Food Research International 233 (2026) 119014

Contents lists available at ScienceDirect

Food Research International

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

# When tradition meets modern labeling: Visual attention and consumer choice for Parmigiano Reggiano PDO under different front-of-pack nutrition-and eco-labels

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A R T I C L E I N F O

*Keywords:*
Nutri-score
NutrInform
Eco-score
Discrete choice
Health and sustainability
PDO product
Italy

A B S T R A C T

International organizations seek practical ways to encourage consumers to adopt healthy and sustainable diets. Visible information on the nutritional and sustainable impact of food through front-of-pack (FOP) labels could be a promising tool. In this scenario, the present study examined how nutritional and environmental labels influence consumer preferences for traditional foods with geographical indications. A lab experiment combining eye-tracking and a discrete choice experiment was conducted among 127 Italian consumers using Parmigiano Reggiano PDO cheese. Product alternatives varied by nutritional labels – Nutri-Score D (NS-D) vs. NutrInform (NI) – sustainable labels – Eco-Score C (ES-C) vs. Eco-Score D (ES-D), and price levels.

Results showed that all attributes significantly influenced choice, with the ES-C and NI generating positive utilities and higher price premiums, while NS-D and ES-D led to negative utilities requiring price discounts. Eye-tracking data suggested that visual attention plays a role in explaining food choices. Specifically, results confirmed that overall visual attention to a product alternative increased its likelihood of being chosen, and that increased attention to price led consumers to make more considered tradeoffs between price and other product attributes. An opposite trend was found for the ES-C, possibly indicating that increased scrutiny led consumers to question the possibility of having higher ESs for the PDO product.

Overall, this research highlights the relevance of visual attention and FOP labels in shaping food choices. These results provide evidence-based insights for harmonized FOP labelling policy development, highlighting the need for context-specific communication strategies that balance public health objectives and sustainable environment with the economic viability of traditional and origin-focused foods.

## 1. Introduction

Global food challenges related to health and environmental concerns have intensified over the last decades (FAO, 2017). On one hand, food choices significantly influence human health and well-being, as they are closely linked to the prevention or onset of chronic noncommunicable diseases, such as heart diseases, diabetes, and cancer (FAO and WHO, 2019; Willett et al., 2019). On the other hand, food systems also impact the environment, with the different steps of the food chain – from production to consumption – contributing to land and water use, deforestation, biodiversity loss, and greenhouse gas emissions, thus driving climate change (Beattie & McGuire, 2016; Boakes et al., 2024).

To address these pressing issues related to both health and environmental concerns, the Food and Agriculture Organization (FAO) has proposed sustainable, healthy diets as dietary patterns that align with nutrient recommendations, have low environmental pressure, and consider social/cultural and economic sustainability (FAO and WHO, 2019). The adoption of such diets is deemed essential to facilitate the transition toward food systems that promote both human and planetary health. However, this transition requires significant changes not only in production methods but also in how individuals and societies perceive, choose, and consume food (FAO, 2018). Therefore, consumers play a pivotal role in driving this transition, as their food choices can foster more resilient and responsible food systems. To support their daily

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https://doi.org/10.1016/j.foodres.2026.119014
Received 20 June 2025; Received in revised form 12 March 2026; Accepted 17 March 2026
Available online 19 March 2026

choices, various strategies have been developed and tested in recent years (Fernqvist et al., 2024). Among these, front-of-pack (FOP) labels have emerged as a promising tool to empower consumers by clearly communicating information about nutritional quality, environmental impact, and other key product attributes (Andreani et al., 2025; De Marchi et al., 2023; Temple, 2020).

At the European level, the potential of FOP labeling schemes has been recognized by the European Commission, which has called for a “harmonized mandatory front-of-pack nutrition labelling” to “empower consumers to make informed, healthy, and sustainable food choices” (European Commission, 2020). Among the various FOP labels developed within the European Union (EU), the Nutri-Score (NS) and NutrInform Battery (NI) have gained significant attention during the last years (Fialon et al., 2023; Fialon, Serafini, et al., 2022; Savov et al., 2022). The NS, a color-coded label, was developed in France in 2014 to provide consumers with a straightforward summary of a product's nutritional quality (Santé Publique France, 2024). Its algorithm combines positive (e.g., fiber) and negative characteristics (e.g., saturated fatty acids) to obtain a final score as a single indicator that is represented as a letter ranging from A (dark green color, higher nutritional quality) to E (red color, lower nutritional quality) (Merz et al., 2024; Santé Publique France, 2024). In contrast, the NI, developed by the Italian government in 2020, is a numeric and graphical label that provides detailed, quantitative information by displaying the individual portion's energy, fat, saturated fat, sugar, and salt content (Ministero della Salute, 2024). These systems, reported in Fig. 1, reflect different philosophies about communicating nutritional information: the NS focuses on synthesizing overall nutritional quality into a simple grade for quick comparisons, while the NI provides detailed quantitative information about specific nutrients to enable informed consumer evaluation. The differences between these two systems (summary indicator vs. nutrient-specific) have led to an ongoing debate on the topic, focused on defining the best scheme to empower consumers in their daily food choices (Andreani et al., 2025; Savov et al., 2022). This debate mostly derives from the methodological differences between the two systems, leading to varying degrees of acceptance across Member States. For example, France, Belgium, and Germany have voluntarily adopted the NS (De Marchi et al., 2023), while the Czech Republic, Cyprus, Greece, Italy, Latvia, Romania, and Hungary have expressed concerns about potential consequences (Donini et al., 2023). A key debate lies in how these labels might affect traditional products with geographical indications (GIs), such as Protected Designation of Origin (PDO) foods. Some stakeholders are concerned that summary indicators might oversimplify the nutritional evaluation of traditional, PDO foods, which – despite being potentially high in fat or salt content – remain important components of cultural diets and local economies (Donini et al., 2023; Fialon, Nabec, & Julia, 2022; Santeramo et al., 2020; Stiletto et al., 2023).

Given this association with the tradition of GI products and their contribution to the local community, and in view of an upcoming adoption of a harmonized nutrition labeling scheme in the EU, further investigation into the economic impact that labelling would have on such products is required. This would also align with the objectives of Regulation (EU) 2024/1143 (2024), which highlights the importance of safeguarding the reputation and added value of GIs, including their potential to support sustainable production and local economies.

In addition to this ongoing debate, there is a growing recognition of the need to integrate sustainability considerations into food labeling, especially given the significant impact of the food sector on the environment (Stein & de Lima, 2021). While the NS and NI focus on nutritional aspects, they do not address the environmental impact of food products. In this context, the Eco-Score (ES) emerges as a complementary labeling system that builds on the format of the NS: a five-color,

