



# Analyzing consumer trends in functional foods: A cluster analysis approach

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## ABSTRACT

This article delves into an analysis of consumer behavior towards functional foods, utilizing a cluster analysis approach. To gather data, a structured online questionnaire was employed, employing a non-probabilistic convenience sampling method. The study focused on the region of Sicily, Italy, to provide a localized perspective on consumer preferences and behaviors related to functional foods. Our research findings indicate that the consumption and frequency of functional foods are influenced by various socio-demographic factors, including age, gender, income, and urban population density, specific to the Sicilian context. The questionnaire responses highlighted unique patterns in consumer behavior within this region, shedding light on the factors shaping the demand for functional foods in Sicily. Furthermore, it is worth noting that other significant determinants also play a role in shaping consumer choices regarding the consumption of these foods. Factors such as consumption frequency and the level of product knowledge contribute to variations in consumption patterns, providing a nuanced understanding of the Sicilian consumer landscape. As a result of our study, potential policy briefs could be developed to inform regional health initiatives and marketing strategies. These policy recommendations might include targeted health education campaigns, collaboration with local producers to enhance product knowledge, and the development of policies that support the affordability and accessibility of functional foods in the Sicilian market. In conclusion, our study underscores the existence of promising market opportunities for food enterprises in the functional food's domain within Sicily.

## 1. Introduction

In developed economies, there is a growing inclination towards healthier eating habits. This prompts consumers to have new needs compared to the past, specifically, the desire for high-quality products with multiple nutritional, beneficial, and functional properties for their bodies [1]. We are talking about what are known as "functional foods." Functional foods are of crucial importance to the competitive strategies of food companies, especially in industrialized economies where food consumption is largely stagnant, as most people meet their daily calorie requirements. In this scenario, companies deliberately focus their growth plans on the more dynamic aspects of the food market, such as services and additional product qualities. In fact, numerous studies [2–4] assert that the consumption of foods enriched with functional ingredients (e.g., vitamins, minerals, fiber, and antioxidants) could reduce the risk of chronic diseases and improve physical and mental well-being. The introduction of "functional food" to the market dates back to 1998 in Japan when Otsuka Pharmaceutical launched a

non-alcoholic beverage enriched with fiber. As early as the 1980s, there was a goal to increase the population's life expectancy and subsequently reduce the soaring healthcare costs. The Japanese authorities recognized the need to improve daily dietary habits. Since then, in Japan, a new category of foods, known as FOSHU (food for specified health use), has been identified with a logo and approved by the Japanese Ministry of Health and Welfare. In Europe, between 1995 and 1998, more than 100 nutrition and related science experts reached an agreement on the definition of functional foods within the European Consensus Document. It states that "a food can be considered functional if it is satisfactorily demonstrated to have a beneficial effect on one or more target functions of the body, beyond the provision of adequate nutrition, in a way that is relevant to improving health and well-being and/or reducing the risk of disease" [5,6]. Understanding the factors that determine consumer acceptance and their relationships is essential for the successful launch of a product and for crafting marketing strategies in the emerging market of functional foods [7]. This is particularly important due to the competitive nature of the functional food market and the intricate process of consumer

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acceptance of these new foods [8]. In this context, Cluster analysis performs a pivotal role in the segmentation of consumer preferences regarding functional foods. It allows the identification of homogeneous groups of consumers with similar preferences for functional foods [9]. This is vital for food companies because it allows them to differentiate between market segments with varying needs and tailor marketing and product strategies to each of them. Segmenting consumers according to their preferences helps companies provide products that meet the specific needs of different consumer groups, thereby enhancing competitiveness and success in the marketplace [10]. From Marketing point of view, Consumer segmentation based on sociodemographic characteristics plays a crucial role in the realm of marketing and business strategies. This practice allows companies to gain a deeper understanding of their target audience dynamics by categorizing them into homogeneous groups based on variables such as age, gender, education level, and socio-economic context. This approach enables businesses to customize their offerings, advertising messages, and communication strategies, tailoring them to the specific needs and preferences of each demographic segment. A detailed understanding of consumers' socio-demographic characteristics is therefore crucial for crafting effective business strategies that cater to the specific needs of each audience segment. A clear definition of the target market allows companies to allocate resources efficiently, adapting their efforts to meet the particular needs of consumers within those segments. Consumer segmentation and target market definition are essential tools for focused marketing, contributing to the establishment of long-term relationships with the target audience.

In the context of this study, we hypothesize that sociodemographic characteristics play a significant role in shaping the consumption patterns of functional foods. Therefore, our research aims to utilize variables such as age, gender, and socio-economic status as investigative tools. Specifically, we seek to explore how these variables influence dietary choices, with a particular emphasis on functional foods. This entails examining the intricate relationship between sociodemographic factors and food preferences among Sicilian consumers.

This investigation seeks to provide valuable insights to tailor marketing strategies, meeting the specific needs of various demographic subgroups, and promote a more targeted functional food awareness among diverse consumer categories.

This paper is organized as follows. First the introduction, review and a description of the functional food sector in Europe and Italy then the literature review and a description of the functional food sector in Europe. Next, data and methods are explained. Finally, results and conclusions are presented.

