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Exploring Italian consumer perceptions and acceptance of innovative foods and food technologies: insights from a national survey

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ABSTRACT

Innovative foods and food technologies face barriers to adoption in Italy, where food plays a central role in identity and social life. This study investigates Italian consumer responses to seven innovative food products and technologies using a consumer survey ($N = 2000$), stratified by age, gender, and geographical region. The survey included psychometric scales assessing food neophobia, food technology neophobia, disgust sensitivity, trust, sensation seeking, and health interest. It measured perceptions of risk, benefit, familiarity, and emotions associated with each product. Findings indicate that Italian consumers show high levels of food and technological neophobia, coupled with low trust and strong health concerns. Acceptability varied significantly across socio-demographic groups: higher education and income were associated with higher trust and sensation seeking and lower neophobia, whereas female and older respondents exhibited higher disgust sensitivity and greater resistance to innovation. Exploratory clustering identified two broad clusters of aggregated consumer profiles. One cluster was associated with younger age, higher educational attainment and household income, together with greater trust and sensation seeking, whereas the other was associated with older age, lower educational attainment and household income, together with greater food and food technology neophobia and disgust sensitivity. Emotional responses emerged as correlates of acceptability, with *curiosity* most positively and disgust most negatively. Products most aligned with product ideals were plant-based proteins, algae, and unusual fruits, while insect-based proteins and cultured meat faced the greatest barriers. These findings highlight the importance of reinforcing *trust* and *curiosity* while addressing *disgust* to promote sustainable Italian food innovation.

1. Introduction

1.1. The emergence of innovative foods and technologies in the global food system

Innovative foods and food technologies have emerged as an important component of the transition toward more sustainable, resilient, and diversified food systems. Within the European regulatory framework (Regulation (EU) 2015/2283), novel foods are defined as products that were not consumed to a significant degree in the European Union before 1997. More broadly, food innovations encompass both legally defined novel foods and emerging food products or technologies designed to improve nutritional quality, sustainability, or consumer experience.

Food innovation is driven by the need to diversify protein sources, improve resource efficiency, reduce environmental impacts, and meet changing consumer expectations. Innovative products may contribute to healthier diets while supporting more sustainable production systems through reduced resource use and greater supply chain resilience (Ferrari et al., 2022; Lee et al., 2025). In addition, food innovations often expand the diversity of flavors, textures, and consumption experiences available to consumers, creating opportunities for improved product appeal and market acceptance (Ferrari et al., 2022; Lee et al., 2025; Willett et al., 2019). Despite these potential benefits, consumer acceptance remains one of the major challenges limiting the successful adoption of innovative foods and technologies.

Together, the existing evidence suggests that consumer openness toward food innovation is unlikely to be explained by any single psychological trait. Rather, acceptance may reflect the interplay between positive motivations, such as health interest, and inhibitory psychological mechanisms, such as food neophobia and disgust sensitivity (Laureati et al., 2024; Siddiqui et al., 2022). This multidimensional and exploratory perspective highlights the need to consider psychological,

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emotional, cultural, and sociodemographic dimensions simultaneously when investigating consumer acceptance of innovative foods.

1.2. Complexity of novel food consumer acceptability

Despite their potential nutritional, environmental, and sensory benefits, consumer acceptance of innovative foods and technologies remains a major challenge. Decisions to adopt these products are shaped by a complex interplay of psychological, sociodemographic, and cultural factors rather than by product characteristics alone (Guiné et al., 2020). Perceived risks and benefits, ethical concerns, trust in science and regulatory institutions, and attitudes toward sustainability all contribute to consumers' evaluations. Among these factors, trust consistently emerges as a key determinant, with higher confidence in scientific and governmental institutions being associated with lower perceived risk and greater openness toward food innovation (Macready et al., 2020; Siegrist, 2008).

Individual psychological traits further influence consumer responses. Food neophobia, food technology neophobia, disgust sensitivity, sensation seeking, and health orientation influence how consumers perceive unfamiliar foods and evaluate information about emerging food technologies. Together, these traits shape willingness to adopt innovative foods by determining whether novelty is perceived as an opportunity or a source of uncertainty (Laureati et al., 2024).

Consumer responses are also influenced by sociodemographic characteristics such as gender, age, education, income, and regional background. Higher education and income have generally been associated with more positive attitudes toward food innovation, whereas older consumers tend to express greater caution (Asioli et al., 2017; Carrillo & Tárrega, 2025; Verbeke, 2015). Gender differences have also been reported, with women often showing greater concern for health and food safety, while men may exhibit greater willingness to engage with unconventional food products (Berthold et al., 2025; Menozzi et al., 2017). Importantly, the magnitude and direction of sociodemographic differences may vary across innovative food categories, as consumer responses can depend on product familiarity, perceived risk, sensory expectations, and the characteristics of the innovation itself. Beyond these individual characteristics, food choices are embedded within cultural identities and social practices. As a symbolic element of everyday life, food connects individuals to tradition, community, and shared values. Consequently, cultural beliefs, emotional attachment to traditional foods, and identity-related meanings can influence the acceptance of innovative food products, sometimes outweighing purely nutritional or technological considerations (Roudsari et al., 2017; Galli, 2024; Ismail et al., 2025).

1.3. Gaps in current research and the Italian context

Despite the growing literature on consumer acceptance of innovative foods, important research gaps remain. Most studies have examined individual psychological constructs, specific food technologies, or single product categories in isolation, limiting a broader understanding of how psychological, cultural, and sociodemographic factors are associated with consumer responses (Laureati et al., 2024; Mosikyan et al., 2024; Wendt & Weinrich, 2023). Furthermore, many studies rely on convenience samples, university populations, or geographically restricted cohorts, which may limit the generalizability of their findings (Guidetti et al., 2018; Schnettler et al., 2017).

These limitations are also evident in Italy, although the existing literature extends beyond insect-based and plant-based foods to include cultured meat and algae-based products (Laureati et al., 2024; Liu et al., 2023; Mancini & Antonioli, 2022; Moruzzo et al., 2021). However, these studies have generally examined individual innovative food categories or specific dimensions of consumer acceptance, making it difficult to compare psychological, emotional, perceptual, and sociodemographic responses across different forms of food innovation within the same population. Moreover, while novel or unfamiliar fruits have received attention within the broader novel food literature, evidence specifically examining their acceptance alongside multiple other innovative food categories among Italian consumers remains limited. Recent reviews and cross-country studies have consequently highlighted the need for larger, nationally representative, and country-specific investigations capable of integrating multiple determinants of consumer acceptability (Asioli et al., 2017; Laureati et al., 2024; Tzompa-Sosa et al., 2023). The present study addresses this gap by evaluating seven heterogeneous innovative food categories using a common analytical framework in a nationally stratified sample of 2000 Italian consumers, allowing direct comparison of familiarity, perceived innovation, healthiness, risk, emotional responses, acceptability, and psychological profiles across products.

Italy provides a relevant context because food occupies a central role in cultural identity and everyday life. Italians devote among the highest amounts of time to meals in Europe, while most consumers associate food with cultural heritage, personal identity, and social relationships (CENSIS, 2024; Liverani, 2024). Consequently, food innovations are introduced into a context where culinary traditions are deeply embedded, likely shaping consumer responses differently than in other cultural settings.

Recent reviews have emphasized that future research should move beyond individual psychological traits and examine how country-specific cultural, social, and economic contexts are associated with consumer acceptance of innovative foods (Laureati et al., 2024). Italy therefore represents not only a challenging market for food innovation, but also an ideal setting to investigate how cultural identity, trust, emotions, and sociodemographic characteristics are associated with consumer acceptability (Zidan et al., 2025).

Food innovation encompasses a broad range of emerging products, ingredients, and technologies, including fermented plant-based beverages, algae-based foods, 3D-printed foods, and novel or unfamiliar fruits, among others. Previous research has examined innovative food categories individually, highlighting the relevance of familiarity, perceived healthiness, risk, sensory expectations, and technological novelty to consumer acceptance (Dolgopolova et al., 2015; Giacalone & Jaeger, 2023; Moss et al., 2026; Siddiqui et al., 2022). The present study focuses on a selected set of innovative food categories reflecting different dimensions of food innovation.

1.4. Research aims

Taken together, these considerations highlight the need for a comprehensive, multidimensional, and nationally representative assessment of how Italian consumers perceive and evaluate food innovation. Developed within the broader OnFOODS project, this study addresses this gap through a stratified national survey integrating psychological, cultural, emotional, and sociodemographic factors associated with consumer acceptability.

Specifically, the study addresses three research questions: (i) Which psychological, sociodemographic and cultural factors are associated with consumer acceptance or rejection of innovative foods and technologies in Italy? (ii) How are these factors reflected in distinct consumer profiles? and (iii) What implications do these findings have for the development, communication, and market adoption of innovative and sustainable food products?

Consumer responses were collected for seven innovative food categories spanning different levels of familiarity, together with a hypothetical ideal innovative food designed to capture consumer expectations regarding product characteristics, emotions, sustainability, and consumption contexts. By integrating psychometric profiling, emotional responses, product evaluations, and sociodemographic characteristics within the same nationally representative survey, this framework enables a multidimensional assessment of the factors shaping Italian consumers' attitudes toward food innovation and the

identification of distinct consumer profiles.

By combining a nationally representative sample with a multidimensional assessment of consumer perceptions, this study provides one of the most comprehensive investigations of food innovation acceptance conducted in Italy to date. The findings offer evidence to support future research, product development, and communication strategies aimed at facilitating the adoption of innovative foods in Italy and other culturally tradition-oriented contexts.

2. Material and methodology

2.1. Consumer sample and recruitment

A nationally representative sample of 2000 Italian adults (51.1% female; mean age 47.8 ± 17.7 years) was recruited through a professional online panel provider. Quota sampling was based on Italian National Institute of Statistics (ISTAT, 2024) data and stratified by gender, five age groups (18 to 29, 30 to 41, 42 to 53, 54 to 64, and 65 to 75), and five macro-regions (Northwest, Northeast, Centre, South, and Islands). Quota details are reported in Supplementary Table S1.

Eligible participants were 18 to 75 years of age and residing in Italy. All participants provided informed digital consent before completing the survey, received financial compensation, and could withdraw at any time. The study was approved by the Research Ethics Committee of the University of Trento (Approval No. 2023-23ESA).

Exclusion criteria included response times outside the expected range, inconsistent reporting of region of residence, and failure to correctly answer two randomly placed attention-check (trap) questions.

2.2. Online survey

The survey was developed in Italian to ensure linguistic clarity and cultural appropriateness. Before the main data collection, the questionnaire was pilot tested with 143 participants to assess item comprehension, clarity, completion time, and internal consistency (Cronbach's α). Minor revisions were implemented based on participant feedback. The final questionnaire was then administered through the Alchemer web-based survey platform (Alchemer LLC, Louisville, CO, USA) during the first quarter of 2025. Data collection was conducted over an eight-week period in eight successive recruitment waves, with the predefined demographic quotas monitored and maintained throughout the recruitment process.

2.2.1. Overview of questionnaire structure

The final questionnaire, provided as Supplementary File S1 (original Italian version administered to participants) and Supplementary File S2 (English translation), comprised 170 items organized into five sections, summarized in Table 1. The first collected informed consent, screening information, and basic sociodemographic data. The second assessed perceptions of seven innovative food categories, including acceptability, emotions, perceived novelty, health benefits and risks, familiarity, technology awareness, and intended consumption contexts, with product presentation order randomized. The third focused on a hypothetical ideal innovative food to explore consumer expectations regarding product attributes, emotions, sustainability, and consumption. The fourth included validated psychometric scales assessing food and food technology neophobia, general trust, health interest, sensation seeking, and disgust sensitivity. The final section collected additional demographic and behavioral information.

