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Carbon footprint awareness and sustainable food choices: an empirical analysis of willingness to pay and restaurant preferences among Italian consumers

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Abstract

Purpose – This study examines whether and how carbon footprint information can foster more sustainable food choices in restaurants. Specifically, it investigates how the perceived informativeness of carbon footprint labels, environmental relevance, individual knowledge of the concept, and restaurant preferences influence consumers' willingness (WTP) to pay for low-carbon dishes in Italy.

Design/methodology/approach – The analysis is based on data from a 2024 survey of 1,067 Italian consumers. Econometric models are employed to assess the relationship between attitudinal, informational and socio-demographic variables and consumers' WTP for low-carbon menu options, controlling for differences in restaurant preferences and levels of environmental awareness.

Findings – Attitudinal and informational factors outweigh socio-demographic characteristics in explaining WTP. Environmental relevance, familiarity with the carbon footprint concept and perceived informativeness significantly increase consumers' WTP. Age, gender, education and income lose significance once these factors are controlled for. Interestingly, environmentally conscious individuals report lower perceived informativeness, suggesting that they may have more critical expectations regarding the adequacy and quality of carbon footprint information.

Originality/value – The study highlights the central role of cognitive and perceptual dimensions, rather than socio-demographic traits for low-carbon food options. It also reveals heterogeneity linked to restaurant preferences and identifies a paradoxical effect among environmentally conscious consumers, contributing nuanced evidence to the debate on the effectiveness of carbon footprint information in promoting sustainable consumption.

Keywords Carbon footprint, Sustainable food choices, Willingness to pay, Environmental labelling, Perceived informativeness, Restaurant preferences

Paper type Research article

1. Introduction

In order to prevent the global average surface temperature from rising more than 2°C above pre-industrial levels, it is vital that global greenhouse gas emissions are drastically reduced (UNFCCC, 2010). It is evident that the primary focus of mitigation efforts to date has been on reducing CO_2 emissions arising from the combustion of fossil fuels and the modification of land use. Despite the fact that these sources account for more than three-quarters of total

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greenhouse gas emissions (Edenhofer *et al.*, 2018), a strategy focused exclusively on reducing them may not be sufficient. To achieve the target of limiting the increase in global temperatures to 2°C, it may also be necessary to implement measures to reduce methane and nitrous oxide emissions from the agricultural sector (Hedenus *et al.*, 2014).

The demand for food has a substantial impact on overall emission levels, as the differences between diets with high and low environmental impact are significant (Stehfest *et al.*, 2009). Indeed, a key impediment to climate mitigation is the tendency of consumers to underestimate the environmental implications of their dietary choices (Camilleri *et al.*, 2019). In high-income countries, the production and consumption of animal-based foods – including meat, fish, dairy products, and eggs – are at levels that are incompatible with achieving greenhouse gas emission reduction targets (Bryngelsson *et al.*, 2016). Consequently, in this context, the selection of diverse protein sources assumes a pivotal role. Plant-based proteins are generally associated with lower emission levels than animal-based proteins (González *et al.*, 2011). Products derived from ruminants, both meat and dairy, generate significantly higher emissions than most other foods (Bryngelsson *et al.*, 2016). Consequently, large-scale changes in human diets have significant theoretical mitigation potential, as demonstrated by numerous studies (Risku-Norja *et al.*, 2009; Berners-Lee *et al.*, 2012; Saxe *et al.*, 2013; Westhoek *et al.*, 2014).

Reviews of global climate policies continue to show a marked gap between the level of ambition stated and actual implementation. This discrepancy is clear in the latest Synthesis Report on Nationally Determined Contributions (NDCs) published under the United Nations Framework Convention on Climate Change (UNFCCC). The NDC (2024) report, also referred to in 2025, highlights that current commitments are clearly insufficient to keep global temperature rise within the 1.5 °C limit set by the Paris Agreement. This situation is further aggravated by global structural factors, such as the world population exceeding 8 billion, the intensification of urbanization processes, and the increase in energy demand linked to consumption patterns and increasingly high-calorie diets (Fanzo and Davis, 2021). These dynamics continue to increase the use of fossil fuels, which are the main source of emissions. Although the European Union is showing a downward trend, the growth in emissions in Asia and other regions confirms the global scale of climate emergency. According to the United Nations, without immediate and decisive action, the world remains on an unsustainable climate trajectory (Soergel *et al.*, 2021).

In order to reduce diet-related emissions, it is essential to investigate the cognitive decision-making mechanisms associated with mental accounting (Hanel and Basil, 2023). One relevant area of application concerns consumer reactions to carbon footprint labels or, more generally, to environmental information associated with the production of a given good (Lohmann *et al.*, 2022).

Food systems are among the main contributors to global greenhouse gas emissions, and consumers' eating habits play a significant role in determining their environmental impact (Camilleri *et al.*, 2019; Garnett *et al.*, 2019; Rondoni and Grasso, 2021). Therefore, in this context, labels that provide information on the environmental impact of the production of certain foods are emerging as a key communication tool for guiding consumer behaviour towards more sustainable food choices (Vanclay *et al.*, 2011; Grankvist *et al.*, 2004). However, the actual effectiveness of such labels is often mediated by individual-level factors such as awareness, perceived informativeness, and willingness to pay (WTP) for sustainable dishes (De-Magistris and Gracia, 2016). Recent studies have shown that consumers often underestimate the emissions associated with food (Camilleri *et al.*, 2019) and that the design and framing of eco-labels (e.g. positive vs negative, numerical vs symbolic [1]) can significantly influence consumer decisions (Panzone *et al.*, 2021; Visschers *et al.*, 2016). Despite the growing number of studies in this field, little evidence is available for Mediterranean countries such as Italy, where cultural attitudes towards food, knowledge of sustainability, and economic variables may influence the perception and effectiveness of carbon labelling (Sgroi and Sciancalepore, 2022).