### 1.1. Functional food sector

According to [11], the average per-capita spending on functional foods globally is estimated to be 26 euros. However, this value varies by geographical region, and we can break down the total global revenue for this sector percentagewise. The primary global market for "functional food" is in Asia, with Japanese consumers spending an average of 150 euros *per year* on functional foods. The second-largest global market is in the USA and Canada, collectively reaching 25% of the global level. Europe has its unique characteristics, primarily marked by the widespread distribution of functional foods across the European territory. The main markets in Europe include Germany (14%), followed by France (13%), and subsequently Italy (11%). Dairy and dairy-based products hold the largest market share at 38%, followed by baked goods and cereals at 22.7%. Overall, Europe holds a market share of approximately 2.8 million euros globally, with a predicted growth rate of 14% in the coming years, especially in products that provide benefits for the digestive and cardiovascular systems. Nevertheless, the market is diversifying with an increase in functional foods aimed at positively impacting the immune, nervous, and skeletal systems, as well as physical well-being. As for Italy, it holds a prominent position in the functional

food market, particularly in the supplements category, with a size of 3.8 billion euros in 2020. Between 2008 and 2020, the Italian market in this sector tripled, with an annual growth rate of 9%. This growth is strongly associated with consumer awareness of the Mediterranean diet, which includes the consumption of fish and "good" fats like omega-3, DHA, and EPA, known to lower blood pressure and help metabolize triglycerides [12]. These substances are used to enrich products such as milk, yogurt, and baked goods like fiber-enriched bread with beta-glucans to regulate cholesterol metabolism [13]. Several economic considerations emerge regarding the Sicily region and the broader context of Italy in relation to the global market of functional food products. Italy plays a significant role in this sector, particularly standing out in the category of functional foods. The sector's growth is closely tied to consumer awareness of the Mediterranean diet. Furthermore, there is a noticeable trend towards a growing diversification of the market into functional food products targeting the immune, nervous, skeletal systems, and overall physical well-being. This trend presents intriguing prospects for growth and diversification for food businesses in Italy, including Sicily, provided they can innovate and adapt their products accordingly. This positive outlook might attract the interest of entrepreneurs and investors operating in the food sector in the Sicilian region. In this context, Sicily and Italy as a whole are positioned favorably to capitalize on the rising demand for functional food products, leveraging their geographical location, rich culinary tradition, and the increasing consumer awareness of a healthy diet.

## 2. Literature review

Many studies have examined the factors that could predict consumer acceptance of functional foods, and there are many influential factors that have been reported [11,12]. This diverse array of influential factors brings about a set of challenges for professionals in the functional foods industry who are tasked with crafting precise communication strategies and promotional materials that can effectively enhance consumer acceptance of these products [14]. In the realm of scholarly literature, the analysis of consumer preferences for functional foods can be categorized into five distinct dimensions, encompassing product attributes, socio-demographic variables, psychological traits, behavioral attributes, and physical aspects [15]. In our current study, the central focus is specifically directed towards investigating the impact of socio-demographic characteristics on the consumption patterns of functional foods. These socio-demographic attributes carry substantial weight when it comes to influencing the acceptance of functional foods among consumers [16,17].

Numerous empirical studies [18,19] have undertaken the examination of a range of factors encompassing age, gender, educational status, household attributes, geographic location, nationality, and marital status. Concerning age, it has been frequently observed that elderly individuals tend to be the predominant consumers of functional foods [20]. For instance, research has pointed out that individuals aged 65 years or older exhibit a heightened preference for various types of functional food. This inclination may stem from their heightened focus on health-related matters compared to their younger counterparts [21, 22]. However, an intriguing counterpoint emerges from other studies, which suggest that younger individuals, particularly those aged 25 and below, display a stronger interest in functional foods compared to their older counterparts [16–26] investigate that attribute this youthful enthusiasm for functional foods to their open-mindedness and their readiness to experiment with novel food items. These findings underscore the importance of young adults as a significant consumer demographic for functional foods. For instance Ref. [27], identify individuals aged 18 to 34 as potential consumers of functional foods [28], posit that individuals aged 19 to 30 represent a future consumer base.

The matter of gender's influence on the acceptance of functional foods has yielded a general consensus across the majority of studies [29,

30]. Specifically, these studies concur that female consumers are more inclined to incorporate functional foods into their diets compared to their male counterparts. One plausible explanation for this gender-based discrepancy may lie in the fact that women often assume the primary role in purchasing and preparing food for their families [31]. Further research has also demonstrated that an individual's level of education wields a significant impact on their acceptance of functional foods. The findings from most studies converge on the idea that individuals with higher levels of education tend to express a stronger intention to purchase and consume functional foods [32,33]. Previous studies have further highlighted the relevance of household characteristics, including income and household size, as socio-demographic determinants that influence the acceptance of functional foods, in fact, the outcomes of these investigations consistently suggest that a higher income level is positively associated with a greater willingness to purchase functional foods [34,35]. This link can be attributed to the notion that consumers with higher incomes possess the financial means to allocate more of their budget toward the procurement of functional foods [36]. In terms of household characteristics, families with young children [37] or teenagers demonstrate a heightened propensity to adopt functional foods into their dietary choices. For instance Ref. [38], discovered that families with smaller household sizes exhibit a stronger inclination to purchase functional foods compared to those with larger households. Nevertheless, other research investigation has identified a positive association between a higher number of household members and the consumption of functional foods [16]. Finally, two of the scrutinized studies have specifically probed the influence of marital status on consumer acceptance [39], established that single individuals are more likely to incorporate functional foods into their diets than their married counterparts, whereas [40] have observed that married or widowed consumers display a greater willingness to invest in functional foods compared to single or divorced individuals. The literature on functional foods has undeniably garnered significant research attention, primarily focusing on consumer acceptance and the identification of influential factors [41]. Despite this extensive exploration, there are noticeable gaps that warrant further investigation. While numerous studies have delved into the multifaceted factors influencing consumer acceptance of functional foods, a conspicuous gap exists in the need for more targeted research that explicitly addresses the nuanced impact of socio-demographic characteristics on consumption patterns [42]. Understanding how age, gender, education, and other socio-demographic factors shape preferences and choices is crucial for developing tailored strategies that resonate with different consumer groups [43].

