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Pulp for health: Measuring consumer interest in avocado's nutritional properties

Daniela Spina [a], Manal Hamam [b,*], Raffaele Zanchini [c], Vincenzo Morreale [a], Raffaella Pergamo [b], Mario D'Amico [a], Giuseppe Di Vita [a]

[a] Department of Agriculture, Food and Environment (Di3A), University of Catania, Catania, 95123, Italy
[b] Research Centre for Agricultural Policies and Bioeconomy (CREA), Rome, 00187, Italy
[c] Department of Agricultural, Forest and Food Sciences (DISAFA), University of Turin, Turin, 10124, Italy

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ABSTRACT

Avocado is one of the most traded, exported, and consumed tropical fruits worldwide. Its rich nutritional profile and associated health benefits have led to its classification as a superfood, enhancing its market appeal. This exploratory study empirically examines the elements that influence Italian consumers' interest in avocado's nutritional properties. Specifically, it considers the roles of objective and subjective knowledge, information exposure, nutritional components and extrinsic product characteristics, sensory properties, and socioeconomic factors. An online survey was conducted, resulting in a sample of 649 Italian consumers. The data were analyzed using an ordered logit model (OLM) and marginal effects estimation. The findings reveal that several factors including sensory attributes (taste, colour, and texture), nutritional components (fat, antioxidants, and minerals), and extrinsic characteristics (italian origin, certification, and price), influence consumers' interest in avocado's nutritional properties. Additionally, socioeconomic variables—particularly gender, education level, and sports participation—emerge as key determinants of perceived nutritional value. These insights have practical implications for market strategies and public health initiatives aimed at promoting avocado consumption.

1. Introduction

In recent years, the global consumption of tropical and exotic fruits has significantly increased, driven by growing consumer awareness of their nutritional benefits, unique flavors, and culinary versatility [1,2].

Tropical fruits such as mango, papaya, and passion fruit have gained prominence in international markets, reflecting shifts in dietary preferences and consumer interest in novel and health-promoting foods [3–6]. Among these, avocado has emerged as one of the most popular and widely traded tropical fruits, often marketed as a "superfood" due to its high nutrient density, healthy fats, and association with various health benefits [7,8].

According to the OECD-FAO Agricultural Outlook 2021–2030, global avocado production is projected to reach 12 million tons by 2030, nearly tripling 2010 levels [9]. Although more recent official data are not yet available, forecasts published prior to 2023 estimated that the global trade value of tropical fruits would grow by 1.8 % in 2023, reaching $11 billion. Similarly, global avocado exports were expected to increase by 2 % in 2024, reaching approximately 2.8 million tons. Mexico remains the world leader, accounting for 50 % of global avocado exports, followed by Peru and Kenya, the latter emerging as a significant exporter. Israel and South Africa have also increased their exports in recent years, driven by growing demand from the European Union, whose imports were projected to rise by 4 % in 2024, reaching 790,000 tons [10].

In Italy, demand for avocados has been growing strongly. Over the past five years, imports have increased by 120 %, from about 20 million kg in 2018 to approximately 45 million kg in 2022 [11]. Additionally, data for the period January–May 2023 indicate a further 4 % increase in imports compared to the same period in 2022. However, the United States continues to be the world's largest importer, accounting for 42 % of global avocado imports [10].

Furthermore, despite the average avocado export prices increased by 26 % in 2024, compared to the same period in 2023, the demand is increasing. The rising demand for these fruits is influenced by multiple factors, including changing dietary trends, globalization, improved supply chains, and heightened awareness of health-conscious eating

* Corresponding author.
E-mail address: manal.hamam@crea.gov.it (M. Hamam).

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habits [12]. Additionally, consumer perceptions of tropical fruits are shaped by intrinsic factors such as taste, texture, and nutritional value, as well as extrinsic factors like branding, origin, sustainability, and marketing efforts [13,14].

This study addresses several gaps in the existing literature on consumer preferences and behavior toward tropical and exotic fruits, with a particular focus on avocados. Its novelty lies in examining avocado's nutritional attributes, an aspect often overlooked in prior research.

While previous studies have broadly explored consumer preferences for tropical and exotic fruits, few have specifically analyzed how nutritional awareness shapes interest in avocados [7,15,16]. In fact, most studies on avocado consumption focus on market trends or sensory preferences rather than the role of nutritional awareness in shaping consumer interest.

In addition, this study differentiates between objective knowledge (factual understanding of nutrition) and subjective knowledge (perceived awareness and confidence in knowledge). While subjective knowledge has been found to drive food choices in other contexts, its influence on the perception of avocado as a nutritious food is a relatively unexplored area. Finally, this study incorporates multiple Factors – by integrating knowledge and information exposure, nutritional and extrinsic product characteristics (e.g., certification, price, and italian origin), and socioeconomic factors (e.g., gender, education, sports participation) into a single model. This holistic approach provides a more nuanced understanding of what drives consumer interest in avocado's health benefits. Understanding these drivers of consumption is essential for stakeholders in the food industry, including producers, retailers, and policymakers, to better align their strategies with evolving consumer preferences.

This study aims to investigate how knowledge, information, product attributes, and socioeconomic characteristics influence Italian consumers' interest in avocados as a nutritious food. This research offers valuable insights into the evolving market for tropical and exotic fruits, providing strategic recommendations to enhance their promotion, accessibility, and consumer engagement.