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To summarize, in the growing body of empirical research on environmental labelling and sustainable food choices, important gaps remain regarding the mechanisms through which carbon footprint information affects consumer awareness and economic behaviour in real consumption contexts such as restaurants. Previous studies have mainly focused on experimental settings or retail environments, while less attention has been devoted to understanding how perceived informativeness, environmental attitudes, and cultural food preferences jointly shape consumers' responses to low-carbon menu options.

Moreover, existing evidence suggests that WTP for sustainable food attributes is highly heterogeneous and driven more by psychological and informational factors than by traditional socio-demographic characteristics. At the same time, food choices are embedded in broader cultural patterns, including preferences for specific cuisines, which may further moderate the valuation of environmental attributes.

Against this background, the present study aims to contribute to the literature by jointly examining the role of perceived informativeness, environmental relevance, carbon footprint knowledge, and restaurant preferences in shaping sustainable food choices and WTP in an Italian consumer sample.

Accordingly, the study examines how consumers' awareness of the carbon footprint concept relates to the perceived informativeness and environmental relevance of carbon footprint information, investigates the factors shaping WTP premium for low-carbon dishes, and explores whether restaurant preferences and age influence this willingness.

The aim of this study is to determine whether and how environmental information on food products and restaurant menu items can promote more sustainable consumption patterns by enabling consumers to make informed choices in both retail and catering contexts, while encouraging restaurants and other catering service providers to offer environmentally friendly alternatives.

The following literature review situates the study within the relevant existing literature and is followed by the study's hypotheses. Subsequently, the methodology section describes the research design and the structure of the questionnaire, followed by the results and the discussion related to the three hypotheses. Finally, the paper concludes with managerial implications, limitations, and directions for future research.

2. Literature review

2.1 Perceived informativeness of carbon footprint information and environmentally driven food choices

A growing body of literature shows that carbon footprint information can influence consumers' food-related decisions when it is perceived as understandable, credible, and decision-relevant. Carbon footprint labels and menu disclosures are designed to reduce information asymmetries regarding the environmental attributes of food products, which are typically credence characteristics, and to support more sustainable choices at the point of purchase (or consumption).

Against this backdrop, the present study makes a distinct contribution by integrating three dimensions that existing research has largely examined in isolation: (1) perceived informativeness of carbon footprint information, (2) WTP for low-carbon dishes, and (3) the moderating role of culinary preferences and restaurant consumption patterns. While prior work has examined either the informational antecedents of sustainable food choice or consumers' WTP for carbon-labelled products, predominantly in retail contexts, no study has investigated these dimensions within a commercial restaurant setting, nor has the literature addressed how food culture variables (such as preferences for traditional versus non-traditional cuisines) condition consumers' responsiveness to carbon disclosure. In the context of carbon-labelled food, attitude toward low-carbon choices is jointly determined by the perceived informativeness of carbon footprint information and by the consumer's underlying environmental orientation. By situating this analysis within the Theory of Planned Behaviour

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(Ajzen, 1991) and drawing on dual-process and nudging frameworks, the present study aims to provide a theoretically grounded and empirically actionable account of the conditions under which carbon footprint menu information can effectively support sustainable food choices.

Previous studies (O'Keefe *et al.*, 2016; Bhaskaran *et al.*, 2006) have shown that clear and accessible carbon labelling can encourage consumers to make more sustainable choices, particularly among those who are already sensitive to environmental issues (Camilleri *et al.*, 2019; Vanclay *et al.*, 2011). At the same time, effectiveness depends on awareness, values, and the perceived credibility of the information (Grankvist *et al.*, 2004; Panzone *et al.*, 2021), as well as consumers' perceived informativeness and the cognitive accessibility of such information.

Several empirical studies document that consumers generally display a low baseline understanding of the carbon footprint concept, but that awareness and use increase significantly when the information is perceived as clear and meaningful. Cross-national evidence reveals a consistent pattern of low baseline comprehension, yet the behavioural implications diverge. For instance, Finnish consumers show substantial misunderstandings of the term "product carbon footprint," they yet report positive attitudes toward carbon labels once their meaning is clarified and indicate that such information can affect their purchasing decisions when other basic criteria (e.g. price and taste) are satisfied (Hartikainen *et al.*, 2014). German consumers, by contrast, systematically discount carbon information during product search relative to origin and price, yet this discount disappears among environmentally oriented segments (Lampert *et al.*, 2017). This divergence suggests that comprehension alone is insufficient. The activation of carbon footprint information depends on the interaction between label clarity and pre-existing environmental schemata, a boundary condition that remains underexplored in the experimental literature. More recent experimental and field evidence further supports the behavioral relevance of perceived informativeness. For instance, providing additional explanations about the meaning and functioning of carbon labels increases consumers' attention to such labels (e.g. scales and traffic-light systems) (Emberger-Klein and Menrad, 2018). These findings are consistent with dual-process accounts of persuasion (Petty and Cacioppo, 1986; Arvai, 2013), where intuitive label formats reduce the cognitive effort required to process carbon information, enabling even low-involvement consumers to integrate environmental cues into their choice heuristics. Conversely, numerical carbon metrics demand systematic processing and are more likely to influence decisions among highly motivated, environmentally concerned individuals. In line with this, a comparative review of 38 empirical studies concludes that consumer understanding and perceived clarity of carbon footprint labels are decisive conditions for their effectiveness and that redesigning labels using user-friendly visual cues substantially improves comprehension and behavioral impact (Rondoni and Grasso, 2021; Bresciani *et al.*, 2026). Beyond information design, individual environmental orientation plays a central role. Survey-based evidence from China indicates that perceived benefits of carbon-labeled products significantly increase purchase intention, while environmental awareness and perceived consumer effectiveness positively affect both acceptance and WTP for low-carbon products (Zhao *et al.*, 2018). Similar patterns emerge in other contexts: structural equation modeling applied to beverage consumption in Hong Kong shows that environmental awareness and pro-environmental attitudes are strong predictors of acceptance of carbon-labeled products, with demographic factors moderating the strength of these relationships (Wong *et al.*, 2020). Experimental auction studies in food markets also confirm that individuals with stronger sustainability-oriented lifestyles and higher concern for environmental issues exhibit systematically higher valuations for products carrying carbon footprint labels (Vecchio *et al.*, 2016).