Furthermore, the functional foods industry operates in a dynamic environment, characterized by continuous innovation and the evolution of consumer preferences. This necessitates a more profound exploration of consumer attitudes towards specific types of functional foods, the identification of key drivers shaping preferences, and the development of targeted marketing strategies resonating with the diverse socio-demographic segments constituting the consumer base. Addressing these aspects, researchers can contribute to a more refined and practical knowledge base, enabling industry stakeholders to adapt their approaches to the dynamic nature of the functional foods market.

### 3. Data and methods

In this section of our study, we conducted a comprehensive analysis of participants' socio-demographic attributes and their consumption profiles. Subsequently, we utilized the K-Means clustering algorithm to partition the participants into homogeneous groups based on their behaviors and preferences. This combined approach provide valuable insights into distinct consumption patterns and trends within the sample, allowing us to gain a better understanding of the characteristics and consumer habits of our study's participants.

We conducted a questionnaire survey from January to April 2023, using Google Forms distributed through various prominent social media

platforms. The choice of this non-probabilistic sampling method was based on several considerations.

1. **Accessibility:** Using online platforms allowed us to reach a broader and more diverse audience, transcending geographical limitations. This approach enabled us to collect responses from individuals across different locations and backgrounds.
2. **Cost-Effectiveness:** Online surveys are cost-effective, as they eliminate the need for physical surveys or face-to-face interviews. This was especially advantageous for a student-led research project with limited resources.
3. **Time Efficiency:** Administering the survey online expedited data collection, analysis, and report generation. The digital format allowed for a quicker turnaround, making it suitable for an academic study with a finite timeframe.
4. **Wider Outreach:** Social media platforms have a vast user base, including individuals from various age groups, genders, family sizes, cities, and occupations. This diversity in the online audience aligns with the variables we aimed to investigate, making it an appropriate choice for our research.
5. **Anonymity and Privacy:** Online surveys provide a level of anonymity and privacy that participants may find comfortable, leading to more candid and honest responses.

Given these advantages, a non-probabilistic sampling approach via online platforms was deemed suitable for our research, allowing us to collect a rich dataset that aligns with the variables we intended to analyze. This approach has been increasingly used in contemporary survey research, making it a valid and practical method for our study.

We are fully aware of the limitations and constraints related to the generalizability of our study's results. It's crucial to acknowledge that our research was conducted using a non-probabilistic sampling method, which means that the participants in our survey were not randomly selected from a larger population. This non-probabilistic approach could result in a few limitations.

1. **Sampling Bias:** Since our data collection primarily relied on individuals who voluntarily participated in the online survey, our sample may not be fully representative of the broader population. This could introduce sampling bias, as certain demographics or characteristics might be overrepresented or underrepresented in our sample.
2. **Limited Geographical Scope:** The survey was administered online, which might have led to overrepresentation from certain geographical regions with better internet access. As a result, the findings may not be applicable to areas with different access or socio-economic conditions.
3. **Self-Selection Bias:** Participants chose to take part in the survey voluntarily. This self-selection bias can influence the results, as those who participated may have different characteristics, interests, or knowledge compared to those who did not take part.
4. **Limited Scope:** Our study focused on a specific group of respondents who had access to and were active on social media. This limits the generalizability of our findings to individuals who are not part of this digital demographic.
5. **Temporal Constraints:** The data was collected during a specific time frame (January to April 2023), and consumer behaviors and attitudes can change over time. Thus, the results may not reflect long-term trends.
6. **Self-Reported Data:** Our findings rely on self-reported data, which can be influenced by recall bias, social desirability bias, or misinterpretation of questions.

Given these limitations, it's important to stress that our results should be interpreted as insights derived from our specific sample and survey methodology. While the findings can provide valuable

information and trends, they may not be readily applicable to the entire population.

This table lists various variables used in a survey or research study, along with their respective coding levels and descriptions. Here's a comment on each variable.

- **Age:** There are 6 coding levels representing age groups, from 15 to 20 years to 60+ years.
- **City dimension:** This variable categorizes geographical areas based on their size and proximity to major cities. There are 3 levels: small towns, medium-sized cities, and large cities/major towns.
- **Consumption frequency:** This variable assesses how often people consume functional foods, which offer specific health benefits beyond their basic nutritional value. The coding levels range from "Never" to "Everyday," with an option "I don't know."
- **Functional food knowledge:** This variable measures the familiarity and understanding of functional foods, known for providing specific health benefits beyond their basic nutritional content. The coding levels include "No," "Yes," and "Maybe."
- **Purchasing place:** This variable examines where people typically do their grocery shopping. The coding levels include "I do not purchase," "district market," "small grocery store," "supermarkets and hypermarkets," and "Online shopping."

Variable encoding is a common practice in cluster analysis for several reasons.

- **Need for Numerical Data:** Many cluster analysis algorithms require numerical data. Transforming categorical or qualitative variables into numerical ones allows these algorithms to be appropriately applied.
- **Data Standardization:** Variable encoding often involves data standardization, such as through normalization or the creation of z-scores. This is important to ensure that variables have the same scale and do not disproportionately influence the clustering process.
- **Distance Calculations:** In cluster analysis, distances between data points are often calculated to determine which observations are similar or dissimilar. Categorical variables do not allow for direct distance calculations, so they need to be transformed into numerical forms.
- **Analysis Simplification:** Variable encoding can significantly simplify the analysis. It is easier to manipulate, visualize, and interpret results when variables are numerical.
- **Algorithm Applicability:** Some clustering algorithms, such as K-Means, require data in numerical form. Variable encoding is, therefore, necessary to use these algorithms effectively.