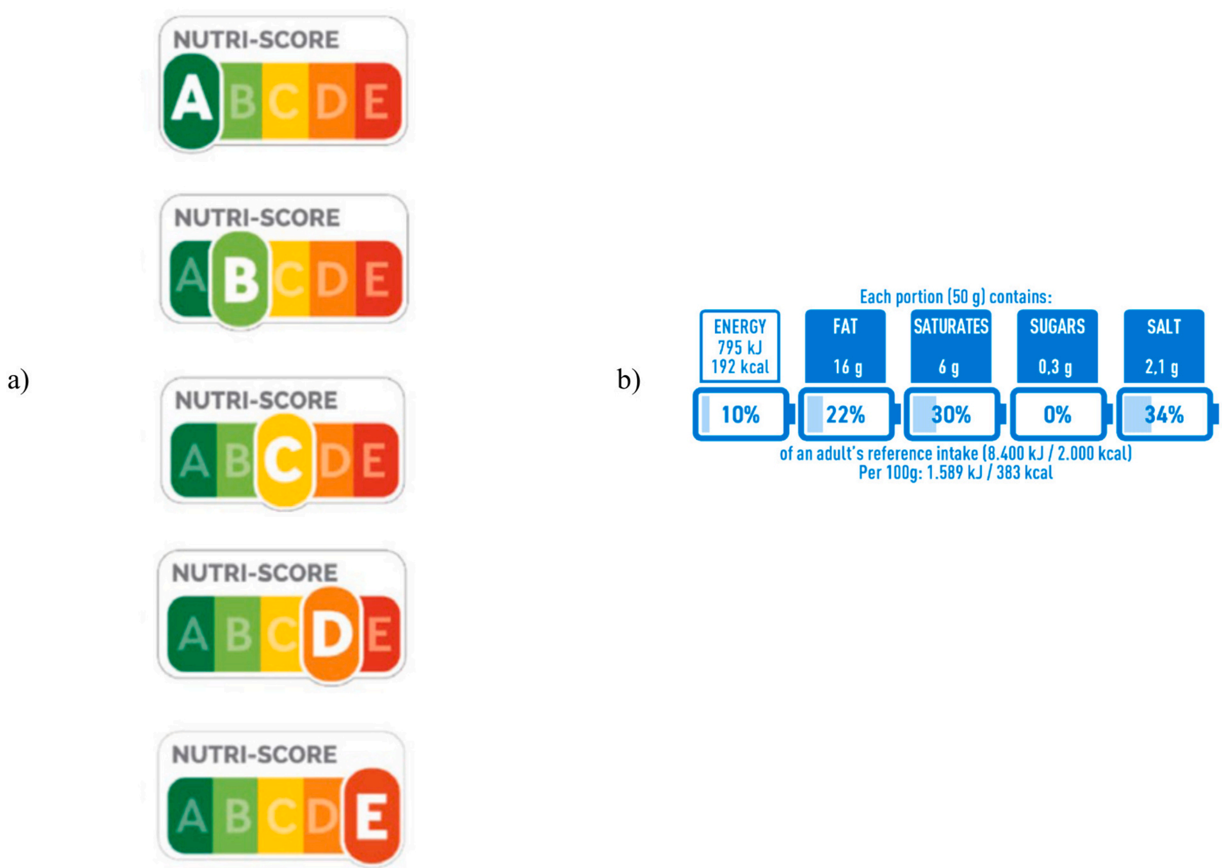


**Fig. 1.** Visual representation of the a) Nutri-Score (NS) and b) NutrInform Battery (NI).

five-letter FOP label (Colruyt Group, 2024). The ES (Fig. 2) aimed at providing accessible and easy-to-interpret information about a product's environmental impact, which is calculated through an algorithm that considers the Life Cycle Assessment plus bonuses and penalties based on other elements (e.g., the ingredients' origin, the presence of certifications, and the packaging) (Colruyt Group, 2024). Given the complexity of quantifying the environmental impact and due to the increasing number of sustainable labels and certifications (e.g., organic, animal welfare, carbon neutral, etc.) (Sonntag et al., 2023), the ES offers a unified, standardized tool to guide consumers in making environmentally conscious choices. While much research has been conducted on the NS and, to a lesser extent, the NI, the ES has received comparatively less attention in scientific literature – also given its more recent development and voluntary adoption (Andreani et al., 2025).

Given the complex interplay between traditional products, like PDO cheese, and these emerging labeling systems addressing both nutrition and sustainability, a comprehensive investigation is needed. By incorporating the ES alongside the NS and NI, this study addresses the need for holistic labeling strategies that empower consumers to make informed choices that consider both nutritional and environmental characteristics. Specifically, as providing new information on the product packaging could change the perceived utility of the product, the objective of this study is to investigate the impact of different FOP labels on consumers' willingness-to-pay (WTP) for an Italian PDO cheese. Furthermore, as previous studies have shown that visual attention to product attributes can influence consumer food choices (Ballco et al., 2020, 2019; Bialkova et al., 2014; Ruppenthal, 2023; Van Loo et al., 2021), this research investigates the role of consumers' visual attention in shaping the final choice. To achieve these objectives, we adopt a novel methodological approach that integrates a discrete choice experiment (DCE) with eye-tracking (ET), thereby capturing both stated preferences and cognitive processes underlying decision-making. Although some studies have already combined DCEs with ET (e.g., Ballco et al., 2019; Van Loo et al., 2015, 2021), this approach remains relatively novel, particularly in the context of traditional products such as PDO foods. Furthermore, while DCEs have been widely used to elicit consumer preferences (Noor et al., 2022), they do not always incorporate direct measures of information processing. Similarly, ET research on FOP labels often focuses on visual metrics without linking them to economic outcomes (e.g., Becker et al., 2015; Bix et al., 2015; M. Dudinskaya et al., 2023). By bridging these approaches, this study provides new insights into the mechanisms through which labels affect consumer valuation of traditional foods. This dual contribution expands the current knowledge on food labeling and informs the ongoing EU debate on a harmonized FOP scheme.

## 2. Hypotheses development

Consumer decision-making is shaped not only by product characteristics but also by the way information is presented, processed, and integrated into choice. Research on consumer behavior highlights that labels can attract attention, frame product utility, and influence food choices (Andreani et al., 2025; Temple, 2020). At the same time, visual attention plays a critical role in determining which cues enter the decision-making process, as attended information influences choice (Mora et al., 2023; Ruppenthal, 2023).

H1: Nutri-Score vs. NutrInform.

While literature has established that NS effectively promotes objective nutritional knowledge and preferences compared to other label formats (Andreani et al., 2025; Fialon et al., 2023; Fialon, Serafini, et al., 2022; Vasseur et al., 2025), limited research has directly compared NS with NI, particularly for traditional PDO products where algorithmic summary scores may conflict with established quality perceptions. According to previous work and the principle of negativity bias (Rozin & Royzman, 2001), consumers are particularly sensitive to negative cues (such as a “D” NS), which may outweigh the benefits of detailed numeric information. As a summary indicator, the NS presents nutrition information in a graded, evaluative format, making unfavorable ratings more salient than the nutrient-specific NI (Grummon et al., 2023). For traditional PDO products that typically receive poor NS ratings despite their cultural value, we expect this negativity bias to be particularly pronounced. We therefore hypothesize that a PDO product displaying a Nutri-Score D will elicit a lower price premium than one displaying the NutrInform.

H2: A PDO product with an Eco-Score C will have a higher price premium than one with an Eco-Score D.

Research shows that, for graded labels as the ES, more favorable signals translate into a higher purchase intention than products displaying a less favorable score (De Bauw, Franssens, & Vranken, 2022; De Temmerman et al., 2021). Within the ES system, a “D” communicates a higher environmental impact than a “C” and may trigger more negative responses. We therefore expect a higher price premium for a PDO product labeled with Eco-Score C compared to Eco-Score D.

H3: The combination of nutritional and environmental impact labels may create interaction effects on consumer utility, potentially differing from the sum of their individual effects.

Consumers rely on multiple product information sources that may interact in shaping their evaluations and choices (Board, N. R. C. (US) F. and N, 1986). Also, when displaying multiple FOP labels, the simultaneous processing of multiple information may produce additive effects and potentiate their effect, as demonstrated by previous studies (e.g., De Bauw et al., 2021; De Bauw, De La Revilla, et al., 2022; Marette, 2022). We therefore hypothesize that the joint presence of nutrition and environmental labels may generate interaction effects on consumer utility, diverging from the sum of their individual effects.

H4: An alternative product that receives more visual attention across all its attributes is more likely to be chosen.

Research on consumers' visual attention (Van Loo et al., 2021) indicates that alternatives receiving more visual attention are more likely to be chosen, as overall attention to a product alternative increases the likelihood of selecting that alternative. Thus, we expect that an alternative product receiving a higher total visual attention across all its attributes will have a higher probability of being selected.

H5: A higher visual attention to a FOP label on a product alternative enhances the probability of selecting that alternative.

Eye-tracking studies show that attention mediates cue influence and higher visual attention for FOP labels can impact consumer behavior (Ballco et al., 2019, 2020). We therefore hypothesize that greater attention to a FOP label increases the probability of choosing the corresponding product.

H6: Visual attention to specific labels moderates their impact on consumer choice.

According to previous consumer literature (Behe et al., 2015; Van Loo et al., 2015) increased visual attention to information cues (e.g., specific label attributes) enhances their influence on choice behavior. A recent meta-analysis by Bhatnagar and Orquin (2022) found that visual attention significantly affects choice. The study showed that when specific information receives more attention, it has a stronger influence on the final decision. This occurs because extended visual attention enables more thorough processing of information, amplifying its impact on decision-making. We therefore hypothesize that visual attention to specific FOP labels (attributes) moderates the strength of those individual labels' influence on choice, with labels receiving more visual attention having stronger effects on consumer evaluation and choice


**Fig. 2.** Visual representation of the Eco-Score (ES).

probability.

By answering these hypotheses, the study aimed at providing comprehensive insights into how FOP labels influence consumer preferences for traditional products to inform future labeling policies tailored to support both public health and sustainable food systems.

## 3. Method

### 3.1. Experimental design

A total of 142 young Italian consumers participated in this study, which was conducted at the University of Parma, Italy. Participants were recruited via flyers and email invitations, which included general information about the study and a screening questionnaire. Eligible participants – defined as adults who were not vegan, regularly purchased and consumed Parmigiano Reggiano PDO cheese (PR) (at least once in the past three months), and did not have major eye conditions – were invited to book a time slot for the study. The study was conducted in May 2024, and each session lasted approximately 30 min, with one participant tested per session. Ethics approval for this study was granted by the Ethics Committee of the University of Parma (protocol number: 93741).

Upon arrival, participants were briefed on the study's objective and signed informed consent before participation. The experiment consisted of two main sections: i) DCE in combination with ET, and ii) a computer-based survey designed to gather information on participants' socio-demographics, attribute importance, and purchasing behaviors. In this last section, participants were asked a series of questions intended to determine the importance they place on different PR's attributes. These attributes were included based on previous studies on consumers' perceptions of PR and general food products (Grunert et al., 2024; Li & Kallas, 2021; Silvestri et al., 2020). Participants were asked "What are the factors that you consider important for purchasing Parmigiano Reggiano PDO?" and rated each of the 14 attributes listed in Table 3 on a 5-point semantic scale from 1 (not important) to 5 (very important). This measurement was then used to compare the results from eye-tracking and investigate whether what stated important attributes matched the ones to which they paid more visual attention.