Beyond label design, a growing body of research in the field of behavioural economics examines how default options, the use of social norms, and menu structure can steer consumers towards dishes with a lower environmental impact without restricting their freedom of choice (Thaler and Sunstein, 2008). Field experiments conducted in canteens and restaurants show

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that repositioning plant-based options as the default choice or highlighting low-carbon dishes on menus significantly increases selection rates regardless of consumers' pre-existing environmental attitudes (Gravert and Kurz, 2021; Bianchi *et al.*, 2018).

The restaurant environment represents a particularly relevant yet still under-explored context for research on carbon footprint disclosure. With regard to the literature on eye-tracking, it has been shown that carbon labels attract visual attention only in a minority of diners. A substantial proportion of consumers report that they would not consult such labels even if they were undecided between options. This suggests that attentional barriers may be the main constraint in restaurant settings (Prothero, 2019).

Taken together, literature suggests a two-stage mechanism. First, the perceived informativeness of carbon footprint information increases the likelihood that consumers incorporate environmental impact into their choice set, thereby raising the probability of selecting lower-impact dishes or products. Second, consumers who attach greater importance to the environmental consequences of their food choices and who actively rely on environmental information when available (e.g. on menus or labels) tend to display higher conceptual awareness and familiarity with the notion of carbon footprint itself. Accordingly, we hypothesize that:

H1. Perceived carbon footprint informativeness increases the likelihood that consumers will choose dishes with a lower environmental impact; furthermore, individuals who attribute greater importance to the environmental impact of their food choices and who report being influenced by environmental information on the menu are more likely to be aware of the concept of carbon footprint.

Finally, this first hypothesis was tested using an ordinal logistic regression model, in which the level of informativeness represented the dependent variable (Y). As reported in Table 2, several explanatory variables were included, such as age, gender, level of education, frequency of eating out, restaurant preferences, and willingness to pay.

2.2 Environmental concerns, carbon footprint awareness, and WTP for low-impact dishes

A substantial body of research in food economics and consumer behavior shows that WTP for environmentally sustainable food attributes is strongly conditioned by both consumers' environmental orientation and their familiarity with sustainability-related information, including carbon footprint indicators. Since environmental impact is a classic credence attribute, meaning that consumers' evaluation of low-carbon options depends not only on the availability of information, but also on their motivation and ability to interpret it.

As previously mentioned, within the TPB framework (Ajzen, 1991), WTP can be conceptualized as a behavioural expression of attitude strength: consumers who hold well-formed, accessible attitudes toward low-carbon food, also supported by familiarity with carbon metrics, are more likely to translate environmental preferences into price premiums, particularly when perceived behavioural control (e.g. the ability to identify lower-impact options) is high.

Experimental auction studies provide robust evidence that sustainability labels, including carbon footprint labels, generate positive price premiums primarily among consumers with stronger pro-environmental attitudes and sustainability-oriented lifestyles. For instance, young Italian consumers participating in incentive-compatible auctions exhibited significantly higher WTP for chocolate bars labeled with carbon footprint and other sustainability certifications, with environmental concern, food habits, and socio-demographic characteristics explaining a substantial share of bid heterogeneity (Vecchio and Annunziata, 2015). These findings confirm that WTP is not uniformly distributed across consumers but is concentrated among individuals who already consider sustainability as a relevant decision criterion.

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Survey-based evidence from emerging and developed markets further corroborates this relationship. In a large study conducted in Chengdu (China), perceived environmental benefits of carbon-labeled products significantly increased purchase intention, while perceived consumer effectiveness, occupation, and income positively affected WTP; moreover, consumers displaying higher acceptance of low-carbon products also reported higher awareness and understanding of carbon labelling schemes (Zhao *et al.*, 2018). Similarly, an analysis of a survey about beverages conducted among 1787 Chinese college students demonstrated a WTP a premium for carbon-labelled products. This willingness is driven by environmental awareness, perceptions, attitudes, and publicity, with attitudes playing a central mediating role.

Cross-country choice experiments reinforce the generalizability of these results. Using discrete choice models in Canada and Germany, Grebitus *et al.* (2016) show that consumers exhibit substantial heterogeneity in the discounts or premiums associated with products' carbon footprints, with environmentally concerned consumers systematically preferring products with lower emissions and accepting higher prices for such attributes across both food and non-food categories (Grebitus *et al.*, 2016). Likewise, conjoint analyses in European fresh produce markets reveal that carbon footprint information contributes positively to product valuation when combined with other ethical and sustainability attributes, particularly among consumers sensitive to environmental and social issues (Colantuoni *et al.*, 2016).

Importantly, the link between environmental concern and WTP is mediated by knowledge and familiarity with the carbon footprint concept. A comprehensive review of the literature highlights that individuals with higher environmental concern, higher education and income, and prior experience with eco-labeled products consistently display greater WTP for carbon footprint labelled foods, while poor understanding of carbon metrics limits the monetization of such information (Rondoni and Grasso, 2021). This mediation mechanism is consistent with dual-process theory: consumers who process carbon information systematically—rather than relying on peripheral cues—are better equipped to form stable, monetisable preferences for low-impact options. It also aligns with the behavioural economics literature on "as-if" rationality: even consumers who are environmentally motivated may fail to act on their preferences if the carbon footprint concept remains cognitively inaccessible (Cadario and Chandon, 2020).