In our research, we conducted a comprehensive analysis of the sample, encompassing an in-depth examination of the socio-demographic attributes and the consumption profiles of the survey respondents. Subsequently, we employed the K-Means clustering algorithm to partition the participants into homogeneous groups based on their behaviors and preferences, enabling us to discern consumption patterns and trends within the sample. This combined approach provided us with valuable insights into the characteristics and consumer habits of our study's participants.

### 3.1. K-means clustering procedure

**1. Initialization:** Begin by randomly selecting K initial centroids, where K is the desired number of clusters.

Equation:  $C = \{c_1, c_2, \dots, c_K\}$ , where  $c_i$  represents a centroid.

**2. Assignment of Data Points to Clusters:** For each data point in the dataset, calculate the distance between the point and each centroid. Assign the point to the cluster whose centroid is closest.

Equation:  $d(x, c_i) = \text{distance between point } x \text{ and centroid } c_i$   
**belongs to:**  $C_j$ , where  $j = \arg \min_i d(x, c_i)$

**Update of Centroids:** Calculate the new centroids for each cluster as the mean of the points assigned to that cluster.

Equation:  $C_i = \left( \frac{1}{|C_i|} \right) \sum (x \text{ in } C_i) x$

**3. Convergence:** Repeat steps 2 and 3 until the centroids no longer change significantly or until a maximum number of iterations is reached.

**4. Result:** At the end of the process, obtained K clusters, each containing a set of similar data points.

Inertia, which measures the quality of the clustering, is calculated as:  
 Equation:  $Inertia = \sum (i = 1 \text{ to } K) \sum (x \text{ in } C_i) \|x - c_i\|^2$

For our analysis, we used the IBM SPSS software. IBM SPSS is a powerful statistical software package that played a pivotal role in our research. We leveraged IBM SPSS for data preprocessing, transformation, and exploratory data analysis, enabling us to gain valuable insights into our dataset. Moreover, we harnessed IBM SPSS to implement the K-Means clustering algorithm, a critical component of our analysis, which enabled us to group participants based on their consumption behavior effectively. The use of IBM SPSS in our research ensured the robustness and precision of our findings.

## 4. Results

### 4.1. Descriptive statistics

The socio-demographic profile of the surveyed participants is characterized by a diverse range of age groups, with the majority falling within the 15–30 years bracket. This range is represented on a scale from 1 to 6, indicating a fairly broad age spectrum. In terms of gender, the distribution is relatively balanced, with 34.19% of participants identifying as male (coded as 1). The average party size among respondents is approximately 3.20, suggesting that the majority of participants typically dine with two or more people. Geographically, participants are predominantly from medium-sized cities, with a mean city dimension code of 2.01, reflecting a distribution that encompasses both small towns and larger urban centers (see Table 1).

The sample comprises 564 valid cases, indicating that 564 participants provided complete and reliable data, while others may have been excluded from the analysis. This socio-demographic diversity in terms of age, gender, and urban setting provides valuable insights for marketing strategies tailored to this heterogeneous consumer base. The consumption profile (Table 2) of the surveyed participants regarding functional foods reveals some noteworthy trends. Participants exhibit varying levels of familiarity with functional foods, with an average functional food knowledge score of approximately 1.01. This indicates that the majority of respondents have at least some awareness of functional foods, even though a considerable portion may not be fully informed.

In terms of consumption frequency, the participants, on average, consume functional foods approximately 2.74 times a week, demonstrating a moderate level of incorporation of such foods into their diets. This suggests that for a substantial portion of the respondents, functional foods are part of their regular nutrition routine.

Regarding preferred purchasing places for functional foods, the average score of 2.59 indicates that participants tend to favor options like small grocery stores or supermarkets and hypermarkets, suggesting convenience and variety as key factors in their choices.

Furthermore, participants seem to place a relatively high emphasis on the attributes influencing their purchasing decisions, particularly

**Table 1**  
Coded variables and descriptions for survey data.

Variable	Levels	Code	Description
<b>Age</b>	1	15–20	Age of interview participants, defined with integer value classes (range 15–60+)
	2	21–30	
	3	31–40	
	4	41–50	
	5	51–60	
	6	60+	
<b>City dimension</b>	<i>Small town (up to 5000 inhabitants)</i>	1	This variable categorizes geographical areas based on their population size and proximity to large cities.
	<i>Medium-sized cities (between 5001 and 250,000 inhabitants)</i>	2	
	<i>Large cities/large towns (&gt;250,000 inhabitants)</i>	3	
<b>Consumption frequency</b>	<i>Never</i>	0	This variable assesses how often individuals consume functional foods, which are foods designed to offer specific health benefits beyond their basic nutritional value
	<i>Almost never</i>	1	
	<i>1-2 times per month</i>	2	
	<i>once a week</i>	3	
	<i>2-3 times per week</i>	4	
	<i>Everyday</i>	5	
<b>Functional food knowledge</b>	<i>I don't know</i>	6	This variable assesses individuals' familiarity and understanding of functional foods, which are foods known to provide specific health benefits beyond their basic nutritional content.
	<i>No</i>	0	
	<i>Yes</i>	1	
<b>Purchasing place</b>	<i>Maybe</i>	2	This variable examines the locations where individuals typically make their food purchases
	<i>I do not purchase</i>	0	
	<i>district market</i>	1	
	<i>small grocery store</i>	2	
<b>Gender</b>	<i>supermarkets and hypermarkets</i>	3	Participant's gender
	<i>Online shopping</i>	4	
	<i>Female</i>	0	
	<i>Male</i>	1	