2.2.2. Innovative foods and technologies questionnaire part and response

Seven innovative food categories were selected through expert consensus among researchers in food innovation, sensory science, and consumer behavior to represent different levels of familiarity and perceived innovation among Italian consumers (Table 2). The selected categories ranged from relatively familiar products already available on the Italian market, such as plant-based protein products and fruits with unusual appearances, to less familiar or emerging products, including cultured meat and 3D printed foods. Intermediate levels of familiarity were represented by algae-based products and insect-based products.

The innovative food categories investigated in the present study encompass products and technologies with different regulatory and authorization statuses under the Novel Food framework (Regulation (EU) 2015/2283). Therefore, the term innovative food categories is used throughout this manuscript to emphasize their perceived novelty from a consumer perspective rather than their specific legal classification.

Each food category was evaluated using the same questionnaire structure. Participants rated expected acceptability, perceived novelty,

Table 1
Conceptual framework of the questionnaire, including assessment domains, measurement approaches, and response formats.

	Domain	Construct	Measurement approach	Response format	Application
1	Product acceptability	Expected acceptability	Hedonic evaluation	9-point scale	Seven innovative food categories
2	Emotional response	Food-evoked emotions	CATA (24 emotions)	Multiple responses	Seven categories + ideal novel food
3	Perceived novelty	Product novelty	Single item	9-point scale	Seven categories + ideal novel food
4	Health perception	Health benefits	Single item	9-point scale	Seven categories + ideal novel food
5	Risk perception	Health risks	Single item	9-point scale	Seven categories + ideal novel food
6	Familiarity	Previous experience	Familiarity scale	Five categories	Seven categories
7	Technology awareness	Knowledge of the technology	Information statement + awareness question	Yes/No	Seven categories
8	Consumption context	Appropriateness of consumption situations	Multiple-choice question	Multiple responses	Seven categories + ideal novel food
9	Sustainability perception	Sustainability dimensions	Three-item scale	9-point scale	Ideal novel food
10	Desired attributes	Product characteristics	Multiple-choice question	Multiple responses	Ideal novel food
11	Food technology neophobia	Food technology neophobia (FTNS)	13-item scale	9-point Likert	Psychometric section
12	Food neophobia	Food neophobia (FNS)	10-item scale	9-point Likert	Psychometric section
13	General health interest	General health interest (GHI)	8-item scale	9-point Likert	Psychometric section
14	Sensation seeking	Sensation seeking (BSSS)	8-item scale	9-point Likert	Psychometric section
15	Disgust sensitivity	Disgust sensitivity (DS-SF)	8-item scale	9-point Likert	Psychometric section
16	Consumer trust	Consumer general trust (CGT)	10-item scale	9-point scale	Psychometric section
17	Consumer profile	Sociodemographic and behavioral variables	Structured questionnaire	Multiple formats	Final section

Table 2
Food categories, information statements, and supporting references used for the development of the experimental stimuli.

Food category	Food category description	Food category benefits knowledge	Reference
3D_print	Products made using 3D food printing technologies.	Additive manufacturing technologies allowing customized foods while reducing waste and improving sustainability.	Pereira et al. (2021)
Insect_p	Products containing insect flour (e.g., pasta, biscuits, or bread made with cricket or mealworm flour).	Products containing 5–20% insect flour with high protein content and potential sustainability advantages.	Arp and Pasini (2024)
Cult_meat	Products produced from cultivated meat.	Cell-based meat production with potential environmental and animal welfare benefits.	Wali et al. (2024)
Ferm_bev	Fermented plant-based beverages containing different microorganisms, such as kombucha (fermented tea) or tepache (fermented fruit beverage).	Natural fermented beverages produced through beneficial microorganisms, resulting in probiotic drinks with novel sensory characteristics.	Žvirdauskienė et al. (2025)
Algae_prod	Algae-based products (e.g., spirulina pasta).	Edible algae products rich in proteins, vitamins, minerals, antioxidants, and omega-3 fatty acids.	Wu et al. (2023)
Unus_fruit	Fruits with unusual appearance (e.g., yellow or red kiwifruit, yellow watermelon, red-fleshed apples).	Non-GMO varieties developed through conventional breeding, potentially enriched in antioxidants and carotenoids.	Catalán et al. (2022); Montefiori et al. (2005)
Veg_Prot	Plant-based proteins and alternatives to animal-derived products.	Products designed to mimic animal-derived foods using exclusively plant ingredients.	Short et al. (2021)

perceived health benefits, perceived health risks, familiarity, technology awareness, emotional responses, and intended consumption contexts. Acceptability, perceived novelty, health benefits, and health risks were assessed as direct single-item evaluations using nine-point structured response scales (1 = not at all; 9 = very much). Familiarity was measured using the five-point scale proposed by Tuorila et al. (2001), ranging from "I do not recognize it" to "I regularly eat it". After reading a brief information statement describing the potential benefits of each category (Table 2), participants indicated whether they were already aware of this information (yes/no). Product presentation order was randomized to minimize order effects.

Emotional responses were assessed using a 24-item Check All That Apply (CATA) questionnaire, adapted from the circumplex models described by Pedroza and Herrell (2022) and Jaeger et al. (2018), and culturally adapted into Italian following Ferrarini et al. (2010). The original emotion lexicon was expanded by adding five emotions (*Powerful, Desirous, Unique, Youthful,* and *Suspicious*) to ensure a more balanced representation of the arousal valence circumplex model and to capture emotional responses considered particularly relevant for innovative food categories. The selection of these additional emotions was informed by previous literature (Giacalone & Jaeger, 2023; Spinelli & Monteleone, 2022), back-translation, expert consensus among bilingual researchers, focus group discussions, and findings from the pilot study (N = 143). The final Italian emotion lexicon was established through this iterative adaptation process, and subsequently used in the main survey (Supplementary Fig. S1).

Participants also evaluated a hypothetical ideal innovative food using a comparable framework. They rated its desired level of novelty, health benefits, acceptable health risk, and the importance of environmental, economic, and socio-cultural sustainability. Additional questions explored the emotions the product should evoke, preferred product attributes, preferred food category, and intended consumption contexts.

2.2.3. Psychometric scales questionnaire part

Validated psychometric instruments were used to assess psychological traits associated with consumer responses to innovative foods. To facilitate direct comparisons across constructs and ensure a consistent response format throughout the questionnaire, all psychometric instruments were administered using harmonized nine-point response scales, regardless of their original response formats. This standardization increased response granularity and measurement sensitivity while minimizing differences attributable solely to scale format (Preston & Colman, 2000). Internal consistency was first assessed during the pilot study (N = 143), yielding satisfactory Cronbach's α values for all instruments. Reliability was subsequently re-evaluated in the full study sample (N = 2000), and these values are reported below.

2.2.3.1. General consumer trust scale (CGT). Trust has consistently been identified as a key determinant of consumer acceptance of emerging food technologies. Consumer trust in institutions, science, and regulatory authorities was assessed using the OECD General Trust Questionnaire (OECD, 2024), translated and back-translated into Italian. The instrument showed high internal consistency (Cronbach's α = 0.89). Although no formal psychometric validation of the Italian version has yet been published, the translated instrument demonstrated satisfactory internal consistency in the present sample.

2.2.3.2. General health interest (GHI). Health interest was assessed using the eight-item General Health Interest subscale of the Health and Taste Attitude Scale (HTAS) (Roininen & Tuorila, 1999), validated in Italian by Saba et al. (2019). Items were rated on nine-point agreement scales, and internal consistency was good (Cronbach's α = 0.84). This construct was included because perceived health benefits are among the primary drivers of innovative food acceptance.

2.2.3.3. Brief sensation seeking scale (BSSS). Higher sensation seeking has been associated with greater openness to novel experiences, including innovative foods. Sensation seeking was measured using the eight-item Brief Sensation Seeking Scale (Hoyle et al., 2002), translated into Italian by Primi et al. (2011). Responses were collected using nine-point agreement scales. Internal consistency was acceptable (Cronbach's α = 0.79).

2.2.3.4. Food technology neophobia scale (FTNS). Food technology neophobia was assessed using the 13-item Food Technology Neophobia Scale (Cox & Evans, 2008), adapted into Italian by Verneau et al. (2014). This scale specifically captures aversion toward food technologies, complementing the broader construct of food neophobia. Items were rated on nine-point agreement scales. Internal consistency was high (Cronbach's α = 0.86).

2.2.3.5. Food neophobia scale (FNS). Food neophobia represents a stable predisposition to avoid unfamiliar foods and is one of the strongest predictors of novel food acceptance. Food neophobia was measured using the ten-item Food Neophobia Scale (Pliner & Hobden, 1992), validated in Italian by Laureati et al. (2018). Responses were recorded on nine-point agreement scales. Internal consistency was good (Cronbach's α = 0.82).

2.2.3.6. Short form disgust sensitivity scale (DS-SF). Disgust sensitivity is particularly relevant when evaluating unconventional food sources, such as insects or algae. Disgust sensitivity was assessed using the eight-item short version of the Disgust Sensitivity Scale (Inbar et al., 2009), validated in Italian by Spinelli et al. (2018). The instrument included agreement and disgust intensity items, both rated on nine-point scales. Internal consistency was high (Cronbach's $\alpha = 0.81$).

2.2.4. Demographic and socioeconomic characteristics

The final section of the questionnaire collected demographic and socioeconomic information, including gender, age, region of residence, monthly household income, educational attainment, household size, presence of minors, employment status, and grocery shopping frequency. Italian administrative regions were grouped into five macro-regions (Northwest, Northeast, Centre, South, and Islands) for subsequent analyses.

2.3. Data processing and analysis

All analyses were performed using XLSTAT 2023.3.0 (Addinsoft, New York, USA). Descriptive statistics (means, standard deviations, and frequency distributions) were used to characterize the sample and summarize responses. Psychometric scale scores were calculated by summing item scores after reverse coding when required. For descriptive purposes, participants were classified into low, medium, and high groups according to psychometric score tertiles (Table 4).

To facilitate descriptive comparisons between consumers exhibiting predominantly positive or predominantly negative attitudes toward food innovation, participants were additionally classified as *likers* or *dislikers*. Because the objective was to characterize consumers' overall disposition toward food innovation rather than acceptance of individual product categories, the classification was based on the mean acceptability across all seven innovative food categories. Participants were first classified according to their mean acceptability score across the seven innovative food categories, with mean scores >5 indicating an initial liker classification and scores ≤ 5 an initial disliker classification. Recognizing that different consumer segmentation strategies may serve different analytical purposes, this classification was adopted exclusively as a descriptive grouping approach to facilitate interpretation of consumer response patterns. Previous studies have applied different approaches to consumer segmentation based on liking or acceptability, and no single universally accepted or superior segmentation method has been established for this purpose (Khatun et al., 2025; Park et al., 2026). The initial classification was then checked against a 4-of-7 consistency criterion to assess whether it reflected the participant's predominant acceptance pattern across the seven categories. Participants were classified as *likers* if they had scores >5 in at least four of the seven categories and as *dislikers* if they had scores ≤ 5 in at least four categories. When the mean-based classification and the predominant response pattern were discordant, the 4-of-7 criterion determined the final classification. For the 48 participants (2.4%) with a mean score exactly equal to 5.0, the 4-of-7 criterion was required to determine the final classification. This threshold corresponds to the minimum simple majority of the seven evaluations and was selected as a transparent and easily interpretable decision rule for descriptive grouping. Accordingly, the liker/disliker grouping was intended solely as a descriptive segmentation to facilitate comparisons between contrasting consumer response patterns and should not be interpreted as a definitive classification of consumer acceptance.