2. Factors influencing avocado consumption and research hypotheses

2.1. Extrinsic attributes

Extrinsic attributes, such as the locality of origin and organic certification, significantly influence the frequency of avocado consumption in Italy, while price serves as a limiting factor, exerting a negative impact [15]. Similarly, in the broader exotic fruit market, factors like sustainability, organic production, and ethical certifications are important to a significant proportion of consumers [8,17].

Further research by Sgroi et al. [18] highlights that price, sustainability, and local origin are among the primary factors influencing mango consumption in Sicily. The role of high price as a consumption barrier for avocados is further confirmed by studies in both the Italian and Chinese markets [7,16].

Additionally, Dos Santos Moreira et al. [19] found that food safety and environmental sustainability play a crucial role in mango purchasing decisions in both Brazil and Italy. However, aspects such as brand awareness, variety, and seasonality were found to have no significant impact on consumer choices, suggesting a limited general knowledge of avocados and tropical fruits [16].

In this regard, the following hypothesis is proposed:

H1. Extrinsic characteristics influence consumers' perception of the nutritional properties of avocados.

2.2. Nutritional components

A large body of literature emphasizes the pivotal role of chemical properties in shaping consumer preferences. The mineral content of avocados is recognized as a key intrinsic attribute among Italian consumers [8], while Chinese consumers particularly value the fruit's healthy fats, fiber, and vitamin content [7].

Spina et al. [6] similarly found that nutritional components are a priority factor for Italian mango consumers, mirroring findings from Bhat et al. [20], who noted that awareness of vitamin C content significantly influences strawberry purchasing decisions in Germany. Conversely, a lack of knowledge regarding the nutritional benefits of cactus fruit has been identified as a barrier to consumption, as reported by Cardoso et al. [21] in Brazil.

The following hypothesis is proposed:

H2. Nutritional components influence consumers' perception of the nutritional properties of avocados.

2.3. Sensory characteristics

Among the most important sensory attributes for exotic fruits, taste, flesh creaminess, and ripeness are key quality factors for Italian avocado consumers [2]. Additionally, texture is highly valued by Italian consumers [16], while visual integrity has also been identified as a crucial quality attribute [2].

Taste is a primary driver of banana consumption among Italian consumers, with a strong correlation between sweetness, ripeness, and colour [8]. Similarly, in the case of mangoes, a review by Kiloes et al. [17] found that taste, skin colour, size, sweetness, and freshness are critical factors influencing purchasing decisions. However, consumer preferences vary by market: in Europe, mangoes with no defects and a strong aroma are preferred, whereas in Asia, attributes such as freshness and sweetness are prioritized.

The fundamental role of taste in consumer choices is also evident for mangoes, where it is the most valued attribute among Italian consumers, followed by considerations of equity and nutritional properties, while tradition holds the least relevance [6]. This is further supported by Dos Santos Moreira et al. [19], who highlight the positive influence of organoleptic characteristics—such as taste and overall sensory quality—on mango consumption. Freshness and taste are also the most valued attributes in European consumers' preferences for fresh fruit [22]. Similarly, these attributes are considered essential among tropical fruit consumers in various geographical contexts, including Pakistan, Italy, and the Czech Republic [18,23,24]. The following hypothesis is proposed:

H3. Sensory characteristics influence consumers' perception of the nutritional properties of avocados.

2.4. Subjective and objective knowledge and information of avocado' s health benefits

Both subjective and objective knowledge increase the likelihood of mango consumption, with subjective knowledge exerting the greatest impact, highlighting the crucial role of personal perception [6]. In addition, studies such as those by Dharanikumar et al. [5] have shown that increased health awareness, often correlated with higher subjective knowledge, is among the main factors influencing exotic fruit consumption in India, especially in the post-Covid-19 pandemic period. During the COVID-19 period, U.S. consumers also relied more heavily on their perceived knowledge to make decisions, in part because food-related memories provided comfort and support for emotional well-being [25]. Further corroboration is provided by Hejkrlik et al. [24], who found that, in the Czech Republic, health benefits were among the most influential factors in tropical fruit consumption, suggesting that knowledge, both objective and subjective, of the health properties of these fruits may incentivize their consumption.

Regarding the health benefits it was shown that healthiness, and therefore nutritional benefits are a relevant aspect for Italian avocado

consumers. Chen et al. [7] further confirm the importance of health benefits, describing avocados as a "superfood" whose popularity grew significantly from 2013 to 2017. Similarly, Giuggioli et al. [8] highlight that health considerations are a primary motivation for banana consumption in Italy.

On a global scale, health awareness and the perceived nutritional benefits of exotic and tropical fruits are consistently relevant across different geographic contexts. This is evidenced by Dharanikumar et al. [5] in India, Hejkrlik et al. [24] in the Czech Republic, and Syarifuddin et al. [26] in Indonesia. Additionally, in Brazil, many consumers show interest in trying cactus fruits after learning about their health benefits [21]. The following hypothesis is proposed:

H4. Objective and subjective knowledge influence consumers' perception of the nutritional properties of avocados.

H5. The information influences consumers' perception of the nutritional properties of avocados.

2.5. Socio-economic characteristics

Regarding the socio-economic characteristics influencing consumer preferences for exotic fruits, women, individuals with higher education levels, and those with medium-high incomes are the primary consumers of avocados in Italy [2,15]. A similar positive correlation between female consumers, higher education, and middle-to-high income levels has been observed among exotic and tropical fruit consumers in India [5] and in the Czech Republic, particularly concerning education and income.