**Table 2**  
Consumption profile of surveyed participants

	N	Min	Max	Mean	St.D
Function_Food_Knowledge	582	0	2	1,01	0,569
Consumption_Frequency	559	0	6	2,74	1398
Purchasing_place	531	0	4	2,59	0,682
Based_onprice	555	1	5	3,17	1114
Based_ongeographicalorigin	553	1	5	3,46	1224
Based_onpersonal taste	552	1	5	4,30	0,832

Source: author's elaboration

when it comes to the perceived importance of price, geographical origin, and personal taste, as indicated by the high average scores of 3.17, 3.46, and 4.30, respectively, on a Likert scale from 1 to 5.

4.2. Cluster analysis

In recent years, several studies have been conducted to understand consumer attitudes towards functional foods. The literature review reveals that cluster analysis has been used in several studies to identify consumer segments based on their attitudes towards functional foods. For example [44], used cluster analysis to examine the relationship between respondents' characteristics and preferences for product variants [45]. conducted a cluster analysis to understand the use of nutritional information among consumers who intend to eat healthily. Similarly [46,47], used factor and cluster analysis to elicit consumer behavior towards functional foods [48]. used cluster analysis to evaluate the level of knowledge about food fibers among consumers in different countries [49]. Kim and Lee (2013) used cluster analysis to identify different consumer groups based on their consumption behavior

towards functional foods. These studies demonstrate the usefulness of cluster analysis in identifying consumer segments based on their attitudes towards functional foods.

Following the precedent set by the studies mentioned, we conducted a cluster analysis on the dataset at hand to gain insights into consumer attitudes and behaviors related to functional foods. In particular, we employed a K-means clustering approach for several reasons.

K-means clustering is a widely used method for partitioning data into distinct clusters or groups. It was chosen because it has proven to be effective and efficient in identifying consumer segments based on their attitudes and behaviors towards functional foods. The K-means algorithm is a centroid-based clustering technique that assigns data points to clusters with similar characteristics. The primary advantages of K-means clustering include its simplicity, speed, and ability to handle large datasets.

The K-means algorithm works by iteratively minimizing the within-cluster variance, attempting to create clusters that are as internally coherent as possible. It identifies cluster centroids (representative points) and assigns data points to the nearest centroid. This allows us to group individuals with similar preferences and behaviors when it comes to functional foods.

However, K-means clustering does have some limitations. One key drawback is that it requires the user to specify the number of clusters (K) in advance, which can be challenging if the optimal number of clusters is not known. Additionally, it assumes that clusters are spherical and equally sized, which may not always be the case in real-world data.

In our analysis, we found that K-means clustering was the most suitable method for our dataset, as it provided clear and interpretable results. By applying this technique (Table 3), we aimed to categorize consumers into distinct segments based on their consumption patterns and preferences regarding functional foods, allowing for a better understanding of the diverse consumer landscape in the context of this study.

**Table 3**  
Cluster procedure.

	Initial cluster centers		
	Cluster		
	1	2	3
Age	1	4	6
Gender_bin	0	1	1
Party_Size	3	4	2
City_Dimension	2	1	2
Function_Food_Knowledge	1	0	0
Consumption_Frequency	1	5	0
Purchasing_place	2	3	3
Based_onprice	2	2	5
Based_ongeographicalorigin	5	1	3
Based_onpersonal taste	3	5	5
	–	–	–
	Final cluster centers		
	Cluster		
	1	2	3
Age	–	–	–
Gender_bin	2	3	4
Party_Size	0	0	0
City_Dimension	4	3	2
Function_Food_Knowledge	2	2	2
Consumption_Frequency	1	1	1
Purchasing_place	1	1	1
Based_onprice	2	4	3
Based_ongeographicalorigin	3	3	2
Based_onpersonal taste	3	3	3
	3	4	4
	4	4	5
<b>Number of cases for each cluster</b>			
Cluster	1	225	
	2	126	
	3	133	

Source: author's elaboration

#### 4.2.1. Cluster 1

- Average age between 15 and 20 and 30 years.
- Individuals in this cluster are mainly from small cities or towns.
- They consume functional foods once or twice a month.
- They have limited knowledge of functional foods.
- Prefer to buy in neighborhood markets or small grocery stores.
- Composed of individuals of unspecified gender (F/M gender is evenly distributed).

#### 4.2.2. Cluster 2

- Average age between 21 and 40 years.
- Individuals in this cluster are predominantly from medium-sized cities.
- They consume functional foods at least once a week or more often.
- They have moderate knowledge of functional foods.
- Prefer to shop in supermarkets or hypermarkets.
- Composed mainly of male (M) individuals.

#### 4.2.3. Cluster 3

- Average age between 41 and 60+ years.
- Individuals in this cluster are predominantly in large cities or larger towns.
- They consume functional foods 2–3 times a week or more often.
- They have good knowledge of functional foods.
- Prefer to shop online or in supermarkets/hypermarkets.
- Composed mainly of female individuals (F).

### 5. Discussion

Food markets in developed economies are characterized by constant innovation and increasing product diversification. Companies try to respond to changing consumer preferences by introducing new and innovative products such as functional foods. In this context, consumers tend to be more health-conscious and focus more on disease prevention. Indeed, literature findings suggest a positive trend among consumers in purchasing functional food to reduce potential informational asymmetries. As confirmed by Ref. [50], information regarding the potential health benefits of antioxidants significantly influences consumers' willingness to pay.