Associations between continuous variables were assessed using Pearson's correlation coefficients. Group differences were evaluated using one-way ANOVA, while categorical variables were compared using chi-square tests. When significant, adjusted standardized residuals ($|z| > 1.96$) were examined to identify the categories contributing to observed associations. Ordinal familiarity scores were compared using the Friedman test followed by pairwise Wilcoxon signed rank tests with Holm correction for multiple comparisons. Statistical significance was set at $p < 0.05$.

Multivariate relationships among perceived familiarity, acceptability, perceived novelty, perceived health benefits, perceived health risks, and emotional responses were explored using Principal Component Analysis (PCA), Principal Coordinate Analysis (PCoA), Multiple Correspondence Analysis (MCA), and Correspondence Analysis (CA), according to the type of variables analysed. Hierarchical Clustering on Principal Components (HCPC) using Ward's method was applied, when appropriate, to explore similarities among the profiles represented in the corresponding multivariate analyses. For the exploratory analyses of sociodemographic and regional characteristics, HCPC was conducted on aggregated profiles defined according to each analytical dimension: 20 profiles for the sociodemographic analysis, comprising 18 sociodemographic profiles and two overall liker/disliker profiles, and 22 profiles for the regional analysis, comprising the 20 Italian administrative regions and the same two overall liker/disliker profiles. In both analyses, the six psychometric variables were used as active variables (Supplementary Fig. S2). For interpretation, the liker and disliker profiles were treated as predefined aggregated profiles within the clustering solution rather than as independently derived clusters. The resulting clusters were interpreted as clusters of aggregated consumer profiles rather than as individual level consumer segments.

Emotional responses were analysed using the Check All That Apply (CATA) module implemented in XLSTAT (Addinsoft, Paris, France). As part of the standard CATA workflow, tetrachoric correlation coefficients were computed among the binary emotion attributes, whereas biserial correlation coefficients were computed between each binary emotion attribute and the corresponding hedonic acceptability score. These coefficients were used as descriptive measures within the exploratory multivariate framework supporting the Principal Coordinate Analysis (PCoA), following the analytical approach described by Meyners et al. (2013). The biserial correlation coefficients were used exclusively for descriptive interpretation of the relationships between emotional attributes and liking within the exploratory CATA framework.

CATA responses were initially analysed using Cochran's Q test followed by Sheskin's multiple pairwise comparisons. Penalty analysis (XLSTAT, 2025) was then performed by combining acceptability scores with CATA responses to estimate the influence of emotion terms and product attributes on overall consumer acceptability. For each attribute, a 2×2 contingency table was generated comparing its presence or absence in the hypothetical ideal innovative food (rows) with its presence or absence in the evaluated products (columns). Cells, denoted as [ideal product, evaluated product] (1 = present; 0 = absent), contained the mean acceptability score and the corresponding proportion of observations. Differences in mean acceptability between the corresponding contingency table cells were evaluated using Student's *t*-tests ($\alpha = 0.05$), as implemented in XLSTAT. According to the hierarchical decision rules implemented in XLSTAT, attributes meeting the corresponding decision criteria were classified as must-have, nice-to-have, does not influence, does not harm, or must-not-have. Specifically, must-have attributes were selected for the hypothetical ideal innovative food and showed significantly higher acceptability when present ([1,1] > [1,0]). Nice-to-have attributes were not selected for the ideal product but showed significantly higher acceptability when present ([0,1] > [0,0]). Must-not-have attributes were absent from the ideal product and significantly reduced acceptability when present ([0,1] < [0,0]). Does not influence attributes were selected for the ideal product but showed comparable acceptability whether present or absent ([1,1] ≈ [1,0]), whereas does not harm attributes were not selected for the ideal product and showed comparable acceptability whether present or absent ([0,1] ≈ [0,0]).

3. Results

3.1. Sociodemographic and psychometric profile of the sample

The study included 2000 Italian consumers, balanced across gender, five age groups, and five macro-regions, achieving national representativeness. Significant regional differences were observed for education, household income, household size, employment status, environmental sustainability importance, general trust, food neophobia, and disgust sensitivity (Table 3).

Overall, participants were predominantly characterized by medium to high educational attainment, low to medium household income (€1000–3000/month), omnivorous dietary habits, high concern for sustainability, small households without children, and full- or part-time employment. The sample distribution closely reflected recent ISTAT demographic estimates.

Mean scores for General Health Interest, Food Technology Neophobia, Food Neophobia, and Disgust Sensitivity were above the midpoint of their respective scales, whereas General Trust and Sensation Seeking were below (Table 4).

Significant sociodemographic differences were observed across most psychometric variables. Women showed lower general trust and higher levels of health interest, food neophobia, and disgust sensitivity than men, whereas men showed higher sensation seeking than women and Food Technology Neophobia did not differ by gender. Older participants exhibited higher health interest, lower sensation seeking, and greater food technology neophobia, while disgust sensitivity was highest among the youngest and oldest age groups (Table 5).

Higher education and household income were associated with greater general trust and sensation seeking, together with lower levels of food and food technology neophobia. Regional differences were smaller but significant, with respondents from Southern Italy exhibiting lower food neophobia but higher disgust sensitivity than those from other macro-regions. Food Technology Neophobia remained consistently high across all regions.

3.2. Familiarity, acceptability, perceived innovation, healthiness and risk of innovative food categories

Plant-based protein products were the most familiar innovative food category (Fig. 1), whereas 3D-printed foods were the least familiar, with 50.5% of respondents reporting that they had never heard of them. Low familiarity was also observed for insect-based products, cultured meat, and fermented beverages, for which most respondents either reported knowing the products but never having tasted them (60.3%, 57.0%, and 29.5%, respectively) or having never heard of them (32.5%, 33.7%, and 49.9%, respectively). Intermediate familiarity levels were observed for algae-based products and fruits with unusual appearances, with 33.4% and 45.8% of respondents, respectively, reporting having consumed these products at least once. In contrast, plant-based protein products were the only category that had been consumed at least once by the majority of respondents (69.0%), and was also the only category consumed occasionally or regularly by more than one-third of the sample. The distribution of familiarity responses differed significantly across the seven innovative food categories based on the underlying five-point familiarity scores (Friedman test, $p < 0.05$), with pairwise differences assessed using Wilcoxon signed-rank tests with Holm correction. The percentages presented in Fig. 1 are descriptive and represent the distribution of familiarity responses within each category.

Mean acceptability, perceived novelty, perceived healthiness, and perceived health risk scores are presented in Fig. 2. Overall acceptability ranged from moderate to low, varying from 2.65 for insect-based products to 5.73 for unusually shaped fruits, with plant-based protein products also receiving relatively high acceptability. All product categories, except insect-based products, were perceived as moderately to highly innovative, with mean scores above the midpoint of the scale. Insect based products, cultured meat, and 3D printed foods were perceived as the least healthy. In contrast, insect-based products, cultured meat, fermented plant-based beverages, and 3D printed foods were associated with the highest perceived health risks. However, none of the products reached a mean perceived health risk score above the midpoint of the scale.

The ordination in Fig. 3 provides an exploratory multivariate representation of the relationships among the evaluated variables and food categories, offering a complementary perspective on the overall consumer response patterns. Familiarity was positively associated with acceptability and perceived healthiness, whereas perceived health risk was positioned in the opposite direction, indicating a negative association with these variables. The PCA supported these findings by revealing a clear multivariate separation between familiar, well accepted products and those perceived as riskier and less acceptable. Plant-based proteins, unusually shaped fruits, and algae-based products were positioned closer to familiarity, perceived healthiness, and acceptability, whereas insect-based products and cultured meat were primarily associated with perceived health risk and lower consumer acceptance.

3.3. Emotional responses toward innovative food categories

Fig. 4 illustrates the relationships between emotional responses and consumer acceptability across the innovative food categories. Positive emotions, particularly *curious* and *surprised*, were positively associated with acceptability, whereas indifferent, uninspired, worried, annoyed, and disgusted showed negative associations. Among all emotions, *curious* exhibited the strongest positive biserial correlation coefficient with liking ($r = 0.529$), whereas *disgust* exhibited the strongest negative biserial correlation coefficient ($r = -0.576$). The complete biserial correlation coefficient matrix is provided in Supplementary Table S2.

3.4. Consumer expectations toward the ideal innovative product

Table 6 summarizes the preferred product attributes, food categories, and consumption motivations for the ideal innovative food, together with significant differences according to gender, age, and region.

Taste, price, nutritional value, and sustainability were the most frequently selected product attributes, each receiving more than 900 citations. Dietary properties, aroma, and texture showed intermediate frequencies, whereas appearance was the least frequently selected attribute. Fruits, meat products, vegetables, composite dishes, legumes, nuts, seeds, and cereals were among the most frequently selected product categories, while eggs, condiments, insects, additives, and fats were selected least frequently. Women more frequently selected health, sustainability, and dietary attributes as desirable characteristics of the ideal innovative food, whereas men more frequently selected sensory characteristics and meat-based or insect-based protein sources. Age was also associated with a broader range of attributes, including sustainability, aroma, texture, several desired food categories, and motivations for consumption such as health, sustainability, regular consumption, and convenience. In comparison, geographical differences were more limited, with only price, appearance, and convenience showing marginally significant associations with macro-region ($p < 0.10$).

Mean scores for the desired health benefits and acceptable health risks of the ideal innovative food are presented in Table 7. Across the sample, participants expressed high expectations regarding health benefits and low tolerance for health risks. Younger participants and women assigned greater importance to health benefits and reported lower acceptable risk levels, whereas no significant regional differences were observed.

The PCoA (Fig. 5) identified two main product groupings. One cluster included the ideal innovative food together with plant-based protein products, algae-based products, and fruits with unusual appearances, whereas the second grouped insect-based products, cultured meat, 3D-printed foods, and fermented plant-based beverages, reflecting

Table 3
Contingency table of categorical variable distributions across the five Italian macro-regions and corresponding chi-square test *p*-values. Frequencies in bold indicate significant deviations identified through chi-square post-hoc residual analysis. Superscript signs denote whether the deviation was positive or negative. *P*-values in bold indicate significance at least at 10% of confidence.

