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# Functional foods at the agrifood interface: consumer knowledge, trust and socio-economic drivers for market uptake and policy in Italy

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ABSTRACT

This study examines how knowledge, trust, and socio-demographic variables influence consumer attitudes and behaviors toward the consumption of functional foods in Italy. A structured questionnaire was administered to a sample of 302 Italian consumers. Data analysis involved the use of Principal Component Analysis (PCA) to identify key consumption profiles and perceived barriers. The findings reveal a multidimensional relationship between knowledge and consumption, shaped by health beliefs, socio-economic status, and generational identity. Trust in available information and the perceived personal relevance of functional foods emerge as critical factors in bridging the gap between intention and actual behavior. The PCA results also highlighted two distinct dimensions socioeconomic and identity-related that significantly structure consumer segmentation. The study provides valuable insights for the development of targeted communication strategies. Findings inform agrifood product development and labeling practices and provide actionable guidance for retailers and regulators, by linking agricultural ingredients and consumer acceptance.

## 1. Introduction

Over the past fifteen years, interest in functional foods has grown significantly, driven by increasing consumer awareness of the links between diet and health [1,2]. Functional foods products that provide health benefits beyond basic nutrition represent a rapidly expanding segment of the global food market [3,4]. Despite rapid market growth, uptake remains constrained by economic, informational and psychological barriers that interact with socio-cultural contexts, particularly where trust in claims and labelling clarity are limited. Economic constraints, notably high costs and low availability are consistently identified as primary obstacles, especially among lower-income groups who see these products as luxuries rather than necessities [5,6]. Moreover, doubts caused by unclear health claims, inconsistent labels, and lack of trust in certifications significantly affect consumer perceptions, with many depending on clear front-of-pack labels approved by trusted institutions [7]. Psychologically, factors such as attention to health, prior experience and fear of trying new foods shape individual willingness to adopt functional foods, while social habits and marital status further distinguish consumer groups [5]. Cultural influences also play an important role: habitual dietary patterns, taste preferences and the degree of fit with traditional diets influence acceptance and frequency of use [8]. Understanding adoption therefore requires a holistic view that brings together trust, socio-economic status, psychological traits and embedded cultural values, rather than isolated cognitive or economic drivers. Originating in Japan in the 1980s, these products have since spread globally, thanks to the addition of probiotics, omega-3s, fibers, and other active ingredients [9–11]. In this study, we adopt an operational definition consistent with prior scholarship: functional foods are conventional or formulated foods that, beyond basic nutrition, deliver verifiable physiological benefits and/or risk-reduction effects when consumed as part of a normal diet [9,11,12]. Illustrative market examples include yoghurt or probiotic drinks (gut health), spreads enriched with plant sterols (LDL-cholesterol), β-glucan-rich cereals (glycaemic and lipid control), and foods or dairy enriched with omega-3 (cardio-protective effects). We focus on consumer-perceived functionality and uptake, rather than clinical efficacy, as our outcomes relate to communication, trust and market adoption. However, actual consumption remains limited; knowledge is often modest and interacts with trust and perceived cost. Baker et al. [5] have shown that only between 21 % and 52 % of consumers consider themselves well-informed about these products, and although the link between knowledge and acceptance is

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positive but limited. Several studies confirm that higher levels of knowledge are associated with more favorable perceptions and a greater willingness to consume functional foods [13]. Nevertheless, such knowledge must be accompanied by trust in information sources and the ability to question marketing messages [14]. Consumers with greater knowledge of functional foods tend to show more positive perceptions and a stronger intention to consume them. Socio-demographic factors also play a key role: age, gender, income, and education level significantly influence both knowledge and attitudes toward these products [14–16]. For instance, women are more likely to prioritize health benefits over taste, while younger consumers demonstrate greater openness to experimentation, although with less consistency in consumption habits [17,18]. Additional consumption barriers include limited familiarity with the concept of "functional," negative past experiences, or lack of trust in certain ingredients [19,20]. Recent research highlights the importance of clear labels and understanding in overcoming these barriers [21]. Finally, behavioral segmentation techniques particularly those employing principal component analysis and cluster analysis have already proven effective in distinguishing consumer profiles based on attitudes, frequency, and motivations [22–24]. The present study aims to further explore this segmentation within a specifically Italian context, which remains underrepresented in the international scientific literature.

Beyond consumer-focused evidence, a growing body of bibliometric and patent-based work maps the evolution of functional food research and innovation. Global patent landscape analyses document a marked increase in patent filings related to functional ingredients, delivery systems and health claims over the last two decades, with geographically concentrated clusters of applicants in Europe, Asia and North America [25,26]. Bibliometric reviews of nutraceuticals and functional foods highlight the centrality of a relatively small set of highly cited papers that structure the field [27], while technology-forecasting studies on functional chocolates and related cocoa-based products show that many innovations remain at the level of patents or pilot developments rather than fully commercialised products [28]. Similarly, bibliometric mapping of coffee and caffeine research reveals rapidly expanding but thematically fragmented knowledge domains [29]. These upstream analyses underscore how dynamic the innovation pipeline is, but they also suggest a potential gap between patent-intensive technological development and the everyday perceptions, trust and purchasing behaviour of consumers in specific national contexts such as Italy.

The research questions addressed in this study are outlined below:

**RQ1:** How does the level of knowledge about functional foods influence consumer perception and willingness to consume them?
**RQ2:** What are the main barriers limiting the consumption of functional foods, and how do they vary among consumers?
**RQ3:** How do variables such as age, gender, income, and education influence the consumption of functional foods?

This research, based on a survey conducted with a sample of Italian consumers, aims to fill a knowledge gap and provide valuable insights for public policy, communication strategies, and the development of innovative products in the food sector.

By linking consumer evidence to product design, labeling credibility and targeted education, this study addresses decision points across the agrifood system from ingredient choice and formulation to retail positioning and public communication. The focus on knowledge, trust and socio-demographics is intended to inform both market strategies and food-policy actions aimed at responsible uptake of functional foods.