In contrast, in China, avocado consumption is more closely associated with younger consumers [7]. Meanwhile, in Italy, athletes are more likely to consume mangoes [6], while in Brazil, women, young people, and university graduates represent the main consumer groups for cactus fruits [21]. The following hypothesis is proposed:

H6. Socioeconomic factors, such as gender, education, and sports participation, play a significant role in shaping consumer perceptions of the nutritional properties of avocados.

3. Materials and methods

3.1. Survey design and data collection

The survey was administered to a sample of Italian consumers. An online questionnaire was conducted via Google Forms with a randomly selected sample of 649 consumers. The survey was finalized in December 2024.

Participants were requested to supply various quantitative data regarding their awareness and preferences for avocado consumption.

Before starting the survey, respondents were asked to answer the following question: "*Do you authorize the processing of your data indicated in the survey by Legislative Decree No. 196/03 as amended and European Regulation 679/2016?*".

The survey gathered data on the following subjects: a) general fruit consumption patterns, b) health concern based on knowledge and information, c) nutritional components and extrinsic factors influencing avocado consumption, and d) participants' sociodemographic characteristics.

The sample comprises 66.26 % females and 33.74 % males. Approximately 49.92 % of the sample possess a bachelor's degree, while 18.49 % hold a postgraduate degree (Master's and/or Ph.D.); conversely, 18.49 % have solely a high school diploma. Concerning income, nearly half of the sample (45.61 %) report earnings between €15000 and €30000, 30.97 % earn more than €30000, and 23.42 % earn less than €15000. Furthermore, over half of the sample (59.48 %) report engaging in sports regularly. The sample is primarily composed of young individuals, with an average age of 36 (Table 1).

Table 1
Socio-economic characteristics of the sample (n = 649).

Variables	Categories	Freq	%
Gender	Male	219	33.74
	Female	430	66.26
Tot.		**649**	**100.00**
Education	High school diploma	205	31.59
	Degree	324	49.92
	Post-graduate (Master and/or Ph.D.)	120	18.49
Tot.		**649**	**100.00**
Income	< €15.000	152	23.42
	>€15.000 and <€30.000	296	45.61
	>€30.000	201	30.97
Tot.		**649**	**100.00**
Sport	No	263	40.52
	Yes	386	59.48
Tot.		**649**	**100.00**
Age	Mean (SD)	36.35	14.15

3.2. Data analysis

3.2.1. Ordered logit model (OLM)

An ordinal logistic regression is a statistical analysis method used to model the relationship between an ordinal response variable and one or more explanatory factors. Additionally, a stepwise backward selection was implemented to test the stability of the coefficients to be compared with the model that includes all the variables. The variables were selected with a threshold p-value of 10 %, as commonly used in consumer analyses [27].

This study employs OLM to assess the likelihood that attributes and socioeconomic variables influence the interest that consumers deserve in the perceived nutritional properties of avocados' (NP)

The dependent variable, in this case, is the perceived importance of avocado's nutritional properties, measured on a *Likert* scale (e.g., "*Not at all important*", "*Slightly important*", "*Moderately important*", "*Important*", "*Very important*").

We selected this model because it accounts for the ordered nature of data—consumer perceptions are ranked rather than continuous, making OLM preferable to linear regression. Additionally, OLM handles multiple predictors, allowing us to model the impact of both categorical (e.g., gender, education level) and continuous variables (e.g., income, frequency of avocado consumption) [28,29].

Several studies have highlighted the significant relationship between tropical fruit consumption and different levels of product characteristics [6,15,30]. Consequently, the dependent variables were expressed in categorical dimensions. This model enables the estimation of the likelihood that a consumer perceives avocados' nutritional properties as important based on socioeconomic and product-related factors [31].

The model was constructed following the structural framework for ordinal outcomes, incorporating a single continuous latent variable, NPsi*, which represents the perception of the *i*-th respondent [32]. Accordingly, we define a linear function of the explanatory variables with an associated random error term, expressed as follows:

$$NPs_i^* = \beta' x_i + \varepsilon_i \quad (1)$$

Where NPs_i^* is the continuous latent variable spanning from -∞ to ∞, β represents a K × 1 vector of parameters to be estimated, x_i is a vector of explanatory factors reflecting the characteristics of the ith respondent, and ε_i is a random error term with a mean of zero.

The model also calculated a series of coefficients ($\alpha 1 < \alpha 2 \ldots < \alpha_j$) together with J-1 intercept terms serving as cut-points in the distribution of the latent variable NPs_i^*. The cut-points denote the threshold values for transitioning between categories of the NPs_i variable. The observable

ordinal variable NPs_i is associated with the latent variable NPs_i^* as follows:

$$NPs_i = j \Leftrightarrow \alpha_{j-1} < NPs_i^* < \alpha_j,\ j = 1, 2, \ldots, J \quad (2)$$

Where $\alpha_0 = -\infty$ and $\alpha J = \infty$. Utilizing equations (1) and (2), it may be reformulated as.

$$NP_i = j \Leftrightarrow \alpha_{j-1} - \beta' x_i < \varepsilon_i < \alpha_j - \beta' x_i,\ j = 1, 2, \ldots, J, \quad (3)$$

Assuming the error term is logistically independent and identically distributed, the probability of the respondent selecting result j is articulated as:

$$\pi_{ij} = P(y_i = j|x_i) = \Lambda\ (a_j - \beta' x_i) - \Lambda\ (a_{j-1} - \beta' x_i),\ j = 1, 2, \ldots, J, \quad (4)$$

Λ (.) represents the cumulative distribution function of a logistic distribution. The parameters' maximum probability estimates can be derived by maximizing this likelihood function:

$$Log L(\beta, \alpha_1, \alpha_2, \ldots, a_{j-1}; y, x) = \Sigma_i \Sigma_j\ z_{ij} \log \pi_{ij} \quad (5)$$

Where z_{ij} is an indicator variable that equals 1 if $NPs_i = j$ and 0 otherwise.

