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RESEARCH ARTICLE

Knowledge, attitude and behaviours towards food sustainability in a group of Italian consumers. A cross-sectional study

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ABSTRACT

Sustainability is crucial for transforming the food system, addressing environmental and nutrition issues and depends on consumer perceptions and values. This cross-sectional study investigates the relationship between sustainability attitudes, knowledge, and eating behaviours. Nearly half reported high level of knowledge regarding food sustainability while 24% expressed high attitude towards food sustainability. Women reported higher levels of knowledge and attitude towards food sustainability. Logistic regression analyses, adjusted for age, sex, and education, revealed that using public transport, biking, or walking was significantly associated with higher odds of having a more positive overall attitude towards food sustainability (OR = 1.77). The overall knowledge score was a strong predictor of a positive overall attitude score (OR = 2.11). Examining individual knowledge-related items, almost all were associated with higher levels of knowledge, except those regarding food and environment interaction. These findings underline a complex scenario where consumers' awareness and knowledge highly influence the applicability of sustainable food choices.

Introduction

The contemporary food system faces an unprecedented challenge, requiring the delicate balance of managing the environmental and socio-economic consequences of the industrial production model. Simultaneously, it must meet the increasing demand for affordable and nutritious food to sustain a growing population (Garnett 2013). This necessitates an active commitment to reduce environmental impacts and prevent the overexploitation of natural resources (Garnett 2013; Willett et al.2019). Currently, the global food production system heavily relies on a significant share of the Earth's resources, including water and land, and contributes substantially to over a third of greenhouse gas (GHG) emissions (Crippa et al.2021). In this critical scenario, sustainability has emerged as a pivotal concept within innovative strategies that advocate for a global transformation of the current food system, aiming to minimise its adverse effects on environmental health.

Initiating a transformative shift in the food system can be started by prioritising sustainable food choices. The Food and Agriculture Organisation of the United Nations (FAO) defines as sustainable diet "a diet with a low environmental impact that contributes to food and nutritional security and a healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically equitable and affordable, nutritionally adequate, safe and healthy, and optimise natural and human resources" (Burlingame and Dernini 2010). This involves adopting a dietary pattern rich in plant-based foods such as vegetables, fruit, whole grains, and legumes, while minimising the consumption of animal products. Notably, meat and meat products, followed by dairy products, exert the most significant environmental impact due to their higher demand for natural resources and elevated GHG emissions when compared to plant-based alternatives (Alsaffar 2016).

Nevertheless, the transition to a more sustainable consumption pattern depends on several consumer-

related factors, including perceptions, values, and attitudes towards environmental issues. This orientation is defined as the relative importance that individuals attribute to themselves, humanity and the entire planet (Klöckner 2013). Similarly, consumer knowledge plays a crucial role in motivating environmentally protective habits. Current literature indicates that consumers with relevant knowledge are more inclined to make environmentally friendly choices (Peschel et al.2016). Despite this, a growing body of evidence indicates that a majority of individuals struggle to define the concept of sustainability. Many tend to associate it primarily with activities like recycling and maintaining a balance between production and consumption, lacking a comprehensive understanding (Busquets et al.2021). Moreover, a substantial portion of the population tends to assess the environmental impact of food solely through indicators such as organic labels (Busquets et al.2021). Conversely, some consumers remain sceptical about the environmental repercussions of meat production, often questioning evolving scientific evidence (Lazzarini et al.2016; Macdiarmid et al.2016; Camilleri et al.2019).

The objective of this study is, therefore, to explore the relationship between sustainability attitudes, knowledge, and eating behaviours in a sample of Italian adults. This approach aims to facilitate the development of precise interventions and educational campaigns promoting a more sustainable and ethical food culture among Italian consumers.