## 2. Methodology

### 2.1. Survey instrument and data collection

To collect empirical data useful for this research, a survey was conducted using a questionnaire administered via the Qualtrics XM platform and promoted through various social media channels between April and May 2024.

Before the main data collection in March, a pre-test was conducted with 50 respondents to assess the reliability and clarity of the questionnaire items. After the pre-test, minor refinements were made to the wording before the main fieldwork. The survey was targeted at potential Italian consumers, with the sample size and content specifically designed to investigate levels of awareness and willingness to consume functional foods in Italy.

A total of 302 valid responses were collected, allowing for a comprehensive analysis of consumer behaviors and attitudes, as well as the identification of emerging trends related to the research objectives.

The purpose of the questionnaire was to examine both qualitative and quantitative aspects of consumer knowledge, consumption habits, and the perceived factors that may discourage the intake of functional foods. To achieve this, the questionnaire was composed exclusively of closed-ended questions, including both dichotomous and multiple-choice formats, ensuring the standardization and comparability of responses.

The questionnaire was organized into three distinct sections. The first section focused on product awareness, beliefs, and consumer perceptions, beginning with a Likert scale to measure self-reported knowledge of functional foods, followed by more specific items to assess the depth and accuracy of this knowledge.

The second section investigated actual consumption behaviors, including frequency and timing of intake, preferred product attributes, and motivations behind non-consumption. This part also aimed to capture patterns related to purchasing decisions and situational contexts influencing consumer choices.

The third and final section collected detailed socio-demographic information, including gender, age (later reclassified into generational cohorts according to ISTAT standards), area of residence (urban or non-urban), household size, and income level.

This enabled the integration of socio-economic variables into the analysis, allowing for a richer interpretation of the results in relation to consumer segmentation. The constructs were operationalised to yield directly actionable levers for agrifood stakeholders (e.g., message clarity, claim credibility, occasion-based formats and affordability). Item development and validation. Survey items on knowledge, trust/claims and perceived barriers were adapted from prior research on functional foods and food labelling, with wording aligned to our context [13,14,21,30–33].

The sample was subsequently subjected to a principal components analysis (PCA) in order to summarise consumer perceptions of functional foods and identify their consumption habits.

The PCA is expressed by the following formula:

$$Y_i = W_{i1}X_1 + W_{i2}X_2 + \ldots + W_{ip}X_p$$

Where $X_1, X_2, \ldots X_p$ are the originally standardized variables and $W_{i1}$, $W_{i2}, \ldots W_{ip}$ are the weight related to each one of them.

This analysis is structured to find out a new set of smaller dimensions than the original variables, capable of expressing "common" information.

To facilitate clearer and more accurate interpretation of the data, the Varimax method was chosen to perform orthogonal rotation of the factors that permits a simpler and more correct interpretation of the variables [34,35].

The extraction of the components was followed by the calculation of the factor scores for each case.

The higher the factor loading, the more the variable is decisive for that factor.

The model was also validated using Bartlett's Test of Sphericity and the KMO (Kaiser-Meyer-Olkin) measure, to determine whether the theorised model was valid (Maesano et al., 2022).

Furthermore, only factors with loadings of no less than 0.4 were considered, a value identified as significant by Hair et al [36]. Beyond statistical adequacy, the retained factors were selected for managerial and policy usefulness, enabling evidence-based consumer segmentation and prioritisation of communication and labeling interventions.

The variables used for the construction of the model are described in Table 1.:

## 3. Results

### 3.1. Data analysis results

The analysis focusing on socio-demographic aspects is summarized in Table 2.

The gender distribution is essentially balanced: 50.99 % of respondents are male (n = 154), while 49.01 % are female (n = 148).

This balance ensures good representativeness with regard to the gender variable.

The generational composition is heavily skewed towards younger individuals: Generation Z constitutes the largest group (49.01 %), followed by Millennials (27,15 %) and Generation X (16.89 %). The Identity Generation accounts for just 6,25 % of the sample.

This data suggests a predominance of participants born after the 1990s, which may be reflected in attitudes, values, and behaviors relevant to the survey.

The majority of respondents live in households composed of 2–4 people (75,83 %).

Only 7,62 % live alone, while 16,56 % belong to families with more than 5 members.

The sample is generally well-educated: over half (53,64 %) hold a university degree, and a further 20,53 % have completed postgraduate studies.

**Table 1**
Variables by nature and type of attribute used for the PCA model analysis construction.

| Variable | | Nature | Type of attribute |
|---|---|---|---|
| **Socio-demographic** | *City size* | Ordinal | Extrinsic |
| | *Generation* | Ordinal | Extrinsic |
| | *Gender* | Nominal | Extrinsic |
| | *Educational level* | Ordinal | Extrinsic |
| | *Income bracket* | Ordinal | Extrinsic |
| **Product knowledge** | *Functional foods have added healthy ingredients* | Nominal | Intrinsic |
| | *Functional foods contain bioactive compounds* | Nominal | Intrinsic |
| | *A dietary supplement is a functional food* | Nominal | Intrinsic |
| | *If overused, they can be harmful* | Nominal | Intrinsic |
| | *They are completely safe* | Nominal | Intrinsic |
| | *They can be in capsule or pill form* | Nominal | Intrinsic |
| | *They are useless for a healthy person* | Nominal | Intrinsic |
| **Consumption barriers** | *I am in good health and don't feel the need* | Nominal | Extrinsic |
| | *I was not satisfied in the past* | Nominal | Extrinsic |
| | *I don't follow a specific diet* | Nominal | Extrinsic |
| **Consumption** | *Consumption frequency* | Ordinal | Extrinsic |
| | *Main meal (breakfast; lunch; snack; dinner)* | Nominal | Extrinsic |
| | *Healt benefits* | Nominal | Extrinsic |
| | *Organoleptic characteristics* | Nominal | Extrinsic |
| | *Packaging sustainability* | Nominal | Extrinsic |
| | *Main products (Beverages; Fischery; baked goods; cereal based products)* | Nominal | Intrinsic |