### 3.2. Choice experiment: Product and attribute selection

Parmigiano Reggiano PDO cheese (PR) was chosen as the product of the experiment due to its importance in Italian cuisine heritage and its market share in the Italian cheese market (Cozzi et al., 2019; Fondazione Qualivita, 2024). After a shopping check in local supermarkets, we selected a 24-month aged PR in a 250 g package, as this maturation period and package size were the most commonly available on the market.

A discrete choice experiment (DCE) was designed in which participants were asked to select their preferred PR from two alternatives and a no-buy option. Each product alternative was described by three attributes: nutritional label (NL), sustainable label, and price (Table 1). The NS and NI were selected to represent NL, while the ES represented the sustainable label. The levels of FOP labels for nutrition and sustainability were determined based on their actual classifications for the product under investigation. Specifically, the NS for PR was rated as "D" and was associated with an orange color. This "low" nutritional classification primarily reflected the product's high energy, sodium, and fat content, particularly saturated fats. In contrast, the NI label for the PR presented its nutritional composition in terms of energy, fats, saturated fats, sugar, and salt. This information was provided for 50 g of product, as specified by the NutrInform App of the Italian government (https://www.nutrinformbattery.it/). Regarding the ES, two ES levels were identified for PR: level C (ES-C) and level D (ES-D) (Colruyt Group, 2025). The variation in ES levels may be influenced by different types of packaging and/or certifications, such as the presence or absence of the organic certification.

**Table 1**
Attributes and attribute levels used for the choice experiment.

| Attributes | Levels |
|---|---|
| FOP nutrition label (NL) | • Nutri-score D (NS-D)<br>• NutrInform (NI)<br>• No NL label |
| FOP sustainable label (Eco-score or ES) | • Eco-score C (ES-C)<br>• Eco-score D (ES-D)<br>• No ES label |
| Price | • 17.0 € /kg (−30%)<br>• 24.3 €/kg (Average)<br>• 31.6 €/kg (+30%) |

Note: FOP = Front of Pack; NL = Nutrition Label; NS = Nutri-Score; NI = NutrInform Battery; ES = Eco-Score.

For the price attribute, three equi-spaced price levels (average retail price, −30%, +30%) were chosen to reflect the range of retail prices for one kilogram of PR at the time of the study (the average market price was 24.3 euro/kg). The choice experiment with 9 choice tasks was generated using an optimal orthogonal design in the differences design (OOD) with NGene (ChoiceMetrics, 2024). We initially conducted a pilot study to obtain prior parameter estimates but found considerable uncertainty in these estimates given the novel combination of nutritional and sustainability labels on PDO products. We then developed both OOD and efficient designs, and the OOD design appeared to produce more realistic choice scenarios while maintaining statistical orthogonality for our specific experimental context. Each of the 9 choice sets contained two product alternatives and a no-buy option. To provide a realistic choice task, we created a series of mock-ups combining images of the product with FOPs on the package. Fig. 3 shows an example of a choice set.

Before the DCE, participants received a description of the FOP labels and an explanation of each attribute and level featured in the choice tasks. They were also provided with instructions and a cheap talk script (Gschwandtner & Burton, 2020; Haghani et al., 2021; Silva et al., 2012) to encourage realistic decision-making. The script emphasized that participants should make choices as if they were in a real supermarket, selecting among identical options while considering budget constraints. The full text provided to participants is available in the Supplementary material (Table A1).

### 3.3. Eye-tracking procedures and measures

Participants' visual attention during the DCE was recorded using Tobii® Pro Fusion ET technology (250 Hz). The ET device was positioned on a panel beneath a 27″ computer screen, with participants seated 50–80 cm from the device, as suggested in Tobii's Eye Tracker Data Quality Test Report (Tobii®, 2018).

The nine choice sets were randomly presented using the Tobii® Pro Lab software. Participants could look at the stimuli for as long as needed to make their selections. Between stimuli, a neutral, blank visual stimulus was displayed to reset their visual attention and ensure consistency. Each participant underwent a 5-point calibration and a 4-point validation process to optimize the accuracy of the ET device and an accuracy value of 0.5° was considered acceptable. Based on the calibration feedback, the eye tracker operator could perform a new calibration for a maximum of five attempts, after which, participants were excluded from the test if no calibration data was acceptable. Also, following previous work (Kasneci et al., 2021; Martinovici et al., 2023), the percentage of valid gaze data was computed for each stimulus, and participants whose recordings had less than 60% of valid gaze data per image were excluded from further analyses.

For each of the nine choice sets, specific areas of interest (AOIs) were predefined and maintained consistent in size (width and height). AOIs included all FOP under investigation (i.e., NS, NI, and ES), the PDO label and the "Parmigiano Reggiano" brand, and the price. The defined AOIs


**Fig. 3.** Example of a choice set containing two alternatives of Parmigiano Reggiano (PR), plus the no-buy option.

are represented in the Supplementary material (Fig. A1). While ES labels (C vs. D) were of comparable size, nutrition-related labels (NI vs. NS) necessarily differed in dimensions due to the different type and amount of information they convey, which is an intrinsic property of these labels.

Visual attention to the AOIs corresponding to price and FOP labels was assessed using fixation time, specifically measured as total visit duration (TVD). As defined by Tobii® Pro Lab software, TVD represents the total amount of time a participant fixates on a given AOI. Although there are other eye-tracking measures available, such as fixation count, we chose TVD as our main measure because it provides a more comprehensive representation of sustained attention (Negi & Mitra, 2020). This is particularly valuable for understanding how consumers weigh different options in our discrete choice experiment. Our approach aligns with previous research that employed TVD to measure visual attention in food choice studies (Ares et al., 2013, 2014; Ballco et al., 2019; Bansal et al., 2024; Bialkova et al., 2014; Fenko et al., 2018; Ruppenthal, 2023; Van Loo et al., 2021) and is supported by the understanding that fixations represent moments of cognitive processing during which visual information is interpreted (Van Loo et al., 2018).

### 3.4. Socio-demographic characteristics

Of the 142 participants, 8 were excluded due to poor eye-tracking calibration, 3 were removed for failing an attention check embedded in the study, and 4 were excluded as "fast responders" (i.e., those who completed the survey in less than 40% of the median completion time (Jaeger et al., 2024; Wongprawmas et al., 2023). A total of 127 participants were included in the analysis.

Table 2 shows the characteristics of the final sample. The average age was 24.9 ± 4.14 years, and the majority of participants were high school graduates (45.7%) and full-time students (68.5%). The self-reported weight and height resulted in an average BMI of 23.0 ± 3.59, indicating normal weight (67.7%). The majority of participants were omnivores (82.7%) and purchased PR once a month or less (43.4%).

### 3.5. Data analysis

Choice experiments are theoretically grounded in Lancaster's theory of consumer choice (Lancaster & Lancaster, 1966) and econometrically based on the Random Utility Model (RUM) (McFadden, 1974; Thurstone, 1927). The principle was that the utility of goods can be segregated into the utility of different attributes of a product, and consumers make decisions based on their preferences for the attributes of the goods.

**Table 2**
Socio-demographic characteristics and basic consumption patterns of the sample (%, $n = 127$).

| Item | | Sample |
|---|---|---|
| **Age** | Mean (year) | 24.9 |
| | (SD) | (4.14) |
| **Gender** | Male | 38.6% |
| | Female | 61.4% |
| **Educational level completed** | High school | 45.7% |
| | Bachelor's degree | 22.0% |
| | Master's or PhD degree | 32.3% |
| **Work status** | Student full-time | 68.5% |
| | Student part-time | 6.3% |
| | Employed | 25.2% |
| **Body Mass Index (BMI)** | Mean | 23.0 |
| | (SD) | (3.59) |
| **BMI Category** | Underweight | 4.7% |
| | Normal weight | 67.8% |
| | Overweight | 22.8% |
| | Obese | 4.7% |
| **Food regime** | Omnivore | 82.6% |
| | Vegetarian | 1.6% |
| | Flexitarian | 13.4% |
| | Pescatarian | 2.4% |
| **Frequency of buying Parmigiano Reggiano PDO in the last 3 months** | Once a month or less | 43.3% |
| | 1–2 times a month | 40.9% |
| | Once a week | 14.2% |
| | More than once a week | 1.6% |

Note: PDO = Protected Designation of Origin. SD = Standard deviation. BMI category: Underweight (BMI < 18.50); Normal weight (18.50 ≤ BMI ≤ 24.99); Overweight (25.00 ≤ BMI ≤ 29.99); and Obese (BMI ≥ 30.00) (WHO, 2018).