Methods

Study design and data collection

This is an observational cross-sectional study conducted among the general population, aimed at assessing the level of knowledge and attitude regarding food sustainability, with a focus on identifying factors associated with attitudes. Eligible participants included individuals aged 18 years and older, living in Italy. Data were collected anonymously between September 2022 and January 2023 through an online questionnaire created using SurveyMonkey (www.surveymonkey.com) and distributed among personal and non-personal contacts *via* social media networks. Before filling out the questionnaire, participants were instructed to review the study's objective, and instructions on how to complete the questionnaire were also provided. Moreover, informed consent was required for each participant, and those who did not provide consent were redirected to the end of the questionnaire.

The survey was divided into two parts. The first part investigated socio-demographic and lifestyle factors. The second part contains the Italian version of the Attitudes towards Sustainable Food Questionnaire (Aureli et al.2022). The questionnaire comprised a total of 12 questions, some of which had multiple sub-questions, organised into three main sections: knowledge and attitude of sustainable food, and eating behaviours (Cronbach's alpha = 0.90) (Aureli et al.2022). The topics covered by the questionnaire were diverse, ranging from the perception of the environmental impact of the global food industry and one's eating habits to the definition of sustainable eating and the barriers to achieving it, willingness to make changes in food choices, red meat consumption, the willingness to substitute meat with innovative foods, and nutritional knowledge. Additionally, opinions were sought on some possible measures to promote the consumption and production of sustainable foods, such as mandatory labelling information or higher taxation on more environmentally impactful foods.

The study was conducted according to the principles of the Declaration of Helsinki, and it was approved by The Ethics Committee of the University of Florence, Florence, Italy (n.199/2022, protocol 11917).

Socio-demographic data

Data regarding gender, age, body weight and height, region of residency, educational level, number of family members, smoking habit, urban mobility, and physical activity were all collected using the first part of the survey. Age was collected on a continuous scale. Weight and height were used to estimate Body Mass Index (BMI), calculated by dividing the body weight (reported in kg) by the square of the person's height in metres. According to the World Health Organisation, BMI was categorised as underweight (values below 18.4), norm weight (values between 18.5 and 24.9), overweight (values between 25.0 and 29.9), or obese (values equal to or higher than 30.0). Educational level was categorised as follows: middle school, high school, degree and postgraduate training. The number of family members was measured on a continuous scale and then categorised into one, two, or three and more members. Smoking habit was investigated with a question: *"Do you smoke or have you ever smoked tobacco?"* with the following options: *"I have never smoked tobacco"*; *"I used to smoke but quit"*; *"I smoke occasionally"*; *"I smoke regularly"*. Urban mobility was assessed with the following question: *"How do you*

make your travels during the day?" the answers were then dichotomised in "private car", which includes "I mainly travel with my car" and "public transports, biking and walking" which includes the following answers: "I mainly use public transportation and try to avoid the car", "It depends; if I can, I prefer to travel on foot or by public transportation", "I often travel on foot or by bicycle". Physical activity was evaluated with the question: "How often do you practice physical activity?" and the answers were dichotomised into active ("I practice it 1-2 times a week", or "I practice it 3 or more times a week") and not active ("I do not practice it").

Knowledge regarding food sustainability

Knowledge regarding food sustainability was assessed through the following 10-point Likert scale questions: item 1.1 "My food habits negatively affect the environment"; item 1.2 "When compared to car use, food habits have only little impact on the environment"; item 8.1 "Eating meat is necessary to have a complete diet"; item 8.2 "I need meat to have energy"; item 8.3 "Eating meat allows me to have a balanced diet"; item 8.4 "Meat is irreplaceable in my diet"; item 8.5 "Replacing meat with plant-based protein sources doesn't provide me with the same energy"; item 12.1 "Emissions from aircraft, trains, cars, trucks and ships"; item 12.2 "The production of meat and dairy products, which we eat and drink"; item 12.3 "The felling of trees and forests". For each item, the mean and standard deviation (SD) were calculated. However, considering that some questions were framed positively and others negatively, the scores were reversed to ensure greater consistency in data interpretation (reversed items: 1.2; 8.1; 8.2; 8.3; 8.4; and 8.5). Furthermore, to obtain synthetic data of knowledge, a total score was calculated. At this point, the scores assigned to each item were summed, and the mean and SD were calculated; obtaining the Overall Knowledge Score. Moreover, item 2 investigates what comes to the responder's mind when thinking about "sustainable" food. The item provided 9 different options for which yes/no answers were allowed.