Overall, existing evidence indicates that consumers who consider the environmental consequences of their food choices to be important and who are familiar with carbon footprint information are systematically more willing to financially support low-impact options. In line with this reasoning, we hypothesize that:

H2. Participants who consider the environmental impact of food choices to be important and who are familiar with the concept of carbon footprint will report a greater willingness to pay for a dish with a low environmental impact.

Considering the methodology, to test this hypothesis was used an Ordinary Least Squares (OLS) regression model, in which willingness to pay was the dependent variable (Y). The model included several explanatory variables, as reported in Table 3, in order to assess their impact on the dependent variable, including gender, age, restaurant preferences, and level of informativeness.

2.3 Restaurant preferences, food culture, and WTP for low-carbon dishes

Consumer evaluation of sustainability attributes in food choices is not only driven by environmental concern and information processing, but also by deeper food-related preferences and cultural consumption patterns. Literature increasingly shows that attitudes toward sustainable food options and WTP for low-carbon products vary systematically across consumer segments characterized by different dietary habits, culinary orientations, and preferences for specific food formats or cuisines.

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Within a TPB framework, these food culture variables can be interpreted as distal antecedents that shape the formation of attitudes toward low-carbon dishes and modulate subjective norms around food choice in social settings (Ajzen, 1991; Steg and Vlek, 2009).

Several empirical studies indicate that food consumption styles and lifestyles significantly shape the evaluation of sustainability labels. Experimental auction evidence demonstrates that food habits and consumption routines are among the most relevant determinants of WTP for carbon-labeled products, alongside socio-demographic factors and environmental attitudes (Vecchio and Annunziata, 2015). Consumers who are more open to product innovation, novel food experiences, and non-traditional food categories tend to display higher responsiveness to sustainability information and a greater propensity to reward environmentally friendly attributes with price premiums.

This segmentation effect is consistent with broader findings in consumer research showing that preferences for food origin, production methods, and ethical attributes are strongly heterogeneous across groups with different culinary orientations. Conjoint and discrete-choice studies in European food markets reveal that consumer evaluation of carbon footprint information interacts with other product attributes such as origin, production method, and ethical certification, generating distinct preference structures across market segments (Colantuoni *et al.*, 2016). Consumers who are less attached to traditional domestic food products and more inclined toward differentiated or "alternative" food categories tend to exhibit a stronger sensitivity to sustainability-related cues.

Moreover, research on the interaction between sustainability labels and other food claims suggests that consumers do not evaluate environmental information in isolation but rather integrate it into broader cognitive frames shaped by their food identities and habitual choices. Evidence from the United States shows that the evaluation of carbon footprint claims differs substantially across consumers who prioritize local and traditional food attributes versus those who are more receptive to other sustainability and ethical claims, such as fair trade or organic certification (Colantuoni *et al.*, 2016). These findings imply that consumers oriented toward more globalized or non-traditional food experiences may process environmental attributes differently from consumers whose preferences are anchored in conventional domestic cuisines.

Finally, the comprehensive review by Rondoni and Grasso (2021) highlights that familiarity with eco-labels, openness to sustainable food innovations, and prior experience with environmentally differentiated products systematically increase both acceptance and WTP for carbon footprint information, reinforcing the idea that sustainability evaluation is embedded in broader food consumption patterns rather than being a purely abstract environmental attitude. This insight connects to the nudging literature: consumers exposed to a wider variety of food contexts (including international cuisines) may be more accustomed to encountering sustainability claims and environmental cues on menus, reducing the novelty effect of carbon footprint disclosures and facilitating more deliberate processing of such information (Thaler and Sunstein, 2008; Gravert and Kurz, 2021).

Applied to the restaurant context, these insights suggest that individuals who frequently choose non-traditional cuisines (e.g. ethnic or sushi restaurants) may represent a consumer segment with higher exposure to food novelty, international food cultures, and sustainability discourse, potentially leading to a distinct evaluation of low-carbon menu options compared to consumers primarily oriented toward traditional Italian cuisine. Accordingly, we hypothesize that:

H3. Participants who report a preference for non-Italian restaurants (e.g. ethnic, sushi) show a significantly different willingness to pay for low-carbon dishes compared to those who primarily prefer Italian restaurants.

From a methodological perspective, as described in the following section, the Mann U Test – Wilcoxon test was employed to assess differences in willingness to pay both at the overall sample level, comparing Italian and non-Italian restaurants, and across different age groups.

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3. Methodology

In order to address the three hypotheses formulated in the previous paragraphs, descriptive and inferential statistical methodologies were employed to analyze the collected data. Data was collected using a questionnaire, which represents one of the most employed methodologies for data collection. The versatility of the instrument enables administration through both physical and digital mediums, facilitating the acquisition of quantitative data via structured surveys and qualitative data through interviews and exploratory research techniques (Slattery *et al.*, 2011). In this specific case, the questionnaire was administered in 2024 and was structured into three distinct sections using the most common social media channels.

The first section of the questionnaire was dedicated to respondent identification and included classic socio-demographic information necessary to profile the subjects: gender, age, education level, and income. The second section was based on food consumption habits, specifically investigating the types and frequency of respondents' use of venues and restaurants. Finally, the third section examined the relationship between environmental impact and factors considered most relevant by participants. This section tried to understand which factors most influence food choices, with particular attention to WTP related to the carbon footprint concept, focusing on knowledge and awareness of this concept in relation to chosen and consumed food products.

