Agriculture and Food

http://www.aimspress.com/journal/agriculture

Research article

Determinants influencing the food digestibility perception: A study based on consumer-stated preferences for sweet peppers

Rachele De Cianni[1], Raffaele Zanchini[1], Angelina De Pascale[2]*, Maurizio Lanfranchi[2], Teresina Mancuso[1], Mario D'Amico[3], Giuseppe Di Vita[3]

[1] Department of Agricultural, Forest and Food Sciences, University of Turin, Turin, Italy
[2] Department of Economics, University of Messina, Messina, Italy
[3] Department of Agriculture, Food and Environment, University of Catania, Catania, Italy

* **Correspondence:** Email: adepascale@unime.it; Tel: +39 0906766157.

Abstract: In recent years, there has been a growing focus on healthy eating. Concerns about general healthiness, food safety, evolving culinary preferences and the shift towards healthier lifestyles are shaping consumers' intentions when it comes to food purchases, impacting the demand for food items that are perceived as healthier than other options. This study aims to enhance our understanding of the significance that consumers place on perceptions of food digestibility, with a specific focus on sweet peppers as a case study. To explore signals linked to consumers' perceptions of digestibility, a questionnaire was administered to 582 Italian consumers. Employing an econometric estimation as the methodological approach, we aim to elucidate the relationship between various factors and the perception of digestibility. The results suggest that intrinsic and extrinsic characteristics of sweet peppers, culinary preparations and sociodemographic traits of consumers may influence perceived digestibility. In conclusion, the study finds that Italian consumers pay significant attention to the digestibility of sweet peppers, and these insights can serve as a valuable tool for the gastronomy sector. This paper introduces novel aspects to the literature, as–to the best of the authors' knowledge–no previous study has explored consumers' perceptions of food digestibility.

Keywords: consumer perception of digestibility; sweet peppers; vegetables and fruits; vegetarian diet; binary logistic regression; consumers' preferences

1. Introduction

Consumer perceptions of food digestibility can significantly vary based on individual factors, including personal experiences, cultural beliefs and dietary habits [1,2]. While some consumers prioritize easily digestible foods due to health reasons, religious restrictions, ethnic customs or cultural significance [3], others may prioritize factors like taste, convenience or other considerations [4].

Nonetheless, a common preference among consumers is for foods that are easily digestible and do not cause digestive discomfort [5]. In recent years, there has been a growing interest in foods perceived as more easily digestible, including fermented foods and beverages such as yogurt, kefir and kombucha [6,7]. Despite being marketed to promote intestinal health and digestion, the scientific evidence supporting these claims requires further investigation [8]. Additionally, certain consumers may steer clear of foods perceived as challenging to digest or those associated with digestive discomfort, such as beans, cruciferous vegetables and high-fat or spicy foods. These foods are often considered "heavier" or "richer" and may be avoided by individuals aiming to manage weight or maintain a healthy diet [9]. In addition, Chowdhury et al. [10] highlighted that the digestibility of various foods is perceived to vary based on their physical forms. Meanwhile, Munialo and Andrei [3], in their analysis of the health benefits of plant-based foods, underscore the role of attitudes and sensory perception in shaping consumers' perspectives on this food category.

Despite the abundance of studies scrutinizing consumer decision-making regarding fruits and vegetables, there is a noticeable gap when it comes to considering the perceived digestibility attribute in the consumer purchasing process. This gap becomes even more pronounced when focusing on the perceived digestibility of vegetables. In the realm of fruit and vegetable consumption, research has extensively explored facets of consumer experience and post-consumption satisfaction. Scholarly investigations underscore the influence of food quality, food safety concerns and the place of purchase on consumer preferences and consumption patterns during purchasing decisions [11–14].

These concerns become more significant during the selection of vegetables due to their complexities related to sensory-related qualities, health benefits, nutritional value and pricing [15–17]. However, there is currently a lack of in-depth analysis on the consumer perception of vegetable digestibility. Certainly, examining how consumers perceive the digestibility of food, particularly with a specific focus on vegetables, holds significant importance. Despite various studies investigating different aspects of vegetable perception [11,18–23], there has been no dedicated study specifically addressing consumer perceptions of food digestibility. Understanding this perception is crucial, as it can impact a consumer's satisfaction and influence their likelihood to repurchase the product in the future. As this topic continues to gain prominence in consumer food choices [3,24], the current study seeks to fill a research gap by investigating the perception of sweet peppers among Italian consumers. There exist numerous ecotypes of peppers (C. annum) globally, ranging from more widespread varieties to locally cultivated ones, exhibiting differences in various aspects, particularly in flesh texture and skin thickness. These variations contribute to distinctions in digestibility and culinary qualities [25]. Notably, the seeds and peel of vegetables, including peppers, are frequently discarded due to perceived poor digestibility, despite containing bioactive compounds with healthful and functional characteristics [26]. While peppers are recognized for causing some digestive issues, as far as the authors are aware, no studies have scrutinized the perceived digestibility of this vegetable by consumers.

Hence, this study aims to investigate consumers' perceptions of peppers regarding their digestibility. It takes into account the intrinsic sensory characteristics and extrinsic variables of peppers,

along with culinary preparations and sociodemographic characteristics. Generally, peppers are considered a healthy and digestible food for the majority of people [27], although some consumers have reported digestive problems [25]. In this context, the novelty of this paper lies in providing a deeper understanding of consumers' perceptions of peppers concerning their digestibility and its implications in gastronomy, utilizing sweet peppers as a case study.

The remainder of this paper is organized as follows: Section 2 offers a comprehensive literature review covering studies on the intrinsic sensory aspects of sweet peppers, as well as the extrinsic and socio-demographic characteristics associated with the consumption of peppers and vegetables. Additionally, this section introduces the research hypotheses. Section 3 provides a detailed overview of the methodology employed. Section 4 presents the primary findings derived from the linear logit model. Section 5 assesses the hypotheses and engages in a discussion of the main results, drawing on the existing literature related to sweet peppers and vegetables. Section 6 summarizes the outcomes, highlights the study's implications and limitations and outlines avenues for future research.

2.   Conceptual background and research hypotheses

Building on the preceding considerations, this section delineates the conceptual background of the study. It subdivides the main groups of determinants that will be analyzed and outlines the research hypotheses. This serves as a foundation before transitioning to the operational phase of data collection.

2.1. Composition and digestibility of sweet pepper

Sweet peppers (*Capsicum annuum*) are nutrient-rich vegetables, serving as a commendable source of vitamins and dietary fibers [28]. Dietary fibers, categorized as carbohydrate polymers resistant to digestion and absorption in the small intestine, undergo fermentation by the host microbiota in the large intestine [26,29]. This fermentation process produces gas, potentially leading to undesirable effects like excessive flatulence or abdominal pain [30,31]. Dietary fibers, encompassing oligosaccharides, disaccharides, monosaccharides and fermentable polyols, are found in various foods, including fruits, vegetables, dairy products, grains and legumes. Despite playing a crucial role in nutrition and contributing to the healthy functioning of the entire gastrointestinal tract, the ingestion of dietary fibers can induce several unpleasant effects, resulting in digestive discomfort [32,33]. However, beyond fibers, peppers also boast a spectrum of nutrients conducive to digestion, such as vitamin C, vitamin A and potassium [34,35]. These nutrients contribute to the support of the digestive system by fostering a healthy gut microbiota, reducing inflammation and maintaining regular bowel movements [36]. Despite these beneficial aspects, some individuals may encounter digestive problems after consuming peppers, especially if they possess sensitivity or allergies to nightshade vegetables [27]. Nightshade vegetables, like peppers, tomatoes, eggplants and potatoes, contain a natural chemical called solanine that may cause digestive discomfort in certain individuals [33]. The digestibility of peppers is contingent on various factors, including their preparation, individual tolerances and species [26,37,38]. Therefore, the first hypothesis was proposed:

Hypothesis 1: Consumers perceive the digestibility of peppers differently.