The socio-demographic characteristics of consumers buying functional foods are necessary to understand the target market. Understanding these characteristics plays a key role in the successful launch of new products. In this context, cluster analysis could help segment the market by identifying groups of customers with similar characteristics, enabling companies to tailor their marketing strategies to specific consumers and better meet customer needs. This is essential for predicting future trends and adapting product offerings to customer needs. Based on the analysis conducted, we grouped the consumer determinants into three clusters.

Cluster 1 primarily consists of young consumers with ages ranging from 15 to 20 to 30 years. They prefer shopping at local neighborhood markets or small grocery stores. Gender does not appear to be a significant factor in this cluster. They are predominantly from small towns or provincial areas. These individuals consume functional foods once or twice a month and have a limited understanding of functional foods. This result is confirmed by the systematic review of [51], in which the majority of the participants in the included studies had limited knowledge, particularly nutrition-related knowledge linked with consuming functional foods and were unfamiliar with the idea of functional foods.

To effectively reach this group, it is essential to focus on education and information about the functionality of these foods. Offering free samples or tastings in local markets or small stores can be a great way to encourage purchases. Pricing strategies should emphasize affordability,

and special promotions for frequent buyers can be implemented. Utilize online and social media marketing channels to engage with this young audience.

Cluster 2 is composed of individuals with an average age ranging from 21 to 40 years. They are primarily residents of medium-sized cities and consume functional foods at least once a week or more frequently. Their knowledge of functional foods is moderate. They prefer shopping in supermarkets or hypermarket. This cluster is predominantly comprised of male individuals. This group can be best targeted with easily accessible functional products in supermarkets. Emphasize the health benefits of functional foods and promote a wellness image. Previous research [52] has shown that emerging adults aged 21 to 40 are more involved in meal preparation and consumption of functional meals, eating them at least once a week or more frequently than young people.

Cluster 3 encompasses individuals with an average age ranging from 41 and above. They are predominantly residents of large cities or larger towns. These consumers incorporate functional foods into their diet 2–3 times a week or more frequently and have a good understanding of these products. They prefer online shopping or supermarkets/hypermarkets. This cluster is primarily composed of female individuals. This finding aligns with existing literature, as confirmed by Ref. [53] in their study, which demonstrated that older individuals tend to have a higher interest in functional products compared to younger demographics due to their stronger belief in the health benefits of such foods. Furthermore, in this study [53] authors discover that women demonstrate a greater inclination to strike a balance between taste and health attributes when making food choices.

### 6. Conclusions

The delineated consumer clusters exhibit discernible characteristics that furnish valuable insights for the formulation of targeted marketing strategies and the advancement of product development. These findings emphasize the crucial necessity of adapting marketing approaches to the distinct needs and preferences inherent within each consumer cluster. Such a nuanced approach holds the potential to enhance the efficacy of promotional endeavors significantly. By aligning marketing strategies with the unique characteristics of each identified cluster, companies can optimize their outreach efforts and foster a more profound resonance with the diverse consumer base in Sicily. This tailored marketing paradigm is instrumental not only in capturing the attention and loyalty of consumers within specific demographic segments but also in fostering the overall triumph of the functional food market in Sicily. It serves as a strategic avenue to address the multifaceted consumer landscape, ultimately contributing to the sustained growth and competitiveness of the functional food industry in the region.

Overall, understanding these distinct consumer segments and tailoring marketing strategies accordingly is essential to effectively target and engage with consumers based on their consumption patterns and preferences. Recognizing the global growth of the functional food market, policy makers can explore the possibilities of exploiting Sicily's potential as a key player in this sector. Their considerations include strategic investments in research and development to increase the added value of locally produced functional foods. In addition, policymakers may seek to support and promote local functional food producers through financial incentives, marketing assistance and simplified regulatory processes. Educational campaigns could be conducted to make Sicilian consumers aware of the health benefits of functional foods, emphasizing the positive impact on general well-being. By integrating these considerations into policy frameworks, policy makers aim to promote economic growth, exploit Sicily's culinary heritage and contribute to the sustainable economic development of the population.

We started from the assumption that the consumption of functional foods is influenced by sociodemographic characteristics, and to verify this hypothesis, we examined variables such as age, gender, and socio-

economic context in relation to dietary choices. Thanks to the statistical analysis conducted, we also identified the significant differences in consumption levels among Sicilian consumers in relation to these characteristics. The hypothesis underlying this research was therefore confirmed and supported by the statistical tools implemented. Through this investigation, we were able to provide valuable insights to adapt marketing strategies, meet the specific needs of various demographic subgroups, and promote a more targeted awareness of functional foods among different categories of consumers. The analysis revealed that sociodemographic characteristics play a significant role in the dietary choices of Sicilian consumers, and the results indicate the presence of distinct consumption patterns based on these variables. With such studies, the literature surrounding the sphere of functional food consumption is enriched, and furthermore, it could lead to more targeted and effective campaigns, promoting an awareness of functional foods that aligns with the various categories of consumers present in Sicily. Ultimately, understanding how sociodemographic variables influence dietary choices has been essential for developing more effective approaches in the functional food market.

### CRedit authorship contribution statement

**Filippo Sgroi:** Project administration, Methodology, Data curation, Conceptualization. **Caterina Sciortino:** Methodology, Data curation, Conceptualization. **Amparo Baviera-Puig:** Resources, Conceptualization. **Federico Modica:** Writing – review & editing, Writing – original draft, Supervision, Formal analysis.

### 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.

### Data availability

Data will be made available on request.