Attitude towards food sustainability

Attitude towards food sustainability was assessed by considering the following questions: item 1.3 "I pay attention to the impact that my food choices have on the environment"; item 1.4 "Sustainability issues influence my food choices"; item 1.5 "I improved my habits in favour of food sustainability, following the government's advertising campaigns"; item 1.6 "I do not want someone to tell me or decide for me what I should eat or not"; item 4.1 "I'm willing to buy mainly seasonal fruit and vegetables"; item 4.2 "I'm willing to spend more money for sustainable food"; item 4.3 "I'm willing to spend more money on food for which I'm sure that farmers get a fair price in return"; item 4.4 "I'm willing to cut down on red meat (beef, lamb and pork)"; item 4.5 "I'm willing to cut down on dairy"; item 4.6 "I am willing to waste less food at home, implementing anti-waste measures (e.g. shopping list, placing foods that expire first in front of the refrigerator, etc.)"; item 4.7 "I'm willing to eat more vegetables/plant-based food, even if they're not to my taste"; item 4.8 "I'm willing to change my eating habits, even if they are not environment-friendly"; item 11.1 "Sustainability information should be compulsory on food labels"; item 11.2 "Food which is less sustainable should be more taxed (and be more expensive)"; item 11.3 "Unsustainable food products should be pulled from shelves (e.g. no strawberries in winter, supermarkets should only sell fish sourced sustainably, etc.)"; item 11.4 "Regulations should force farmers and food producers to meet more stringent sustainability standards (in terms of greenhouse gas emissions, water use, biodiversity impact, etc.)"; item 11.5 "Barmers should be given incentives (e.g. through subsidies) to produce food more sustainably"; and item 11.6 "The EU should not be more proactive on sustainable food policies unless other countries such as China or the USA do the same". For each item, the mean and SD were calculated. However, considering that some questions were framed positively and others negatively, the scores were reversed to ensure greater consistency in data interpretation (reversed items: 1.6, 4.8; and 11.6). In this case, as well, a summary measure was adopted by deriving the Overall Attitude Score, estimated as the sum of the means (and SD) of the individual items.

Eating behaviours towards food sustainability

The remaining sections of the questionnaire were considered to be related to eating behaviours. None of these were Likert scale questions; instead, they featured yes/no responses (items 3 and 6), multiple-choice questions with a single response option (items 5, 9, and 10), and a question that included the following response options: yes/no/I do not know/if to my test (item 7). In detail, the questions investigated reasons preventing individuals from eating more sustainably, the reduction of red meat consumption, alternative protein sources to replace meat, and willingness to

do so in the future. Moreover, the respondents were asked if they would eat the same amount of meat even if all meat products comply with farm animal welfare rules. Lastly, their opinion regarding using meat-related names to describe meat-free vegetarian products was also sought.

Statistical analysis

Statistical analysis was performed using R version 4.3.1. Descriptive statistics were used to analyse and report the data. Shapiro-Wilk test was used to check the normal distribution of continuous variables, and it was found that no variable followed the normal distribution. Descriptive results were presented as the median and interquartile range (IQR) for continuous variables and as frequency and percentage (%) for categorical variables. Differences in the distribution of continuous variables between groups were estimated using the Wilcoxon test, while Pearson's Chi – squared test was used to detect differences among categorical variables

Knowledge and attitude questions were all on the Likert scale. Therefore, the mean was calculated for each subject to calculate an Overall Attitude Score. The same approach was used for the knowledge-related items, resulting in the Overall Knowledge Score. Individual overall scores were dichotomised into "high" and "low" based on whether they had a score above or below the sample median of the two scores, respectively.