Category	Variable	Total (*N* = 2000)	Centre (*N* = 334)	Island (*N* = 256)	NorthE (*N* = 396)	NorthW (*N* = 602)	South (*N* = 412)	*P*-value
	None	0.2%	0	0	0	0	**3**$^{+}$	
	Elementary sch.	0.6%	1	1	5	4	0	
Education level	Middle sch.	6.6%	18	22	48	28	**16**$^{-}$	**<0.001**
	High sch.	54.6%	181	**164**$^{+}$	**304**$^{-}$	225	217	
	BSc. or MSc.	31.7%	116	**54**$^{-}$	203	115	145	
	PhD.	6.5%	18	15	42	24	31	
	<1.000€	9.3%	25	**44**$^{+}$	45	28	44	
	1.000–2.000€	32.0%	101	**102**$^{+}$	**172-**	116	148	
	2.000–3.000€	26.4%	**108**$^{+}$	**50-**	157	105	107	
Monthly income	3.000–4.000€	18.7%	56	**32-**	**128**$^{+}$	**95**$^{+}$	**62**$^{-}$	**<0.001**
	4.000–5.000€	7.2%	29	12	49	25	28	
	5.000–6.000€	3.5%	10	5	**29**$^{+}$	14	11	
	>6.000€	3.2%	**5-**	11	22	13	12	
	Flexitarian	10.6%	**25**$^{-}$	**38**$^{+}$	72	44	**32**$^{-}$	
	Omnivore	82.4%	284	**196**$^{-}$	497	321	350	
Diet	Pescatarian	2.4%	7	7	9	11	14	0.238
	Vegan	1.1%	2	3	8	5	3	
	Vegetarian	2.5%	12	8	11	11	8	
	Other	1.1%	4	4	5	4	5	
	Low	10.1%	36	24	60	43	38	
Envir. sust. Importance	Medium	25.4%	87	45	159	111	**106**$^{-}$	**0.098**
	High	64.6%	211	187	384	241	**268**$^{+}$	
	Low	10.8%	36	31	64	43	42	
Social. sust. Importance	Medium	32.0%	103	69	196	**146**$^{+}$	125	0.337
	High	57.3%	195	156	343	**206**$^{-}$	245	
	Low	9.5%	36	26	**44**$^{-}$	44	40	
Econo. sust. Importance	Medium	30.1%	93	70	**202**$^{+}$	124	113	0.197
	High	60.4%	205	160	357	227	259	
	one	13.5%	39	29	**101**+	**67**+	**33-**	
	two	30.4%	**99**+	76	183	135	115	
Household size	three	29.2%	113	73	173	104	121	**<0.001**
	four	21.0%	69	58	114	**66-**	**113**+	
	more than four	6.0%	14	20	32	23	30	
Minors (<18) in household	Yes	31.4%	104	**66**$^{-}$	**208**$^{+}$	120	129	0.145
	No	68.7%	230	**190**$^{+}$	**394**$^{-}$	276	283	
	Full-time	44.7%	152	**87**$^{-}$	**299**$^{+}$	**196**+	**160**$^{-}$	
	Homemaker	7.4%	27	**27**$^{+}$	**26**$^{-}$	24	**44**$^{+}$	
	Part-time	15.9%	48	30	105	64	70	
Work status	Retired	15.8%	48	45	92	70	61	**<0.001**
	Student	5.5%	**33**$^{+}$	19	27	**8**$^{-}$	22	
	Unemployed	8.5%	22	**36**$^{+}$	41	25	**46**$^{+}$	
	Other	2.3%	4	**12**$^{+}$	12	9	9	
	Always	44.0%	136	102	272	189	180	
	Never	0.5%	0	3	2	2	3	
Grocery shopping freq.	Occasionally	8.5%	28	25	48	28	41	0.363
	Often	45.3%	162	120	266	172	185	
	Rarely	1.8%	8	6	14	5	3	
	Low	*	**92**$^{-}$	89	195	144	148	
General trust (CGT)	Medium	*	**137**$^{+}$	95	202	**115**$^{-}$	147	**0.021**
	High	*	105	72	206	136	117	
	Low	*	125	**71**$^{-}$	216	143	140	
Health interest (GHI)	Medium	*	114	110	229	154	156	0.305
	High	*	95	75	156	100	116	
	Low	*	**245**$^{-}$	205	466	322	320	
Sensation-seeking (BSSS)	Medium	*	62	40	106	57	73	0.183
	High	*	**27**$^{+}$	11	31	16	19	
	Low	*	23	24	46	20	26	
Food tech. Neophobia (FTNS)	Medium	*	33	29	81	51	52	0.421
	High	*	278	203	476	324	334	
	Low	*	52	40	88	**37-**	64	
Food neophobia (FNS)	Medium	*	180	137	305	220	229	**0.087**
	High	*	102	79	210	138	119	
	Low	*	117	71	212	129	**112**$^{-}$	
Disgust sensitivity (DSS)	Medium	*	150	116	267	174	183	**0.036**
	High	*	67	69	**124**$^{-}$	92	**117**$^{+}$	

* Grouping into terciles derived from quantitative data.

Table 4
Raw scores of the six psychometric scales administered to 2000 Italian participants, with terciles dividing low, medium, and high levels of each variable. Higher values indicate, respectively, a higher level of general trust, greater interest in healthiness, higher propensity to seek new sensations, stronger aversion to new food technologies, stronger aversion to new foods, and higher propensity to feel disgusted.

						Tercile limit scores		
Psychometric scale	Min	Middle scale	Max	Mean	SD	Lower	Middle	Upper
General trust	10	50	90	47,4	13,7	10–42	43–54	55–90
Health interest	8	40	72	47,4	10,8	10–42	43–52	53–72
Sensation seeking	8	40	72	32,5	12,8	8–26	27–38	39–72
Food-tech neophobia	13	65	117	69,1	18,2	13–62	63–76	77–117
Food neophobia	10	50	90	51,0	9,18	10–48	49–54	55–90
Disgust sensitivity	8	40	72	46,4	10,6	10–43	44–52	53–72

Table 5
Means of the scores from six psychometric tests applied to 2000 participants in relation to sociodemographic characteristics and participants' perceptions of the seven innovative foods and technologies evaluated. Different letters within each column indicate significantly different means at the 5% level according to the Holm-Bonferroni post-hoc ANOVA test for the respective category.

		Mean score in each psychometric scale					
Category	Variable	General trust	Health interest	Sensation seeking	F. tech neophobia	Food neophobia	Disgust sensitivity
	Female	46.8 b	48.9 a	30.2 b	69.7 a	51.5 a	48 a
Gender	**Male**	48.0 a	46.0 b	34.7 a	68.5 a	50.5 b	44.8 b
Pr > F (Model)		***0.045***	***<0.001***	***<0.001***	*0.147*	***0.026***	***<0.001***
	Young adults (19–29)	50 a	43.3 d	38.1 a	61.8 c	50.6 a	45.1 b
	Early midlife (30–41)	47.8 ab	45.8 c	35.9 b	67.0 b	50.7 a	45.6 b
	Midlife (42–53)	44.9 c	47.3 bc	31.4 c	70.3 a	51.1 a	46.3 ab
	Late midlife (54–64)	47.1 bc	48.4 b	31.0 c	71.2 a	50.6 a	47.1 ab
	Older adults (65–75)	48.6 ab	51.6 a	27.1 d	73.1 a	51.9 a	47.8 a
Age							
Pr > F (Model)		***<0.001***	***<0.001***	***<0.001***	***<0.001***	*0.242*	***0.003***
	<1.000€	42.0 c	46.4 a	27.9 c	71.4 a	53.6 a	46.5 a
	1.000–2.000€	45.8 b	47.1 a	31.8 b	70.5 a	51.3 b	46.2 a
	2.000–3.000€	48.2 a	47.3 a	32.8 b	69.4 a	50.6 b	46.3 a
	3.000–4.000€	49.7 a	48.0 a	32.6 b	68.4 ab	50.2 b	46.8 a
	>4.000€	50.2 a	48.3 a	36.4 a	64.9 b	50.4 b	46.5 a
Monthly income							
Pr > F (Model)		***<0.001***	*0.256*	***<0.001***	***<0.001***	***<0.001***	*0.935*
	Up to Middle school	45.5 b	45.9 a	28.1 c	71.7 a	52.4 a	46.7 a
	High school	45.8 b	47.3 a	31.7 b	70.7 a	51.4 a	46.2 a
	Bachelor or Master	50.4 a	47.8 a	34.6 a	66.2 b	50.2 b	46.7 a
	Doctorate	48.4 ab	49.1 a	33.8 ab	66.7 b	50.1 b	46.5 a
Education							
Pr > F (Model)		***<0.001***	*0.074*	***<0.001***	***<0.001***	***0.009***	*0.784*
	Centre	48.1 a	47.7 a	33.8 a	69.0 a	51.0 a	45.7 bc
	Island	46.9 a	47.9 a	31.7 ab	68.7 a	50.9 ab	47.7 ab
	NorthE	48.0 a	47.0 a	33.0 ab	68.3 a	51.0 a	45.4 c
	NorthW	47.0 a	46.8 a	31.1 b	69.5 a	51.9 a	46.2 bc
	South	46.6 a	48.1 a	32.5 ab	70.3 a	50.2 b	47.9 a
Macro-region							
Pr > F (Model)		*0.394*	*0.327*	***0.037***	*0.546*	***0.049***	***0.001***
Innovative foods and technologies acceptability	***Dislikers***	44.5 b	46.7 b	30.6 b	73.7 a	51.9 a	46.5 a
	Likers	54.1 a	49.0 a	36.7 a	58.5 b	49.0 b	46.1 a
Pr > F (Model)		***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	*0.411*

distinct emotional response profiles.

Emotions clustered around *happy*, reflecting positive emotional valence, including safe, desirous, and enthusiastic, were primarily associated with plant-based products, unusually shaped fruits and the ideal product. Conversely, emotions clustered around *unhappy*, reflecting negative emotional valence, including aggressive, disgusted, and tense, were associated with the remaining innovative food categories.

Penalty analysis (Fig. 6) classified emotion terms according to their contribution to overall consumer acceptability as “must-have”, “nice-to-have”, “does not influence”, “does not harm”, or “must-not-have”. Among the evaluated emotions, *Curious* was the only emotion classified as “must-have”, indicating that it was consistently associated with higher acceptability and was also selected for the hypothetical ideal innovative food. *Surprised* was classified as “nice-to-have”, as it was associated with significantly higher acceptability despite not being selected for the ideal product. In contrast, *Indifferent, Uninspired, Worried, Disgusted*, and *Annoyed* were classified as “must-not-have”, reflecting a significant reduction in acceptability when elicited and their absence from the emotional profile of the hypothetical ideal innovative food. *Alert, Bland*, and *Overwhelmed* were classified as “does not harm”, indicating that although these emotions were not desired for the ideal product, their presence did not significantly reduce consumer acceptability. No emotion met the criteria for the “does not influence” category. The remaining emotion terms did not satisfy the hierarchical decision criteria implemented and were therefore not assigned to any penalty analysis category.

Participants considered all sustainability dimensions to be important when describing an ideal innovative food product, with all mean scores above 6 on the 9-point scale. However, significant differences were observed among the three sustainability dimensions (ANOVA, $p = 0.001$). Environmental sustainability received the highest importance ratings (6.73 ± 2.16), whereas economic (6.56 ± 2.04) and

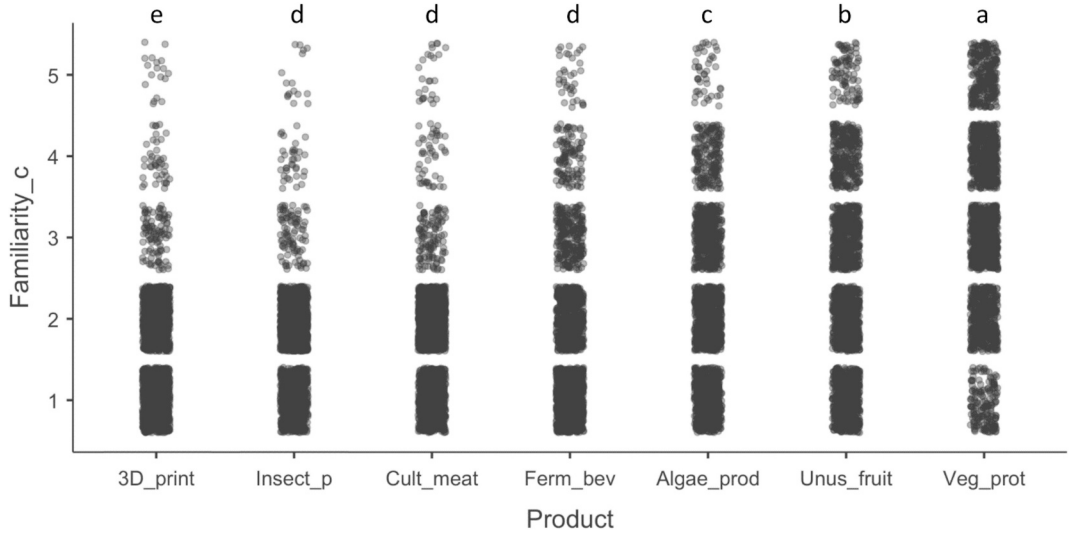


Fig. 1. Consumer familiarity with the evaluated food products (n = 2000). Jittered points represent individual responses. Different letters indicate significant differences among products according to the Friedman test followed by pairwise Wilcoxon signed rank tests with Holm correction ($p < 0.05$).