Source: Our elaborations

**Table 2**
Socio-demographic variables (n = 302).

| *Variable* | *n.* | *%.* |
|---|---|---|
| *Gender* | | |
| Male | 154 | 50,99 |
| Female | 148 | 49,01 |
| *Generation* | | |
| I-Generation | 148 | 49,01 |
| Millennials | 82 | 27,15 |
| Generatione-X | 51 | 16,89 |
| Identity Generation | 21 | 6,25 |
| *How many members are in your household* | | |
| One member | 23 | 7,62 |
| From 2 to 4 members | 229 | 75,83 |
| More than 5 | 50 | 16,56 |
| *What is your highest level of education* | | |
| Middle school diploma | 7 | 2,32 |
| High School diploma | 71 | 23,51 |
| University degree | 162 | 53,64 |
| Post-graduate degree | 62 | 20,53 |
| *Residential area* | | |
| Small (up to 50.000 inhabitants) | 110 | 36,42 |
| Medium (from 50.000 to 100.000 inhabitants) | 37 | 12,25 |
| Large (from 100.000 to 500.000 inhabitants) | 113 | 37,42 |
| Metropolis (over 500.000 inhabitants) | 42 | 13,91 |
| *Income bracket* | | |
| Less than 10.000€ | 41 | 13,58 |
| Between 10.000 and 30.000€ | 157 | 51,99 |
| Between 30.000 and 60.000€ | 78 | 25,83 |
| Between 60.000 and 90.000€ | 18 | 5,96 |
| Over 90.000€ | 8 | 2,65 |

Source: Our elaborations

Only 2,32 % hold a lower secondary school certificate as their highest qualification.

The residential distribution is fairly balanced, with a slight prevalence of residents in large cities (100.000–500.000 inhabitants, 37,42 %) and small towns (up to 50.000 inhabitants, 36,42 %).

Metropolitan areas account for just over 13,91 %, while medium-sized cities represent 12,25 %.

The largest income group falls within the €10,000–€30,000 annual range (51,99 %), followed by those earning between €30.000 and €60.000 (25,83 %).

Only a small portion of respondents report incomes above €60.000 (8,61 %), while 13,58 % earn less than €10.000.

The concentration in lower to middle income brackets may reflect the economic conditions of the target population, with potential implications for consumption patterns and personal priorities.

The first group considered for the factor analysis consisted of the socio-demographic variables.

The exploratory analysis produced a model composed of two factors, explaining 52,86 % of the total variance.

As previously mentioned, the model was validated using the KMO test and Bartlett's test of sphericity, which returned values of 0,603, indicating mediocre but sufficient adequacy and 73,195 (p-value <0,001), respectively. These diagnostics support the use of factor scores in downstream decision-making, such as targeting, portfolio design and front-of-pack guidance.

These results confirm the presence of significant correlations among

the variables, thus justifying the use of factor analysis.

The first factor observable in Table 3., which alone explains 29,88 % of the variance, shows high loadings on three variables: area size of residence (0,746), income bracket (0,734), and level of education (0,505).

These three dimensions together describe a profile that can be defined as an "urban socio-economic profile."

In other words, individuals living in larger urban centre tend, in the examined sample, to have higher levels of education and to fall within middle to high income brackets.

The second factor, which contributes a further 22,98 % to the explanation of variance, focuses instead on demographic characteristics: gender (with a very high loading of 0,877) and generational cohort (0,595).

This second axis can be interpreted as an identity related factor, linked to relatively stable and structural characteristics of individuals.

It is interesting to note that these aspects do not blend with socio-economic variables, but rather constitute an independent factor.

The second analysis was conducted to explore the perceptions and barriers related to the consumption of these foods and is explained in Table 4.

In terms of adequacy, the KMO test is equal to 0,578, a value considered weak but still acceptable to proceed with the factor analysis followed by the Bartlett test of sphericity, that is highly significant (275,558, $p < 0,001$), confirming that the observed correlations are not random and support the validity of the model.

Four factors were extracted, which together explain 57,76 % of the total variance.

Specifically, the first factor explains 16,73 %, the second 14,69 %, the third 14,45 % and the fourth 11,89 % of the variance.

The first factor is mainly about the knowledge and the methods for functional foods.

The highly loaded factors in this one are "a dietary product is a functional food" (0,807), "they can be in capsule or pill form" and, with more moderate but significant loads, "functional foods have added healthy ingredients" (0,432).

These loads factors reflect the knowledge and consumption behavior relating them to dietary or pharmaceutical products.

The second factor reflects barriers related to perceived health and personal experience, configuring itself as a component centered on the absence of subjective need.

The two variables that strongly saturate this factor are "I am in good health and I do not feel the need" (0,767) and "I have not been satisfied in the past" (0,793).

In this case, the refusal or resistance to the consumption of functional foods does not derive from a value judgment on the product, but from a perception of inadequacy with respect to one's personal situation.

The third factor captures a dimension linked to the perception of risk.

In fact, three highly representative statements emerge: "If used in excess, they can be harmful" (0,715), "They are completely safe" (−0,711) and "they are useless for a healthy person" (−0,527), which shows a negative saturation. The coexistence of these three items, in opposite directions, suggests that the dimension does not limit itself to representing a univocal opinion, but reflects a tension between reassurance and concern.

Lastly, the fourth factor considers implicit judgments about usefulness and personal habits.

The representatives of this factor are "Contain bioactive compounds" (0,517), "Contain healthy ingredients" (0,568) and "I don't follow a specific diet" (0,741).

The joint positioning of these statements could reflect an ambivalent or selective attitude towards functional foods: one recognizes their health benefits, but does not necessarily integrate their consumption into one's daily routine.

In Table 5 is summarized the analysis carried out on variables related to consumption habits yielded a model composed of four factors, which was validated as previously described using the KMO test and Bartlett's test of sphericity.