Two logistic regressions adjusted for age, sex, and educational level were performed to identify which socio-demographic characteristics were associated with higher levels of Knowledge and Attitude, separately. In these cases, a score higher than the sample median was categorised as 1, whereas a score lower than the median was categorised as 0. This approach was used for both Knowledge and Attitude, respectively. Furthermore, a logistic regression analysis adjusted for age, sex, and education was conducted between each single item of knowledge in Likert-scale and dichotomised Overall Attitude Score. Furthermore, considering that differences in knowledge and attitudes may be influenced by age, we divided the participants into two groups based on the median age of the sample. Participants older than the median (> 31 years old) were assigned a value of 1, while those equal to or younger than the median (≤ 31 years old) were assigned 0. We conducted a multiple logistic regression analysis, adjusting for sex and education level, for each knowledge and attitude item, as well as for the overall knowledge and attitude scores, with the participant's age group as the dependent variable. Thus, an odds ratio greater than 1 indicated that participants above the sample median age were more likely to agree with the specified item.

Results were reported as adjusted odds ratio (aOR) and 95% confidence intervals (CI). A p-value < 0.05 was considered statistically significant.

Results

Descriptive characteristics of the sample

Descriptive characteristics of the study population, stratified by gender, are reported in Table 1. In total, 449 subjects took part of the survey. Participants had a median (IQR) age of 31.0 (25.0 – 45.0) years, with 66.1% being women, mainly highly educated (51.2%), physically active (54.8%), and never smokers (57.5%). Women were more frequently normal weight and were more physically active compared to men. No differences were detected regarding educational level, number of family members, smoking habit, or in-urban mobility among the sexes (Table 1). Furthermore, a logistic regression analysis, adjusted by sex and level of education, was conducted based on age. In this case, a higher statistically significant odds ratio was detected between being willing to spend more on food that ensures farmers receive a fair share and old age. Conversely, a lower odds ratio was found between not considering proactive intervention on sustainable food policies necessary on the part of the European Union. No differences were found regarding level of knowledge or attitude. Results are shown in Table S1.

Knowledge towards food sustainability

When considering the Overall Knowledge Score, 49.0% of participants exhibited a high level of knowledge about food sustainability. When differences among sexes were considered, women (53.5%) more frequently than men (40.1%) reported a high level of knowledge ($p = 0.010$), as shown in Table 1. Additionally, Table S2 displays item-by-item knowledge-related questions and Overall Knowledge Score, reported as mean scores, ranges, and SD, stratified by sex. In this case, all the differences between women and men were statistically significant, except for three questions (items 1.1 and 1.2 related to food and environmental interaction, and item 12.3 related to activities that contribute to climate change). Based

Table 1. Descriptive characteristics of the overall sample, and stratified by sex.

Characteristic	Overall N = 449	Stratification by Sex Women N = 297	Men N = 152	p-value
Age (years)	31.0 (25.0, 45.0)	31.0 (25.0, 45.0)	30.0 (25.0, 42.3)	0.725[a]
BMI				0.001[b]
Norm weight	297 (66.2%)	207 (69.7%)	90 (59.2%)	
Underweight	19 (4.2%)	18 (6.0%)	1 (0.7%)	
Overweight	110 (24.5%)	59 (19.9%)	51 (33.5%)	
Obesity	23 (5.1%)	13 (4.4%)	10 (6.6%)	
Educational level				0.068[b]
Middle School	19 (4.2%)	10 (3.3%)	9 (5.9%)	
High School	200 (44.6%)	124 (41.8%)	76 (50.0%)	
Degree and postgraduate training	230 (51.2%)	163 (54.9%)	67 (44.1%)	
Family members (person)				0.087[b]
1	41 (9.1%)	21 (7.0%)	20 (13.2%)	
2	104 (23.2%)	73 (24.6%)	31 (20.4%)	
≥3	304 (67.7%)	203 (68.4%)	101 (66.4%)	
Physical activity				0.014[b]
Active	246 (54.8%)	175 (58.9%)	71 (46.7%)	
Not active	203 (45.2%)	122 (41.1%)	81 (53.3%)	
Smoking habit				0.215[b]
Never smoker	258 (57.5%)	179 (60.3%)	79 (52.0%)	
Former smoker	90 (20.0%)	54 (18.2%)	36 (23.7%)	
Smoker	101 (22.5%)	64 (21.5%)	37 (24.3%)	
Urban mobility				0.178[b]
Private car	249 (55.5%)	158 (53.2%)	91 (59.9%)	
Public transports, biking, walking	200 (44.5%)	139 (46.8%)	61 (40.1%)	
Overall Knowledge Score				0.010[b]
Low (Score < 7)	229 (51.0%)	138 (46.5%)	91 (59.9%)	
High (Score ≥ 7)	220 (49.0%)	159 (53.5%)	61 (40.1%)	
Overall Attitude Score				0.029[b]
Low (Score < 8)	340 (75.7%)	215 (72.4%)	125 (82.2%)	
High (Score ≥ 8)	109 (24.3%)	82 (27.6%)	27 (17.8%)	