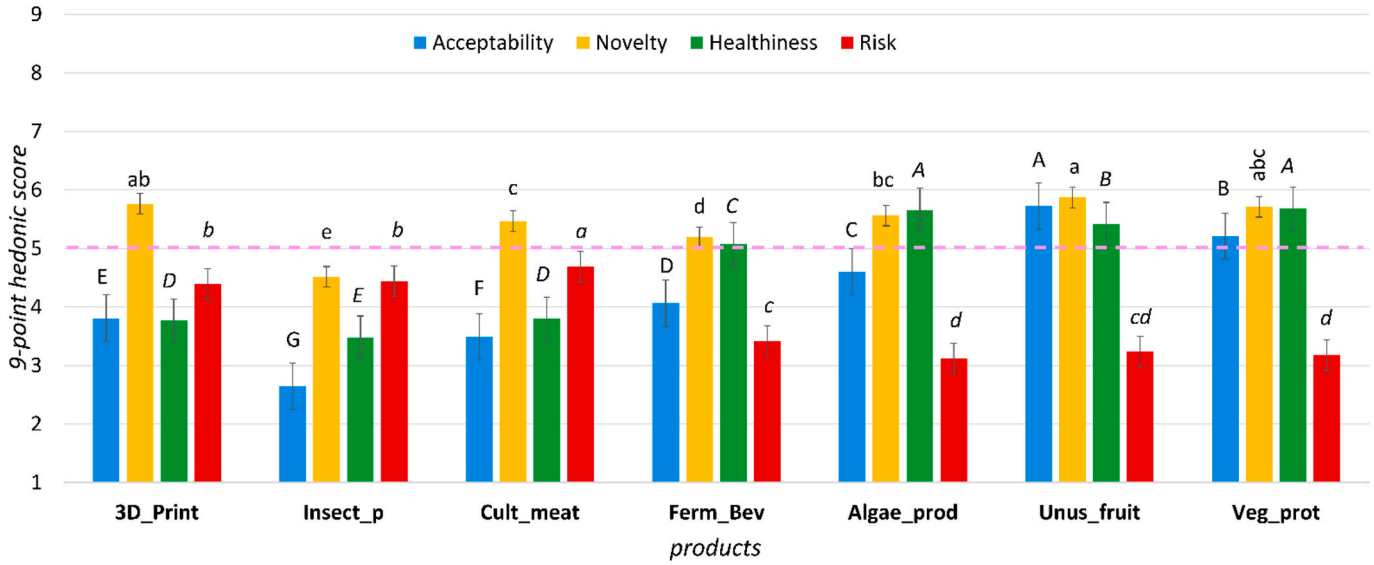


Fig. 2. Mean scores for the seven innovative food categories in terms of overall acceptability, perceived novelty, perceived healthiness, and perceived health risk. The dotted line represents the midpoint of the scale. Different letters indicate significant differences among food categories within the same variable according to Tukey's post-hoc test ($p < 0.05$). Uppercase letters, lowercase letters, uppercase italic letters, and lowercase italic letters correspond to acceptability, novelty, healthiness, and perceived risk, respectively.

sociocultural sustainability (6.44 ± 2.13) showed significantly lower scores and did not differ from each other.

3.5. *Exploratory clustering of aggregated consumer profiles*

To complement the descriptive classification of participants as *likers* (30.4%) and *dislikers* (69.6%), a sensitivity analysis was conducted by removing the 4 of 7 consistency criterion and classifying participants solely according to their mean acceptability score. Under this alternative classification, 674 participants (33.7%) were classified as *likers* and 1326 (66.3%) as *dislikers*. Overall, 198 participants (9.9%) changed classification relative to the original procedure, including 132 changes from liker to disliker and 66 from disliker to liker. Importantly, the pattern of statistically significant differences in the ANOVA and Tukey HSD comparisons (Table 5) remained unchanged. The original classification was retained for the subsequent analyses because the 4 of 7 criterion was intended to ensure that the classification reflected the predominant direction of responses across the seven food categories.

Cluster 1a in Fig. 7A comprised aggregated profiles predominantly associated with younger age groups, higher educational attainment, and higher household income, together with higher General Trust and Sensation Seeking scores. This cluster also included the predefined aggregated liker profile. Cluster 2a comprised aggregated profiles predominantly associated with older age groups, lower educational attainment, and lower household income, together with higher Food Neophobia, Food Technology Neophobia, and Disgust Sensitivity scores. This cluster also included the predefined aggregated disliker profile.

The presence of the predefined liker and disliker profiles within these clusters is a descriptive feature of the exploratory solution and should not be interpreted as evidence that the HCPC independently identified liker and disliker segments. Within the psychometric space, the liker profile was positioned toward higher General Trust, General Health

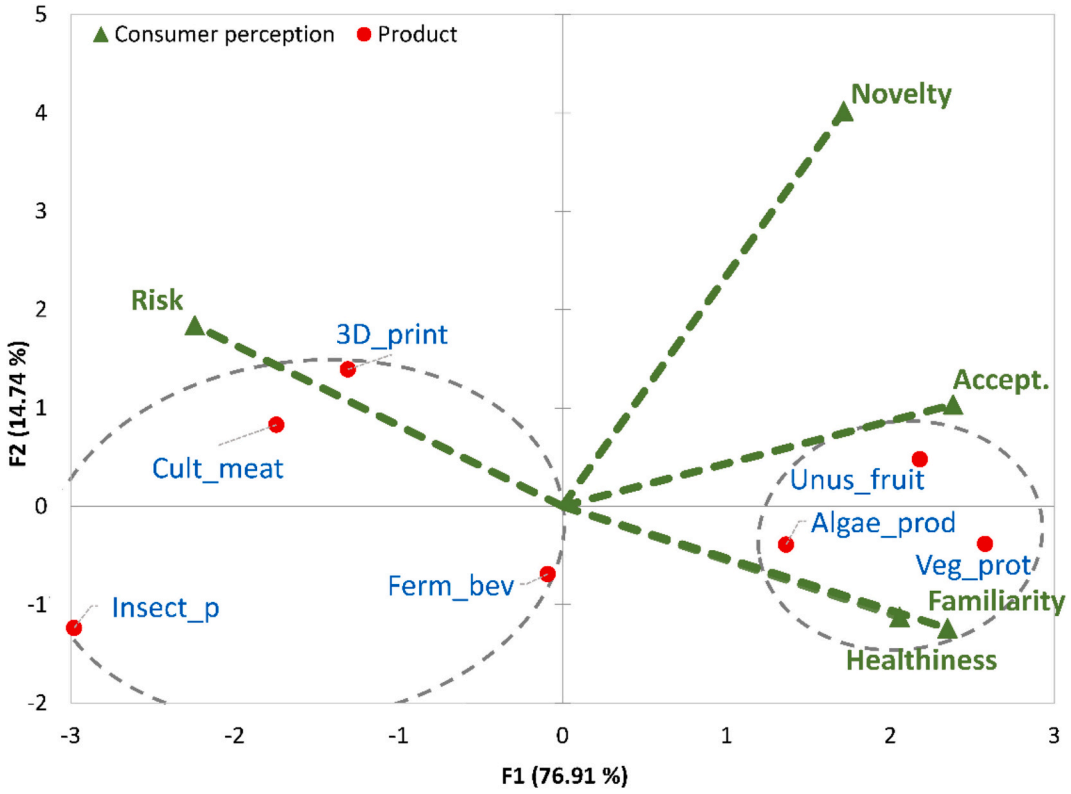


Fig. 3. Principal component analysis (PCA) biplot illustrating relationships between the seven evaluated products and the variables familiarity, acceptability, perceived novelty, perceived healthiness, and perceived health risk. Grey clusters represent the hierarchical cluster analysis (HCA) performed on the seven products. The ordination is presented as an exploratory descriptive representation of the multivariate relationships among the variables included in the analysis.

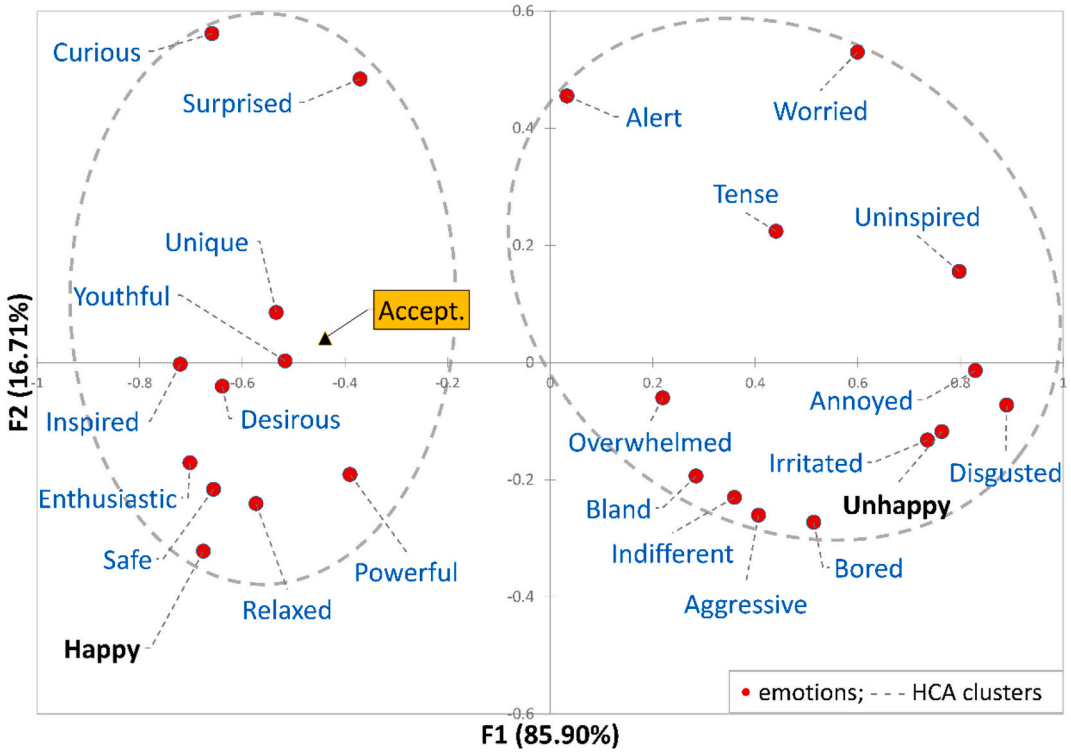


Fig. 4. Principal Coordinate Analysis (PCoA) illustrating the spatial relationships among the emotions evoked by the seven innovative food categories and overall consumer acceptability. Overall consumer acceptability represents the mean acceptability score across the seven innovative food categories for each participant. Grey clusters represent the Hierarchical Cluster Analysis (HCA) of the 24 emotion terms. The ordination is presented as an exploratory descriptive representation of the multivariate relationships among the variables included in the analysis.

Table 6
Total citation frequencies reported by survey participants for categorical variables related to questions about the ideal innovative product, and corresponding chi-square significance values across macro-region, age group, and gender stratifications. (n.s.: not statistically significant).