These returned values of 0,598, indicating sufficient adequacy, and 246,094 (p-value <0,001), confirming the presence of significant correlations among the variables.

The first factor, explaining 16,23 % of the variance, is strongly characterized by the regularity and centrality of main meals in the daily diet. Managerially, this points to main-meal formats and clear use-instructions as high-yield vehicles for functional propositions.

In particular, lunch (0,775) and dinner (0,767) show high factor loadings, suggesting that these moments represent fixed points in the eating routine.

Overall consumption frequency (0,562) and a preference for aquaculture products (0,521) are also positively associated with this factor, outlining a structured dietary profile oriented towards regular and potentially healthy choices.

The second factor, accounting for 12,07 % of the variance, is dominated by two less formal but recurring eating occasions breakfast (0,636) and afternoon snacks (0,666). This suggests on-the-go, portion-controlled options and concise claims as suitable routes to lower trial

**Table 3**
Rotated matrix of Socio-demographic variables.

| Variables | Factors | |
|---|---|---|
| | A1 | A2 |
| City size | 0,746 | |
| Generation | | 0,595 |
| Gender | | 0,877 |
| Educational level | 0,505 | |
| Income bracket | 0,734 | |
| Total variance explained | 29,88 | 22,98 |
| KMO Test | 0,603 | |
| Bartlett Test of Sphericity | 73,195 | |
| Significance | <0,001 | |
| Factors with values below 0,4 excluded | | |

Source: Our elaboration by IBM SPSS software

**Table 4**
Rotated component matrix of product knowledge and consumption barriers.

| Variables | Factors | | | |
|---|---|---|---|---|
| | B1 | B2 | B3 | B4 |
| *Product knowledge* | | | | |
| Functional foods have added healthy ingredients | 0,432 | | | 0,568 |
| Functional foods contain bioactive compounds | | | | 0,517 |
| A dietary supplement is a functional food | 0,820 | | | |
| If overused, they can be harmful | | | 0,715 | |
| They are completely safe | | | −0,711 | |
| They can be in capsule or pill form | 0,807 | | | |
| They are useless for a healthy person | | | −0,527 | |
| *Consumption barriers* | | | | |
| I am in good health and don't feel the need | | 0,767 | | |
| I was not satisfied in the past | | 0,793 | | |
| I don't follow a specific diet | | | | 0,741 |
| Total variance explained | 16,73 | 14,69 | 14,45 | 11,89 |
| KMO Test | 0,578 | | | |
| Bartlett's test of sphericity | 275,558 | | | |
| Significance | <0,001 | | | |
| Factors with a value below 0.4 excluded | | | | |

Source: Our elaborations by IBM SPSS software

**Table 5**
Rotated factor matrix of consumption habits.

| Variables | Factors | | | |
|---|---|---|---|---|
| | C1 | C2 | C3 | C4 |
| *Consumption frequency* | 0,562 | | | |
| *Meal* | | | | |
| Breackfast | | 0,636 | | |
| Lunch | 0,775 | | | |
| Snack | | 0,666 | | |
| Dinner | 0,767 | | | |
| *Consumption reasons* | | | | |
| Healt benefits | | | | 0,594 |
| Organoleptic characteristics | | 0,444 | 0,488 | |
| Packaging sustainability | | | 0,693 | |
| *Food types* | | | | |
| Beverages | | | | 0,635 |
| Fishery products | 0,521 | | | |
| Baked goods | | | 0,401 | 0,576 |
| Cereal based products | | | 0,595 | |
| Total variance explained | 16,23 | 12,07 | 11,82 | 11,76 |
| KMO Test | 0,598 | | | |
| Bartlett's test of sphericity | 246,094 | | | |
| Significance | <0,001 | | | |
| Factors with a value below 0.4 excluded | | | | |

Source: Our elaborations by IBM SPSS software.

barriers in dynamic routines.

These results indicate a behavioral dimension related to the flexibility and fragmentation of food intake throughout the day, typical of dynamic lifestyles.

Consumption during these timeframes is likely driven by needs for quick energy, personal habits, or demands imposed by work and school commitments.

The third factor, explaining 11,82 % of the variance, groups variables that refer to the sensory and environmental dimensions of food choices.

The variable "eco-sustainability of packaging" shows a high loading (0,693), followed by "cereal-based products" (0,595) and "organoleptic characteristics" (0,488). Emphasising taste alongside environmentally responsible packaging integrates quality and sustainability, two attributes that jointly drive acceptance.

This suggests that a segment of consumers bases their preferences not only on taste and perceived quality, but also on values related to environmental sustainability.

The factor thus seems to integrate an appreciation for food tradition (such as cereal-based products) with an ecological awareness that is increasingly relevant in modern consumption patterns.

Finally, the fourth factor, which accounts for 11,76 % of the variance, is centered on health-related and functional motivations in food choices.

The "beneficial effects" associated with the consumption of certain foods show a loading of 0,594, along with "beverages" (0,635) and "baked goods" (0,576).

This profile suggests that a portion of the surveyed sample tends to value food based on its perceived positive impact on physical and mental well-being, including both functional foods and common food items considered healthy. For health-motivated consumers, simple, specific and verifiable benefit statements paired with guidance on effective portions can translate intention into repeat use.

In summary, Table 6 reports the main descriptive statistics for the variables included in each section of the PCA analysis.