Under the assumption that consumers are rational and make decisions to maximize their utility within the constraints of their budget, RUM proposed the existence of a latent construct (unknown part) that underpins choice behavior in the utility function (Marschak, 1959; McFadden, 1974).

Choice experiments are based upon the assumption that individual $i$ receives utility ($U$) from selecting option $j$ in choice situation $t$. The utility is represented by a deterministic ($\beta'_i.X_{ijt}$) and a stochastic component ($\varepsilon_{ijt}$), and is specified as:

$$U_{ijt} = \beta'_i X_{ijt} + \varepsilon_{ijt} \quad (1)$$

where $X_{ijt}$ is a vector of observed variables relating to alternative $j$

and individual $i$ in choice situation $t$, $\beta_i$ is a vector of coefficients of these variables for a person $i$ representing that person's taste, and $\varepsilon_{ijt}$ is an unobserved error term that is independent and identically distributed (iid) extreme value type I (Gumbel). It is considered a panel data model where individual $i$ is the cross-sectional element and choice situations $t$ for each individual are the time-series component (Alfnes, 2004).

We employed a random parameter logit (RPL) model, which took into consideration both random taste variation and correlation patterns between random parameters (Train, 2003), to estimate the consumer preferences for the multiple FOPs. All models were estimated on 1143 choices, based on 127 participants, each performing 9 choice tasks. An alternative-specific constant representing the no-buy option choice ($\beta_0$) and the other considered attributes and attribute were included in the specification of the utility function. All attribute variables (except price) and covariates were effect-coded to eliminate confounding effects between the constant and the attributes (Bech & Gyrd-Hansen, 2005). The reference levels were no NL label and no ES label. The attributes take a value of 1 when the specific level is present, a value of −1 when the reference level applies, and zero otherwise, with coefficients constrained to sum to zero across levels (Olynk et al., 2010; Tonsor et al., 2009).

To test H1 and H2, the first RPL model (RPL1) accounted only for the product attributes; the utility that individual $i$ obtained from alternative $j$ at choice situation $t$ is defined as follows:

$$U_{ijt} = \beta_0 No\_Buy_{ijt} + \beta_1 Price_{ijt} + \beta_2 NS_{ijt} + \beta_3 NI_{ijt} + \beta_4 ESC_{ijt} + \beta_5 ESD_{ijt} + \varepsilon_{ijt} \tag{2}$$

where $i = 1, \ldots, N$ is the number of respondents, $t$ is the number of choice occasions, and $j$ is option A, B, or C (no-buy option); $U_{ijt}$ is the individual utility for each participant, alternatives, and choice set; $\beta_0$ is an alternative-specific constant representing the no-buy option choice. $Price_{ijt}$ is the price for 1 kg of Parmigiano Reggiano PDO of alternative $j$; $NS_{ijt}$, $NI_{ijt}$, $ESC_{ijt}$, and $ESD_{ijt}$ are attributes of alternative $j$, and $\varepsilon_{ijt}$ is the error term.

Average WTP for each attribute level of NL and ES attributes was then calculated as follows:

$$\mathrm{WTP}(\mathrm{Label_k}) = -\left(\beta_k - \beta_{\text{no info}}\right)/\beta_1 \tag{3}$$

The parameter on price ($\beta_1$) approximates the mean marginal utility of income and the parameters on each label ($\beta_2$, $\beta_3$, $\beta_4$ and $\beta_5$) indicate the marginal (dis)utility change from no information to NS, NI, ES-C, and ES-D, respectively. Ninety-five percent confidence intervals for the WTP estimates were created using delta method (Hole, 2007).

In order to analyze the effect of having both NL and ES together (H3), the RPL2 model included their interaction terms, and the utility function is as follows:

$$\begin{aligned} U_{ijt} = {} & \beta_0 No\_Buy_{ijt} + \beta_1 Price_{ijt} + \beta_2 NS_{ijt} + \beta_3 NI_{ijt} + \beta_4 ESC_{ijt} + \beta_5 ESD_{ijt} \\ & + \beta_6 \left(NS_{ijt}{}^{*}\, ESC_{ijt}\right) + \beta_7 \left(NS_{ijt}{}^{*}\, ESD_{ijt}\right) + \beta_8 \left(NI_{ijt}{}^{*}\, ESC_{ijt}\right) \\ & + \beta_9 \left(NI_{ijt}{}^{*}\, ESD_{ijt}\right) + \varepsilon_{ijt} \end{aligned} \tag{4}$$

This model investigated interaction effects between NL and ES labels. While RPL1 examined the independent effects of each label type, this model adds interaction terms to test whether the combined presence of both types of labels creates synergistic effects on consumer choice. These interactions helped us to understand whether consumers process multiple FOP labels as complementary information or if they could lead to information overload or conflicting signals.

To test H4 that an alternative product that received more visual attention across all its attributes was more likely to be chosen, *VisitDurAlt* (visit duration on the alternative product in seconds) was added to the estimated utility functions in RPL3:

$$\begin{aligned} U_{ijt} = {} & \beta_0 No\_Buy_{ijt} + \beta_1 Price_{ijt} + \beta_2 NS_{ijt} + \beta_3 NI_{ijt} + \beta_4 ESC_{ijt} + \beta_5 ESD_{ijt} \\ & + \beta_6 VisitDurAlt_{ijt} + \varepsilon_{ijt} \end{aligned} \tag{5}$$

This model tested whether the total visit duration of a product alternative (regardless of which specific attribute is being viewed) influenced the likelihood of choosing that alternative.

To test H5 that higher visual attention for FOPs of a particular product alternative resulted in a higher choice likelihood for that alternative, the visit duration (s) of the attribute for each alternative (*VisitDurNS*, *VisitDurNI*, *VisitDurESC*, *VisitDurESD*, and *VisitDurPrice*) were included in the estimated utility function of RPL4, following Grebitus et al. (2015) and Van Loo et al. (2021).

$$\begin{aligned} U_{ijt} = {} & \beta_0 No\_Buy_{ijt} + \beta_1 Price_{ijt} + \beta_2 NS_{ijt} + \beta_3 NI_{ijt} + \beta_4 ESC_{ijt} + \beta_5 ESD_{ijt} \\ & + \beta_6 VisitDurNS_{ijt} + \beta_7 VisitDurNI_{ijt} + \beta_8 VisitDurESC_{ijt} \\ & + \beta_9 VisitDurESD_{ijt} + \beta_{10} VisitDurPrice_{ijt} + \varepsilon_{ijt} \end{aligned} \tag{6}$$

This model examined how visual attention to specific attributes of the product alternatives affected choice probability. While eq. 5 considered overall attention to each alternative, this model broke down attention by specific attributes so that we can determine whether greater visual attention to particular attributes has a differential impact on choice probability.

To test H6 that visual attention to specific labels moderated their impact on consumer choice, interaction terms between attributes and mean-centered variables of each attribute (*MC_NS, MC_NI, MC_ESC, MC_ESD*, and *MC_Price*) were included in the estimated utility function of RPL5, following the same procedure as described by Van Loo et al. (2015) and (Van Loo et al., 2021). First, the total visit duration of each attribute was summed over the 9 choice sets to calculate the overall mean visit duration for each attribute for each participant. Afterward, the mean-centered variables of each attribute were calculated by subtracting the overall mean visit duration from the visit duration of that attribute for each participant. Since variables with positive values are above the mean and those with negative values are below it, the mean-centered variables become relative to their mean and have a zero mean.

$$\begin{aligned} U_{ijt} = {} & \beta_0 No\_Buy_{ijt} + \beta_1 Price_{ijt} + \beta_2 NS_{ijt} + \beta_3 NI_{ijt} + \beta_4 ESC_{ijt} + \beta_5 ESD_{ijt} \\ & + \beta_6 \left(NS_{ijt}{}^{*} MC\_NS\right) + \beta_7 \left(NI_{ijt}{}^{*} MC\_NI\right) + \beta_8 \left(ESC_{ijt}{}^{*} MC\_ESC\right) \\ & + \beta_9 \left(ESD_{ijt}{}^{*} MC\_ESD\right) + \beta_{10} \left(Price_{ijt}{}^{*} MC\_Price\right) + \varepsilon_{ijt} \end{aligned} \tag{7}$$

This model tested whether the impact of specific attributes on choice was moderated by the level of visual attention they received. Unlike eq. 6 that examined the direct effect of visual attention, this model incorporates interaction terms between each attribute and its mean-centered visual attention measure (e.g., $NS \times MC\_NS$), allowing the interpretation of the interactions relative to the average attention level across participants. A significant positive coefficient for these interaction terms would indicate that the attribute's influence on choice becomes stronger when it receives above-average visual attention, while a significant negative coefficient indicates that the influence of the attribute becomes weaker when it receives above-average visual attention.