As previously stated, several statistical approaches were utilized to verify the formulated hypotheses. For H1, an Ordinary Least Squares regression model, which is a linear regression technique that minimizes the sum of squared residuals to estimate relationships between variables, was employed (for additional information, see Montgomery *et al.*, 2021). Moreover, an ordinal logistic regression model, a statistical method used to predict ordinal outcomes when the dependent variable has ordinal categories with natural ranking (for additional information, see Harrell, 2015), was used for H2. To assess model robustness, diagnostic tests for residual normality, heteroskedasticity, and the proportional odds assumption were performed, with results reported in the following sections. Finally, specific hypothesis tests were conducted and, considering the non-normality of the data, the Mann-Whitney U test Wilcoxon was chosen. It is a non-parametric statistical test used to compare two independent groups when data violates normal distribution assumptions (for additional information, see Wall Emerson, 2023).

3.1 Descriptive statistics

The sample included 1,067 valid answers (50 respondents were excluded due to missing data or absence of relevant information), with a 1:4 ratio of male to female respondents. The majority of respondents were young to middle-aged adults. The 25–34 age group had the greatest representation, with 452 individuals, followed by 290 in the 35–44 range, highlighting the centrality of adults in their prime working years. Younger participants (18–24) made up 128 responses, while only 19 of them were 18 years old, suggesting limited adolescent engagement in the survey.

Moreover, there was a notably high level of education: over 65% of participants held at least a bachelor's degree, with 407 having a master's and 46 a doctorate. High school graduates also represented a significant portion (354), while lower levels, such as middle school (37) and vocational qualifications (18), were less common. It is possible to affirm that this is consistent with the distribution channel used, indicating that the respondents were highly educated in comparison to the overall Italian population.

Subsequently, the data on net annual income reveals a marked concentration in lower brackets. In fact, about 65% earn less than €30000, with 279 respondents earning under €15000. Only a small minority exceed €60000, indicating a rather polarized financial distribution. Finally, the significant number of "prefer not to answer" responses (124) suggests hesitancy about sharing financial details, possibly due to privacy concerns.

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Regarding the data about eating habits, most participants (670) reported typically eating out 1–2 times per week, highlighting moderate engagement with dining outside the home. Additionally, a substantial portion (365 respondents) reported eating out less than once weekly. In contrast, dining out with higher frequency was rare: only 79 individuals reported doing so three or more times weekly, with just 8 reporting daily or near-daily restaurant visits. Considering this information, it is possible to determine that frequent eating out was not the norm for the sample.

Finally, the environmental impact of food choices appeared to be a key concern among respondents; in fact, a relevant majority (971 out of 1,067) considered it either "very important" (391) or "fairly important" (580), suggesting strong ecological awareness and a tendency toward more sustainable consumption habits. Only a small fraction did not consider this factor: 83 believed it to be of little importance, and 12 dismissed it altogether. From a descriptive point of view, the survey population was generally self-aware of the ecological consequences associated with their eating behaviour.

3.2 Variables

As described in the methodology section above, H1 was tested through an Ordinary Least Squares (OLS) regression model, while H2 was tested through an ordinal logistic regression model. Before presenting the results of these models, a brief description of the variables used in the analysis is provided.

The independent variables included in the regression models were: respondent's age, gender, the number of years required to obtain the reported educational qualification (used as a proxy for the highest level of education attained), the frequency with which the individual consumes meals at restaurants or other dining establishments, the importance attributed to environmental impact in food choices, the level of knowledge regarding the carbon footprint of food, the WTP for sustainable dishes, and the perceived informativeness of the topic (more details are presented in Table 1).

The sample analysed exhibits the following descriptive characteristics: an average age of 36 years, an average educational level equivalent to 16 years of study, an average annual income of €25000, and an average frequency of dining out equal to 1.26 times per week. Regarding dining preferences, 83 respondents (9.4%) prefer ethnic cuisine, 470 (53.2%) favour Italian restaurants, and 383 (43.4%) report mixed preferences. The average level of importance attributed to environmental aspects in food choices was 3.25 on a Likert scale, and 68% of the sample reported having knowledge of the carbon footprint of food, while the average WTP for dishes with a lower carbon footprint was 9.2% more compared to traditional dishes. Finally, concerning the level of informativeness, 496 respondents considered themselves well-informed, 91 not informed, and 348 partially informed on the topic.

4. Results

In the next sections, the results of the empirical investigation substantiate the pivotal function of information and attitudinal factors in delineating sustainable food choices, overriding socio-demographic characteristics.

4.1 Hypothesis 1

In the following table (Table 2), the ordinal logistic regression model is presented.

The ordinal logistic regression model reveals that gender, environmental relevance, and WTP are significantly related to perceived informativeness. Male respondents are more likely to report higher levels of informativeness. Surprisingly, greater concern for environmental impact is associated with lower perceived informativeness, suggesting that more environmentally aware individuals may hold higher standards for information adequacy. Moreover, individuals with higher WTP for sustainable dishes are less likely to perceive

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Table 1. Used variables

Variable	Type	Description
Age	Continuous	Respondent's age (years)
Gender	Binary categorical	Respondent's gender
Education level	Continuous	Number of years required for the obtained educational qualification
Income	Continuous	Annual income (euros)
Dining-out frequency	Continuous	Weekly frequency of eating at restaurants
Restaurant preference	Nominal categorical	Preference for Italian/Ethnic/Mixed restaurants
Environmental relevance	Ordinal	Importance of environmental impact in food choices (Likert scale)
Knowledge of carbon footprint	Binary categorical	Presence/absence of knowledge on food carbon footprint
Willingness to pay	Continuous	Additional percentage willing to pay for sustainable dishes
Perceived informativeness	Ordinal categorical	Self-reported level of informativeness on the topic