This study evaluated how product attributes and socioeconomic characteristics influence Italian consumers' interest in avocados as a nutritious food.

The dependent variable NPs was associated with 17 independent variables, comprising 12 avocado attributes and 5 consumer socio-demographic variables.

All explanatory variables were categorized into six classes: a) knowledge, both subjective and objective; b) information, that is the availability that consumers have about the health effects of avocados; c) nutritional components, such as fats, antioxidants, and minerals; d) extrinsic characteristics, including Italian origin, certification, and price; e) sensorial characteristics, such as taste, colour, and texture; and f) socio-economic characteristics, including gender, age, education, income, and sports.

Concerning subjective and objective knowledge, three items were offered to the respondents, the average of which constituted a new variable used as a regressor.

Specifically, items related to subjective knowledge were treated as categorical variables. Respondents were asked to rank the following statements on a *Likert* scale from 1 "*disagree*" to 5 "*fully agree*": a) "*Compared to an average person, I feel that I know the health and nutritional properties of foods*"; b) "*I feel that I have a good knowledge of the nutritional characteristics from the main types of fruits*"; c) "*People who know me consider me competent concerning my ability to evaluate the quality of foods*".

Conversely, objective knowledge was seen as a nominal variable. Participants were requested to denote 0 = false and 1 = true regarding the following assertions: a) "*the sugar content in avocados is less than 1 g per serving, which is the lowest amount compared to all other fresh fruits*"; b) "*avocados contain mono- and polyunsaturated fats and, when consumed in moderation and substituted for saturated or trans fats, can aid in lowering blood cholesterol levels and diminishing the risk of heart disease*"; c) "*avocado consumption may more effectively displace empty caloric options than other foods due to their elevated levels of appetite-suppressing fatty acids and fiber*".

The variable information on health benefits was treated as a dummy (0 = no, 1 = yes). Respondents were asked: "*Do you have information available about the health effects of avocados?*".

Variables related to nutritional components (fats, antioxidants, and minerals), extrinsic (italian origin, certification, and price) and sensory characteristics (taste, colour, and texture) were treated as categorical variables. Each of the respondents was asked: "*Listed below are some characteristics that define avocado quality. Can you indicate how important each is to you on a scale of 1 to 5, where 1 corresponds to "not at all important" and 5 to "very important"*?".

The certification variable, on the other hand, was treated as a dummy variable (0 = no, 1 = yes) and asked: "*Would you be interested in purchasing a certified avocado*?".

Furthermore, socioeconomic characteristics were incorporated, encompassing gender (0 = male, 1 = female) and sports participation (0 = no, 1 = yes) as dummy variables, education levels (high school diploma; degree; and postgraduate, Master's and/or Ph.D.) and income (<€15000; from €15000 to €30000; >30000) as categorical variables, with age represented as a continuous variable (Table 1). Tables 2 and 3 present the list of explanatory variables and the descriptive statistics, respectively.

In the ordered logit model, the coefficients' sign and magnitude are not interpretable [33]. Therefore, to assess the alteration in probability, it is essential to compute marginal effects. This enables the estimation of how a marginal alteration in the value of an explanatory variable affects the outcome probability [34,35], while maintaining the other regressors at their mean values.

We further computed other measures of model fit. McFadden's Pseudo-R^2, at .205, indicates a satisfactory degree of fit. Nagelkerke's R^2, at .453, signifies a satisfactory explanation of the model's variability, whilst Cox–Snell's R^2, at .478, underscores a good fit of the model to the data.

The diagnostic analysis after estimate was grounded on the confusion matrix. The algorithm excels at differentiating the extreme categories (1 and 5), but has challenges in reliably categorizing the intermediate categories, in particular the third value of the Likert scale representing the neutrality of the statements provided by the respondents. This issue often occurs in ordered models due to the challenge of differentiating

Table 2
Explanatory variables employed in the ordered logit model.

Group	Variable	Type	Range
Knowledge and information	Subjective Knowledge	Categorical	*Likert scale* (1 = disagree/ 5 = fully agree)
	Objective Knowledge	Dummy	(0 = false/1 = true)
	Information on health benefits	Dummy	(0 = no/1 = yes)
Nutritional components	Fats	Categorical	*Likert scale* (1 = not at all important/5 = very important)
	Antioxidants	Categorical	*Likert scale* (1 = not at all important/5 = very important)
	Minerals	Categorical	*Likert scale* (1 = not at all important/5 = very important)
Extrinsic characteristics	Italian origin	Categorical	*Likert scale* (1 = not at all important/5 = very important)
	Certification	Dummy	(0 = no/1 = yes)
	Price	Categorical	*Likert scale* (1 = not at all important/5 = very important)
Sensory characteristics	Taste	Categorical	*Likert scale* (1 = not at all important/5 = very important)
	Colour	Categorical	*Likert scale* (1 = not at all important/5 = very important)
	Texture	Categorical	*Likert scale* (1 = not at all important/5 = very important)
Socio-economics characteristics	Gender	Dummy	0 = Male; 1 = Female
	Age	Continuous	
	Education	Categorical	High school diploma; degree; and postgraduate (Master's and/or Ph.D)
	Income	Categorical	<€15000; from €15000 to €30000; from €31000 to €50000; >€50000
	Sport	Dummy	(0 = no; 1 = yes)

Table 3
Descriptive statistics of the variables.