2.2. Sensory attributes of fruit and vegetables and digestibility

Color, flavor and texture represent sensory intrinsic attributes crucial for immediate product differentiation and have demonstrated significance in consumer choices for fruits and vegetables [19,39]. The visual appearance of a product forms the consumer's initial impression, leading to associations with other sensory characteristics such as aroma, taste and texture. For instance, displaying images of differently colored apples elicits perceptions among consumers, with green apples considered sour, red apples perceived as sweet and yellow apples suggesting a soft texture [40]. Bell peppers, whether consumed raw (green) or ripe (e.g., red, yellow), offer a diverse range of flavors [41]. The color of sweet peppers emerges as a primary factor influencing a consumer's purchasing decisions [42]. In markets, green, yellow and red peppers are available, and color can significantly impact consumer choices and their willingness to consume [43]. Hence, visual appearance serves as a pivotal criterion for post-harvest quality assessment of fruits and vegetables [44].

Beyond color, visual appearance encompasses perceptions of size, shape, gloss, texture and the absence of blemishes, wilting or rotting [45]. Since color can influence the perception of taste and texture, the authors posit that it may also impact consumers' perceptions of digestibility. In the case of sweet peppers, assessing their digestibility and organoleptic and culinary properties involves considerations such as the consistency of the pulp, crunchiness and peel thickness [25,26]. Accordingly, the second hypothesis was proposed:

Hypothesis 2: Taste-related sensory attributes such as consistency of pulp, crunchiness, and peel thickness as well as visual appearance attributes such as color influence consumers' perception of digestibility

2.3. The effect of cooking on digestibility

Peppers serve the dual purpose of adding color and flavor to various food products and meals. Their culinary versatility extends from being used as a vegetable, such as bell or sweet peppers, to acting as a spice, as in the case of chili, or even as a colorant, like paprika. This diversity is contingent upon the different intensities of flavor and textures they impart [46]. Culinary preparations encompass a range of options, including pickled peppers, frozen slices or cubes for pizza and raw inclusion in salads [47]. Peppers are incorporated into diverse dishes, whether consumed fresh, powdered or cooked with vegetables. They are commonly featured in pasta, pickles and sauces and can be prepared through boiling or sautéing [48]. These cooking processes, often employed to enhance palatability and improve the edibility of foods [49], can bring about alterations in the physical characteristics and chemical compositions of peppers. However, the tolerability of individuals to cooked peppers is contingent on the specific preparation method. Studies indicate that cooking methods can indeed impact the digestibility of peppers [38]. For instance, grilling or roasting peppers can assist in breaking down tougher fibers, rendering them easier to digest [38,50]. Conversely, overcooking peppers may lead to the breakdown of essential nutrients, diminishing their digestibility [51]. Thus, it is evident that cooking methods play a crucial role in influencing the digestibility of peppers [38]. Therefore, the third hypothesis was proposed:

Hypothesis 3: Preparation methods of peppers influence consumers' perceptions of digestibility.

2.4. Socio-demographic characteristics of vegetables consumers (including sweet peppers)

Food choices are intricate, influenced by a myriad of factors that can impact individuals differently, contingent upon context, personality, social groups and sociocultural position [21]. A study scrutinizing the sociodemographic characteristics of consumers concerning various fruit and vegetable attributes [21] revealed that the typical fruit and vegetable consumer is predominantly middle-aged, with both women and men playing significant roles. Notably, consumer choices are markedly influenced by factors such as average income and age. Household economic resources, in particular, have proven to be discriminative in purchasing decisions, guiding low-income consumers toward generic products without distinctive features. In the realm of sweet peppers, a study that segmented consumers based on their preferences found that a few segments displayed noteworthy differences from the overall sample, with gender, household size and the frequency of green and yellow bell pepper purchases identified as the demographic and behavioral variables that predominantly determined membership in most segments. Consequently, the identification of purchasing patterns based on socioeconomic characteristics [18] remains a crucial priority in this field, with a specific emphasis on income, education, gender and age [52,53]. Accordingly, the fourth hypothesis was proposed:

Hypothesis 4: Sociodemographic characteristics such as gender, age, income and education can have an impact on different perceived digestibility by consumers.

2.5. Extrinsic attributes related to sustainability.

It is crucial to recognize that with the diminishing direct link to producers in recent years [19], consumers often rely on extrinsic attributes such as brand name or country of origin as indicators of product quality and safety when making food choices, alongside considerations of production methods and process certifications [35,54]. Attributes linked to production methods have diverse impacts on purchasing decisions in consumer studies, covering aspects related to the environment, risks and certification criteria. For instance, organic production encompasses, albeit broader in scope, the "pesticide-free" attribute, as it prohibits the use of synthetic pesticides [39]. Extrinsic quality characteristics, encompassing style, labeling, branding, packaging and other elements of the marketing mix, are pivotal not only for enhancing consumer appreciation of a specific product but also for increasing producer benefits by enabling the offering of a unique selling proposition and creating added value [55,56]. While intrinsic characteristics have been deemed more crucial in consumer evaluations of fruits and vegetables [14], the incorporation of additional extrinsic quality characteristics in fruit and vegetable offerings is readily adaptable [55]. It is imperative to consider extrinsic aspects related to sustainability, given the growing consumer emphasis on more sustainable products [57–59]. Therefore, the fourth hypothesis was proposed:

Hypothesis 5: Production method of bell pepper related to sustainability can affect overall consumer perception of digestibility.

3. Materials and methods

3.1. Survey design

The survey was designed to assess consumers' perceptions of digestibility based on their stated

preferences. A questionnaire, encompassing demographic information, sweet pepper consumption habits and factors influencing digestibility, was created to collect data and insights on the perceptions of Italian consumers regarding sweet pepper digestibility.

The questionnaire consisted of a multi-section survey divided into three groups: (1) general characteristics of sweet pepper consumption, where also perceived digestibility was investigated; (2) importance of extrinsic and intrinsic characteristics for sweet-pepper consumption and (3) socio-demographic characteristics of the sample. The first section included the culinary preparation of peppers and color, while the second section had questions related to sensory and taste attributes and finally production process sustainability index. To quantitatively investigate consumers behavior, Likert scales were adopted ranging from 1–7 in section 1 and 2. The 7-point Likert scale was chosen because it facilitates consumer responses while maintaining good accuracy [60]. Furthermore, it is widely used in consumer-oriented surveys [2,61,62].

The questions in section 1 were developed as follows:

• How often do you consume red/yellow/green pepper? (1 = never; 7 = very often)
• How often do you consume raw/sautéed/baked pepper? (1 = never; 7 = very often)

Section 2 included the questions:

• How important are the following intrinsic attributes for pepper consumption (consistency of pulp/crunchiness/peel thickness? (1 = not important; 7 = very important)?

• How important are the following extrinsic attributes for pepper consumption environmental impact/place of production/certification of integrated productions? (1 = not important; 7 = very important)?

Prior to conducting the study, a pilot survey involving 40 individuals (with different gender, educational background, places of residence and age) was organized to check if questions could be understood by consumers and to make any necessary adjustments. This preliminary phase led to minor corrections and the validation of the final survey.

Respondents were selected through convenience sampling–a nonprobability method–due to budget constraints. Only participants who were aged 18 or older, currently residing in Italy and consumers of sweet peppers were included in the survey, meeting the specified criteria.

Data was gathered online in Italy by using a questionnaire divided in different sections that was shared via link and generated using Google form. To effectively collect data and to reach consumers in different Italian locations by bridging the limitations of physical distance, chain referencing was used [2]. This method, also known as snowball sampling, is considered a nondiscriminatory and nonprobabilistic method that, using existing social structures, allows exponential data collection [63]. The effectiveness of this sampling procedure can be related to the chain reaction generated by data collection. Indeed, respondents participating in the survey have the possibility to share the questionnaire to their acquaintances [64]. The survey was shared in different social media platforms and respondents were involved after being informed about the topic and the goal of the research. In fact, informed consent was provided to the respondents, also indicating that the survey should only be compiled by adults over 18. In addition, to improve the reliability of responses, a screening question was introduced that asked consumers whether they were currently responsible for food expenditures. Data collection leads to a convenient sample of 582 valid records whose characteristics are depicted in Table 1. A power analysis was conducted utilizing the Conjointly website [65]. The findings revealed that, for a population of 60,000,000, with a 95 percent confidence level, a 5 percent margin of error and a sample proportion of 0.5 (all commonly used criteria), the suggested sample size is 385

respondents. This suggests that a sample of 582 respondents provides adequate power for the study. However, given the exploratory nature of this study, it relies on a sample that may not meet the criteria for statistical representativeness, but the primary goal is to generate novel ideas on an unexplored topic [66].