Ideal novel food	Attributes	Total freq. (*N* = 2000)	Signif. Chi-square* M-region	Age	Gender
Desired key aspects	Taste	1384	n.s.	n.s.	n.s.
	Price	1159	***p* < 0,1**	n.s.	n.s.
	Nutritional properties	1010	n.s.	n.s.	n.s.
	Sustainability	992	n.s.	**p < 0,05**	**p < 0,05**
	Functional properties	734	n.s.	n.s.	**p < 0,1**
	Aroma	682	n.s.	**p < 0,1**	n.s.
	Special dietary properties	566	n.s.	n.s.	**p < 0,05**
	Texture	535	n.s.	**p < 0,05**	n.s.
	Appearance	406	**p < 0,1**	n.s.	n.s.
	Other	76	n.s.	**p < 0,05**	n.s.
Desired food category	Fruit and derived products	601	n.s.	**p < 0,05**	n.s.
	Meat and meat products	590	n.s.	**p < 0,05**	**p < 0,05**
	Fresh vegetables and derived products	568	n.s.	**p < 0,05**	**p < 0,05**
	Composite food preparations	565	n.s.	n.s.	n.s.
	Legumes, seeds, and nuts and derived products	550	n.s.	n.s.	**p < 0,05**
	Cereals and derived products	501	n.s.	n.s.	n.s.
	Milk and dairy products	480	n.s.	**p < 0,1**	**p < 0,05**
	Savory snacks	459	n.s.	**p < 0,05**	n.s.
	Roots, tubers, bulbs	431	n.s.	**p < 0,05**	**p < 0,05**
	Food supplements and related products	404	n.s.	n.s.	n.s.
	Foods intended for particular nutritional uses	391	n.s.	n.s.	n.s.
	Fish, crustaceans, and derived products	331	n.s.	**p < 0,05**	n.s.
	Drinks	324	n.s.	n.s.	n.s.
	Sweets and sugars	321	n.s.	n.s.	**p < 0,1**
	Eggs and egg products	272	n.s.	n.s.	n.s.
	Spices and condiments	233	n.s.	n.s.	n.s.
	Insects, larvae, and derived products	207	n.s.	**p < 0,05**	**p < 0,05**
	Food additives	191	n.s.	**p < 0,1**	n.s.
	Fat and oils	173	n.s.	n.s.	n.s.
	Other	122	n.s.	**p < 0,05**	n.s.
Why/When it would be consumed	I feel like trying something new	918	n.s.	n.s.	**p < 0,05**
	I want something healthy	638	n.s.	**p < 0,05**	n.s.
	To shift my diet in a more sustainable direction	610	n.s.	**p < 0,05**	**p < 0,05**
	As a regular part of my diet	510	n.s.	**p < 0,05**	**p < 0,05**
	I want something I like	415	n.s.	n.s.	n.s.
	As part of easy and convenient meals	349	**p < 0,1**	**p < 0,05**	n.s.
	To set a good example for those around me	202	n.s.	**p < 0,05**	n.s.
	Other	128	n.s.	**p < 0,05**	n.s.
	To post on social media	53	n.s.	n.s.	n.s.

Table 7
Mean scores on a 9-point hedonic scale for the desired health benefit and acceptable risk of the ideal innovative food, stratified by age group, gender, and Italian macro-region. Different letters within each column indicate significant differences at the 0.05 level according to the Holm–Bonferroni post-hoc ANOVA test.

Participants class	Desired health benefit	Acceptable risk
18–29	7,21 a	2,95 a
30–41	7,01 ab	3,01 a
42–53	6,82 ab	2,86 a
54–64	6,84 ab	2,86 a
65–75	6,64 b	2,61 a
Pr > F(Model)	0,007	0,143
Female	6,98 a	2,71 b
Male	6,79 b	3,01 a
Pr > F(Model)	0,036	0,003
Centre	6,79 a	2,89 a
Island	6,81 a	3,11 a
NorthE	6,97 a	2,83 a
NorthW	6,71 a	2,71 a
South	7,05 a	2,88 a
Pr > F(Model)	0,105	0,316

Interest, and Sensation Seeking and lower Food Neophobia and Food Technology Neophobia, whereas the disliker profile was positioned toward higher Disgust Sensitivity and Health Interest.

The PCA ordination further showed that Food Neophobia and Food Technology Neophobia were negatively associated with General Trust and Sensation Seeking, whereas Disgust Sensitivity was positively associated with General Health Interest.

The regional projection (Fig. 7B) indicated that Umbria, Molise, and Valle d'Aosta were positioned closer to Cluster 2b and to variables associated with higher General Trust and Health Interest, whereas most remaining regions were positioned closer to Cluster 1b and to variables related to higher neophobia. These regional patterns should be interpreted descriptively because the regional distributions largely overlapped.

4. Discussion

4.1. Interpreting the psychometric landscape of Italian consumers

The psychometric profile observed in this study suggests that Italian consumers combine strong health orientation with a cautious attitude toward food innovation. High levels of Food and Food Technology Neophobia, together with lower General Trust and Sensation Seeking, indicate a preference for familiar eating practices and greater caution toward unfamiliar foods and technologies. This pattern is consistent

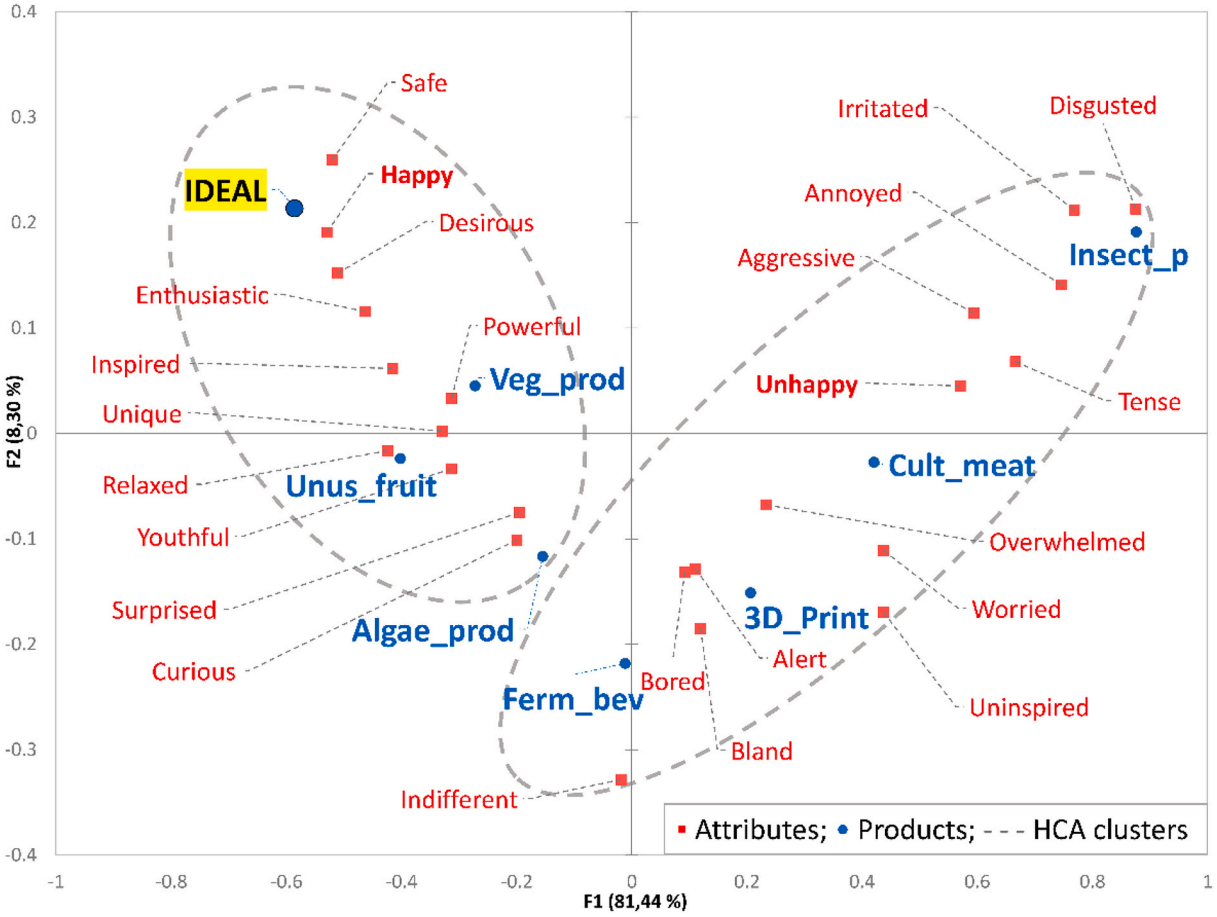


Fig. 5. Principal Coordinate Analysis (PCoA) illustrating the relationships among the emotions evoked by the seven innovative food categories and the hypothetical ideal innovative food. Grey emotion clusters were identified using Hierarchical Cluster Analysis (HCA) of the 24 emotions term. The ordination is presented as an exploratory descriptive representation of the multivariate relationships among the variables included in the analysis.

with the central role of food in Mediterranean cultures, where eating practices are closely linked to tradition, family, and cultural identity (Alley & Potter, 2011; Predieri et al., 2020; Tsimitri et al., 2022). In this context, attachment to established culinary practices may reduce openness to unfamiliar food innovations, even when these are perceived as environmentally or nutritionally beneficial (Mascarello et al., 2020).

The observed psychometric profile is consistent with previous studies conducted in Italy, which have reported relatively high levels of food neophobia and the important role of personality traits in shaping food acceptance (Laureati et al., 2016; Vanhonacker et al., 2013; Verneau et al., 2016). Evidence from the Italian Taste project further suggests that food choices emerge from the interaction of personality, sensory responsiveness, and demographic characteristics, with women generally exhibiting greater disgust sensitivity and stronger avoidance of intense sensory stimuli (Monteleone et al., 2017; Spinelli et al., 2018; Tolve et al., 2025). Our findings extend this evidence by showing that these psychometric characteristics coexist within a nationally representative sample and are associated with broader attitudes toward innovative foods and technologies rather than with specific product categories alone.

Importantly, the coexistence of high Food Neophobia, high Food Technology Neophobia, low General Trust, and low Sensation Seeking suggests that resistance to food innovation should not be interpreted as the consequence of a single psychological trait. Rather, it reflects a broader psychometric profile in which multiple predispositions coexist to favour familiar food choices and increase caution toward unfamiliar products and technologies.

The coexistence of high Health Interest and high Disgust Sensitivity further suggests that consumers may simultaneously value healthier food choices while remaining cautious toward unfamiliar technologies. This apparent paradox highlights the multidimensional nature of consumer acceptance, in which health motivations do not necessarily translate into greater openness to innovation. Public debates surrounding emerging food technologies and previous food safety crises may also have contributed to reinforcing cautious attitudes toward food innovation, although this hypothesis warrants further investigation (Cui & Shoemaker, 2018; Kuttschreuter, 2006).

Consequently, resistance toward innovative foods may emerge not simply from the characteristics of individual products, but from a broader cognitive framework in which unfamiliarity, uncertainty, and perceived lack of control are closely intertwined. The familiarity patterns across the seven categories further support this interpretation. Plant-based protein products were the most familiar, whereas 3D-printed foods showed the lowest familiarity, with insect-based products, cultured meat, and fermented plant-based beverages also showing relatively low familiarity. These categories may therefore face greater resistance when unfamiliarity represents a salient barrier to acceptance. However, resistance may depend not only on novelty, but also on how readily consumers relate innovations to familiar food experiences and expectations (Siddiqui et al., 2022), consistent with the exploratory multivariate results linking familiarity with acceptability and perceived healthiness.