Table 2. Ordinal logistic regression models

Variable Y (Informativity YES, NO, SOME)	Estimate	Std. error	z-value	Pr(>z)	Significance
Age (in years)	0.0116	0.0074	1.581	0.114	
Gender (1 = male; 0 = female)	0.8323	0.3007	2.768	0.0057	**
Education level (years of study)	−0.0225	0.0296	−0.76	0.4471	
Annual income (in euros)	−0.0002	0.0049	−0.043	0.9654	
Dining-out frequency (per week)	−0.0836	0.0663	−1.261	0.2074	
Restaurant preference: Italian	−0.2043	0.2819	−0.725	0.4687	
Restaurant preference: Mixed	0.1477	0.2845	0.519	0.6038	
Environmental relevance (Scale)	−1.2303	0.1481	−8.305	<0.001	***
Knowledge of carbon footprint	0.0712	0.1692	0.421	0.6738	
Willingness to pay (Sustainable)	−5.3061	1.2716	−4.173	<0.001	***

Note(s): Model summary: Link function: logit; Observations: 843 (91 excluded due to missing data); Log-likelihood: −505.63; AIC: 1033.26

themselves as well-informed, possibly reflecting a demand for more transparency. Finally, other socio-demographic variables and restaurant preferences show no significant effects, and these elements can be linked with the psychological and attitudinal dimensions of perceived information adequacy.

4.2 Hypothesis 2

The model using OLS regression for H2 is presented in the following table (Table 3).

The results of the Ordinary Least Squares regression indicate that psychological and informational variables (environmental relevance, knowledge, and perceived informativeness) are the primary drivers of WTP, while socio-demographic and behavioural controls do not show statistically significant effects for sustainable dishes. These findings suggest that informational and attitudinal factors play a more critical role in shaping WTP than demographic characteristics [2] [3]. Concerning the data, the presence of heteroskedasticity was confirmed by a significant Breusch–Pagan test result ($p < 0.001$). Therefore, heteroskedasticity-consistent (HC1) standard errors were used to obtain robust inference.

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Table 3. Ordinary least squares regression models

Variable Y(WTP)	Estimate	Std. error	*t*-value	Pr(>*t*)	Significance
Intercept	0.0253	0.019	1.331	0.1836	
Age (in years)	−0.0003	0.0002	−1.638	0.1018	
Gender (1 = male; 0 = female)	−0.0001	0.008	−0.013	0.9896	
Education level (years of study)	−0.0008	0.0008	−1.041	0.2981	
Annual income (in euros)	0.0001	0.0001	0.779	0.4363	
Dining-out frequency (per week)	0.0013	0.0018	0.74	0.4593	
Restaurant preference: Italian	0.0089	0.0077	1.158	0.247	
Restaurant preference: Mixed	−0.0006	0.0078	−0.072	0.9427	
Environmental relevance (Scale)	0.0155	0.0038	4.119	<0.001	***
Knowledge of carbon footprint	0.0178	0.0046	3.876	<0.001	***
Perceived informativeness: Some	0.0118	0.0078	1.524	0.1279	
Perceived informativeness: High	0.0318	0.0081	3.934	<0.001	***

Note(s): Model summary: Residual standard error: 0.0634 (df = 922); *R*-squared: 0.1132; Adjusted *R*-squared: 0.1026; F-statistic: 10.69 (df = 11, 922); *p*-value (model): <2.2e−16

This approach corrects the estimated variance-covariance matrix of the coefficients without affecting OLS point estimates.

To summarize, the analysis highlights the central role of environmental attitudes and perceived information in shaping sustainable food choices. The OLS model shows that WTP for sustainable dishes is significantly influenced by environmental relevance, knowledge of carbon footprint, and perceived informativeness, rather than by socio-demographic factors. In contrast, the ordinal logistic model reveals that perceived informativeness is shaped by gender, environmental attitudes, and WTP, with environmentally conscious individuals and those more willing to pay reporting lower perceived informativeness. Together, the models suggest that psychological and informational dimensions outweigh demographic variables in promoting sustainable consumer behaviour.

4.3 Hypothesis 3

In order to understand the role of WTP for low-carbon footprint dishes in relation to consumer preferences for different types of restaurants, specific hypothesis tests were conducted. The sample was initially considered in its entirety, dividing respondents into two broad groups based on their primary restaurant category preference. This variable distinguishes between respondents who reported primarily frequenting Italian restaurants and those who prefer other kind/ethnic cuisine restaurants.

Subsequently, the same analysis was conducted by considering different age groups, divided as follows: two macro-groups were created, the first consisted of individuals aged up to 34 years, and the second consisted of individuals aged over 35. Although this does not represent a strict generational classification, it allows for a meaningful segmentation of the sample.

Table 4 below presents the results of the Wilcoxon tests related to WTP, considering both the entire sample and the subgroups defined by age and restaurant category.

As shown in the analysis, two tests yielded statistically significant results, while the other two did not reach statistical significance. Regarding WTP in the overall sample, a statistically significant difference was found when comparing individuals who primarily frequent Italian restaurants with those who prefer ethnic cuisine. The analysis, based on our data, indicates that WTP is higher among those who frequent Italian restaurants, suggesting that respondents are willing to pay a higher premium for low-carbon dishes in Italian restaurants compared to ethnic ones. The second statistically significant test, although with a *p*-value slightly above

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Table 4. Results of the wilcoxon tests

Mann U test – wilcoxon	W	*p*-value
Overall WTP Italian restaurant vs Foreign restaurant	W = 95,452	<0.001
Under 34 Italian vs Over 34 Italian	W = 27,486	0.97
Under 34 Foreign vs Over 34 Foreign	W = 23,409	0.06
Under 34 Overall vs Over 34 Overall	W = 105,071	0.39

5%, concerns ethnic restaurants segmented by age group. WTP is significantly higher among respondents under the age of 34. This indicates that, within the subset of the sample that primarily frequents ethnic cuisine restaurants, younger individuals show a greater WTP for low-carbon footprint dishes. The other two tests did not reach statistical significance, indicating no relevant differences in WTP among individuals who frequent Italian restaurants regardless of age, as well as in the overall analysis that includes both restaurant categories without age distinction.