[a]Wilcoxon rank sum test.
[b]Pearson's Chi−squared test.
Differences were calculated using the Wilcoxon rank sum test and Pearson's Chi−squared test, as appropriate.

on these, women (mean 7.08 ± SD 1.34) reported a significantly ($p < 0.001$) higher level of Overall Knowledge Score than men (mean 6.42 ± SD 1.52), data reported in Table S2.

Lastly, low environmental impact ($n = 428$, 95.3%), a local supply chain ($n = 396$, 88.2%), and high animal welfare standards ($n = 388$, 86.4%) were the three options more frequently reported for explaining the "sustainable food" concept. However, when differences among sexes were considered, low environmental impact and high animal welfare standards were significantly more frequently reported by women (67.5% and 69.3%, respectively) compared to men (32.5% and 30.7%, respectively). Data are shown in Figure 1. Lastly, when considering socio-demographic predictors of higher overall knowledge score, none of the included variables was significantly associated apart of being a former smoker [aOR= 1.79 (95%CI= 1.07 − 3.00), $p = 0.027$] (Table S3).

Attitude towards food sustainability

When considering the Overall Attitude Score, 24.3% of the sample demonstrated a high level of attitude

towards food sustainability, as depicted in Table 1. The comparison between genders revealed that women (27.6%) more frequently than men (17.8%) reported a high level of attitude towards food sustainability ($p = 0.029$). Additionally, Table S4 displays item-by-item attitude-related questions and Overall Attitude Score, reported as mean scores, ranges and SD, stratified by sex. In particular, women paid more attention than men to the impact their own food choices have on the environment and on the sustainability of food choices.