Group	Variable	Mean	Std. Dev.
	Preference for Nutritional properties	3.70	1.35
Knowledge and information	Subjective Knowledge	3.02	1.18
	Objective Knowledge	.76	.24
	Information on health benefits	.81	.39
Nutritional components	Fats	3.19	1.34
	Antioxidants	3.59	1.20
	Minerals	3.13	1.20
Extrinsic characteristics	Italian origin	3.42	1.40
	Certification	.72	.45
	Price	2.71	1.34
Sensory characteristics	Taste	3.51	1.42
	Colour	3.00	1.36
	Texture	2.58	1.26
Socio-economic characteristics	Gender	.66	.47
	Age	36.35	14.15
	Education	4.81	.80
	Income	.59	.49
	Sport	2.14	.85

neighbouring categories. However, the model has a sufficient predictive ability of 67.95 %.

Furthermore, multicollinearity was assessed by the variance inflation factor (VIF) (Table 4), revealing that the values for each variable were less than two with values ranging from 1.05 to 1.98, indicating the absence of substantial multicollinearity issues in our dataset [36]. The sensory characteristics texture (1.98), colour (1.96) and taste (1.65) show the highest VIFs, but still below the critical threshold. Statistical analyses were conducted using Stata 18 (StataCorp LP, College Station, TX, USA).

4. Results

4.1. Ordered logit model results

This study aimed to examine the factors influencing consumer interest in the nutritional properties of avocados.

The findings indicate that over 60 % of the sample regards the nutritional properties of avocados as highly significant. Table 5 displays the frequency of the five categories of the dependent variable.

An ordered logit model was created to assess the impact of features on perceived nutritional qualities, with the results in Table 6 where coefficients and odds ratios are depicted. The goodness of fit is satisfactory, as indicated by the Pseudo R^2 score (.20).

Table 4
Multicollinearity check (variance inflated factors – VIFs).

Group	Variable	VIF	1/VIF
Knowledge and information	Subjective Knowledge	1.42	.701929
	Objective Knowledge	1.05	.950578
	Information on health benefits	1.15	.867352
Nutritional components	Fats	1.44	.692451
	Antioxidants	1.95	.513762
	Minerals	1.73	.576713
Extrinsic characteristics	Italian origin	1.44	.695080
	Certification	1.09	.913757
	Price	1.50	.666566
Sensory characteristics	Taste	1.65	.605860
	Colour	1.96	.510025
	Texture	1.98	.506167
Socio-economic characteristics	Gender	1.08	.925767
	Age	1.13	.885161
	Education	1.08	.922960
	Income	1.11	.904798
	Sport	1.08	.922040

Table 5
Frequencies of answer categories for the dependent variable nutritional properties perception.

	Freq.	%
Not at all important	69	10.63
Slightly important	73	11.25
Moderately important	87	13.41
Important	172	26.50
Very important	248	38.21
Tot	**649**	**100.00**

A substantial and noteworthy association was identified between subjective knowledge and the assessment of the product's nutritional qualities ($\beta = .217$; $p < 0.05$), suggesting that customers who see themselves as knowledgeable are inclined to assess the product as possessing more nutritional validity. This phenomenon may be elucidated by the notion that subjective knowledge, rooted in personal perception of one's abilities, directly impacts decision-making and opinion formation, even in the absence of genuine technical expertise. Individuals who see themselves as knowledgeable often assign more nutritional value to the food, irrespective of the factual correctness of their information.

The strong and statistically significant correlation ($\beta = .920$; $p < 0.001$) between health benefit information and the perception of nutritional attributes underscores the critical significance of information in influencing consumer evaluations. This outcome indicates that those who get or have access to clear and trustworthy information on a product's health benefits are inclined to assess it as more nutritious. In essence, the successful communication of health advantages enhances the impression of nutritional value, likely because it enables customers to link the product with a healthy and mindful lifestyle.

Concerning the group associated with "nutritional components", our findings indicate that all three variables analyzed for this group were statistically significant.

In particular, "fats" ($\beta = .177$; $p < 0.05$) and "antioxidants" ($\beta = .175$; $p < 0.05$), compared to "minerals" ($\beta = .165$; $p < 0.10$), are quality-defining attributes of avocados and positively influence consumers' interest in the nutritional aspects of avocados. This outcome aligns with the prevalent view of avocado as a functional food, recognized for its beneficial fats and antioxidants, often emphasized in nutritional and marketing messages.

Similarly, about extrinsic characteristics, all three variables examined for this group were found to be statistically significant. Specifically, although "certification" ($\beta = .590$; $p < 0.001$) and "price" ($\beta = .385$; $p < 0.001$) are both significantly and positively correlated with "nutritional properties," of the two, "certification" appears to have a greater weight. This outcome may be understood considering that certification, often linked to established quality standards, serves as a robust indicator of trustworthiness and quality for consumers, hence enhancing their confidence in the product's health attributes. Conversely, although price affects the impression of quality, it may be read ambiguously, perhaps indicating both superior quality and marketing methods or market positioning.