Table 1. Sociodemographic characteristics and perceived digestibility of the sample (n = 582).

Group of variables	Items	Frequency	Percent
Age cohort	19–33 y.o.	147	25.26
	34–48 y.o.	189	32.47
	49–63 y.o.	176	30.24
	>64 y.o	70	12.03
Gender	Male	226	38.83
	Female	356	61.17
Education	Primary and middle schools	43	7.39
	High school	237	40.72
	Bachelor's and master's degrees	230	39.52
	Higher education	72	12.37
Perceived digestibility	Bad digestibility (0)	227	39.00
	Good digestibility (1)	355	61.00

3.2. Data analysis

In this study, data analysis was conducted using two logistic regressions, with and without interaction terms, to find relations between perceived digestibility as a dependent variable and different predictors of consumers choices. The same objective could have been achieved by implementing probit models. However, since probit specifications and logit regressions are quite similar, their results are comparable and there is no compelling reason to prefer one over the other [67]. Thus, logistic regression was deemed a suitable tool to deal with the binary dependent variable [68,69]. Indeed, perceived digestibility was investigated by asking consumer the following question:

Do you perceive sweet peppers as a vegetable with good digestibility after consumption? The possible responses to this question were: (a) "yes, I perceive good digestibility after peppers consumption" coded as value 1 and (b) "no, I do not perceive good digestibility after peppers consumption" coded as value 0.

This strategy allows the generation of a dummy variable. Therefore, by applying linear regression based on ordinary least squares (OLS), problems would arise in the predicted probabilities. OLS is called linear probability model when applied on dummy variables and cannot properly predict probabilities since estimates not included between 0–1 can be provided. Moreover, normality and heteroscedasticity assumption cannot be met [70]. Based on these consideration, logistic regressions were adopted and formalized as indicated in Equation (1).

$$logit[P(y = 1)] = \alpha + \beta_1 x_1 + \cdots + \beta_k x_k \qquad (1)$$

Equation 1 indicate that the model includes several variables, therefore regression can be considered a multiple logistic regression [71]. In the first formula constant term is indicated with α,

while β are the estimated coefficients of the regression, used to transform a binary dependent variable in to a continuous one using the natural logarithm of the odds ratio. Indeed, logit transformation provides a continuous logarithmic function starting from non-continuous data. The estimation of the coefficient is conducted using the maximum likelihood estimation (MLE) [72].

Finally, x_1 to x_k are the regressors included in the model. Equation 2 can be obtained from Equation 1 and allows prediction of the probability of the dependent variable to assume value 1, i.e., to have experienced a good digestibility by eating peppers.

$$P(y = 1) = \frac{e^{\alpha + \beta_1 x_1 + \cdots + \beta_k x_k}}{1 + e^{\alpha + \beta_1 x_1 + \cdots + \beta_k x_k}} \qquad (2)$$

Based on the formalized logistic regression, the analysis was performed in two steps. The first regression, i.e., the no-interaction model, was conducted with the following groups of variables and specific items:

- Sociodemographic variables:

Gender (dummy); age (categorical 1–4); education (categorical 1–4)

- Sensory/taste attributes variables:

Consistency of pulp (categorical 1–7); crunchiness(categorical 1–7); peel thickness (categorical 1–7)

- Culinary preparations variables:

Raw (categorical 1–7); sauteed (categorical 1–7); baked (categorical 1–7)

- Color/visual appearance variables:

Red (categorical 1–7); yellow (categorical 1–7); green (categorical 1–7)

- Variables related to the production process sustainability index:

Environmental impact (categorical 1–7); place of production (categorical 1–7); certification of integrated production (categorical 1–7)

The second regression, i.e., the interaction models, combined variables to obtain a deeper understanding of factors affecting self-perceived digestibility of peppers. The selection of interaction terms was made with the awareness that adding too many interactions can lead to excessively large models, resulting in a loss of degrees of freedom. Therefore, the number of interactions was decreased to align with the goals of the survey [73,74]. In particular, the role of colors was combined with socio-demographic variables. The colors considered were red and green, since descriptive analyses have shown them to be the most and least preferred colors by consumers, respectively, so they can cover the entire range of preferences. Instead, the sociodemographic variables considered were age cohort, gender and education. The variables were chosen based on similar studies adopting similar methodology [75,76]. Indeed, in this analysis, the role of intrinsic and extrinsic characteristics combined with socio-demographic predictors were included, specifically: red#age, red#gender, red#education, green#age, green#gender and green#education. Integrated pest management (IPM) was preferred to the organic certification because the latter is investigated in the literature [77], while few studies focus on IPM label.

The log transformation of odds ratio or coefficients in logistic regression cannot be used directly to retrieve quantitative information. Coefficient have the important advantage related to the linearization of a dummy variable but can provide only indication of the direction of the effect and the qualitative magnitude. In fact, average marginal effects were adopted rather than the direct probability estimation to describe discrete change in probability due to a discrete change of regressors [61].

To allow the model obtaining robust estimated coefficients, variable selection was conducted

combining stepwise backward selection to both the regressions. This procedure consists of an iterative process that considers an original pool of variables and removes those that are not significant by generating the least inflation in residual sum of square [78].

To deal with multicollinearity, i.e., a problem related to multiple regression model, variance inflation factor (VIF) analysis was conducted [76]. Any predictors adopted in this study were checked trough this method, excluding the interaction variables since they are naturally multicollinear. Also, motivation should not be included in VIF analysis [79].

4. Results

4.1. Descriptive statistics

As a preliminary result, descriptive statistics of the variables used in the econometric model are presented. Summary statistics are listed in Table 2 and refer to the average importance attached by consumers to selected attributes when purchasing sweet peppers. From a descriptive point of view, all variables except one are considered important by consumers since the average score is always above the threshold value of the 7-point Likert scale (3.5), but some features turn out to be more crucial than others. The color of the sweet pepper is the attribute considered most important, and red peppers, followed by yellow peppers, appear to be the consumer favorites. Subsequently, among the intrinsic sensory characteristics of sweet peppers, the consistency of the pulp and crunchiness are particularly valued and considered during purchase and consumption processes, followed by the peel thickness. Extrinsic characteristics related to production also have a high level of relevance and particularly the place of production of sweet pepper as well as the environmental impact of the production are attributes considered relevant when purchasing this vegetable. Considering the most appreciated culinary preparation by order of importance, consumers on average prefer sautéed, baked and raw peppers.

Table 2. Descriptive statistics of regressors used in logit models (n = 582).

Variables	Mean	SD
Raw	3.06	2.16
Sauteed	4.80	1.95
Baked	4.44	2.03
Peel thickness	4.69	1.95
Consistency of pulp	5.28	1.71
Crunchiness	5.25	1.81
Red	5.95	1.46
Yellow	5.54	1.64
Green	3.57	1.87
Environmental impact	4.76	1.94
Place of production	5.17	1.83
Certification of integrated production	4.15	1.98

4.2. The econometric model

This section presents the results of logistic regressions, which were performed using consumers' perceived digestibility as the dependent variable and intrinsic sensory characteristics, extrinsic characteristics related to production, culinary preparations and sociodemographic characteristics as explanatory variables. Before focusing on the main results of the logit models, VIF analysis is provided in Table 3. The table shows the VIF values for each significant variable of the logit model, useful to check for multicollinearity. When the 1/VIF value is greater than 0.2, as in this case, the estimates are considered not affected by multicollinearity issues. Therefore, the interpretation of models estimates can be conducted.