4.2. *Sociodemographic associations with acceptability*

Sociodemographic characteristics were significantly associated with

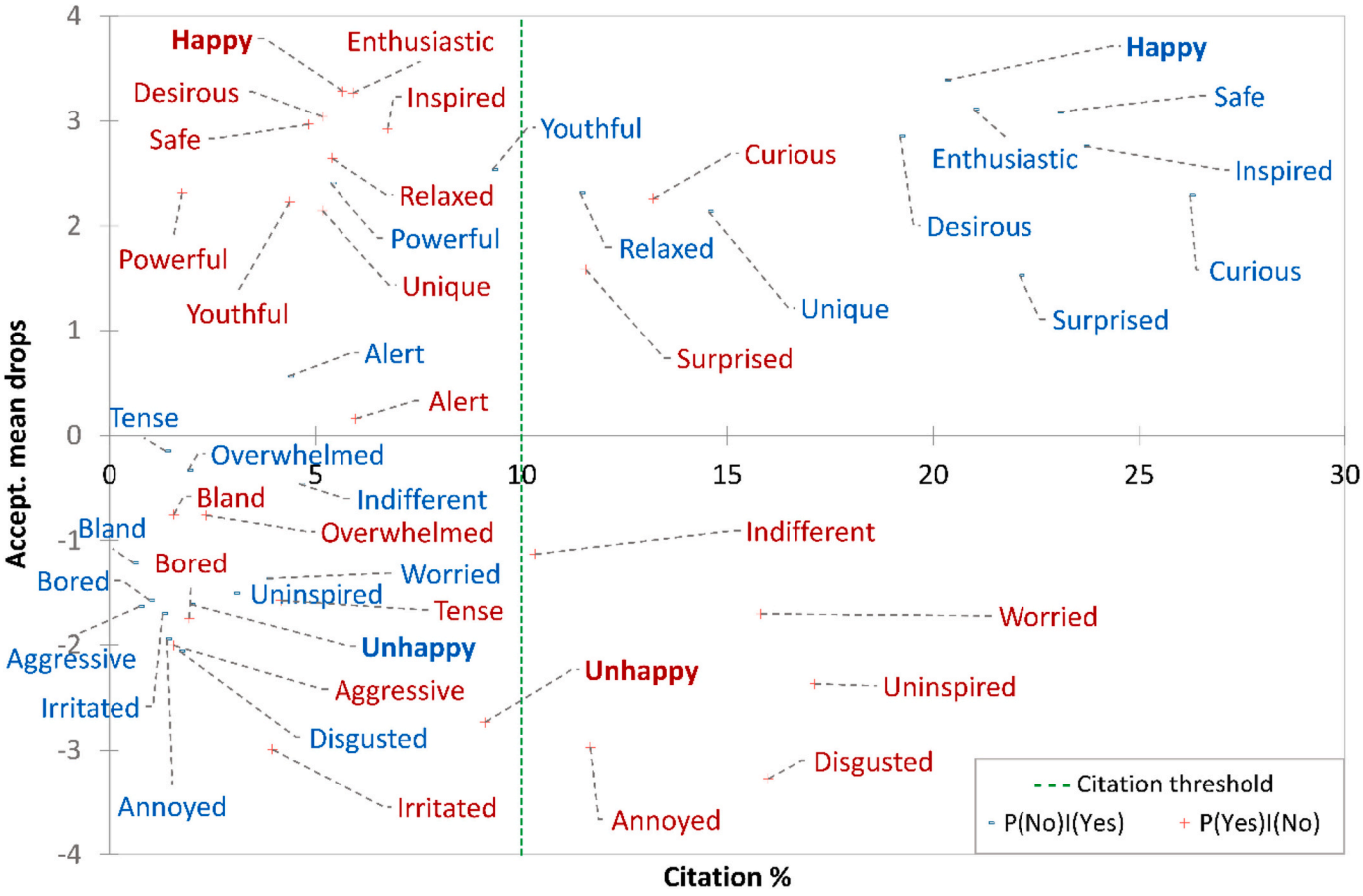


Fig. 6. Summary of the penalty analysis showing the classification of emotion terms according to their citation for the evaluated products (P) and the hypothetical ideal innovative food (I), their citation frequencies, and their effects on overall consumer acceptability.

consumer openness toward innovative foods. Women showed greater Health Interest but also higher Food Neophobia and Disgust Sensitivity than men, whereas men reported higher Sensation Seeking and greater acceptance of unconventional products such as insect-based foods. These findings are consistent with previous studies suggesting that women place greater emphasis on food safety and health, while men generally exhibit greater willingness to try novel food products (Berthold et al., 2025; Menozzi et al., 2017; Nordin et al., 2004; Verbeke, 2015).

Older participants expressed greater caution toward food innovation, particularly regarding emerging technologies, whereas younger consumers showed greater openness despite exhibiting similar levels of institutional trust. This finding supports previous evidence that age influences food innovation acceptance, although its magnitude appears to depend on the surrounding cultural context (Barrena et al., 2015; Carrillo & Tárrega, 2025; Stratton et al., 2015; Vanhonacker et al., 2013). In countries where culinary traditions play a central role in cultural identity, attachment to familiar food practices may reinforce resistance toward unfamiliar food technologies.

Higher education and household income were associated with greater General Trust and lower levels of Food and Food Technology Neophobia, suggesting that broader exposure to diverse foods and information may facilitate openness toward innovation consistent with findings reported for Italian consumers by Annunziata and Vecchio (2011). However, even participants with higher educational attainment remained relatively cautious, indicating that greater knowledge alone may be insufficient to overcome emotional barriers associated with unfamiliar food technologies. This finding reinforces previous evidence that consumer acceptance appears to be associated with both cognitive and emotional factors rather than knowledge alone (Siddiqui et al., 2022; Meiselman et al., 2010; Cattaneo et al., 2019).

4.3. *The role of trust, neophobia, and emotional barriers*

General trust was one of the psychological constructs associated with higher consumer acceptability. Its strong negative association with both Food Neophobia and Food Technology Neophobia suggests that resistance to innovative foods appears consistent not only reluctance toward novelty itself but also uncertainty regarding the reliability of the institutions, technologies, and actors involved in their development. This finding is consistent with previous studies identifying trust as a key predictor of consumer acceptance of emerging food technologies, including cultured meat (Frewer et al., 2003; Siegrist, 2008; Siegrist & Hartmann, 2020). In Italy, where consumers often place greater confidence in familiar sources such as family, local producers, and traditional brands than in governmental or industrial institutions, communication about food innovation may therefore depend on trusted and culturally familiar intermediaries (Nocella et al., 2011).

The distinction between social trust (confidence in other people) and epistemic trust (confidence in scientific knowledge and institutions) provides a useful framework for interpreting these findings. Acceptance of innovative foods may depend not only on interpersonal confidence but also on consumers' willingness to extend trust from familiar food systems to unfamiliar technological domains. This interpretation is consistent with the view that responses to food innovation are associated with both psychological predispositions and perceptions of uncertainty. This distinction is particularly relevant because consumers may simultaneously trust people within their everyday food networks while remaining skeptical toward unfamiliar technologies or institutional actors. Successful communication strategies therefore need to strengthen

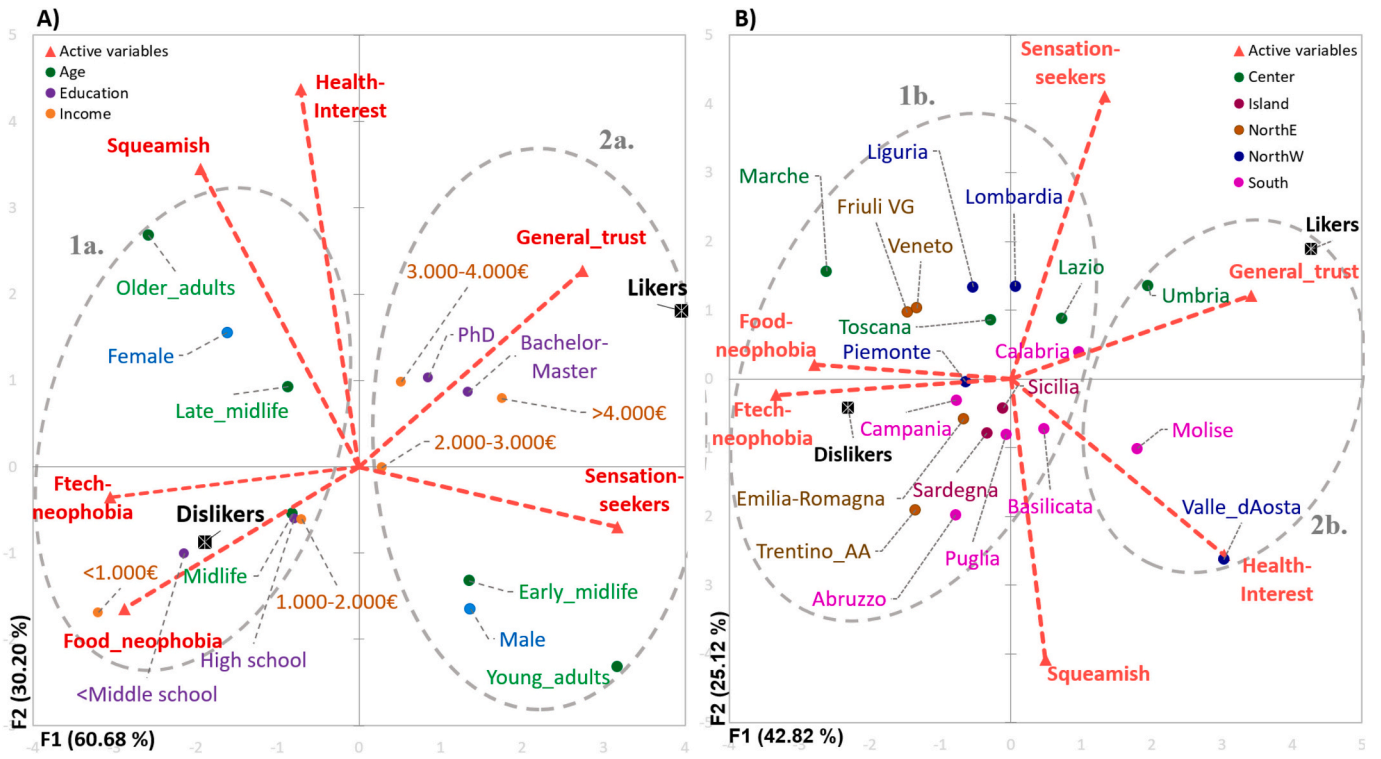


Fig. 7. (A) Principal Component Analysis (PCA) showing the spatial distribution of 18 aggregated consumer profiles defined according to sociodemographic characteristics and overall liker/disliker classification, based on six psychometric variables. Grey clusters indicate the two clusters identified by Hierarchical Clustering on Principal Components (HCPC), denoted as Clusters 1a and 2a. (B) PCA showing the spatial distribution and correlations across the 20 Italian regions and the psychometric variables. Grey clusters indicate the two clusters identified by hierarchical clustering of regional profiles, denoted as Clusters 1b and 2b. Although quota sampling was stratified by the five Italian macro regions, respondents reported their specific region of residence. Regional scores were therefore calculated directly from participants belonging to each of the 20 Italian administrative regions and are presented for descriptive purposes only.

both interpersonal confidence and confidence in the scientific processes underlying food innovation.