"Italian origin" is statistically significant ($\beta = .174$; $p < 0.05$), although its lower coefficient relative to "certification" and "price" indicates a comparatively less influence on the assessment of the product's nutritional characteristics. This result may indicate that, although Italian provenance is often linked to quality, tradition, and authenticity, it does not inherently provide a definitive assurance of nutritional advantages. In contrast to certification, which denotes adherence to objective and controlled criteria, and pricing, which may be seen as a measure of value, origin serves primarily as an identity or cultural reference, exerting a more indirect impact on customers' nutritional evaluations.

The variables associated with the group "sensory characteristics"

Table 6
Ordered logit model results (n = 649).

Group	Variable	Coefficient	Odds ratio	Coefficient (*Stepwise .10*)	Odds ratio (*Stepwise .10*)
Knowledge and Information	Subjective Knowledge	.217**	1.242	.214**	1.238
	Objective Knowledge	−.146	.864		
	Information on health benefits	.920***	2.509	.905***	2.473
Nutritional components	Fats	.177**	1.193	.164**	1.179
	Antioxidants	.175**	1.191	.167*	1.182
	Minerals	.165*	1.180	.170**	1.185
Extrinsic characteristics	Italian origin	.174**	1.190	.178*	1.195
	Certification	.590***	1.805	.578***	1.782
	Price	.385***	1.469	.389***	1.475
Sensory characteristics	Taste	.520***	1.681	.513***	1.672
	Colour	.133*	1.142	.136*	1.145
	Texture	−.176**	.839	−.175**	.839
Socio-economic characteristics	Gender	.324*	1.382	.329**	1.389
	Age	.004	1.004		
	Education	−.220**	.802	−.241**	.786
	Income	−.116	.890		
	Sport	.319**	1.376	.291*	1.338
	cut 1	2.841		2.871	
	cut 2	4.268		4.301	
	cut 3	5.367		5.403	
	cut 4	6.969		7.000	
McFadden's Pseudo-R^2		.205		.203	
Nagelkerke's R^2		.453		.450	
Cox–Snell's R^2		.478		.476	
Log likelihood		−760.37645		−761.41052	

Note: *, **, and *** denote significance at 10 %, 5 %, and 1 % levels, respectively.

also seem to be correlated with "nutritional properties", confirming the fact that the hedonic aspects of the food experience influence the way consumers evaluate the nutritional value of a product.

Specifically, "taste" emerges as the most significant explanatory variable ($\beta = .520$; $p < 0.001$) and exerts the greatest influence on customers' perceptions of "nutritional properties". This phenomenon may be elucidated by the notion that taste serves as a quality indicator, since products deemed palatable are often instinctively linked to a nutritious and gratifying diet, particularly for items seen as "natural" or healthful, such as avocado.

Colour demonstrates a favorable correlation with the impression of the nutritious attributes of avocado ($\beta = .133$; $p < 0.10$), but with minimal significance. This outcome may be ascribed to the notion that colour serves as an initial visual cue of quality and freshness; vibrant and consistent hues are often seen by customers as indicators of a healthy, natural, and nutrient-dense food.

Texture, conversely, shows a negative evaluation with the perception of nutritional properties ($\beta = -.176$; $p < 0.05$).

Ultimately, the socioeconomic aspects of "gender" ($\beta = .324$; $p < 0.10$) and "sport" ($\beta = .319$; $p < 0.05$) exhibit a positive correlation with nutritional properties. In summary, female individuals who engage in physical activity are more likely to regard the nutritional properties of avocados as significant. This phenomenon may be attributed to the observation that women, as a demographic, exhibit heightened attentiveness to health and diet compared to males. Moreover, engagement in sports is often linked to enhanced nutritional awareness; individuals who participate in physical activities are inclined to acquire knowledge about food and make dietary choices aligned with a healthy lifestyle.

Conversely, the link between education and perception of nutritional properties is negative ($\beta = -220$; $p < 0.05$), suggesting that those who are more educated tend to evaluate the declared nutritional properties with greater caution or scepticism, reducing their positive perception of the product.

The marginal effects of the ordered logit model were assessed to see how attributes and other socioeconomic indicators may influence perceptions of nutritional properties (Table 7).

Given that the dependent variable in the ordered logit model has five categories, there exist five sets of marginal effects that elucidate the

Table 7
Marginal effects for the ordered logit model.