Table 3. Variance inflation factor (VIF) of the logistic regression models.

	No-interactions		Interaction model	
Variables	VIF	1/VIF	VIF	1/VIF
Raw	1.06	0.94	1.07	0.93
Sauteed	1.07	0.93	1.17	0.86
Peel thickness	1.13	0.88	1.24	0.80
Gender	1.22	0.82	1.23	0.82
Age	1.27	0.79	1.28	0.78
Education	1.04	0.96	n.a.	n.a.
Red	n.a.	n.a.	1.92	0.52
Red#Education	n.a.	n.a.	1.73	0.58
Mean VIF	1.13		1.38	

Note (s): n.a. = not available.

Two models are presented in Table 4, one without interactions and one in which interaction variables, socio-demographic#colors were included, as explained in Section 2.2. Both were generated by the stepwise process that selected only significant regressors. Thus, in Table 4, only covariates with a significant effect on the perceived digestibility are presented. The average marginal effects of each variable were calculated in both logistic regression models to allow the quantitative interpretation of the coefficients using percentages (Table 5).

As for the model without interactions, sociodemographic characteristics can be considered the strongest predictors of perceived digestibility, with gender being the most important variable in terms of magnitude and with a negative effect. The negative coefficient is related to a bad perceived digestibility after consumption. Thus, when the perceived digestibility of consumers increases, the variable gender decreases. Hence, as shown in Table 5, being a woman decreased the probability to perceive a good digestibility of 13.8%. Gender is followed, in terms of magnitude, by the respondents' level of education and age. Conversely, the latter two variables show a positive effect on perceived digestibility, namely, as these covariates increase, positive perceived digestibility of sweet pepper increases. This means that predictors with positive coefficient are related to a good perceived digestibility of peppers. In particular, consumers with higher levels of education and older are more likely to perceive a better digestibility of bell pepper, 6.2% and 5.8% respectively for discrete variations of regressors.

Table 4. Logistic regression of variables influencing perceived digestibility of peppers (n = 582).

Variables	No interactions model		Interaction model	
	Coeff.	*p*-value	Coeff.	*p*-value
Raw	0.149	0.001***	0.150	0.001***
Sautéed	0.121	0.009***	0.126	0.010***
Peel thickness	−0.129	0.007***	−0.122	0.017**
Gender	−0.621	0.003***	−0.634	0.002***
Age	0.261	0.012**	0.267	0.011**
Education	0.281	0.013**	n.s.	n.s.
Red	n.s.	n.s.	−0.164	0.049**
Red#Education	n.a.	n.a.	0.054	0.004***
Constant	−0.893	0.062*	−0.094	0.835
Log likelihood	−370.57448		−369.31483	
Pseudo R2	0.0479		0.0511	

Note (s): n.s. = not significant; n.a. = not available, *p*-value significance: * < 0.1; ** < 0.05; *** < 0.01.

Table 5. Average marginal effects of logistic regression models.

	No interactions		Interaction model	
Variables	dy/dx	*p*-value	dy/dx	*p*-value
Raw	0.033	0.000	0.033	0.000
Sauteed	0.027	0.008	0.028	0.008
Peel thickness	−0.029	0.006	−0.027	0.015
Gender	−0.138	0.002	−0.141	0.002
Age	0.058	0.011	0.059	0.010
Education	0.062	0.011	0.071	0.003
Red	n.s.	n.s.	−0.006	0.699

Among intrinsic and extrinsic characteristics, the preference for raw peppers has a significant and positive effect on perceived digestibility, while the peel thickness has a significant negative effect. In other words, a preference for culinary preparation such as "raw" increases the probability of perceiving good digestibility of 3.3%, while giving a high level of importance to the peel thickness during sweet peppers purchasing decreases the probability to perceive a good digestibility of 2.9%. Finally, the weakest predictor in terms of magnitude is the culinary preparation "sautéed", which has a negative effect on perceived digestibility. Thus, preferring the culinary preparation "sautéed" increases the probability of perceiving good digestibility of 2.7%. Overall, the strongest predictors of perceived digestibility are those related to the socio-demographic variables. The role of the other regressors can play a role in describing perceived digestibility, but as secondary drivers. Focusing on the interaction model, the interaction variables allow the list of covariates affecting perceived digestibility to be expanded. Indeed, the "red" color covariate and the interaction between "red" and "education" are added to those already present in the first model without interactions. "Red" shows a negative effect on perceived digestibility, indeed the preference for red peppers decrease the probability of perceiving a good digestibility of 0.6%. However, when "red" is combined with "education" the effect is positive. This suggests that perceived digestibility increases when both red and education increase. Therefore,

highly educated respondents that consume red peppers are more likely to perceive peppers as easy to digest. Moreover, a high level of education and preference for red peppers increases the probability of perceiving a good digestibility of 7.1%.

Hence, the logit models allowed to identify several variables which influence the perceived digestibility of bell peppers. These covariates were identified among the sensory intrinsic characteristics such as red peppers and peel thickness, culinary preparations such as raw or sautéed peppers and consumers sociodemographic characteristics such as gender, age and education. Conversely, the variables related to the sustainability of the production process, namely environmental impact, place of production and certification of integrated production as specified above, did not yield significant results. This indicates that they cannot be considered predictors of perceived digestibility.

5. Discussion

The findings of this study reveal that certain factors linked to the intrinsic and extrinsic characteristics of sweet pepper, its culinary preparations and the sociodemographic profile of consumers may impact the perception of digestibility. The application of econometric and descriptive analyses enabled the testing of hypotheses and facilitated a discussion on whether these hypotheses find support in the obtained results.

Hypothesis 1: Consumers perceive differently the digestibility of peppers.

Despite the excellent nutritional profile of peppers [34,35], many individuals commonly find this vegetable challenging to digest, and the reasons for this difficulty are not yet fully understood. The descriptive analysis (Section 2.1) indicated that, in this sample, 39% of individuals reported poor perceived digestion of sweet peppers, indicating the likelihood of experiencing digestive problems after consumption. Indeed, the digestibility of peppers may hinge on various individual factors and the specific variety of bell pepper consumed. Bell peppers, along with other vegetables like tomatoes, potatoes and eggplant, contain toxic GAs (steroid alkaloids), including α-solanine, which can induce gastrointestinal upset and other discomforting symptoms, ranging from mild to severe [33]. Furthermore, the peel of peppers contains a high amount of fiber, which can lead to gas production and complicate the digestion process [30,31]. Apart from individual factors arising from the diversity of gastrointestinal function among individuals, it is crucial to recognize that the variety of bell pepper consumed can significantly influence digestion. For instance, studies have demonstrated that the PDO bell pepper "Cornetto di Montecorvo," a widely cultivated ecotype in central Italy, possesses a thin peel that is rich in nutraceuticals and is highly digestible, making it suitable for various culinary preparations [25,26]. Therefore, it can be suggested that the data supports Hypothesis 1, although further investigations are warranted. Indeed, econometric analysis provides a partial understanding of the psychological aspects influencing digestibility, while medical factors can be assessed in different research fields.

Hypothesis 2: Taste-related and visual appearance sensory attributes influence consumers' perception of digestibility.

Among the attributes related to the sensory aspects of peppers, specifically taste and visual appearance, the variables that exhibited significant results regarding the perception of good digestibility in the econometric model were the importance assigned to the thickness of the peel during the purchase phase and the preference for red peppers. Notably, the importance attached to the thickness of the peel negatively influenced the perception of good digestion. This aligns with the

understanding that pepper peel can potentially cause digestive issues and a thinner peel has been associated with higher digestibility [25,26,30,31]. Concerning the color of sweet peppers, the econometric model revealed that higher levels of preference for the red color, particularly in interaction with elevated levels of education, had a positive effect on perceived digestibility. Color holds significance in influencing consumer expectations of fruits and vegetables, as it is intertwined with taste, maturity and nutritional content [40]. In the case of peppers, color is linked to nutritional properties, where red peppers contain carotenoids and flavanols absent in green peppers, imparting antioxidant activity [28,42]. Additionally, the vitamin C content in red peppers is greater and also exhibits higher bio-accessibility values [80], positively impacting the gut microbiome and restoring gut-liver functions [81,82]. Furthermore, this vitamin can stimulate the secretion of gastric juices, indirectly contributing to the digestion of food [28]. Therefore, it is plausible to assume that consumers with higher levels of education are cognizant of these characteristics, forming an association between the nutritional content of red peppers and improved digestibility, thus supporting Hypothesis 2.