In all the models, it was assumed that the coefficients of the FOPs (except price) and visit duration were random and followed a normal distribution. In the RPL2 and RPL5 models, the interaction terms were also assumed to be random and to follow a normal distribution. Descriptive data were analyzed using Statistical Package for the Social Sciences, SPSS 29.0 (IBM Corp, 2023). Choice experiment data were analyzed using the statistical software NLOGIT 6.0 (Econometric Software Inc, 2016).

## 4. Results

### 4.1. Relationship between stated importance of PR attributes and visual attention

When asked to evaluate the PR attributes, participants stated that

**Table 3**
Importance of Parmigiano Reggiano PDO attributes ($n$ = 127).

| No. | Attributes | Mean | SD | Median | IQR |
|---|---|---|---|---|---|
| 1. | Taste | 4.5 | 0.8 | 5.0 | 4.0–5.0 |
| 2. | PDO Certification label | 4.3 | 0.9 | 5.0 | 4.0–5.0 |
| 3. | Cheese Maturation | 4.2 | 0.8 | 4.0 | 4.0–5.0 |
| 4. | Price | 4.0 | 1.1 | 4.0 | 3.0–5.0 |
| 5. | Offers (i.e. discount) | 3.9 | 1.1 | 4.0 | 3.0–5.0 |
| 6. | Parmigiano Reggiano Consortium brand | 3.8 | 1.2 | 4.0 | 3.0–5.0 |
| 7. | Place of origin of milk | 3.7 | 1.1 | 4.0 | 3.0–5.0 |
| 8. | Animal Welfare Indication and/or Certification | 3.5 | 1.0 | 4.0 | 3.0–4.0 |
| 9. | Indication of Environmental Impact | 3.3 | 1.1 | 3.0 | 3.0–4.0 |
| 10. | Nutritional Labeling and/or Indications | 3.2 | 1.2 | 3.0 | 2.0–4.0 |
| 11. | Place of product transformation | 3.2 | 1.3 | 3.0 | 2.0–4.0 |
| 12. | Producer brand (e.g., “Parmareggio”) | 3.0 | 1.3 | 3.0 | 2.0–4.0 |
| 13. | Organic Certification | 3.0 | 1.1 | 3.0 | 2.0–4.0 |
| 14. | Private label (e.g., “Conad”, “Coop” supermarkets) | 2.1 | 1.1 | 2.0 | 1.0–3.0 |

Note: PDO = Protected Designation of Origin. SD = Standard deviation. IQR = Interquartile range (IQR). The importance of Parmigiano Reggiano PDO attributes was measured on a 5-point scale from 1 (“Not important”) to 5 (“Very important”).

taste is the most important attribute, followed by PDO certification label, cheese maturing duration, and price. Environmental impact and nutritional labels, however, were less significant (Table 3). Notably, while participants stated that environmental impact and nutritional labels were relatively unimportant (ranked 9th and 10th), eye-tracking data revealed substantial attention to these labels. This gap between stated and revealed preferences underscores the value of behavioral methods in understanding actual decision-making processes. Results of average visit duration over 9 choice sets on the PR attributes from the eye-tracking (Table 4) show that NI received the longest fixation time while fixation times for other attributes were relatively similar. Visual attention patterns showed that participants spent more time examining NI compared to NS labels, possibly reflecting the cognitive effort required to process the more detailed, quantitative nutritional information presented on the NI label. Fig. 4 provides a heatmap illustrating visual attention patterns for a single choice task as an example.

We then analyzed the correlation between stated importance attributes and eye-tracking measures using Spearman's correlation coefficients (Table 5). For price, there is a positive and significant relationship between stated importance and visual attention in terms of visit duration. Moreover, there is a strong negative relationship between the stated importance of price and visual attention to nutritional labeling, suggesting that price-sensitive consumers make a trade-off between their attention to NL labels and price when purchasing PR. The correlations between stated importance and visit duration for NL and environmental impact indication were positive in direction but did not reach statistical significance, and should therefore be interpreted cautiously.

**Table 4**
Average eye-tracking measures for the stimuli (n = 127).

| Area of interest | Fixation time (s) | | | |
|---|---|---|---|---|
| | Mean | Std.dev. | Min | Max |
| **Price** | 1.3 | 0.6 | 0.1 | 3.7 |
| **NL** | 1.6 | 0.8 | 0.2 | 4.7 |
| NS | 1.4 | 0.7 | 0.1 | 3.5 |
| NI | 1.8 | 1.2 | 0.1 | 7.4 |
| **ES** | 1.3 | 0.7 | 0.2 | 4.2 |
| ES-C | 1.4 | 0.8 | 0.2 | 5.1 |
| ES-D | 1.3 | 0.7 | 0.1 | 3.8 |

Note: NL = Nutritional labels, including NS (Nutri-score) and NI (NutrInform). ES = Eco-score label.

### 4.2. Heterogeneity in consumer preferences

Estimates of the RPL models with only product attribute effects are reported in Table 6. The baseline model, RPL1, assumes random taste heterogeneity and correlation patterns across random parameters (attributes), whereas RPL2 includes interaction terms between the NL and ES labels. Results from both RPL models indicate that all coefficients of the selected attributes are significantly different from zero at the 1% significance level. This means participants consider all chosen attributes (NL, ES, and price) relevant. The coefficient of the no-buy option is negative and statistically significant in both models, indicating that participants gain more utility from choosing one of the product profiles rather than the no-buy choice. As expected, the coefficient for price is negative, indicating that an increase in price decreases utility and lowers purchase probability.

In RPL1, the coefficients of NI and the more positive ES level (ES-C) are positive and statistically significant at the 1% significance level, indicating that consumer utility increases when these labels appear on PR packages. Conversely, the coefficients of the more negative ES level (ES-D) and NS(D) are negative and statistically significant at the 1% significance level, indicating that consumer utility decreases when these labels appear on PR packages. Additionally, the significant standard deviation parameters of NL and ES labels indicate preference heterogeneity among consumers for these labels.

In RPL2, the main effects remain consistent with the RPL1 model, and all standard deviations of random parameters are significant, indicating preference heterogeneity across consumers for both main effects and interactions. None of the interaction coefficients reached statistical significance at conventional thresholds, suggesting that on average, consumers tend to process nutritional and environmental labels largely independently. The interaction between NI and ES-C was positive in direction ($\beta = 0.59$), consistent with a possible complementary effect, but did not reach significance and should be interpreted cautiously. However, all standard deviation parameters of the interaction terms are statistically significant ($p \leq 0.01$), indicating substantial heterogeneity across consumers in how they respond to label combinations. This means that while there is no consistent average effect of presenting labels together, individual consumers vary considerably in whether they perceive nutritional and environmental labels as complementary or conflicting signals. This model therefore provides additional insights into FOP labeling strategies by revealing not only the absence of a dominant average interaction effect, but also the presence of individual differences in consumers' joint processing of multiple labels.

The estimated mean consumer WTP and 95% confidence intervals for the attributes in the RPL1 model are presented in Table 7. WTP represents the maximum additional price consumers are willing to pay for labeled products compared to unlabeled products (baseline price: 24.3 euro/kg). Findings reveal that consumers are willing to pay a premium of 7.47 euros/kg for PR with the NI label and 6.70 euros/kg for PR with the ES-C label. Conversely, consumers require a discount of 4.59 euros/kg for PR with the ES-D label and 2.45 euros/kg for PR with the NS label compared to unlabeled. It is important to note that these WTP estimates are based on a sample of 127 participants and should be interpreted with caution, as they may not generalize to the broader population. Nevertheless, the results show directional patterns in consumer valuation of different labeling schemes for the proposed product.

### 4.3. Effect of PR attributes and visual attention on choice preferences

By incorporating eye-tracking data in the RPL models, we further analyze the effect of visual attention on consumer preferences during the product choice process. Table 8 presents estimates of the RPL models with visual attention effects. RPL3 combines total visit duration for product alternatives with RPL1, allowing us to evaluate whether participants who pay more attention to an alternative are more likely to choose it. RPL4 supplements RPL1 with visual attention measures for

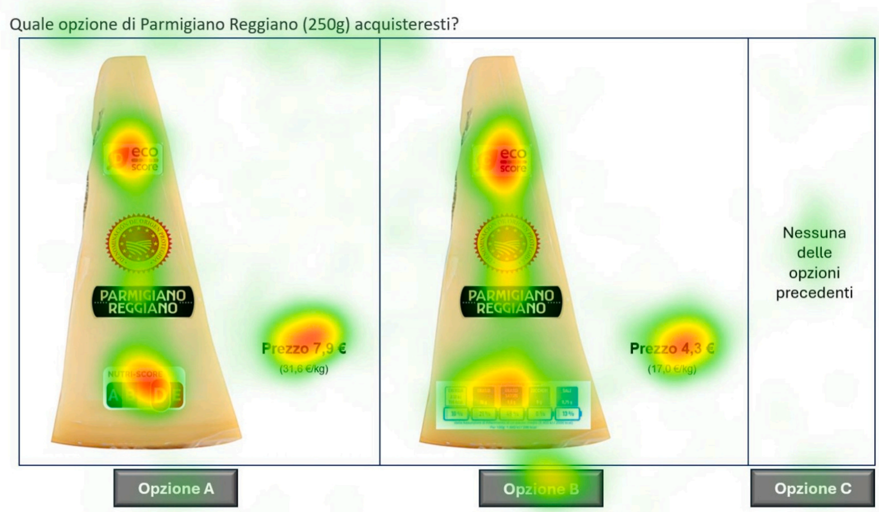


**Fig. 4.** Heatmap of visual attention for a single choice task. Note: Warmer colors indicate areas of higher visual focus. Translation = "Quale opzione di Parmigiano Reggiano (250g) acquisteresti?" is "Which option of Parmigiano Reggiano (250g) would you buy?"; "Prezzo" is "Price"; "Nessuna delle opzioni precedenti" is "None of these options"; "Opzione" is "Option".