Another highly relevant aspect concerning WTP is whether there is a difference in payment propensity between individuals who self-reported having prior knowledge about the carbon footprint of the dishes they consume and those who declared that they had no such information and acquired it solely through the questionnaire. It is important to note that for respondents who stated that they had no prior understanding of this concept, a brief description was provided, which is assumed to have been read by all participants. The sample was divided into two groups: 720 respondents reported being familiar with the notion of carbon footprint prior to the survey, while 346 indicated that they learned about it only during the questionnaire. What emerged from our data is a clear descriptive difference: individuals with prior knowledge reported an average WTP of +9.9%, compared to +7.4% among those without previous information.

5. Discussion

This study aimed to investigate the role of perceptions of carbon footprint informativeness, environmental concern, and restaurant preferences in shaping consumers' sustainable food choices and their WTP for low-carbon dishes. Overall, the results in this study provide empirical evidence suggesting that cognitive and attitudinal factors play a more relevant role than socio-demographic characteristics within the analysed sample, contributing to the literature on environmental information disclosure in food consumption contexts.

The results for H1 partly confirm the theoretical expectations derived from previous research: in line with the literature emphasizing the importance of clarity and accessibility of environmental information (Hartikainen *et al.*, 2014; Lampert *et al.*, 2017; Emberger-Klein and Menrad, 2018; Rondoni and Grasso, 2021), the results show that the perception of informativeness is significantly associated with individual attitudes towards sustainability and WTP for sustainable dishes.

However, contrary to the initial hypothesis, individuals in our sample attached greater importance to the environmental impact of food choices and those with a higher WTP were less likely to perceive themselves as well informed. This counterintuitive finding suggests that environmentally conscious consumers may take a more critical stance towards the quality and completeness of available information. Rather than reflecting lower objective knowledge, reduced perceived informativeness may indicate higher expectations in terms of transparency, methodological rigor, and comparability of carbon footprint data.

This interpretation is consistent with previous evidence showing that respondents with greater environmental commitment are more sensitive to ambiguities and inconsistencies in

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sustainability labels and may be wary of simplified indicators or poorly contextualized information (Rondoni and Grasso, 2021). In this sense, greater environmental concern appears to raise information standards, thereby reducing subjective satisfaction with existing disclosure practices. The significant gender effect (men reported a higher perception of informativeness) also echoes previous findings on gender differences in trust in technical or numerical information related to sustainability metrics. Taken together, these findings refine the two-stage mechanism suggested in the literature: while the perception of informativeness is crucial for the behavioural integration of environmental criteria, highly environmentally oriented individuals may simultaneously be the most demanding in terms of information quality, transparency, and scientific credibility.

The results for H2 provide empirical support for existing evidence. In our sample, WTP for low-carbon dishes is positively associated with environmental relevance, familiarity with the concept of carbon footprint, and perceived informativeness. These findings are consistent with previous experimental and survey-based studies that document how sustainability-oriented consumers tend to reward low-impact food options with higher prices (Vecchio and Annunziata, 2015; Zhao *et al.*, 2018; Wong *et al.*, 2020; Grebitus *et al.*, 2016).

As previously discussed, socio-demographic variables such as age, income, education, and gender do not show statistically significant associations once attitudinal and informational variables are included. In our sample, this pattern suggests that sustainable consumption is primarily associated with values, beliefs, and cognitive commitment rather than structural characteristics alone. Therefore, environmental concern and carbon footprint knowledge appear to be key conditions associated with the translation of sustainability preferences into willingness to pay.

Furthermore, additional descriptive evidence showing higher WTP among respondents with prior knowledge of carbon footprints (+9.9% versus +7.4%) further strengthens the argument that familiarity and conceptual understanding serve as catalysts for monetizing environmental attributes. In practical terms, based on our data, this implies that investments in consumer education and standardized communication frameworks can generate tangible market rewards for low-carbon food offerings.

The analysis of hypothesis H3 highlights the moderating role of food culture and restaurant preferences in shaping sustainability assessments. Contrary to the expectation that consumers who prefer ethnic or non-traditional cuisines would show a higher WTP for low-carbon dishes, the results derived from our sample indicate that people who mainly frequent Italian restaurants report a significantly higher overall WTP.

This finding suggests that attachment to traditional cuisine is not necessarily at odds with sustainability assessment and may instead coexist with a stronger perception of quality, authenticity, and food responsibility. Concerning our results, Italian cuisine is often associated with local sourcing, seasonality, and culinary heritage, attributes that may implicitly reinforce environmental values and justify higher prices for sustainable options.

At the same time, generational heterogeneity emerges within the ethnic restaurant segment: younger consumers show significantly higher WTP than their older counterparts. This pattern confirms previous research highlighting the interaction between novelty orientation, generational identity, and sustainability sensitivity. Moreover, younger consumers may combine openness to international cuisines with stricter environmental standards, exposure to digital information, and social signaling motives related to sustainable consumption.

Taken together, these findings indicate that restaurant type and cultural orientation do not exert uniform effects but rather interact with age-and lifestyle-related factors to shape consumers' evaluation of low-carbon dishes. Consequently, sustainability communication strategies should consider the heterogeneous profiles of consumers and avoid assuming that non-traditional food preferences automatically translate into a stronger environmental evaluation.