Hypothesis 3: Preparation methods of peppers influence consumers' perceptions of digestibility.

Different cooking methods can alter the sensory characteristics and nutritional content of vegetables [83]. Peppers offer versatile consumption options, and this study explored whether raw, baked or sautéed peppers could impact the consumer's perceived digestibility. Previous research has examined the effect of various cooking methods on the quantity and accessibility of antioxidants in peppers, revealing that heat treatments positively affect the bio-accessibility of polyphenols [38]. However, extended boiling can result in a greater loss of antioxidant activity, with microwave cooking and stir-frying proving to better retain bioactive compounds in peppers [84].

According to our findings, it appears that both raw and sautéed peppers positively influence perceived digestibility, with raw peppers having a more pronounced effect. This aligns with some previous studies, suggesting that raw peppers may indeed be more easily digestible than cooked ones. The susceptibility of cells in raw vegetable tissues to break down during digestion, potentially enhancing the release of carotenoids, has been proposed as a contributing factor [37]. Additionally, raw peppers contain more enzymes compared to their cooked counterparts, which can further aid in the digestion process [38]. While no study has directly investigated how cooking methods influence the perception of digestibility, the considerations mentioned above support Hypothesis 3.

Hypothesis 4: Sociodemographic characteristics have an impact on different perceived digestibility by consumers.

In this study, all socio-demographic variables incorporated into the econometric model exhibited an impact on the perception of digestibility; age and level of education had a positive effect, while gender had a negative effect. Previous research has indicated that various chronic conditions, including digestive problems, may be linked to dietary choices and sociodemographic characteristics. For instance, women and the elderly tend to be more susceptible to these conditions, with their prevalence also increasing among younger individuals [85]. Another study exploring sociodemographic characteristics in relation to perceptions of self-perceived gastrointestinal health found that individuals aged 20–40 tended to have worse perceptions [86]. Similarly, findings from another study suggested that gastrointestinal symptoms were associated with poor perceived health, with women more likely to report a worse perceived health status than men. Additionally, individuals with higher levels of education were more inclined to report a better perceived health status [87]. These outcomes align with our study, wherein gender is negatively correlated with perceived digestibility, while age and education exhibit a positive correlation. Assuming that the perception of digestibility may be linked to consumers'

overall and/or gastrointestinal health perceptions, these results provide support for Hypothesis 4.

Hypothesis 5: Sustainable pepper production methods can influence overall consumer perception of digestibility.

Concerning intrinsic sensory characteristics, the model also integrated extrinsic factors associated with sustainable production processes. Variables pertaining to the significance of environmental considerations, place of production and integrated production certification were collectively defined as the "sustainability index of the production process." Regrettably, these variables did not demonstrate significant effects on the perception of digestibility. This outcome is unsurprising, given that, for the selection of fruits and vegetables, extrinsic attributes typically play a subordinate role to intrinsic characteristics tied to taste or health-related aspects [20,88]. Although low pesticide usage is deemed important to consumers [89], recent studies underscore the increasing emphasis on health considerations when purchasing organically certified products [62,89]. Moreover, literature emphasizes the significance of enhancing consumer health and advocating sustainability, both environmentally and socially. Consumers perceiving greater health and sustainability benefits tend to exhibit more positive attitudes toward purchasing behavior [90]. Nevertheless, the findings from this study do not provide grounds to suggest a relationship between sustainability attributes and perceived digestibility as part of a healthful perception. Consequently, Hypothesis 5 cannot be supported by the results.

6. Conclusions

This study aimed to assess the primary determinants influencing consumers' perception of food digestibility. The results affirm nearly all the hypotheses formulated at the research's outset. It was observed that consumers perceive sweet pepper digestibility differently. Concerning sensory attributes, taste-related factors and visual appearance, particularly color, strongly impact consumers' perceptions of digestibility. Notably, red peppers are perceived as the easiest to digest, while the thickness of the peel is negatively correlated with digestibility.

Regarding culinary methods, the study highlights the significance of raw and sautéed peppers in positively influencing perceived digestibility, as consumers associate these preparation methods with easier digestibility. Additionally, sociodemographic characteristics play a highly relevant role, with age, gender and education significantly influencing consumers' perceived digestibility. However, in terms of the sustainability of the production method, the overall consumer perception of digestibility does not appear to be influenced by a more sustainable growing approach for bell peppers.

6.1. Implications

This paper introduces novel contributions to the existing literature, as, to the authors' knowledge, no prior study has addressed consumers' perception of food digestibility. The adoption of an econometric approach enhances our understanding of the relationships among various factors and the perception of digestibility. Integrating this approach with technological and medical studies could improve producers' ability to select cultivars appreciated by consumers. Perceived digestibility, when understood, can prevent consumers from purchasing certain products, potentially hindering market growth. Moreover, this understanding can aid firms in developing strategies to cater to consumers' interests, benefiting the secondary sector as well. Restaurants and food markets could prefer specific

products or preparations, or they could at least be aware of limitations in dishes that may be unacceptable to consumers. From an academic standpoint, this study marks an initial evaluation, suggesting that psychological aspects such as perception can be influenced by different food characteristics, paving the way for future exploration. In the gastronomy sector, this study demonstrates that the subjective perception of digestibility can impact consumers' choices of certain food products, influencing the demand for sweet peppers in both home consumption and restaurants as part of a perceived healthier diet. Furthermore, the preparation or cooking methods of sweet peppers–e.g., raw, sautéed and baked–and the color–particularly red, followed by yellow peppers–directly affect consumers' perceptions of digestibility. Understanding these factors can assist food chain actors in designing diets that align with consumers' culinary interests. Restaurants and catering services adopting new culinary trends can gain greater awareness of how to enhance the preparation and acceptability of dishes. In conclusion, the econometric approach employed in this study not only offers a scientific understanding of the relationship between different factors and consumers' subjective perceptions of digestibility but also suggests the potential extension of this approach to other food products, enhancing the ability of all actors in the gastronomy supply chain to select the most popular food products.

6.2. Limitation and further research

Building upon the aforementioned considerations, the assessment of food perception and digestibility can be enhanced. Econometric analysis, when coupled with research from various fields, has the potential to amalgamate social, medical and technological perspectives. It is important to note that this study does not purport to make a scientific contribution in terms of general information on digestion. Instead, it generates ideas for further exploration concerning consumers' perceptions of the food they consume. The study acknowledges its limitations, emphasizing that the results only present a subjective perspective of consumers, which may not necessarily align with medical and nutritional scientific evidence. This inherent subjectivity represents a primary constraint of the paper. Other limitations include the sampling method, which only partially matches some sociodemographic characteristics of the general Italian population, such as gender. As a convenience sample, it may not precisely reflect the sociodemographic composition of the adult Italian population in terms of age, gender and education level. Another limitation of this study lies in the omission of ethnicity as a factor in the analysis. Furthermore, this study primarily focuses on intrinsic and extrinsic determinants related to digestibility perception, overlooking potential variations influenced by diverse ethnic backgrounds. Ethnicity can play a pivotal role in shaping dietary preferences and perceptions of food attributes. Future research agenda should consider incorporating ethnicity as a variable, enabling a more nuanced understanding of how cultural and ethnic differences might influence the perceived digestibility of specific foods other than sweet peppers. This inclusion could contribute to a more comprehensive exploration of consumer behaviors and preferences, ensuring a more representative and inclusive examination of the factors influencing food perception. Moving forward, digestibility perception could be integrated into other analyses as predictors of food consumption or willingness to pay (WTP) for specific food attributes. The WTP related to digestibility can be assessed using choice experiments or experimental auctions, incorporating this variable into econometric estimations. Moreover, employing multivariate models such as structural equation modeling (SEM) could integrate this aspect into psychologically validated scales, revealing diverse relationships in consumer behavior. Future research

endeavors may also explore the association between perceived healthiness and digestibility perception, offering a comprehensive understanding of consumers' attitudes towards food.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

The authors declare no conflict of interest related to the work presented in this paper.