Group	Variable	*Not at all important*	*Slightly important*	*Moderately important*	*Important*	*Very important*
Knowledge and information	Subjective Knowledge	−.008 (.009**)	−.018 (.007**)	−.022 (.008**)	.003 (.338)	.045 (.005**)
	Objective Knowledge	.005 (.652)	.012 (.652)	.015 (.652)	−.002 (.681)	−.030 (.651)
	Information on health benefits	−.044 (.002**)	−.091 (.000***)	−.081 (.000***)	.051 (.020**)	.165 (.000***)
Nutritional components	Fats	−.006 (.018**)	−.015 (.016*)	−.018 (.017**)	.002 (.349)	.036 (.013**)
	Antioxidants	−.006 (.052*)	−.015 (.051*)	−.017 (.053*)	.002 (.368)	.036 (.047**)
	Minerals	−.006 (.061*)	−.014 (.055*)	−.016 (.057*)	.002 (.361)	.034 (.053*)
Extrinsic characteristics	Italian origin	−.006 (.012**)	−.015 (.011**)	−.017 (.011*)	.002 (.346)	.036 (.008**)
	Certification	−.024 (.006**)	−.054 (.003**)	−.057 (.001***)	.020 (.098*)	.115 (.000***)
	Price	−.014 (.000***)	−.032 (.000***)	−.038 (.000***)	.005 (.321)	.079 (.000***)
Sensory characteristics	Taste	−.019 (.000***)	−.044 (.000***)	−.052 (.000***)	.007 (.318)	.107 (.000***)
	Colour	−.005 (.108)	−.011 (.104)	−.013 (.103)	.002 (.383)	.027 (.099*)
	Texture	.006 (.057*)	.015 (.054*)	.018 (.054*)	−.002 (.365)	−.036 (.050**)
Socio-economics characteristics	Gender	−.012 (.078*)	−.028 (.067*)	−.032 (.056*)	.007 (.288)	.065 (.049**)
	Age	−.000 (.479)	−.000 (.476)	−.000 (.476)	.000 (.554)	.001 (.476)
	Education	.008 (.035**)	.018 (.032**)	.022 (.033**)	−.003 (.358)	−.045 (.028**)
	Income	.004 (.220)	.010 (.215)	.012 (.216)	−.001 (.418)	−.024 (.214)
	Sport	−.012 (.063*)	−.027 (.053*)	−.032 (.049**)	.006 (.286)	.065 (.044**)

Note: *, **, and *** denote significance at 10 %, 5 %, and 1 % levels, respectively.

influence of variations in covariates on the projected probability. If the predicted probabilities derived from the regression presented in Table 5 vary across the categories of the dependent variable, the marginal effects can be employed to assess their rise or decrease.

An examination of the marginal effects reveals that "subjective knowledge" assumes a negative value for the lowest categories (fully disagree; disagree; and don't know), suggesting that as individuals perceive an increase in their knowledge regarding the nutritional properties of foods and fruits, they assign diminishing importance to the nutritional properties of avocados.

Similarly, being in possession of information about the health effects of avocados is positively correlated with the highest categories ("important"; "very important") of the dependent variable "nutritional properties", thus indicating that the availability of information about nutritional properties influences the perception of how important these properties are for avocado consumption.

Comparable outcomes are demonstrated by "nutritional components". Specifically, "fats", "antioxidants", and "minerals" exhibit a negative correlation with the lowest categories ("not at all important"; "slightly important"; "moderately important"), suggesting that as the significance attributed to the nutritional properties of the avocado increases, these characteristics are regarded as defining attributes of product quality.

Identical results occur for "extrinsic characteristics". Specifically, "italian origin", and "price" are positively correlated with the highest level ("very important") among the categories related to "nutritional properties", while "certification" with the two highest levels ("important"; "very important"). Among the attributes, "price" exerts a significantly greater influence on the perception of "nutritional properties" of avocados.

However, divergent outcomes arise from "sensory characteristics". Specifically, while "taste" is positively correlated with the highest level of importance in the "nutritional properties" category, "texture" exhibits a negative correlation. This indicates that, unlike "texture", individuals who prioritize the nutritional properties of avocados regard "taste" as a defining characteristic of product quality.

"Colour" is notably significant and positively connected solely with the highest category ("very important"), suggesting it is a pertinent quality for individuals who prioritize the nutritional properties of the food.

Concerning socioeconomic variables, "gender" and "sport" have a positive correlation with the highest category ("very important"), suggesting that probabilistically, women and individuals who regularly engage in sports place significant importance on the nutritious aspects of avocados.

Conversely, "education" exhibits a negative correlation with the highest category ("very important"), suggesting that as the educational attainment of the sample increases, the likelihood of seeing the nutritional features of avocado as important diminishes.

5. Discussion

Although various studies have explored the nutritional properties of avocados, this research represents the first attempt to quantify consumers' interest in these properties when purchasing the fruit, providing an innovative contribution to the existing literature [37].

The findings show that over 60 % of the sample assigns high importance to the nutritional properties of avocados. This suggests a growing consumer awareness of the nutritional value of foods and the impact of dietary choices on health. Additionally, 38 % of respondents classified nutritional properties as "very important", reinforcing an increasing trend toward healthier and more informed eating habits [38]. This result aligns with previous studies highlighting the role of nutritional awareness in shaping food preferences [39,40].

Among the extrinsic characteristics, certification and price emerge as key factors in consumers' perception of avocados' nutritional properties. The emphasis on certification underscores consumers' strong sensitivity to product quality and safety assurance [41]. While price plays a significant role [42], the fact that certification prevails as the dominant factor suggests that consumers are willing to pay a premium for a guaranteed product, consistent with findings from previous studies [43,44].

From a nutritional perspective, the predominant influence of fats and antioxidants on avocado perception reinforces its image as a functional food, valued for their healthy fats and bioactive compounds. While minerals, are acknowledged as relevant, they have a lesser impact, suggesting that consumers primarily view avocados as a source of beneficial fats rather than micronutrients. This contrasts with the findings of Giuggioli et al. [16], possibly due to geographical, cultural, and dietary habits that shape consumer perceptions of avocados. These differences highlight the need for companies to tailor their promotional messages based on market-specific preferences.