**Table 6**
Main variables indicators related to the PCA.

| Factor | Variables | Main indicators | | | | |
|---|---|---|---|---|---|---|
| | | *Min.* | *Max.* | *Mean* | *Std. Deviation* | *Std. Error* |
| **A** | *City size* | 1 | 4 | 2,29 | 1103 | 0,063 |
| | *Generation* | 1 | 4 | 1,82 | 0,952 | 0,055 |
| | *Gender* | 0 | 1 | 0,49 | 0,501 | 0,290 |
| | *Educational level* | 1 | 4 | 2,92 | 0,727 | 0,042 |
| | *Income bracket* | 1 | 5 | 2,32 | 0,878 | 0,051 |
| **B** | *Functional foods have added healthy ingredients* | 0 | 1 | 0,38 | 0,486 | 0,028 |
| | *Functional foods contain bioactive compounds* | 0 | 1 | 0,80 | 0,400 | 0,023 |
| | *A dietary supplement is a functional food* | 0 | 1 | 0,28 | 0,452 | 0,026 |
| | *If overused, they can be harmful* | 0 | 1 | 0,61 | 0,488 | 0,028 |
| | *They are completely safe* | 0 | 1 | 0,60 | 0,491 | 0,028 |
| | *They can be in capsule or pill form* | 0 | 1 | 0,29 | 0,455 | 0,026 |
| | *They are useless for a healthy person* | 0 | 1 | 0,16 | 0,363 | 0,021 |
| | *I am in good health and don't feel the need* | 0 | 1 | 0,01 | 0,099 | 0,006 |
| | *I was not satisfied in the past* | 0 | 1 | 0,01 | 0,081 | 0,005 |
| | *I don't follow a specific diet* | 0 | 1 | 0,11 | 0,308 | 0,018 |
| **C** | *Consumption frequency* | 0 | 5 | 4,50 | 0,850 | 0,056 |
| | *Breackfast* | 0 | 1 | 0,52 | 0,501 | 0,033 |
| | *Lunch* | 0 | 1 | 0,48 | 0,501 | 0,033 |
| | *Snack* | 0 | 1 | 0,29 | 0,457 | 0,029 |
| | *Dinner* | 0 | 1 | 0,38 | 0,487 | 0,033 |
| | *Healt benefits* | 0 | 1 | 0,55 | 0,498 | 0,029 |
| | *Organoleptic characteristics* | 0 | 1 | 0,39 | 0,489 | 0,028 |
| | *Packaging sustainability* | 0 | 1 | 0,09 | 0,286 | 0,016 |
| | *Beverages* | 0 | 1 | 0,27 | 0,445 | 0,026 |
| | *Fishery products* | 0 | 1 | 0,31 | 0,462 | 0,027 |
| | *Baked goods* | 0 | 1 | 0,37 | 0,485 | 0,028 |
| | *Cereal based products* | 0 | 1 | 0,22 | 0,414 | 0,024 |

Source: Our elaborations by IBM SPSS Software

## 4. Discussion

### *4.1. Knowledge and perception: a direct but non-linear relationship (RQ1)*

The findings partially confirm the hypothesis that a higher level of knowledge about functional foods is associated with more positive perceptions and a greater willingness to consume them. Factor analysis revealed that knowledge is structured across multiple representations of the product, distinguishing between technical aspects, safety perceptions, therapeutic functions, and preventive value [37,38].

Among consumers with higher scores on the first factor related to knowledge and familiarity with functional foods, a strong propensity to consumption emerges, supported by positive attitudes toward sustainability and health benefits [5]. This aligns with existing literature, where well-informed consumers tend to associate functional foods with health benefits and more conscious dietary choices [13,39,40]. By contrast, some individuals, while recognizing the benefits of functional foods as highlighted by the fourth factor, do not consistently translate this awareness into behavior. This pattern is likely linked to persistent distrust or difficulties in correctly identifying such products [20,41]. These results suggest that simply knowing what a functional food is does not suffice for its consumption; knowledge must also be accompanied by

trust, clear product identification, and the absence of communicative ambiguity [12]. Taken together, these findings point to practical actions: simplifying functional messaging and anchoring it to familiar usage occasions can help convert perceived benefits into consistent purchase and consumption.

### 4.2. Barriers to consumption: between misinformation, cost, and distrust (RQ2)

The factor analysis of consumption barriers provided a clear and nuanced understanding of the obstacles limiting the intake of functional foods. The main barriers are organized along four dimensions: lack of motivation, limited knowledge, negative experiences/cost, and distrust toward ingredients [15,19,42].

These barriers are not evenly distributed across socio-demographic profiles. For instance, younger individuals with lower socio-economic status identified through the identity-related component of the PCA show a higher incidence of mistrust and poor information. This suggests that in the absence of cultural and economic resources, the adoption of new dietary behaviors becomes more challenging [32,43].

Older male participants who score higher on the identity-related component tend to exhibit moderate consumption levels but also significant distrust toward ingredients. This indicates that transparency in product composition and labeling is a critical factor for this demographic segment [31,44].

Conversely, individuals with higher socio-economic and educational profiles identified along the first PCA component tend to demonstrate greater openness and fewer consumption barriers. This reinforces the notion that clear communication, nutritional education, and trust in the perceived quality of the product are essential levers for overcoming resistance to functional food consumption [45]. Accordingly, priority actions should match barriers and segments: plain-language claims to address limited knowledge, transparent ingredient narratives to counter ingredient distrust (notably among older male groups), and accessible price points to ease cost-related resistance in lower-SES younger consumers each underpinned by credible sources.

### 4.3. The role of socio-demographic variables: heterogeneity and segmentation (RQ3)

The analysis confirms that socio-demographic variables significantly influence consumption behaviors, resulting in distinct population profiles characterized by specific traits and attitudes [43]. Principal Component Analysis (PCA) identified two key axes: a socioeconomic axis (income, education, urban area) and an identity-related axis (gender, generation). These two components enable the identification of distinct consumer profiles. For example, one group associated with higher scores in both the socio-economic and identity-related components is typical of urban, young, and predominantly female consumers, marked by high sensitivity to health, environmental concerns, and food quality [46].

Another profile includes younger individuals with lower educational and income levels, who tend to show limited engagement and face more barriers to functional food consumption [18]. Adults with high scores on the socio-economic component appear particularly inclined toward conscious and consistent consumption. This group represents a key target for loyalty strategies and the promotion of functional foods [47].