Authors contributions

Rachele De Cianni: Formal analysis, Writing - original draft, writing - review & editing, analyzed literature, wrote the methodology of the paper, discussed the results, and read and approved the final manuscript. Raffaele Zanchini: Writing - original draft, writing - review & editing, defined the research design, wrote the body of the paper, discussed the results, and read and approved the final manuscript. Angelina De Pascale: Writing - original draft, writing - review & editing, carried out a detailed revision, contributed to the final version of the manuscript and read and approved the final manuscript. Maurizio Lanfranchi: Writing review & editing, carried out a detailed revision, contributed to the final version of the manuscript and read and approved the final manuscript. Teresina Mancuso: Writing - review & editing, carried out a detailed revision, contributed to the final version of the manuscript and read and approved the final manuscript. Mario D'Amico: Writing - review & editing, carried out a detailed revision, contributed to the final version of the manuscript and read and approved the final manuscript. Giuseppe Di Vita: Devised the main conceptual ideas, writing - original draft, writing - review & editing, defined the research design, contributed to the final version of the manuscript, discussed the results and read and approved the final manuscript.

References

1. Azeredo HMC, Tonon RV, McClements DJ (2021) Designing healthier foods: Reducing the content or digestibility of key nutrients. *Trends Food Sci Technol* 118: 459–470. https://doi.org/10.1016/j.tifs.2021.10.023
2. Hamam M, Di Vita G, Zanchini R, et al. (2022) Consumers' attitudes and purchase intention for a vitamin-enriched extra virgin olive oil. *Nutrients* 14: 1658. https://doi.org/10.3390/nu14081658
3. Munialo CD, Andrei M (2023) Chapter 2—General health benefits and sensory perception of plant-based foods. In: Prakash S, Bhandari BR, Gaiani C (Eds.), *Engineering Plant-Based Food Systems,* Academic Press, 13–26. https://doi.org/10.1016/B978-0-323-89842-3.00017-8
4. Yang Z, Zhang Y, Wu Y, et al. (2022) Factors influencing the starch digestibility of starchy foods: A review. *Food Chem* 406: 135009. https://doi.org/10.1016/j.foodchem.2022.135009
5. Drolet-Labelle V, Laurin D, Bédard A, et al. (2023) Beliefs underlying older adults' intention to consume plant-based protein foods: A qualitative study. *Appetite* 180: 106346. https://doi.org/10.1016/j.appet.2022.106346

6. Shiferaw Terefe N, Augustin MA (2020) Fermentation for tailoring the technological and health related functionality of food products. *Crit Rev Food Sci Nutr* 60: 2887–2913. https://doi.org/10.1080/10408398.2019.1666250

7. Cais-Sokolińska D, Walkowiak-Tomczak D (2021) Consumer-perception, nutritional, and functional studies of a yogurt with restructured elderberry juice. *J Dairy Sci* 104: 1318–1335. https://doi.org/10.3168/jds.2020-18770

8. Xiang H, Sun-Waterhouse D, Waterhouse GIN, et al. (2019) Fermentation-enabled wellness foods: A fresh perspective. *Food Sci Hum Wellness* 8: 203–243. https://doi.org/10.1016/j.fshw.2019.08.003

9. Hou JK, Lee D, Lewis J (2014) Diet and inflammatory bowel disease: Review of patient-targeted recommendations. *Clin Gastroenterol Hepatol* 12: 1592–1600. https://doi.org/10.1016/j.cgh.2013.09.063

10. Chowdhury AMM, Helman C, Greenhalgh T (2023) Food beliefs and practices among British Bangladeshis with diabetes: implications for health education. *Anthropology & Medicine* 7: 209–226. https://doi.org/10.1080/713650589

11. Chikkamath M, Atter BR, Srivastava SK, et al. (2012) Factors influencing consumers behaviour for vegetable purchase. *Veg Sci* 39: 35–39.

12. Owusu V, Owusu-Sekyere E, Donkor E, et al. (2019) Smallholder farmer perceptions of risk and benefits across three cocoa chains in Ghana. *J Agribus Dev Emerg Econ* 8: 1–40.

13. Bearth A, Cousin ME, Siegrist M (2014) Poultry consumers' behaviour, risk perception and knowledge related to campylobacteriosis and domestic food safety. *Food Control* 44: 166–176. https://doi.org/10.1016/j.foodcont.2014.03.055

14. Amoah P, Drechsel P, Abaidoo RC, et al. (2006) Pesticide and pathogen contamination of vegetables in Ghana's urban markets. *Arch Environ Contam Toxicol* 50: 1–6. https://doi.org/10.1007/s00244-004-0054-8

15. Labrie CW, Sijtsema SJ, Snoek HM, et al. (2019) Flavour and nutrition of fruits and vegetables create added value to consumers. In: *Proceedings of the XII International Rubus and Ribes Symposium: Innovative Rubus and Ribes Production for High Quality Berries in Changing,* 1277: 425–432. https://doi.org/10.17660/ActaHortic.2020.1277.61

16. Mueller S, Szolnoki G (2010) The relative influence of packaging, labelling, branding and sensory attributes on liking and purchase intent: Consumers differ in their responsiveness. *Food Qual Prefer* 21: 774–783. https://doi.org/10.1016/j.foodqual.2010.07.011

17. Byrne DV (2020) Current trends in multidisciplinary approaches to understanding consumer preference and acceptance of food products. *Foods* 9: 1380. https://doi.org/10.3390/foods9101380

18. Frank CA, Nelson RG, Simonne EH, et al. (2001) Consumer preferences for color, price, and vitamin C content of bell peppers. *HortScience* 36: 795–800. https://doi.org/10.21273/HORTSCI.36.4.795

19. Hussein M, Silva A, Fraser I (2015) Linking intrinsic quality attributes of agricultural produce to revealed consumer preferences. *Food Qual Prefer* 41: 180–188. https://doi.org/10.1016/j.foodqual.2014.11.018

20. Massaglia S, Borra D, Peano C, et al. (2019) Consumer preference heterogeneity evaluation in fruit and vegetable purchasing decisions using the best-worst approach. *Foods* 8: 266. https://doi.org/10.3390/foods8070266

21. Wongprawmas R, Mora C, Pellegrini N, et al. (2021). Food choice determinants and perceptions of a healthy diet among Italian consumers. *Foods* 10: 318. https://doi.org/10.3390/foods10020318

22. Sridhar K, Bouhallab S, Croguennec T, et al. (2022) Recent trends in design of healthier plant-based alternatives: Nutritional profile, gastrointestinal digestion, and consumer perception. *Crit Rev Food Sci Nutr* 63: 10483–10498. https://doi.org/10.1080/10408398.2022.2081666

23. Jang SS, Ha A, Silkes CA (2009) Perceived attributes of Asian foods: From the perspective of the American customers. *Int J Hosp Manag* 28: 63–70. https://doi.org/10.1016/j.ijhm.2008.03.007

24. Figueira N, Curtain F, Beck E, et al. (2019) Consumer understanding and culinary use of legumes in Australia. *Nutrients* 11: 1575. https://doi.org/10.3390/nu11071575

25. Tripodi P, D'Alessandro R, Festa G, et al. (2022). Profiling the diversity of sweet pepper 'Peperone Cornetto di Pontecorvo' PDO (Capsicum annuum) through multi-phenomic approaches and sequencing-based genotyping. *Agronomy* 12: 1433. https://doi.org/10.3390/agronomy12061433

26. Sobolev AP, Mannina L, Capitani D, et al. (2018) A multi-methodological approach in the study of Italian PDO "Cornetto di Pontecorvo" red sweet pepper. *Food Chem* 255: 120–131. https://doi.org/10.1016/j.foodchem.2018.02.050

27. Rana N, Ghabru A, Vaidya D (2019) Defensive function of fruits and vegetables. *J Pharmacogn Phytochem* 8: 1872–1877.