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6. Conclusion

Reducing greenhouse gas emissions from food systems is increasingly recognized as a necessary complement to mitigation strategies related to energy and land use. In this context, carbon footprint information on menus and food products has been proposed as a pragmatic tool to help consumers align their daily choices with climate goals. However, the effectiveness of such information depends on consumers perceiving it as informative, understanding the basic concept, and being willing to financially reward low-impact options. Addressing these issues in an Italian context, this study investigates the relationships between perceived informativeness, environmental relevance, carbon footprint knowledge, restaurant preferences, and WTP for low-carbon dishes. The results of this study suggest that, within the analysed sample, attitudinal and informational factors prevail over socio-demographic variables in determining sustainable consumption outcomes. First, perceived informativeness is not simply a function of education, income, or dietary habits, but is significantly associated with psychological dimensions. Notably, respondents who place greater importance on the environmental impact of food choices, along with those who have a greater WTP, report *lower* perceived informativeness. This apparent paradox suggests that environmentally engaged consumers may have higher standards for what counts as "adequate" information and may be more critical of carbon footprint information that appears simplified, insufficiently transparent, or difficult to compare. In other words, greater environmental concern may increase informational expectations rather than automatically increasing the perception of knowledge.

Second, the study provides evidence that, among the respondents surveyed, the WTP for low-carbon dishes is significantly higher among consumers who (1) consider environmental impact important, (2) are familiar with the concept of carbon footprint, and (3) consider themselves well-informed. Within the analysed sample, these findings support the idea that carbon footprint knowledge and perceived informational adequacy serve as enabling conditions that allow consumers to translate pro-environmental values into concrete economic behaviour. It is important to note that traditional socio-demographic predictors (age, gender, education, income) become insignificant once these cognitive and attitudinal variables are taken into account, reinforcing the idea that sustainability-oriented consumption is more strongly rooted in values, awareness, and information processing than in structural characteristics alone.

Thirdly, restaurant preference introduces significant segmentation concerning this data. Contrary to the expectation that consumers who prefer non-Italian cuisines would show a greater WTP for low-carbon dishes, the analysis indicates a significantly higher WTP among those who mainly frequent Italian restaurants. This suggests that preferences for traditional cuisine are not necessarily at odds with sustainability considerations, but, in our sample, may coexist with perceptions of quality, seasonality, authenticity, and responsible sourcing often associated with Italian culinary culture. At the same time, within the subgroup that prefers ethnic cuisines, younger participants show a higher WTP than older ones, indicating generational heterogeneity and the possibility that openness to new foods and sensitivity to sustainability interact in a non-linear way.

6.1 Policy and managerial implications

The results of this paper suggest that, from a management perspective, carbon footprint disclosure can support more sustainable consumption choices, but only when it is embedded within credible, transparent, and easily interpretable communication strategies. In this field, food service providers should not rely solely on simplified label designs, as consumers who are highly sensitive to environmental issues may still experience low satisfaction if information is perceived as insufficiently trustworthy or difficult to compare across options. Moreover, to address this, restaurants could combine intuitive visual cues that enhance attention and comprehension with accessible methodological explanations (e.g. short descriptions of how the footprint is calculated), thereby improving perceived credibility and reducing scepticism.

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It is relevant to analyse the results also from a policy perspective. In this paper, the results from our respondents highlight the importance of establishing standardized and comparable carbon footprint metrics in the food service sector. Standardization could reduce ambiguity across disclosure formats and increase comparability across restaurants, thereby strengthening the effectiveness of environmental information as a market signal. Finally, public authorities could support initiatives aimed at improving consumer environmental literacy, for example through guidelines or educational campaigns that provide brief and accessible explanations of carbon footprint indicators. These measures may help translate positive environmental attitudes into more informed and consistent low-carbon consumption behaviours.

6.2 Limitations and future research

The use of social media as the recruitment channel represents the primary limitation of this study, as it does not ensure full representativeness of the target population. In particular, it cannot be assumed that there is a perfect overlap between individuals who visit restaurants and those who are active social media users, thereby introducing a potential self-selection bias (Hollingshead *et al.*, 2022). Moreover, the sample is characterised by a predominance of female respondents and a relatively high level of education, which may further limit the generalisability of the findings.

In addition, the cross-sectional nature of the research design constitutes an additional limitation, as data were collected at a single point in time. This prevents the identification of causal relationships among the analysed variables and does not allow for the observation of potential temporal dynamics; consequently, the results should be interpreted as statistical associations rather than causal effects. Another limitation of the model is the violation of the proportional odds assumption (Brant test, $p < 0.05$), indicating that some explanatory variables do not have constant effects across outcome categories. Therefore, results should be interpreted as average effects across thresholds rather than uniform effects. Finally, knowledge and WTP may be jointly determined, and reverse causality cannot be excluded, suggesting a need for longitudinal or experimental future research designs.

Future research should test these mechanisms in real restaurant settings through field experiments and menu interventions and further explore how different disclosure formats influence both perceived informativeness and actual choices. Cross-country comparisons within the Mediterranean context would also be useful to understand how food culture moderates' responses to carbon footprint information. Moreover, from a methodological perspective, a partial proportional odds models or multinomial logistic regression should be employed.

In conclusion, this study contributes to demonstrating that knowledge of carbon footprint, perceived informativeness, and environmental relevance are key determinants of WTP for low-carbon dishes, while socio-demographic variables play a secondary role. By highlighting the critical stance of environmentally conscious consumers towards the adequacy of information, the results suggest that effective carbon footprint communication must focus not only on visibility, but also on credibility, interpretability, and standardization, which are essential conditions for carbon footprint disclosure to become a significant lever for climate-friendly food transitions.

Notes

1. Symbolic labels convey information through visual cues such as icons, colours, or ratings, offering simplified, intuitive evaluations rather than precise quantitative data.
2. For both models, correlation and collinearity were assessed using the VIF. No significant relationships were found that would warrant the exclusion of any variables from the previously developed models.
3. The model shows limited explanatory power ($R2 \approx 0.11$), indicating that a substantial proportion of variance in WPT remains unexplained.

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Further reading

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