These findings highlight that age, income, gender, and urban context do not act as isolated variables but rather intersect to shape distinct dietary behaviors. This underscores the importance of differentiated marketing and communication strategies capable of addressing the specific needs, knowledge levels, and resistances of each consumer segment [48,49]. Accordingly, segment-specific mixes of channels, claim framing and price architecture aligned with the PCA-identified socioeconomic and identity-related axes should be tailored to the resulting segments to translate evidence into execution and focus resources where impact is highest.

### 4.4. Patents, innovation dynamics and implications for functional food uptake (RQ1-RQ3)

Patent-oriented studies offer a complementary view of how functional food innovation is evolving upstream. Recent patent landscape analyses focusing on plant-derived bioactives show, for example, that Lamiaceae species such as *Mentha*, *Salvia* and *Perilla* are increasingly protected for functional food applications, with marked activity in East Asia, North America and the European Union [50]. Other reviews emphasise enabling technologies rather than specific ingredients, highlighting the rapid expansion of patents on nanostructured ingredients, active packaging and lipid-based delivery systems designed to improve the stability and bioavailability of bioactive compounds [51,52]. Together, these contributions depict a highly dynamic and technology-intensive innovation landscape.

Work on functional crops and nutritional quality documents an expanding body of research on gene-edited plants and molecular farming strategies explicitly framed as tools for developing functional foods and nutritionally enhanced ingredients [53]. When read against our results, this upstream evidence suggests a gap between the sophistication of technological development and the more uneven patterns of knowledge, trust and purchasing behaviour observed among consumers. Narrowing this gap requires not only further innovation, but also transparent communication on health effects, rigorous validation of functional properties and initiatives aimed at making functional products understandable and accessible to different population groups.

## 5. Conclusion and implications

The analysis carried out has made it possible to explore, from an integrated perspective, the dynamics underlying the growing interest in functional foods. The results highlight a significant trend of increasing consumer awareness, progressively oriented toward a dietary model that combines health, prevention, and everyday well-being. In particular, there emerges a broad-based awareness of the potential role of these products in managing specific physiological functions such as digestion, immune support, or cholesterol control indicating an explicit search for foods with added functional value. For industry, the evidence supports three immediate levers: (i) occasion-aligned formats, (ii) claim clarity with proof-points, and (iii) affordability tactics for trial.

For public health and consumer education, concise materials that explain ‘what it does’ and ‘how to use it’ in mainstream channels such as pharmacies, schools and primary care can raise informed uptake. In practical terms, organisations should pair short, specific front-of-pack statements with a single proof-point accessible via QR code (e.g., ingredient, mechanism, suggested portion), align on-pack and digital messages, and demonstrate use through simple “when/how to consume” cues at main meals and at breakfast/snack occasions. To lower trial barriers, manufacturers and retailers can offer entry-price or portion-controlled formats, introductory bundles and, where appropriate, private-label functional options in high-traffic channels.

Moreover, firms should invest in long-term consumer education strategies that combine simple, visual messaging about functional benefits with continuous communication across sales points, social media, and collaboration with health professionals. Such initiatives can strengthen food literacy, reduce perceived risk and mistrust, and translate awareness into regular consumption behavior.

Local and national authorities can amplify these efforts by standardising terminology and claim wording, issuing clear front-of-pack guidance, and supporting co-branded public-health campaigns with pharmacies, schools and primary care. Partnerships with industry and professional bodies can ensure credible content, while periodic monitoring and public reporting can reduce ambiguity and sustain trust over time.

In addition, public authorities can actively foster functional food adoption by introducing fiscal incentives for research and innovation, establishing uniform guidelines on functional claims, and promoting nationwide information programs in schools and primary healthcare centers. A systemic, shared-governance approach between institutions, producers, and consumers can consolidate public trust and amplify the nutritional and economic impact of these initiatives.

However, the interpretation of these findings must be contextualized in light of certain methodological and structural limitations. First, while the sample used was adequate for an initial exploratory analysis, it presents limitations in terms of statistical representativeness. The socio-demographic characteristics and geographic concentration of respondents may have influenced the results, limiting the generalizability of the findings to a broader population. Second, the study's reliance on a single-administration, self-reported questionnaire introduces potential cognitive distortions, including social desirability bias, idealized self-perception, and the tendency to overestimate virtuous behaviors. These often underestimated factors can create a gap between stated intentions and actual behaviors one that only longitudinal observation and triangulation with other methodological tools (e.g., real consumption studies or ethnographic analyses) could help bridge.

Future implementation should be accompanied by simple evaluation designs (e.g., A/B testing of claims and formats, price experiments, and follow-up surveys) to verify which messages and access levers most effectively convert intention into sustained use.

From an analytical standpoint, another relevant consideration concerns the semantic and value-laden dimension of the concept of "functional food." Its definition is not always clear-cut in public perception, which risks generating interpretive ambiguities. The meaning consumers assign to such products is heavily influenced by cultural context, communication practices, and corporate marketing strategies. This calls for a qualitative inquiry capable of decoding the symbolic processes underlying food choices.

Overall, the coordinated engagement of firms, institutions, and consumers represents the cornerstone for promoting responsible and informed adoption of functional foods within the Italian agrifood system.

Despite the limitations discussed above, this study contributes to the development of a knowledge base useful for both theoretical reflection and practical application. The evolution of the functional food market cannot be fully understood through economic or nutritional lenses alone, but instead requires a multidimensional approach that integrates psychological, sociological, and communicative dimensions. Aligning these actions across the agrifood chain can improve credibility, reduce confusion and unlock responsible growth in functional foods. Taken together, these coordinated actions strengthen real-world relevance by linking evidence to clear roles for producers, retailers and public institutions, thereby supporting informed choice and equitable access to functional foods. Future research should broaden its methodological scope and critically examine the interaction between perceived needs, product offerings, and the construction of consumer trust.

## CRediT authorship contribution statement

**Carbone Roberto:** Writing – review & editing, Writing – original draft, Software, Methodology, Data curation, Conceptualization. **Nicotra Lorenzo:** Writing – review & editing, Software, Methodology, Data curation, Conceptualization. **Spina Daniela:** Writing – review & editing, Validation, Formal analysis, Conceptualization. **Mario D'Amico:** Validation, Supervision. **Chinnici Gaetano:** Validation, Supervision, Funding acquisition, Data curation.