### References

- [1] D. Villaño, A. Gironés-Vilapana, C. García-Viguera, D.A. Moreno, Development of functional foods, *Innovation strategies in the food industry* (2022) 193–207. Academic Press.
- [2] M.S. Arshad, W. Khalid, R.S. Ahmad, M.K. Khan, M.H. Ahmad, S. Safdar, H.A. R. Suleria, Functional foods and human health: an overview, *Functional Foods Phytochem Health Promoting Potential* 3 (2021).
- [3] L. Sharma, A. Yadav, Role of functional foods in human health and disease prevention, in: *Bioactive Components: A Sustainable System for Good Health and Well-Being*, Springer Nature Singapore, Singapore, 2022, pp. 225–243.
- [4] Y. Herdiana, Functional food in relation to gastroesophageal reflux disease (GERD), *Nutrients* 15 (16) (2023) 3583.
- [5] M.B. Roberfroid, Global view on functional foods: European perspectives, *Br. J. Nutr.* 88 (S2) (2002) S133–S138.
- [6] CE n. Regolamento, Parlamento europeo e del Consiglio, del 20 dicembre 2006, relativo alle indicazioni nutrizionali e sulla salute fornite sui prodotti alimentari, 1924/2006 del. <https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:404:0009:0025:IT:PDF>. November, 2023.
- [7] J. Bogue, L. Repar, Market-oriented methodologies that integrate the consumer into the functional foods new product development process: Part 1 contemporary approaches, in: *Case Studies on the Business of Nutraceuticals, Functional and Super Foods*, Woodhead Publishing, 2023, pp. 31–56.
- [8] S. Sumaedi, T. Rakhmawati, N.J. Astrini, M. Yarmen, I.G.M.Y. Bakti, S. Damayanti, Key company success factors in creating high-quality innovative food products, *Sage Open* 13 (1) (2023) 21582440221148145.
- [9] D. Szakos, The Role of Functional Food in Healthy Ageing: a Consumer Research Perspective, 2022 (PhD dissertation).
- [10] A. Kumar, Customer segmentation of shopping mall users using K-means clustering, *Advancing SMEs Toward E-Commerce Policies for Sustainability* (2023) 248–270. IGI Global.
- [11] Euromonitor, Emerging Trends in Functional Food, 2020. <https://www.euromonitor.com/>. November, 2023.
- [12] F. Sgroi, C.M. Moscato, R. Moscato, Consumer preferences for the mediterranean diet: results of an empirical analysis, *Journal of Agriculture and Food Research* 10 (2022) 100371.
- [13] A. Mykhalevych, G. Polishchuk, K. Nassar, T. Osmak, M. Buniowska-Olejnik,  $\beta$ -Glucan as a techno-functional ingredient in dairy and milk-based products—a review, *Molecules* 27 (19) (2022) 6313.
- [14] 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.
- [15] K. Küküköz, M. Trzaskowska, Nondairy probiotic products: functional foods that require more attention, *Nutrients* 14 (4) (2022) 753.
- [16] E. Hadjimbei, G. Botsaris, S. Chrysostomou, Beneficial effects of yoghurts and probiotic fermented milks and their functional food potential, *Foods* 11 (17) (2022) 2691.
- [17] F.P. Salvatore, N. Adamashvili, F. Conto, Factors affecting consumer purchasing behavior of functional food: a comparative analysis for consumer management, *Br. Food J.* 124 (5) (2022) 1519–1536.
- [18] S. Rai, P.P. Wai, P. Koirala, S. Bromage, N.P. Nirmal, R. Pandiselvam, N.K. Mehta, Food product quality, environmental and personal characteristics affecting consumer perception toward food, *Front. Sustain. Food Syst.* 7 (2023) 1222760.
- [19] G. Precup, C.B. Pocol, B.E. Teleky, D.C. Vodnar, Awareness, knowledge, and interest about prebiotics—a study among Romanian consumers, *Int. J. Environ. Res. Publ. Health* 19 (3) (2022) 1208.
- [20] O.A. Femi-Oladunni, M.P. Martínez-Ruiz, P. Ruiz-Palomino, A.I. Muro-Rodríguez, Food values influencing consumers' decisions in a sub-Saharan African country, *Br. Food J.* 125 (5) (2023) 1805–1823.
- [21] A.E. Ozen, M. del Mar Biliboni, A. Pons, J.A. Tur, Sociodemographic and lifestyle determinants of functional food consumption in an adult population of the Balearic Islands, *Ann. Nutr. Metab.* 63 (2013) 200–207.
- [22] K.T. Kombanda, C. Margerison, A. Booth, A. Worsley, Socio-psychological factors associated with young Australian adults' consumption of energy dense and nutrient poor (EDNP) foods, *Nutrients* 14 (4) (2022) 812.
- [23] A. Sparacino, V.M. Merlino, S. Blanc, D. Borra, S. Massaglia, A choice experiment model for honey attributes: Italian consumer preferences and socio-demographic profiles, *Nutrients* 14 (22) (2022) 4797.
- [24] B. Schnettler, H. Miranda, G. Lobos, J. Sepúlveda, L. Orellana, M. Mora, Willingness to purchase functional foods according to their benefits, *Br. Food J.* 117 (2015) 1453–1473.
- [25] W. Verbeke, Consumer acceptance of functional foods: socio-demographic, cognitive and attitudinal determinants, *Food Qual. Prefer.* 16 (2005) 45–57.
- [26] A. Ballini, I.A. Charitos, S. Cantore, S. Topi, L. Bottalico, L. Santacrose, About functional foods: the probiotics and prebiotics state of art, *Antibiotics* 12 (4) (2023) 635.
- [27] W. Verbeke, Consumer acceptance of functional foods: socio-demographic, cognitive and attitudinal determinants, *Food Qual. Prefer.* 16 (1) (2005) 45–57.
- [28] N. Urala, Functional Foods in Finland: Consumers' Views, Attitudes and Willingness to Use, Academic Dissertation. VTT Publication, 2005, p. 581.
- [29] E. Carrillo, V. Prado-Gascó, S. Fiszman, P. Varela, Why buying functional foods? Understanding spending behavior through structural equation modelling, *Food Res. Int.* 50 (2013) 361–368.
- [30] B.T. Nystrand, S.O. Olsen, Consumers' attitudes and intentions toward consuming functional foods in Norway, *Food Qual. Prefer.* 80 (2020) 103827.
- [31] M. Mohammad, "The impact of socio-demographic profile and product identity on functional food acceptance: a review." *IJARBM – International Journal of Applied Research in Business and Management*, 3(2), (pp. 48–65).
- [32] T. Madařás, E. Kontor, E. Antal, G. Kasza, D. Szakos, Z. Szakály, Food purchase behavior during the first wave of COVID-19: the case of Hungary, *Int. J. Environ. Res. Publ. Health* 19 (2) (2022) 872.
- [33] N. Palmieri, V. Stefanoni, F. Latterini, L. Pari, Factors influencing Italian consumers' willingness to pay for eggs enriched with omega-3-fatty acids, *Foods* 11 (4) (2022) 545.
- [34] C. Contini, K. Grunert, R.N. Christensen, F. Boncinelli, G. Scozzafava, L. Casini, Does attitude moderate the effect of labelling information when choosing functional foods? *Food Qual. Prefer.* 106 (2023) 104795.
- [35] H. Öztop, P. Pekmezci, C. Misirlioglu, The child rearing roles and responsibilities of women in terms of gender, in: *Handbook of Research on Policies, Protocols, and Practices for Social Work in the Digital World*, IGI Global, 2021, pp. 411–426.
- [36] I.E. Aguilar-Rodríguez, L.G. Arias-Bolzmann, Lifestyle and purchase intention: the moderating role of education in bicultural consumers, *J. Int. Consum. Market.* 35 (1) (2023) 30–46.
- [37] E. Savelli, F. Murmura, The intention to consume healthy food among older Gen-Z: examining antecedents and mediators, *Food Qual. Prefer.* 105 (2023) 104788.
- [38] G. Rezaei, P.K. Teng, Z. Mohamed, M.N. Shamsudin, Functional food knowledge and perceptions among young consumers in Malaysia, *Int. J. Econ. Manag.* 6 (2012) 307–312.
- [39] M.P. Corso, D.L. Kalschne, M.D.T. Benassi, Consumer's attitude regarding soluble coffee enriched with antioxidants, *Beverages* 4 (2018) 72.
- [40] R. Pahwa, S. Arora, S. Kaur, Health-taste trade-off in consumer decision-making for functional foods, *Technology, Management and Business* 31 (2023) 127–141. Emerald Publishing Limited.
- [41] D. Moro, M. Veneziani, P. Scokoi, E. Castellari, Consumer willingness to pay for catechin-enriched yogurt: evidence from a stated choice experiment, *Agribusiness* 31 (2015) 243–258.
- [42] J. Markovina, J. Cacic, J.G. Kjusuric, D. Kovacic, Young consumers' perception of functional foods in Croatia, *Br. Food J.* 113 (1) (2011) 7–16.
- [43] C.H. Lee, Korean Food and Foodways: the Root of Health Functional Food, Springer Nature, 2022.