**Table 5**
Spearman's correlation coefficients between stated importance and visual attention to the attributes.

| | Visit duration (s) | | |
|---|---|---|---|
| Stated importance[a] | Price | NL | ES |
| **Price** | 0.203** | −0.272*** | −0.123 |
| **NL** | −0.067 | 0.164 | 0.125 |
| **Environmental impact indication** | −0.043 | 0.046 | 0.163 |

Note: NL = Nutritional labels, including NS (Nutri-score) and NutrInform. ES = Eco-score label. **, *** Correlation is significant at the 0.05 and 0.01 level, respectively (2-tailed). [a] Stated importance was measured on a 5-sematic scale from 1 ("Not important") to 5 ("Very important").

specific product attributes, enabling us to assess whether attention to particular attributes increases selection likelihood. RPL5 includes interactions between attributes and their mean-centered visit durations to test whether the impact of attributes on choice is moderated by the level of visual attention they receive. All models show consistently higher utilities for NI and ES-C labels, and lower utilities for NS and ES-D labels. Also, results consistently demonstrate that visual attention and choice are related, with higher attention leading to higher choice likelihood.

In RPL3, the positive and significant coefficient for total visit duration to alternatives (*TVD_Alternative*) indicates that the more attention paid to a product alternative, the more likely that product is to be chosen. RPL4 accounts for both attribute effects and the impact of visit duration on consumers' utility. Among the visual attention variables, only the coefficient for attention to price (TVD_Price) is positive and statistically significant, indicating that increased attention to price increases the likelihood of selecting that product. Visual attention effects for all other attributes (NS, NI, ES-C, and ES-D) did not reach statistical significance, suggesting that for these labels, viewing time does not consistently modify choice probability on average. However, the significant standard deviation parameters for all visual attention variables indicate substantial heterogeneity across consumers in how visual attention influences their choices, meaning that while no dominant average effect exists for label attention, individual consumers vary considerably in how their viewing behavior relates to their product selection.

RPL5 includes interactions between each attribute and its mean-centered total visit duration. These interactions reveal how visual attention modifies the effect of attributes on choice probability. The

**Table 6**
Estimated parameters of Random Parameter Logit (RPL) for main effect variables (RPL1) and the interaction between attributes (RPL2).

| Variables | RPL1 | | RPL2 | |
|---|---|---|---|---|
| | Mean | SD | Mean | SD |
| **No Buy** | −4.43*** | – | −3.85*** | – |
| | (0.27) | | (0.28) | |
| **Price** | −0.14*** | – | −0.12*** | – |
| | (0.01) | | (0.02) | |
| **NL** | | | | |
| No-NL[a] | −0.23 | – | −0.21 | – |
| NS | −0.57*** | 0.68*** | −0.78*** | 0.97*** |
| | (0.10) | (0.11) | (0.24) | (0.20) |
| NI | 0.80*** | 0.74*** | 0.99*** | 0.98*** |
| | (0.10) | (0.11) | (0.19) | (0.13) |
| **ES** | | | | |
| No-ES[a] | −0.10 | – | −0.07 | – |
| ES-C | 0.83*** | 0.44*** | 1.08*** | 0.56*** |
| | (0.09) | (0.11) | (0.18) | (0.14) |
| ES-D | −0.73*** | 0.45*** | −1.01*** | 0.77*** |
| | (0.09) | (0.13) | (0.24) | (0.21) |
| **Interactions** | | | | |
| NS x ES-C | | | 0.20 | 0.76*** |
| | | | (0.27) | (0.27) |
| NS x ES-D | | | −0.50 | 1.55*** |
| | | | (0.46) | (0.52) |
| NI x ES-C | | | 0.59 | 1.60*** |
| | | | (0.35) | (0.44) |
| NI x ES-D | | | −0.001 | 0.75*** |
| | | | (0.28) | (0.28) |
| Number of participants | 127 | | 127 | |
| Number of observations | 1143 | | 1143 | |
| Log likelihood | −934.99 | | −881.78 | |
| McFadden's pseudo $R^2$ | 0.26 | | 0.30 | |
| AIC/N | 1.664 | | 1.623 | |

Note: Standard errors are presented in parentheses. SD = Standard deviation. ** and *** denote significant difference at the 0.05, and 0.01 level, respectively. AIC/N = Akaike Information Criterion divided by sample size. NL = Nutritional label, NS = Nutri-score D, NI = NutrInform. ES = Eco-score label, ES-C = Eco-score C, ES-D = Eco-score D. [a] Reference levels of NL and ES. Coefficients of reference levels were calculated by coefficient (ref.lev.) = − Σ coefficients (attribute levels). Presented models were estimated using NLOGIT 6.0, RPL models were estimated with Halton draws, and 1000 replications for simulated probability.

**Table 7**
WTP [95% confidence intervals] for NL & ES labels on PR in euro per kg (n = 127).

| Attribute | WTP | 95% Confidence interval |
|---|---|---|
| **NS** | −2.45** | [−4.40, −0.51] |
| **NI** | 7.47*** | [5.36, 9.60] |
| **ES-C** | 6.70*** | [4.84, 8.57] |
| **ES-D** | −4.59*** | [−6.42, −2.79] |

Note: *** and ** indicate significance at 1% and 5% level, respectively. WTP = Willingness to Pay; NI = NutrInform Battery; NS = Nutri-Score; ES-C = Eco-score C, ES-D = Eco-score D.

interaction between price and its mean-centered variable is positive and significant, while the main effect of price is significantly negative. This indicates that increased attention to price weakens its negative impact on choice probability. The interaction between ES-C and visual attention is negative and significant, while the main effect of ES-C is strongly positive, indicating that increased attention to ES-C reduces its positive impact on choice probability. The non-significance of the interactions for NS, NI, and ES-D suggests that attention to these labels doesn't significantly modify their effects on consumer choice.

The derived standard deviation parameters for all attributes and visual attention measures in all models are significantly different from zero, confirming substantial heterogeneity among consumers not only in their preferences for NS, NI, ES-C, and ES-D labels, but also in how visual attention influences their choices. This finding highlights individual differences in both preferences and information processing.

## 5. Discussions

By merging ET into a DCE, this study provides valuable insights into the effects of FOP labeling on consumer preferences and WTP for a PDO product. Although price remains an important factor influencing