## Declaration of competing interest

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

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## Data availability

Data will be made available on request.

## References

[1] D. Granato, G.F. Branco, F. Nazzaro, A.G. Cruz, J.A.F. Faria, Functional foods and nondairy probiotic food development: trends, concepts, and products, Compr. Rev. Food Sci. Food Saf. 9 (3) (2010) 292–302, https://doi.org/10.1111/j.1541-4337.2010.00110.x.

[2] Grand View Research, Functional foods market size worth $586.1 billion by 2030, Last access: April 2025, https://www.grandviewresearch.com/press-release/global-functional-foods-market, 2022.

[3] K. Menrad, Market and marketing of functional food in Europe, J. Food Eng. 56 (2–3) (2003) 181–188.

[4] B. Bigliardi, F. Galati, Innovation trends in the food industry: the case of functional foods, Trends Food Sci. Technol. 31 (2) (2013) 118–129.

[5] M.T. Baker, P. Lu, J.A. Parrella, H.R. Leggette, Consumer acceptance toward functional foods: a scoping review, Int. J. Environ. Res. Publ. Health 19 (3) (2022) 1217, https://doi.org/10.3390/ijerph19031217.

[6] B. Nichifor, L. Zait, L. Timiras, Drivers, barriers, and innovations in sustainable food consumption: a systematic literature review, Sustainability 17 (5) (2025) 2233, https://doi.org/10.3390/su17052233.

[7] W. Wu, A. Zhang, R.D. van Klinken, P. Schrobback, J.M. Muller, Consumer trust in food and the food system: a critical review, Foods 10 (10) (2021) 2490, https://doi.org/10.3390/foods10102490.

[8] P. Mullie, I. Guelinckx, P. Clarys, et al., Cultural, socioeconomic and nutritional determinants of functional food consumption patterns, Eur. J. Clin. Nutr. 63 (2009) 1290–1296, https://doi.org/10.1038/ejcn.2009.89.

[9] M.B. Robertfroid, Concepts and strategy of functional food science: the European perspective, Am. J. Clin. Nutr. 71 (6) (2000) 1660S–1664S.

[10] S. Arai, Global view on functional foods: asian perspectives, Br. J. Nutr. 88 (S2) (2002) S139–S143.

[11] I. Siró, E. Kápolna, B. Kápolna, A. Lugasi, Functional food. Product development, marketing and consumer acceptance—A review, Appetite 51 (3) (2008) 456–467.

[12] D. Martirosyan, T. Lampert, M. Ekblad, Classification and regulation of functional food proposed by the functional food center, Functional Food Science 2 (2) (2022) 25–46. Online ISSN: 2767-3146.

[13] M. Sääksjärvi, M. Holmlund, N. Tanskanen, Consumer knowledge of functional foods, Int. Rev. Retail Distrib. Consum. Res. 19 (2) (2009) 135–156.

[14] K.G. Grunert, J.M. Wills, L. Fernández-Celemín, Nutrition knowledge, and use and understanding of nutrition information on food labels among consumers in the UK, Appetite 55 (2) (2011) 177–189.

[15] N. Darmon, A. Drewnowski, Does social class predict diet quality? Am. J. Clin. Nutr. 87 (5) (2008) 1107–1117, https://doi.org/10.1093/ajcn/87.5.110.

[16] F. Bimbo, A. Bonanno, G. Nocella, R. Viscecchia, The role of consumers' heterogeneity in the market for functional foods: a quantile regression analysis, Food Policy 66 (2017) 1–12.

[17] B. Villegas, Á.A. Carbonell-Barrachina, E. Costell, Acceptability of a high-fibre orange juice, Food Res. Int. 41 (2) (2008) 197–203.

[18] T. Marina, C. Marija, R. Ida, Functional foods and the young, J. Food Prod. Market. 20 (5) (2014) 441–451.

[19] A. Toorani, M. Moodi, T. Zeinali, F. Salmani, E. Norozi, Consumption status of functional drinks based on the theory of planned behavior and the stages of change model in female employees, Sci. Rep. 14 (1) (2024) 14197.

[20] M. Jezewska-Zychowicz, M. Plichta, M.E. Drywień, J. Hamulka, Food neophobia among adults: differences in dietary patterns, food choice motives, and food labels reading in poles, Nutrients 13 (5) (2021) 1590.

[21] G. Pappalardo, J.L. Lusk, The role of beliefs in purchasing process of functional foods, Food Qual. Prefer. 53 (2016) 151–158.

[22] D. Spina, R. Zanchini, M. Hamam, G. Di Vita, G. Chinnici, M. Raimondo, F. Caracciolo, M. D'Amico, Unveiling the exotic fascination of tropical fruits: the role of food values on consumer behavior towards mangoes, J. Agric. Food Res. 15 (2024) 100956.

[23] A. Krystallis, G. Maglaras, S. Mamalis, Motivations and cognitive structures of consumers in their purchasing of functional foods, Food Qual. Prefer. 19 (6) (2008) 525–538.

[24] V. Stancu, P. Haugaard, L. Lähteenmäki, Determinants of consumer food waste behavior: two routes to food waste, Appetite 96 (2016) 7–17.

[25] D. Hilachuk, C. Crisóstimo, A.J.A.D. Silva, D.D. Paula, Patenting activity on functional foods: a Brazilian scenario, J. Technol. Manag. Innovat. 16 (2) (2021) 70–81.