- [44] G. Hailu, A. Boecker, S. Henson, J. Cranfield, Consumer valuation of functional foods and nutraceuticals in Canada. A conjoint study using probiotics, *Appetite* 52 (2) (2009) 257–265.
- [45] K.G. Grunert, J.M. Wills, Use of nutritional information: analysing clusters of consumers who intend to eat healthily, *BMC Publ. Health* 19 (1) (2019) 1–10.
- [46] A. Annunziata, R. Vecchio, Factors affecting Italian consumer attitudes toward functional foods, *AgBioforum* 14 (1) (2011) 20–32.
- [47] M.P.G. Broen, et al., Cluster analysis to the factors related to information about food fibers: a multinational study, *Journal of Open Agriculture* 5 (1) (2020) 526–534.
- [48] V.M. Gómez-López, et al., Cluster analysis to the factors related to information about food fibers: a multinational study, *Journal of Open Agriculture* 5 (1) (2020) 526–534.
- [49] H.J. Kim, S.Y. Lee, *Functional Foods and Adult Consumers' Consumption Behavior*, Doctoral dissertation, 2013.
- [50] A. Markosyan, J.J. McCluskey, T.I. Wahl, Consumer response to information about a functional food product: apples enriched with antioxidants, *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie* 57 (3) (2009) 325–341.
- [51] M. T Baker, P. Lu, J.A. Parrella, H.R. Leggette, Investigating the effect of consumers' knowledge on their acceptance of functional foods: a systematic review and meta-analysis, *Foods* 11 (8) (2022) 1135.
- [52] L. Vorage, N. Wiseman, J. Graca, N. Harris, The association of demographic characteristics and food choice motives with the consumption of functional foods in emerging adults, *Nutrients* 12 (9) (2020) 2582.
- [53] K. Topolska, A. Florkiewicz, A. Filipiak-Florkiewicz, Functional food—consumer motivations and expectations, *Int. J. Environ. Res. Publ. Health* 18 (10) (2021) 5327.