredients such as refined flours, palm oil, artificial sweeteners, and additives can compromise the perceived nutritional benefits of this food. Greater awareness of these components is essential for making healthier and more informed dietary choices. However, the confusion surrounding nutritional or health claims and the variability in their regulatory frameworks point to an urgent need for clearer communication and education for consumers. Ensuring that consumers can accurately interpret these claims will support informed purchasing decisions, contributing to better overall health outcomes. Ultimately, enhancing the clarity and accuracy of health-related claims will promote a healthier consumer base and enable producers to align better with evolving market demands for transparency and quality.

CRedit authorship contribution statement

Francesco Di Cosola: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Alessandro Petrontino:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Michel Frem:** Writing – review & editing, Writing – original draft, Investigation. **Emanuela Tria:** Writing – original draft, Data curation. **Francesco Bozzo:** Validation, Supervision, Project administration, Funding acquisition, Conceptualization.

Declaration of interests

The authors have nothing to declare.

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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.

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Concluding Remarks

The thesis analyzed, through a series of empirical studies, how Italian consumers react to different forms of product and process innovation in the agri-food sector, highlighting the extent to which these innovations increase perceived utility in terms of quality, naturalness, health benefits, informational transparency, and sustainability, generating an interest that translates into a greater willingness to pay. Although the studies on which the thesis is developed have been conducted in different contexts, the results obtained allow to outline a unified picture of the dynamics that drive value formation towards innovations in the agri-food market. In fact, across the categories analysed, Italian consumers tend to reward agri-food innovations that maintain cultural continuity and the perceived authenticity of the product, while those that radically alter its identity structure meet with resistance.

In the case of legume-based snacks, which introduce a nutritious and ready-to-eat product to the market, the preference for high-quality ingredients, such as extra-virgin olive oil, highlights how innovation is welcomed when it aligns with expectations of naturalness and health benefits. Similarly, in bread-making, clear differences emerge between process innovations and formulation innovations: fermentation with sourdough and digital traceability are appreciated, while more radical reformulations, such as the use of alternative flours, meet resistance. Similar results emerge in other contexts: the absence or reduction of chemical treatments in the production of raw materials with which tomato pasta and tomato puree are made, as well as the use of indigenous yeasts in wine, shows that process innovations such as natural fermentations, the reduction of invasive interventions and artisanal techniques are more easily accepted than interventions that modify the identity structure of products. This set of evidence confirms the centrality of cultural continuity and the recognizability of processes in the interpretation of food innovation: the consumer tends to reward forms of innovation that consistently extend the production tradition, without altering elements considered central to the definition of quality.

Innovations geared towards information transparency also follow a similar logic. Digital traceability and blockchain generate value when they make already relevant credence attributes, such as safety, origin, and environmental and social sustainability, more readable. Studies that integrate psychographic variables also show that the acceptance of innovation also depends on individual predispositions: attention to credence attributes, attitudes towards technology and beliefs about the value of traceability significantly influence the willingness to adopt digital systems and to enhance sustainable innovations. The technologies are therefore more effective among consumers who attach importance to transparency and recognize digitization as a useful tool to reduce uncertainty.

The thesis contributes to the literature on agri-food innovation from conceptual, methodological and applied perspectives. On a conceptual level, it proposes an integrated perspective that relates product, process and system innovations, overcoming the traditional distinction between technological and sustainable innovation. Studies show that the evaluation of innovation is based on transversal criteria, such as quality, naturalness, transparency and territorial identity, which operate as decisive interpretative lenses in determining the credibility and desirability of novelty. In line with what has emerged in the literature, the results also highlight the relevant role of attributes related to sustainability, origin and information transparency in the formation of economic value. At the same time, the thesis highlights that the enhancement of innovation is neither automatic nor uniform, since some forms of novelty can meet resistance when they come into tension with consolidated expectations and with the identity structure of the product. The psychographic traits of individuals also contribute to the heterogeneity, whose inclusion, as shown in the chapters related to blockchain, makes it possible to explain the different willingness to pay and to clarify the conditions in which innovation is more easily accepted and monetized.

From a methodological point of view, the work consistently applies choice-based models (Hedonic Pricing Model and Discrete Choice Experiment) and, when necessary, integrates them with psychometric and structural tools such as Partial Least Squares Structural Equation Modeling. This system allows to simultaneously analyze expressed preferences, latent heterogeneity and dispositional determinants, offering a solid and replicable framework to study the acceptance of innovations. The inclusion of quantile regressions in the case of wine adds an additional layer of depth, clarifying how attributes take on different meanings in different market segments.

Finally, from an applied level, the thesis offers useful information for companies and policy makers interested in understanding which innovations are recognized and rewarded by the market. The results show that attributes related to traceability, sustainability and naturalness generate value when they are communicated in a clear, verifiable and consistent way with the identity of the product. Innovations that reinforce signals of authenticity, transparency or cultural continuity are more effective than those that radically change composition or sensory structure, suggesting the need to integrate novelties within familiar interpretative frameworks, avoiding abrupt shifts that consumers are not yet ready to legitimize.

Some limitations deserve to be highlighted. First, estimate-level comparability across chapters is limited by the heterogeneity of the product categories examined and by differences in the configuration of the attributes considered. As a result, rather than enabling a one-to-one comparison of individual estimates, the evidence should be interpreted in terms of converging patterns and recurrent mechanisms. Second, the generalizability of the findings is linked to the study context and to the specific samples used in the different studies; therefore, the results primarily reflect the preferences of Italian consumers under the conditions analyzed. Third, the adoption of heterogeneous methodological approaches (DCE, HPM, PLS-SEM and, in the case of wine, quantile regressions) represents an added value in terms of complementary insights and robustness of the evidence but also implies that economic and behavioral estimates are not always directly comparable across chapters. Future research could strengthen robustness and comparability through more standardized designs across product categories, cross-country replications, and integrated modelling strategies within the same empirical context.