Emotional responses further reinforce this relationship. Higher Disgust Sensitivity and lower curiosity were associated with lower acceptability, supporting psychological models in which negative emotions exert a stronger influence than perceived benefits when individuals evaluate unfamiliar foods (Dolgopolova et al., 2015). Together, these findings suggest that strategies aimed at increasing trust may also reduce emotional resistance by presenting innovative foods as safe, familiar, and compatible with existing food cultures.

The consumer segment characterized by high neophobia and lower trust closely resembles the "technophobic" profile described by Platta et al. (2025), reinforcing the idea that trust represents not only an important psychological correlate of consumer acceptance but also a central challenge for the successful communication of food innovation.

Consumer trust therefore emerges not only as an important psychological correlate of food acceptance, but also as one of the principal communication challenges facing the food innovation sector.

4.4. *Emotional determinants of product acceptability*

Emotional responses emerged as important correlates of consumer acceptability. Within the exploratory CATA analysis, curiosity exhibited the strongest positive biserial correlation coefficient with liking, whereas disgust exhibited the strongest negative biserial correlation coefficient. Rather than representing strictly opposite emotional states, these responses may coexist with emotions such as surprise and mild concern, supporting recent evidence that consumer evaluations of innovative foods are frequently characterized by emotional ambivalence (Mosikyan et al., 2024). Thus, positive emotional engagement may be associated with greater openness toward food innovation, whereas negative emotional responses may accompany greater resistance. However, given the exploratory and cross-sectional nature of the present study, these associations should not be interpreted as causal or temporal relationships.

Importantly, emotional patterns differed across the seven innovative food categories. The exploratory PCoA positioned the hypothetical ideal innovative food, plant-based protein products, algae-based products, and fruits with unusual appearances together, primarily associated with positive emotions such as happy, safe, desirous, and enthusiastic. In contrast, insect-based products, cultured meat, 3D-printed foods, and fermented plant-based beverages formed a second grouping associated with more negatively valenced emotions, including unhappy, aggressive, disgusted, and tense. The relatively favorable positioning of algae-based products may be consistent with the nutritional and health attributes commonly associated with algae-based foods (Moss et al., 2026), whereas the response to less familiar technologies and products may involve greater emotional resistance.

These patterns were broadly consistent with differences in familiarity and acceptability. Plant-based protein products were the most familiar category, with 69.0% reporting previous consumption, whereas 3D-printed foods were the least familiar, with 50.5% reporting that they had never heard of them. However, fruits with unusual appearances showed the highest acceptability (M = 5.73), despite intermediate familiarity, whereas insect-based products showed the lowest (M = 2.65). This suggests that unfamiliarity alone may not necessarily generate resistance. Research on visually novel fruits similarly suggests that consumer responses can vary according to perceptions of novel visual characteristics, familiarity, and individual consumer profiles (Laaksonen et al., 2016; Silvestri et al., 2018). In contrast, the stronger negative emotional responses observed for insect-based products and cultured meat are consistent with previous research linking these

categories to disgust and other negative emotional reactions (Liu et al., 2023; Serpico et al., 2021). Disgust has similarly been identified as an important barrier to acceptance, whereas curiosity may facilitate more positive responses toward food innovation (Penedo et al., 2022; Siegrist & Hartmann, 2020).

For 3D-printed foods and fermented plant-based beverages, the less favorable emotional positioning may reflect different forms of unfamiliarity related to technological novelty and novel ingredients, fermentation processes, or sensory expectations, respectively (Manstan & McSweeney, 2020; Ueda et al., 2025). Previous research has highlighted the relevance of food-evoked emotions to consumer evaluations, showing that emotional profiles can provide information beyond liking and that negative emotional responses such as disgust may act as barriers to acceptance of innovative foods (Gutjar et al., 2015; Serpico et al., 2021). Although curiosity showed the strongest positive association with acceptability in the present study, this coefficient was calculated across the complete assessor/product dataset and therefore does not establish that curiosity is particularly relevant to any one innovation. This finding is nevertheless consistent with previous research identifying curiosity as a predictor of willingness to try novel foods (Stone et al., 2022; Tan et al., 2016).

4.5. Perceptions and expectations toward ideal innovative foods

Consumers appear not to reject innovation itself, but rather innovations perceived as compromising sensory pleasure, product authenticity, or culinary identity. Taste, nutritional value, price, and sustainability emerged as the most valued attributes, indicating that consumers expect innovative foods to complement rather than replace traditional sensory and cultural standards. The comparison between the evaluated food categories and the hypothetical ideal innovative food therefore reveals a clear gap between the characteristics desired in an ideal innovative product and the perceptions associated with several of the innovative food categories evaluated in this study.

The relatively low importance assigned to appearance and texture further suggests that product evaluation is driven primarily by sensory satisfaction, perceived quality, and coherence with existing food practices rather than by visual novelty. This interpretation is consistent with previous studies indicating that Italian consumers place substantial importance on sensory quality, product origin, and production methods when evaluating foods, with taste and other sensory characteristics emerging as important drivers of food choice (Asioli et al., 2017; Mascarello et al., 2015; Wongprawmas et al., 2021). Accordingly, communication strategies emphasizing authentic taste, culinary tradition, and product quality may prove more effective than narratives centred exclusively on technological novelty. Innovation framed as an extension of familiar culinary traditions, rather than as a radical technological disruption, may therefore resonate more effectively with Italian consumers.

Gender and age further modulated these expectations. Women placed greater emphasis on sustainability and health-related attributes, whereas men showed greater acceptability of protein-rich and less familiar food categories, in agreement with previous observations (Feraco et al., 2024; Horovitz, 2024). Nevertheless, the consistent importance attributed to taste and health across demographic groups suggests that sensory quality remains a fundamental prerequisite for consumer acceptance. Taken together, these findings indicate that sensory quality remains the primary gateway through which consumers evaluate innovative foods, regardless of demographic differences.

The lower acceptability of 3D-printed foods, cultured meat, and insect-based products, all characterized by lower familiarity and perceived naturalness, further supports the importance of these factors in shaping food acceptance, as previously reported by Protano et al. (2025) and Giacalone and Jaeger (2023). Together, these findings indicate that successful food innovation should be presented as an extension of established culinary values rather than as a disruption of them.

Finally, the higher importance assigned to environmental sustainability than to economic or sociocultural sustainability suggests that consumers primarily associate food innovation with environmental benefits, whereas its broader social and economic contributions remain less salient. This pattern agrees with previous evidence showing that environmental concerns dominate consumer perceptions of sustainable foods (Grunert et al., 2014; Hartmann & Siegrist, 2017; Verain et al., 2012). Increasing awareness of the social and economic dimensions of food innovation may therefore represent an important opportunity for communication strategies targeting consumers, producers, and other stakeholders.

4.6. Implications for innovation and market strategy

The present findings suggest that successful food innovation in Italy requires strategies addressing psychological, emotional, and cultural dimensions in addition to technological performance.

First, strengthening consumer trust should be a priority. Communication strategies emphasizing transparency, traceability, and product safety are likely to be more effective when delivered through trusted and culturally familiar intermediaries, such as local producers, chefs, and regional food networks (Salvatore, 2025).

Second, communication should stimulate curiosity rather than simply reduce perceived risk. Our findings indicate that emotional responses were strongly associated with consumer acceptability, suggesting that storytelling, sensory experiences, and opportunities for direct product interaction may be more effective than information-based approaches alone (Ares et al., 2010; Jaeger et al., 2018; Tuccillo et al., 2020).

Third, product development should prioritize sensory quality, health benefits, and sustainability while maintaining continuity with familiar culinary traditions. The strong preference for taste, nutritional value, and sustainability observed in the ideal innovative food suggests that consumers favour innovations perceived as natural extensions of existing food practices rather than radical departures from them.

Finally, policy initiatives should prioritize transparent communication and consumer engagement to increase familiarity with emerging food technologies while addressing concerns related to safety, naturalness, and perceived benefits. Such approaches may strengthen trust and facilitate the emotional acceptance of innovative foods, particularly among more neophobic consumer segments (Frewer et al., 2003; Grunert et al., 2008).

Collectively, these findings indicate that successful food innovation in Italy will depend less on introducing radically different products than on integrating technological advances within familiar culinary experiences. Aligning innovation with existing sensory expectations, cultural identity, and trusted communication channels may facilitate consumer acceptance while supporting the transition toward more sustainable food systems.

The observed differences across innovations may nevertheless have implications for communication strategies. For example, products characterized by lower familiarity and more negative emotional responses, such as cultured meat, insect-based products, and 3D-printed foods, may require communication that addresses consumer uncertainty and perceived risk, whereas more favorably evaluated innovations may be communicated by emphasizing attributes already associated with acceptance. These possibilities remain hypotheses that should be tested in future research.

4.7. Limitations and future research

Some limitations should be considered when interpreting these findings. First, the *liker/disliker* classification was based on overall acceptability across the seven categories and therefore may not fully capture product-specific acceptance profiles or heterogeneity across

innovations. Future studies could examine product-specific segments and apply multilevel or mixed-effects approaches to better account for differences between consumers and innovations. Second, although standardized information was provided for each innovation, participants' comprehension of these statements was not directly assessed; future research could examine whether differences in information understanding influence perceived benefits, risks, and acceptability. Third, the General Trust instrument used in this study has not been formally validated in Italian, although it showed satisfactory internal consistency in the present sample (Cronbach's $\alpha = 0.89$); formal validation and assessment of its factor structure would strengthen future applications. The seven categories examined here also do not encompass the full diversity of emerging foods, while the multiple-choice assessment of desired attributes captures attribute selection without explicit trade-offs. Future studies could therefore consider additional innovations, trade-off-based approaches such as Best-Worst Scaling or Discrete Choice Experiments, additional psychometric traits, and more diverse dietary groups, particularly vegetarian, vegan, and flexitarian consumers. Finally, longitudinal and repeated-exposure studies could clarify how familiarity, trust, emotional responses, and acceptance evolve over time.

5. Conclusion

This study provides the first nationally representative and multidimensional assessment of Italian consumer acceptability toward a broad range of innovative food categories. Unlike previous studies focusing on individual products or isolated psychological constructs, it demonstrates that consumer responses to food innovation were associated with multiple psychological, emotional, sociodemographic, and product related factors, highlighting the multidimensional nature of innovative food acceptance.

Rather than rejecting innovation itself, Italian consumers appear to favour products that preserve familiar sensory experiences while delivering clear health and sustainability benefits. Trust, familiarity, and emotional responses, particularly curiosity and disgust, were consistently associated with consumer acceptability, highlighting the importance of addressing psychological and cultural dimensions alongside technological innovation.

The findings provide practical guidance for researchers, policymakers, and the food industry. Successful innovation strategies should combine transparent communication, consumer engagement, and product development focused on sensory quality, health, sustainability, and cultural familiarity. Aligning technological innovation with established culinary values may facilitate greater acceptance of innovative foods while supporting the transition toward more sustainable food systems.

Beyond these practical implications, this study provides evidence that technological innovation and culinary tradition should not be viewed as opposing forces. Instead, innovation is more likely to be accepted when it complements rather than replaces the sensory, cultural, and symbolic values that consumers already associate with food. Ultimately, the future success of food innovation may depend less on how radically foods are transformed than on how successfully innovation is integrated into the cultural and sensory expectations that define everyday eating.

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CRediT authorship contribution statement

Bruno Domingues Galli: Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Flavia Gasperi:** Writing – review & editing, Validation, Conceptualization. **Isabella Endrizzi:** Writing – review & editing, Validation, Resources, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Ethics statement

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki and was approved by the Research Ethics Committee of the University of Trento (Approval No. 2023-23ESA). All participants provided informed electronic consent prior to participation and were informed of their right to withdraw from the study at any time.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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