Sensory characteristics showed a significant correlation with the importance attributed to nutritional properties. Taste, in particular, emerged as a decisive factor, indicating that consumers who prioritize nutritional benefits also tend to consider the flavor of the food. Similarly, previous studies [45,46] have shown that a food product is unlikely to be accepted if consumers do not enjoy its taste, even if it excels in terms of nutritional value or health benefits. This implies that promotional strategies for avocados should not be limited to highlighting their nutritional benefits but should also emphasize their organoleptic qualities. The negative correlation with texture and the weak but positive correlation with colour indicate that while taste is a key factor for health-conscious consumers, texture may act as a deterrent. On the other hand, the role of colour, although less impactful, suggests that visual appearance also contributes to the overall perception of the product, as demonstrated in other studies on fruits and vegetables [47,48].

Regarding the role of knowledge, the data suggest that subjective knowledge, defined as an individual's self-assessment of their nutritional competence, is positively associated with the perceived importance of the avocado's nutritional properties, whereas objective knowledge did not show a significant impact. This data implies that the perception of being informed has a greater influence than actual knowledge, aligning with previous research [49,50]. Several studies have highlighted that subjective and objective knowledge are conceptually distinct constructs with generally low correspondence [51]. Research has shown that consumers often exhibit overconfidence in their knowledge, with subjective knowledge levels frequently exceeding objective knowledge [52]. This discrepancy is particularly relevant in consumer decision-making, as subjective knowledge has been found to be a stronger driver of behavior than objective knowledge [53,54]. Moreover, the strong correlation between the level of information about health benefits and the importance attributed to nutritional properties ($\beta = 2.509$, $p < 0.001$) denotes that greater exposure to information about the benefits of avocado can enhance the perception of its nutritional importance. This is consistent with Grunert [55], who stated that consumers do not merely assess the quality of a fruit but also consider how its properties can contribute to achieving their health and well-being goal.

Finally, socioeconomic factors have had a significant impact on the perception of the nutritional properties of avocados [56]. In particular, gender and physical activity have been positively associated with attention to nutritional aspects, suggesting that women and physically active individuals tend to place greater value on the health benefits of the fruit. Previous studies indicate that women possess greater nutritional knowledge [57,58], likely because food and health are often considered areas of greater interest to women [59,60]. As a result, women may be more frequently exposed to information about nutrition and well-being, leading to a deeper awareness of these topics [61]. On the other hand, the negative correlation between education level and the importance attributed to the nutritional properties of avocados may highlight a potentially meaningful behavioral pattern. This outcome is

partially supported by existing studies [62–64], which suggest that consumers with higher educational attainment often exhibit greater confidence in their nutritional knowledge and may, as a result, place less emphasis on detailed nutritional information, favoring instead attributes like taste or convenience. Although our study did not directly test this link, the observed result points to an area worth exploring in future research to better understand the relationship between education and nutritional perception.

6. Conclusion

a) Major insights

This study sheds light on the factors shaping consumers' perception of the nutritional properties of avocados, emphasizing the interaction between knowledge, sensory attributes and external product characteristics.

The findings suggest that while consumers value nutritional benefits, their perceptions are strongly influenced by subjective knowledge and exposure to health-related information. This highlights the need for clear and effective communication strategies that enhance consumer understanding and engagement.

Beyond nutritional aspects, sensory appeal – particularly taste – plays a crucial role in consumer acceptance, reinforcing the idea that health benefits alone are not sufficient to drive purchasing decisions. Additionally, certification emerges as a key factor in shaping perceptions, underscoring the importance of transparency and quality assurance in food marketing. Targeting specific groups, such as women and physically active individuals, could further strengthen the effectiveness of communication strategies, ensuring that messages resonate with the most receptive audiences.

b) Limitations and future research

Given its exploratory nature, this study has certain methodological limitations that should be acknowledged. While the findings provide valuable insights into the factors influencing Italian consumers' interest in the nutritional properties of avocados, further confirmatory analyses are needed to enhance the robustness and generalizability of the results.

In particular, future research could incorporate validated psychometric scales to more precisely assess consumers' perceptions of avocado's health benefits. Such scales would enable a more rigorous measurement of constructs such as health perception and perceived healthiness, offering deeper insights into how consumers evaluate the nutritional value of this fruit. Additionally, longitudinal studies or experimental designs could help establish causal relationships between knowledge, product attributes, and consumer behavior.

Furthermore, this study relies on self-reported data, which may be subject to biases such as social desirability or an overestimation of nutritional knowledge. Regarding sample representativeness, it may not fully capture the diversity of the Italian population. Expanding the sample to include a broader range of socio-demographic groups would improve the external validity of the findings.

CRediT authorship contribution statement

Daniela Spina: Writing – review & editing, Writing – original draft, Validation, Supervision, Investigation, Formal analysis, Conceptualization. **Manal Hamam:** Writing – review & editing, Writing – original draft, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Raffaele Zanchini:** Visualization, Data curation. **Vincenzo Morreale:** Writing – original draft. **Raffaella Pergamo:** Visualization, Validation. **Mario D'Amico:** Visualization, Validation, Supervision, Resources, Investigation, Conceptualization. **Giuseppe Di Vita:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Formal analysis, Conceptualization.

Ethical considerations

This study was conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from all participants, who were adults and took part voluntarily and anonymously. Ethical approval was not required, as *per* the University of Catania's current guidelines for non-clinical social science research.

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.

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