**Table 8**
Estimated parameters of Random Parameter Logit (RPL) models with visual attention effects.

| Variables | RPL3 | | RPL4 | | RPL5 | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| **No Buy** | −3.84*** | – | −5.01*** | – | −5.25*** | – |
| | (0.33) | | (0.40) | | (0.37) | |
| **Price** | −0.14*** | – | −0.17*** | – | −0.16*** | – |
| | (0.01) | | (0.01) | | (0.01) | |
| **NL** | | | | | | |
| No-NL[a] | −0.05 | – | −0.22 | – | −0.33 | – |
| NS | −0.68*** | 0.78*** | −0.75*** | 1.13*** | −0.66*** | 1.13*** |
| | (0.11) | (0.14) | (0.18) | (0.22) | (0.15) | (0.18) |
| NI | 0.73*** | 0.90*** | 0.97*** | 1.16*** | 0.99*** | 1.01*** |
| | (0.12) | (0.13) | (0.19) | (0.18) | (0.15) | (0.18) |
| **ES** | | | | | | |
| No-ES[a] | 0.01 | – | −0.17 | – | 0.01 | – |
| ES-C | 0.83*** | 0.64*** | 1.00*** | 0.84*** | 0.94*** | 0.57*** |
| | (0.11) | (0.12) | (0.17) | (0.22) | (0.13) | (0.17) |
| ES-D | −0.84*** | 0.60*** | −0.83*** | 0.74*** | −0.95*** | 0.80*** |
| | (0.11) | (0.13) | (0.16) | (0.21) | (0.13) | (0.16) |
| **TVD_Alternative** | 0.38*** | 0.44*** | | | | |
| | (0.06) | (0.06) | | | | |
| **TVD_NS** | | | 0.14 | 0.60*** | | |
| | | | (0.13) | (0.19) | | |
| **TVD_NI** | | | 0.17 | 0.47*** | | |
| | | | (0.10) | (0.19) | | |
| **TVD_ESC** | | | 0.07 | 0.70*** | | |
| | | | (0.13) | (0.17) | | |
| **TVD_ESD** | | | −0.08 | 0.78*** | | |
| | | | (0.16) | (0.24) | | |
| **TVD_PRICE** | | | 0.56*** | 0.97*** | | |
| | | | (0.15) | (0.15) | | |
| **Interactions MC of attribute x attribute** | | | | | | |
| MC_NS x NS | | | | | 0.03 | 0.58*** |
| | | | | | (0.12) | (0.18) |
| MC_NI x NI | | | | | 0.03 | 0.33*** |
| | | | | | (0.07) | (0.08) |
| MC_ESC x ES-C | | | | | −0.24** | 0.47*** |
| | | | | | (0.12) | (0.14) |
| MC_ESD x ES-D | | | | | 0.09 | 0.48*** |
| | | | | | (0.12) | (0.20) |
| MC_PRICE x PRICE | | | | | 0.02*** | 0.03*** |
| | | | | | (0.01) | (0.01) |
| Number of participants | 127 | | 127 | | 127 | |
| Number of observations | 1143 | | 1143 | | 1143 | |
| Log likelihood | −842.70 | | −861.95 | | −892.00 | |
| McFadden's pseudo $R^2$ | 0.33 | | 0.31 | | 0.29 | |
| AIC/N | 1.513 | | 1.606 | | 1.659 | |

Note: Standard errors are presented in parentheses. SD = Standard deviation. ** and *** denote significant difference at the 0.05 and 0.01 level, respectively. AIC/N = Akaike Information Criterion divided by sample size. NL = Nutritional label, NS = Nutri-score D, NI = NutrInform. ES = Eco-score label, ES-C = Eco-score C, ES-D = Eco-score D. [a] Reference levels of NL and ES. Coefficients of reference levels were calculated by coefficient (ref.lev.) = − Σ coefficients (attribute levels).TVD_Alternative = total visit duration in seconds to the product alternative. TVD_NS = total visit duration in seconds to the NS. TVD_NI = total visit duration in seconds to the NI. TVD_ESC = total visit duration in seconds to the ES-C. TVD_ESD = total visit duration in seconds to the ES-D. TVD_PRICE = total visit duration in seconds to the price. MC stands for mean-centered visit duration in seconds for each product attribute levels. Presented models were estimated using NLOGIT 6.0, the model was estimated with Halton draws, and 1000 replications for simulated probability.

consumer decisions, as shown by its consistently significant negative coefficient across all models, results demonstrate that nutritional and environmental labels significantly influence consumer utility and choice, shaping consumer choices for traditional PDO products.

In line with H1, the NS generated lower utilities and price premiums compared to the Italian NI label, which supports the idea that consumers are particularly sensitive to negative evaluative cues (Rozin & Royzman, 2001) and that unfavorable ratings may overshadow the more detailed nutrient-specific information (Grummon et al., 2023; Stefanella et al., 2025). The positive effect of the NI on consumers' WTP for the PDO product may thus suggest a competitive advantage for PDO producers; however, several factors may contribute to this finding, which require further investigation. An important consideration is the role of cognitive load in interpreting these findings. The more detailed format of NI likely requires greater cognitive effort to process, which could partially explain the longer fixation duration observed for this label. However, it is important to acknowledge that both cognitive load and value perception are likely to operate simultaneously, and the current study design does not permit conclusions about their relative weight - whether consumer preference for NI reflects genuine understanding, familiarity, cultural context, or actual information processing remains an important direction for future research. Note that the substantial WTP differences observed (premium for NI vs discount for NS) reflect consumer responses within our experimental context rather than precise market valuations. These findings should be interpreted as directional evidence of how different information presentation formats can influence perceived product value, particularly for traditional products where labeling may conflict with established quality perceptions.

Conversely, the presence of the NS-D led to lower utilities when compared to the no-label condition. This finding is consistent with prior research (Stiletto et al., 2024; Stiletto & Trestini, 2022), which showed that displaying a low Nutri-Score can generate negative utility even for products with GIs – especially among consumers who are already familiar with the labeling system. These results suggest that when a GI product carries an unfavorable NS rating, the negative nutritional signal may affect the positive associations typically linked to GIs.

Regarding the environmental label, results confirmed H2 as the ES-C generated higher utilities than the ES-D, in line with the literature showing that higher ESs are associated with increased product appeal (De Bauw, Franssens, et al., 2022). While – to the best of our knowledge – research on ES in the context of GI products does not yet exist, our findings suggest that even in the context of a traditional PDO product, consumers remain sensitive to environmental impact, consolidating the growing importance of sustainability in food systems (Meemken et al., 2021; Nelson et al., 2016; Stein & de Lima, 2021; Weber, 2021).

For H3, no significant interaction effect was observed, suggesting that consumers tend to process nutritional and environmental labels largely independently rather than integrating them holistically into a combined assessment. The interaction between NI and ES-C was positive in direction, consistent with a possible complementary effect, but did not reach statistical significance and should be interpreted cautiously. Moreover, the significant standard deviation parameters for all interaction terms indicate substantial heterogeneity across consumers in how they respond to label combinations, suggesting that individual consumers vary considerably in whether they perceive nutritional and environmental labels as complementary or conflicting signals. These findings only partially support H3. Given the limited research on NI combined with environmental indicators and the fact that the few studies on a dual NS-ES scheme did not focus on WTP (Berden & Hung, 2025; De Bauw et al., 2021; De Bauw, De La Revilla, et al., 2022; Marette, 2022), future research should continue to explore these topics. A particular concern is the waterbed effect that occurs when consumers focus on a single dimension (such as nutrition), which may inadvertently lead to negative consequences in the evaluation of other dimensions (such as environmental impact), creating a fragmentation in consumers' understanding of sustainability as an integrated concept (Torma & Thøgersen, 2021). This effect is especially relevant when products carry potentially conflicting nutrition and sustainability labels, which could lead to the tension between labels mentioned by Berden and Hung (2025) and ultimately affect consumer perception and decision-making through cognitive dissonance. Larger samples and segmentation based on attitudinal variables may also reveal hidden patterns or interaction effects that were not evident in our sample, as suggested by previous research on FOP (Godden et al., 2023; van Herpen and van Trijp, 2011).

The eye-tracking component of this research offered additional evidence of the role that visual attention plays in decision-making. Supporting H4, our results confirmed that the TVD to a product alternative significantly increased the likelihood of that product being chosen, confirming previous studies suggesting that visual attention plays a role in explaining food choices (Ballco, de-Magistris and Caputo, 2019; Bialkova et al., 2014; Gidlöf et al., 2017; Jantathai et al., 2013; Van Loo et al., 2021; Vu et al., 2016). We also found that price-sensitive consumers may consciously prioritize price over other attributes (i.e., NL) when evaluating Parmigiano Reggiano PDO cheese, as evidenced by the significant positive correlation between price importance and price attention, and the significant negative correlation between price importance and NL attention. While positive correlations between stated importance and visual attention were also observed for NL and environmental labels, these did not reach statistical significance, and therefore the evidence for alignment between stated importance and actual visual attention is robust only for price-related behavior.

However, visual attention to individual attributes in the DCE did not consistently predict product choice – only attention to price had significant effects leading to the rejection of H5. This highlights findings by Balcombe et al. (2017), who argued that, although ET data can provide insights into attribute engagement, its relationship with choice outcomes is often weak and complex. Interestingly, while our findings for price align with previous studies showing visual attention to price affects choice (Van Loo et al., 2015, 2018, 2021), we did not have the same findings that visual attention to other attributes significantly impacts choice likelihood. One possible explanation for this difference could be related to the way attributes were presented (e.g., text vs. labels), underlining the importance of how information presentation influences consumers' processing and response.

Nevertheless, our findings also showed that visual attention moderates attribute effects, partially supporting H6. Specifically, increased attention to the price reduced its negative influence on utility. This finding suggests that when consumers deliberately examine the price (rather than glancing quickly), they are less likely to be deterred by high prices. This may indicate that consumers are making more considered trade-offs between price and other product attributes when they pay closer attention to pricing information. This is consistent with findings by Pieniak et al. (2009), who observed that although European consumers recognize the price premiums often associated with traditional foods, this awareness does not negatively impact their attitudes toward these products. Thus, this moderation effect indicates that paying close attention to pricing information leads to less price-sensitive decision-making, suggesting that consumers can better contextualize the price within the product's overall value proposition. Conversely, the positive effect of the ES-C decreased with increased attention, possibly indicating that increased scrutiny may lead consumers to question whether higher environmental scores are achievable for the PDO product.