28. Nadeem M, Anjum FM, Khan MR, et al. (2011) Antioxidant potential of bell pepper (Capsicum annum L.)—A review. *Pak J Food Sci* 21: 45–51.

29. Yao H, Flanagan BM, Williams BA, et al. (2023) Particle size of dietary fiber has diverse effects on in vitro gut fermentation rate and end-products depending on food source. *Food Hydrocoll* 134: 108096. https://doi.org/10.1016/j.foodhyd.2022.108096

30. Wong JMW, Jenkins DJA (2007) Carbohydrate digestibility and metabolic effects. *J Nutr* 137: 2539–2546. https://doi.org/10.1093/jn/137.11.2539S

31. Manichanh C, Eck A, Varela E, et al. (2014) Anal gas evacuation and colonic microbiota in patients with flatulence: Effect of diet. *Gut* 63: 401408. https://doi.org/10.1136/gutjnl-2012-303013

32. Urminská D, Haring N, Fábry V, et al. (2022). Fermentable oligosaccharides, disaccharides, monosaccharides and polyols and their role in food digestion. *J Microbiol Biotechnol Food Sci* 11: 1–11. https://doi.org/10.55251/jmbfs.5521

33. Koleva II, van Beek TA, Soffers AEMF, et al. (2012) Alkaloids in the human food chain—Natural occurrence and possible adverse effects. *Mol Nutr Food Res* 56: 30–52. https://doi.org/10.1002/mnfr.201100165

34. Loizzo M, Pugliese A, Bonesi M, et al. (2015) Evaluation of chemical profile and antioxidant activity of twenty cultivars from Capsicum annuum, Capsicum baccatum, Capsicum chacoense and Capsicum chinense: A comparison between fresh and processed peppers. *LWT-Food Sci Technol* 64: 623–631. https://doi.org/10.1016/j.lwt.2015.06.042

35. Guilherme R, Reboredo F, Guerra M, et al. (2020) Elemental composition and some nutritional parameters of sweet pepper from organic and conventional agriculture. *Plants* 9: 863. https://doi.org/10.3390/plants9070863

36. Popov SV, Ovodova RG, Golovchenko VV, et al. (2011) Chemical composition and anti-inflammatory activity of a pectic polysaccharide isolated from sweet pepper using a simulated gastric medium. *Food Chem* 124: 309–315. https://doi.org/10.1016/j.foodchem.2010.06.038

37. Tydeman EA, Parker ML, Faulks RM, et al. (2010) Effect of carrot (Daucus carota) microstructure on carotene bioaccessibility in the upper gastrointestinal tract. 2. in vivo digestions. *J Agric Food Chem* 58: 9855–9860. https://doi.org/10.1021/jf1010353

38. Juániz I, Ludwig IA, Bresciani L, et al. (2016). Catabolism of raw and cooked green pepper (Capsicum annuum) (poly) phenolic compounds after simulated gastrointestinal digestion and faecal fermentation. *J Funct Foods* 27: 201–213. https://doi.org/https://doi.org/10.1016/j.jff.2016.09.006

39. Moser R, Raffaelli R, Thilmany DD (2011) Consumer preferences for fruit and vegetables with credence-based attributes: A review. *Food Agribusiness Manag Rev* 14: 121–142. https://doi.org/10.22004/ag.econ.103990

40. Bowen A, Grygorczyk A (2022) Chapter 17—Consumer eating habits and perceptions of fresh produce quality. In: Florkowski WJ, Banks NH, Shewfelt RL, et al. (Eds.), *Postharvest Handling,* 4th Edition, Academic Press, 487–515. https://doi.org/10.1016/B978-0-12-822845-6.00017-8

41. Luning PA, De Rijk T, Wichers HJ, et al. (1994) Gas chromatography, mass spectrometry, and sniffing port analyses of volatile compounds of fresh bell peppers (Capsicum annuum) at different ripening stages. *J Agric Food Chem* 42: 977–983.

42. Sun T, Xu Z, Wu CT, et al. (2007) Antioxidant activities of different colored sweet bell peppers (Capsicum annuum L.). *J Food Sci* 72: S98–102. https://doi.org/10.1111/j.1750-3841.2006.00245.x

43. Hasenbeck A, Cho S, Meullenet JF, et al. (2014) Color and illuminance level of lighting can modulate willingness to eat bell peppers. *J Sci Food Agric* 94: 2049–2056. https://doi.org/10.1002/jsfa.6523

44. Kyriacou MC, Rouphael Y (2018) Towards a new definition of quality for fresh fruits and vegetables. *Sci Hortic* 234: 463–469. https://doi.org/10.1016/j.scienta.2017.09.046

45. Barrett DM, Beaulieu JC, Shewfelt R (2010) Color, flavor, texture, and nutritional quality of fresh-cut fruits and vegetables: Desirable levels, instrumental and sensory measurement, and the effects of processing. *Crit Rev Food Sci Nutr* 50: 369–389. https://doi.org/10.1080/10408391003626322

46. O'Sullivan L, Jiwan MA, Daly T, et al. (2010) Bioaccessibility, uptake, and transport of carotenoids from peppers (Capsicum Spp.) using the coupled in vitro digestion and human intestinal Caco-2 cell model. *J Agric Food Chem* 58: 5374–5379. https://doi.org/10.1021/jf100413m

47. Castro SM, Saraiva JA, Lopes-da-Silva JA, et al. (2008) Effect of thermal blanching and of high-pressure treatments on sweet green and red bell pepper fruits (Capsicum annuum L.). *Food Chem* 107: 1436–1449. https://doi.org/10.1016/j.foodchem.2007.09.074

48. Hwang IG, Shin YJ, Lee S, et al. (2012) Effects of different cooking methods on the antioxidant properties of red pepper (Capsicum annuum L.). *Prev Nutr Food Sci* 17: 286–292. https://doi.org/10.3746/pnf.2012.17.4.286

49. Adefegha SA, Oboh G (2011) Cooking enhances the antioxidant properties of some tropical green leafy vegetables. *Afr J Biotechnol* 10: 632–639.

50. Ryan L, O'Connell O, O'Sullivan L, et al. (2008) Micellarisation of carotenoids from raw and cooked vegetables. *Plant Foods Hum Nutr* 63: 127–133. https://doi.org/10.1007/s11130-008-0081-0

51. Sanatombi K, Rajkumari S (2020) Effect of processing on quality of pepper: A review. *Food Rev Int* 36: 626–643. https://doi.org/10.1080/87559129.2019.1669161

52. De Cianni R, Pippinato L, Mancuso T (2023) A systematic review on drivers influencing consumption of edible mushrooms and innovative mushroom-containing products. *Appetite* 182: 106454. https://doi.org/https://doi.org/10.1016/j.appet.2023.106454

53. Singleton CR, Winkler M, Houghtaling B, et al. (2020) Understanding the intersection of race/ethnicity, socioeconomic status, and geographic location: A scoping review of U.S. consumer food purchasing. *Int J Environ Res Public Health* 17: 7677. https://doi.org/10.3390/ijerph17207677

54. Fernqvist F, Ekelund L (2014) Credence and the effect on consumer liking of food—A review. *Food Qual Prefer* 32: 340–353. https://doi.org/10.1016/j.foodqual.2013.10.005

55. Schreiner M, Korn M, Stenger M, et al. (2013) Current understanding and use of quality characteristics of horticulture products. *Sci Hortic* 163: 63–69.

56. Lanfranchi M, Giannetto C, De Pascale A, et al. (2015) An application of qualitative risk analysis as a tool adopted by public organizations for evaluating "green projects". *Amfiteatru Econ* 17: 872–890.