[26] M. Matin, D. Hrg, O. Litvinova, et al., The global patent landscape of functional food innovation, Nat. Biotechnol. 42 (2024) 1493–1497, https://doi.org/10.1038/s41587-024-02410-0.
[27] A.W.K. Yeung, A. Mocan, A.G. Atanasov, Let food be thy medicine and medicine be thy food: a bibliometric analysis of the most cited papers focusing on nutraceuticals and functional foods, Food Chem. 269 (2018) 455–465.
[28] C.R. Balcázar-Zumaeta, E.M. Castro-Alayo, L.D. Munoz-Astecker, I.S. Cayo-Colca, F. Velayarce-Vallejos, Food technology forecasting: a based bibliometric update in functional chocolates, Heliyon 9 (9) (2023) e19578.
[29] N. Contreras-Barraza, H. Madrid-Casaca, G. Salazar-Sepúlveda, M.Á. Garcia-Gordillo, J.C. Adsuar, A. Vega-Muñoz, Bibliometric analysis of studies on coffee/caffeine and sport, Nutrients 13 (9) (2021) 3234.
[30] N. Urala, L. Lähteenmäki, Reasons behind consumers' functional food choices, Nutr. Food Sci. 33 (4) (2003) 148–158.
[31] I. Dolgopolova, R. Teuber, V. Bruschi, Consumers' perceptions of functional foods: trust and food-neophobia in a cross-cultural context, Int. J. Consum. Stud. 39 (6) (2015) 708–715.
[32] K. Topolska, A. Florkiewicz, A. Filipiak-Florkiewicz, Functional food—Consumer motivations and expectations, Int. J. Environ. Res. Publ. Health 18 (10) (2021) 5327.
[33] I.S. Arvanitoyannis, M. Van Houwelingen-Koukaliaroglou, Functional foods: a survey of health claims, pros and cons, and current legislation, Crit. Rev. Food Sci. Nutr. 45 (5) (2005) 385–404.
[34] L. Fabbris, Analisi Esplorativa Di Dati Multidimensionali, Cluep, Padova, 1983.
[35] H.F. Kaiser, The varimax criterion for analytic rotation in factor analysis, Psychometrika 23 (3) (1958) 187–200.
[36] J.F. Hair, W. Black, B.J. Babin, R.E. Anderson, Multivariate Data Analysis, Pearson Prentice Hall, US, 2009.
[37] L. Frewer, E. Risvik, H. Schifferstein (Eds.), Food, People and Society: a European Perspective of Consumers' Food Choices, Springer, 2001, https://doi.org/10.1007/978-3-662-04601-2.
[38] I.S. Doğan, O. Yildiz, E. Eyduran, S. Kose, A study on determination of functional food consumption habits and awareness of consumer in Turkey, Bulgarian Journal of Agricultural Science 20 (6) (2014) 1373–1380.
[39] M. Siegrist, V.H.M. Visschers, C. Hartmann, Factors influencing changes in sustainability perception of various food behaviors: results of a longitudinal study, Food Qual. Prefer. 46 (2015) 33–40, https://doi.org/10.1016/j.foodqual.2015.07.011.
[40] V.D.J.P. Franco, J.J.M. Escobar, A.L.C. Páez, Neuromarketing as a tool for inferring consumption preferences in functional foods, Rev. Gestão Secr. 16 (4) (2025) e4749-e4749.
[41] A. Annunziata, R. Vecchio, A. Kraus, Awareness and preference for functional foods: the perspective of older Italian consumers, Int. J. Consum. Stud. 39 (4) (2015) 352–361.
[42] A. Kaur, A. Scarfe, M. Saeed, The barriers to functional food consumption in the United Kingdom: a qualitative study, Foods 9 (12) (2020) 1702.
[43] G. Turrell, B. Hewitt, C. Patterson, B. Oldenburg, Measuring socio-economic position in dietary research: is choice of socio-economic indicator important? Public Health Nutr. 6 (2) (2003) 191–200, https://doi.org/10.1079/PHN2002424.
[44] N. Urala, H. Schutz, J. Spinks, Consumer perceptions of "functional food" in the United States, J. Food Prod. Market. 17 (4) (2011) 407–419.
[45] I.H.M. Steenhuis, W.E. Waterlander, A. De Mul, Consumer food choices: the role of price and pricing strategies, Public Health Nutr. 14 (12) (2011) 2220–2226, https://doi.org/10.1017/S1368980011001637.
[46] U. Hjelmar, Consumers' purchase of organic food products. A matter of convenience and reflexive practices, Appetite 56 (2) (2011) 336–344, https://doi.org/10.1016/j.appet.2010.12.019.
[47] A. Drewnowski, P. Eichelsdoerfer, Can low-income Americans afford a healthy diet? Nutr. Today 44 (6) (2010) 246–249, https://doi.org/10.1097/NT.0b013e3181c29f79.
[48] D. Remar, J. Campbell, R.B. DiPietro, The impact of local food marketing on purchase decision and willingness to pay in a foodservice setting, J. Foodserv. Bus. Res. 18 (2) (2015) 143–160, https://doi.org/10.1080/15378020.2015.1008194.
[49] S. Chen, D. Martirosyan, Marketing strategies for functional food products, Functional Foods in Health and Disease 11 (8) (2021) 345–356.
[50] R. El Boukhari, A. Fatimi, Advancing functional food innovation: a patent landscape analysis of Lamiaceae bioactives through cooperative patent classification systems, in: Biology and Life Sciences Forum, vol. 38, MDPI, 2024, December, p. 1, 1.
[51] E. Perez-Esteve, A. Bernardos, R. Martinez-Manez, J. M Barat, Nanotechnology in the development of novel functional foods or their package. An overview based in patent analysis, Recent Pat. Food Nutr. Agric. 5 (1) (2013) 35–43.
[52] X. Liu, Z. Song, W. Tian, Abdullah, Q. Huang, M. Chen, J. Xiao, Advancements in lipid-based delivery systems for functional foods: a comprehensive review of literature and patent trends, Crit. Rev. Food Sci. Nutr. 65 (13) (2025) 2456–2472.
[53] X. Wei, Y. Long, C. Yi, A. Pu, Q. Hou, C. Liu, X. Wan, Bibliometric analysis of functional crops and nutritional quality: identification of gene resources to improve crop nutritional quality through gene editing technology, Nutrients 15 (2) (2023) 373.