The heterogeneity observed across models, confirmed by significant standard deviation parameters for all attributes and visual attention effects, underscores that consumer preferences and attention to different information can vary, in line with previous research (Andreani et al., 2025; (van Herpen and van Trijp, 2011)). Our limitation is that the current analysis does not identify the sources of this variability. This highlights the need for further research to model latent consumer classes based on characteristics such as demographics, dietary habits, and attitudes. Understanding how specific consumer groups interpret and prioritize nutritional and sustainability information could guide the adoption of more targeted label communication and market positioning.

This study presents several strengths. By combining DCE with eye-tracking, it offers both stated preference data and objective measures of visual attention, providing a richer understanding of consumer responses to FOP labels. Moreover, while WTP for the NS in the context of PDO cheese has previously been explored (Stiletto et al., 2023), this study extends the literature by incorporating visual attention metrics and comparing multiple FOP labeling schemes – including both nutrition and environmental FOP – within the same experimental framework.

While this study provides valuable insights, it is important to acknowledge its limitations. As a hypothetical study, it relied on stated preferences rather than actual purchasing behavior, and no monetary transactions occurred. Future research should address this limitation by conducting non-hypothetical experiments to determine whether similar results are observed in real-world purchasing scenarios. Furthermore, although the eye-tracking methodology offered controlled insights into visual attention, future studies should explore how consumers interact with FOP labels in real-world settings – for instance, by using virtual reality tools – where labels compete with other packaging elements, such as claims, branding, and promotional cues using virtual reality (VR). Such investigations would help uncover the context-related factors influencing decision-making and label effectiveness (Schruff-Lim et al., 2023). Expanding this research to include other traditional GI products would further enhance our understanding of the impact of FOP labels across diverse product categories. By applying the approach used in this study to other GI products, researchers could assess whether nutritional and sustainability labels similarly influence consumer preferences and perceptions. Given the cultural and economic importance of GI products, such research could provide valuable guidance for policymakers and industry stakeholders seeking to promote healthy and sustainable diets while preserving traditional food systems (Sogari et al., 2023).

An additional limitation of our study lies in the sample, which included Italian consumers only and was recruited through convenience sampling. While convenience samples are commonly used in choice experiments and eye-tracking studies due to practical constraints in laboratory settings (e.g., (Balcombe et al., 2014; E. C. Dudinskaya et al., 2020; M. Dudinskaya et al., 2023; Fenko et al., 2018; Van Loo et al., 2021), this approach can introduce selection bias. Given the ongoing local debate regarding different nutritional labeling systems (Stiletto et al., 2023), it is possible that participants held pre-existing attitudes that could have influenced their responses to the different labels. Future research should thus explore consumer responses across different national contexts and with more diverse recruitment strategies to assess the generalizability of these findings and to better understand consumer comprehension and responses to various FOP labelling systems in diverse cultural and regulatory environments. Lastly, our sample was skewed toward young, female consumers, which can further limit the generalizability of our findings. Future studies should consider more diverse and representative samples. Nonetheless, this research offers a valuable starting point for further work aimed at supporting informed decision-making and policy development in the context of FOP labeling and GIs.

## 6. Theoretical, policy and managerial implications

From a theoretical perspective, our findings contribute to the literature on consumer information processing in several ways. While our results show consumer preference differences between the two systems, determining the specific mechanisms behind these preferences – whether related to understanding, familiarity, cultural context, or actual information processing – remains an important direction for future research. This finding underscores the complexity of consumer responses to FOP labelling systems and the need for a comprehensive understanding of the factors influencing these perceptions.

Our findings also contribute to information processing theories in food choice contexts. Dual-process theories of decision making (Krämer & Kahneman, 2011) that differentiate between intuitive (System 1) and deliberative (System 2) processing are supported by the differential moderation effects for price and environmental labels. The results suggest that increased visual attention transforms attribute interpretation rather than simply enhancing or diminishing its importance. For price, deeper processing facilitates more thorough valuation beyond monetary cost, while for environmental labels, it may trigger critical evaluation. This extends the findings of Orquin and Mueller Loose (2013) that attention plays an active role in constructing decisions by demonstrating that the impact of attention varies by attribute type and product context, particularly for traditional foods with strong cultural dimensions. Future studies should account for how deliberative processing qualitatively changes information interpretation.

For policymakers and industry stakeholders, these findings offer several practical implications for labeling system design and implementation.

First, although the NS should be intended as an “indication of use” (Andreani et al., 2025), our results suggest that it is often interpreted as a judgment of the overall product quality. This potential misinterpretation can be particularly critical for traditional or PDO products, which may not meet certain nutritional benchmarks due to their inherent composition (European Commission, 2021). If the NS were to become mandatory at the EU level, targeted communication campaigns would likely be essential to ensure consumers correctly understand its purpose. Without such efforts, the widespread implementation of the NS could lead to unintended consequences for GI products, potentially leading to economic repercussions for producers. Future research should thus explore how various communication strategies – such as infographics, slogans, or narrative framing – can improve consumer comprehension of FOP labels, particularly in the context of traditional and origin-linked foods. Such work would not only support informed decision-making but also help safeguard the cultural and economic value of traditional products within evolving policy frameworks (Sogari et al., 2023). In addition, while our experimental findings provide evidence under controlled conditions, policy implementation should consider that real-world contexts involve additional complexities such as varying levels of consumer familiarity with labels and diverse shopping environments.

While the nutritional quality of GI products faces significant constraints due to traditional production methods and composition requirements, producers could consider improving the environmental performance (e.g., packaging, transportation, energy use) to achieve a higher ES and attract consumers. This could represent a pragmatic pathway for promoting sustainable production in line with the ambitions of Regulation (EU) 2024/1143 (2024), which emphasizes the role of GI schemes in encouraging sustainable practices that go beyond mandatory requirements. As such, adopting and communicating these improvements could serve environmental goals without compromising traditional values.

## 7. Conclusion

This study integrated discrete choice experiments with eye-tracking data to investigate how FOP nutritional and environmental labels, combined with price information, influence consumer choices in the context of a PDO product. Results indicated that all attributes had a significant impact on the final choice. Interestingly, price sensitivity moderated by visual attention suggests that deliberate examination leads to more considered trade-offs among product attributes. In contrast, environmental labels showed different effects based on visual attention, with increased attention to the ES-C potentially triggering skepticism about the possibility of having higher scores for the PDO product. ET findings further showed that visual attention tends to align with stated attribute importance, especially among price-sensitive consumers who seemed to trade off attention to NLs in favor of price.

These results have important implications for policy development regarding mandatory, harmonized FOP labeling in the EU. The study highlights the complexity of consumer responses to multiple information systems, suggesting that effectiveness may vary across product categories and cultural contexts. For traditional PDO products, communication strategies may be needed to ensure proper interpretation of nutritional indicators. Overall, this study demonstrates the potential of FOP labeling strategies to influence consumer choices for traditional PDO products like Parmigiano Reggiano PDO cheese. While interpreting eye-tracking data requires careful consideration of both cognitive load and utility assessment, the integration of visual attention measures with choice data provides meaningful insights into consumer information processing, particularly through the moderation effects observed between attention and attribute evaluation. As the food sector continues to evolve in response to global challenges, these findings emphasize the need for further research and innovation in labeling systems to support healthier, more sustainable food choices while preserving the economic viability of traditional foods.

## CRediT authorship contribution statement

**Rungsaran Wongprawmas:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Giulia Andreani:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Data curation, Conceptualization. **Giovanni Sogari:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Conceptualization. **Davide Menozzi:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **Cristina Mora:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization.

## Ethical statement

We confirm that the research complied with the Declaration of Helsinki and the study received ethical approval from the Ethics Committee of the University of Parma (protocol number: 93741).

We also confirmed that an informed consent was obtained from all participants.

## Funding statement

Project funded under the National Recovery and Resilience Plan (NRRP), Mission 4 Component 2 Investment 1.3 - Call for tender No. 341 of 15 March 2022 of Italian Ministry of University and Research funded by the European Union - NextGenerationEU; Project code PE00000003, Concession Decree No. 1550 of 11 October 2022 adopted by the Italian Ministry of University and Research, Project title "ON Foods - Research and innovation network on food and nutrition Sustainability, Safety and Security - Working ON Foods".

## 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.

## Acknowledgment

The authors would like to thank Setareh Motevallian and Lorenzo Abbiati for their support during data collection.

Project funded under the National Recovery and Resilience Plan (NRRP), Mission 4 Component 2 Investment 1.3 - Call for proposals No. 341 of 15 March 2022 of Italian Ministry of University and Research funded by the European Union – NextGenerationEU. Award Number: Project code PE0000003, Concession Decree No. 1550 of 11/10/2022 adopted by the Italian Ministry of University and Research, CUP D93C22000890001, Project title "Research and innovation network on food and nutrition Sustainability, Safety and Security – Working ON Foods" (ONFoods)

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodres.2026.119014.

## Data availability

Data available on request from the authors.

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