57. Seyfang G (2006) Ecological citizenship and sustainable consumption: Examining local organic food networks. *J Rural Stud* 22: 383–395. https://doi.org/https://doi.org/10.1016/j.jrurstud.2006.01.003

58. Boca GD (2021) Factors influencing consumer behavior in sustainable fruit and vegetable consumption in maramures county, Romania. *Sustainability* 13: 1812. https://doi.org/10.3390/su13041812

59. De Cianni R, Pippinato L, Zanchini R, et al. (2023) Parental behaviour in choosing snacks for children aged six to ten: The role of mothers' nutritional awareness. *Br Food J* 125: 713–730. https://doi.org/10.1108/BFJ-09-2021-1010

60. Taherdoost H (2019) What is the best response scale for survey and questionnaire design; review of different lengths of rating scale/attitude scale/Likert scale. *IJARM* 8: 1–10. Available from: https://ssrn.com/abstract=3588604

61. Di Vita G, Zanchini R, Spina D, et al. (2022) Exploring purchasing determinants for a low fat content Salami: Are consumers willing to pay for an additional premium? *Front Sustain Food Syst* 6: 794533. https://doi.org/10.3389/fsufs.2022.794533

62. Molinillo S, Vidal-Branco M, Japutra A (2020) Understanding the drivers of organic foods purchasing of millennials: Evidence from Brazil and Spain. *J Retail Consum Serv* 52: 101926. https://doi.org/10.1016/j.jretconser.2019.101926

63. Iofrida N, De Luca AI, Zanchini R, et al. (2022) Italians' behavior when dining out: Main drivers for restaurant selection and customers segmentation. *Int J Gastron Food Sci* 28: 100518. https://doi.org/10.1016/j.ijgfs.2022.100518

64. Heckathorn D, Cameron C (2017) Network sampling: From snowball and multiplicity to respondent-driven sampling. *Annu Rev Sociol* 43: 101–119. https://doi.org/10.1146/annurev-soc-060116-053556

65. Conjointly (2023) Sample Size Calculator and Guide to Survey Sample Size. Available from: https://conjointly.com/blog/sample-size-calculator/.

66. Swedberg R (2020) Exploratory Research. In: Elman C, Gerring J, Mahoney J (Eds.), *The Production of Knowledge: Enhancing Progress in Social Science (Strategies for Social Inquiry),* Cambridge: Cambridge University Press, 17–41. https://doi.org/10.1017/9781108762519.002

67. Gujarati DN, Porter DC (2009) *Basic Econometrics.* 5th Edition, New York, McGraw Hill Inc.

68. Salgado A, Moreira-Leite B, Afonso A, et al. (2023) Chocolates enriched with seaweed: Sensory profiling and consumer segmentation. *Int J Gastron Food Sci* 33: 100747. https://doi.org/10.1016/j.ijgfs.2023.100747

69. Ma L, Li Z, Zheng D (2022) Analysis of Chinese consumers' willingness and behavioral change to purchase green agri-food product online. PLoS ONE 17: e0265887. https://doi.org/10.1371/journal.pone.0265887

70. Breen R, Karlson K B, Holm A (2018). Interpreting and understanding logits, probits, and other nonlinear probability models. *Annu Rev Sociol* 44: 39–54. https://doi.org/10.1146/annurev-soc-073117-041429

71. Agresti A (2002) *Categorical Data Analysis.* 792. John Wiley & Sons.

72. Healy L (2006) *Logistic Regression: An Overview*. Eastern Michighan College of Technology.

73. Di Vita G, Strano A, Maesano G, et al. (2020) The role of individual knowledge in functional olive oil preferences: Does self-coherence lead to different health attributes perception? *Foods* 9: 1428. https://doi.org/10.3390/foods9101428

74. Darby K, Batte MT, Ernst SC, et al. (2006) Willingness to pay for locally produced foods: A customer intercept study of direct market and grocery store shoppers. No. 379-2016-21958.

75. Merlino VM, Brun F, Versino A, et al. (2020) Milk packaging innovation: Consumer perception and willingness to pay. *AIMS Agric Food* 5: 307–326. https://doi.org/10.3934/agrfood.2020.2.307

76. Zanchini R, Di Vita G, Brun F (2022) Lifestyle, psychological and socio-demographic drivers in functional food choice: a systematic literature review based on bibliometric and network analysis. *Int J Food Sci* 73: 709–725. https://doi.org/10.1080/09637486.2022.2048361

77. Kushwah S, Dhir A, Sagar M, et al. (2019) Determinants of organic food consumption. A systematic literature review on motives and barriers. *Appetite* 143: 104402. https://doi.org/10.1016/j.appet.2019.104402

78. Derksen S, Keselman HJ (1992) Backward, forward and stepwise automated subset selection algorithms: Frequency of obtaining authentic and noise variables. *Br J Stat Psychol* 45: 265–282. https://doi.org/10.1111/j.2044-8317.1992.tb00992.x

79. Mehmetoglu M, Jakobsen T (2017) *Applied Statistics Using Stata: A Guide for the Social Sciences*.

80. Andaç Öztürk S, Yaman M (2022) Investigation of bioaccessibility of vitamin C in various fruits and vegetables under in vitro gastrointestinal digestion system. *J Food Meas Charact* 16: 3735–3742. https://doi.org/10.1007/s11694-022-01486-z

81. Traber MG, Buettner GR, Bruno RS (2019) The relationship between vitamin C status, the gut-liver axis, and metabolic syndrome. *Redox Biol* 21: 101091. https://doi.org/https://doi.org/10.1016/j.redox.2018.101091

82. Pham VT, Fehlbaum S, Seifert N, et al. (2021). Effects of colon-targeted vitamins on the composition and metabolic activity of the human gut microbiome—A pilot study. *Gut Microbes* 13: 1875774. https://doi.org/10.1080/19490976.2021.1875774

83. Fabbri ADT, Crosby GA (2016) A review of the impact of preparation and cooking on the nutritional quality of vegetables and legumes. *Int J Gastron Food Sci* 3: 2–11. https://doi.org/https://doi.org/10.1016/j.ijgfs.2015.11.001

84. Chuah AM, Lee YC, Yamaguchi T, et al. (2008) Effect of cooking on the antioxidant properties of coloured peppers. *Food Chem* 111: 20–28. https://doi.org/https://doi.org/10.1016/j.foodchem.2008.03.022

85. Sturmer J, Franken DL, Ternus DL, et al. (2022) Dietary pattern as a predictor of multimorbidity patterns: A population-based cross-sectional study with women. *Clin Nutr ESPEN* 51: 452–460. https://doi.org/https://doi.org/10.1016/j.clnesp.2022.06.105

86. Chen JJ, Tsai LY, Tsai JM, et al. (2021) Food away from home and self-perceived gastrointestinal health. *Front Nutr* 8: 1–7. https://doi.org/10.3389/fnut.2021.741647

87. Al-Windi A (2010) Association between perceived health and sociodemographic characteristics, workplace, and complaint symptoms-epidemiological study among healthy workers in Kurdistan, Iraq (ESHWKI). *J Chin Clin Med* 5: 520–529.

88. Torán-Pereg P, Mora M, Thomsen M, et al. (2023) Understanding food sustainability from a consumer perspective: A cross cultural exploration. *Int J Gastron Food Sci* 31: 100646. https://doi.org/https://doi.org/10.1016/j.ijgfs.2022.100646

89. Rizzo G, Borrello M, Guccione D, et al. (2020) Organic food consumption: The relevance of the health attribute. *Sustainability* 12: 595. https://doi.org/10.3390/su12020595

90. Dorce LC, da Silva MC, Mauad JRC, et al. (2021) Extending the theory of planned behavior to understand consumer purchase behavior for organic vegetables in Brazil: The role of perceived health benefits, perceived sustainability benefits and perceived price. *Food Qual Prefer* 91: 104191. https://doi.org/https://doi.org/10.1016/j.foodqual.2021.104191