Moreover, women more than men were willing to cut down red meat ($p < 0.001$) and dairy products ($p < 0.001$), waste less food at home ($p = 0.033$), eat more vegetables ($p < 0.001$), and were more willing to change eating habits in favour of the environment ($p = 0.001$). With regard to regulatory aspects, women, more than men, expressed a greater attitude towards the need to force farmers and food producers to meet more stringent sustainability standards ($p = 0.012$), are more inclined to support the compulsory presence of food labels regarding sustainability information ($p = 0.001$) and, at the same time, women were more inclined to give incentives to farmers in order to produce more sustainable food ($p = 0.007$).
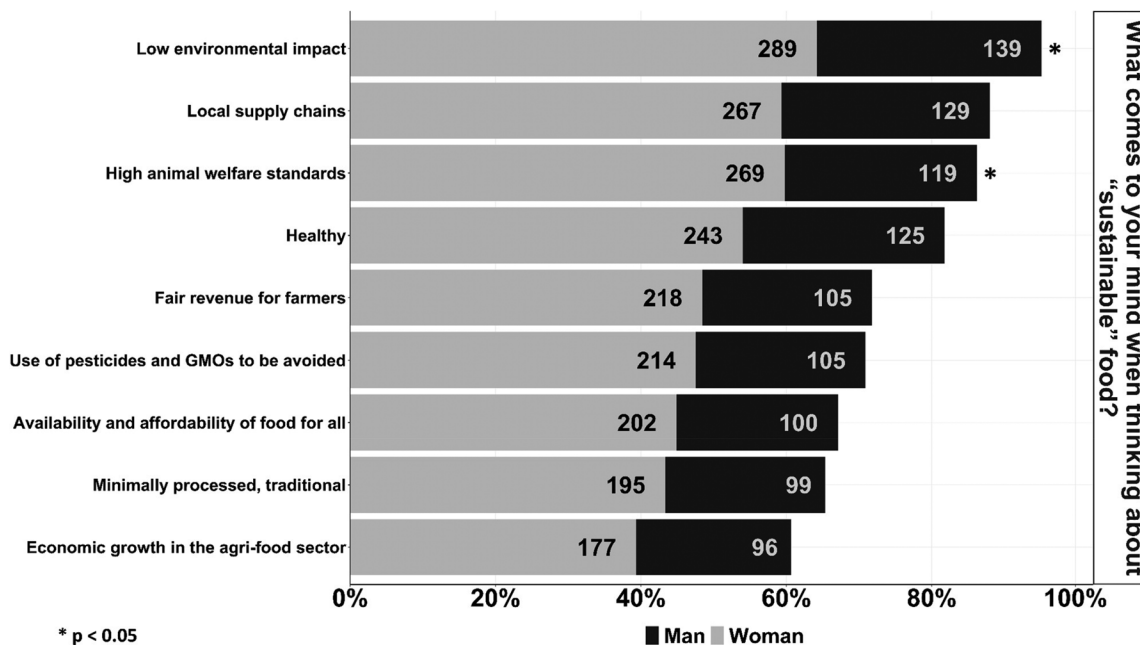
Figure 1. Frequencies and percentages, stratified by sex, of themes emerged about sustainable food (*$p < 0.05$).
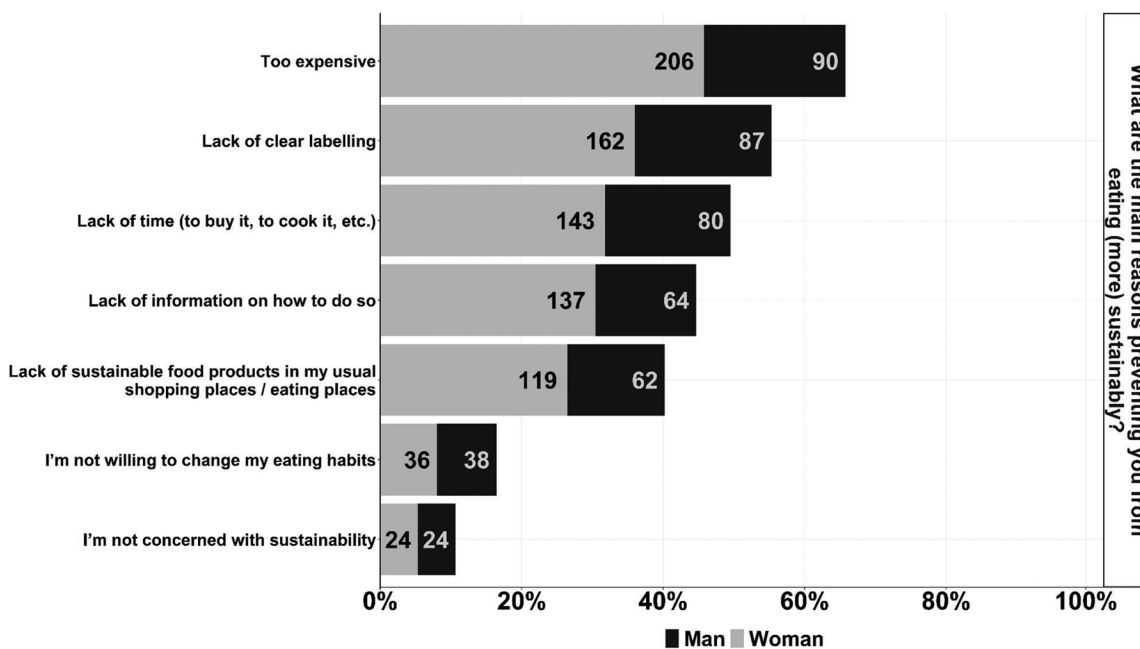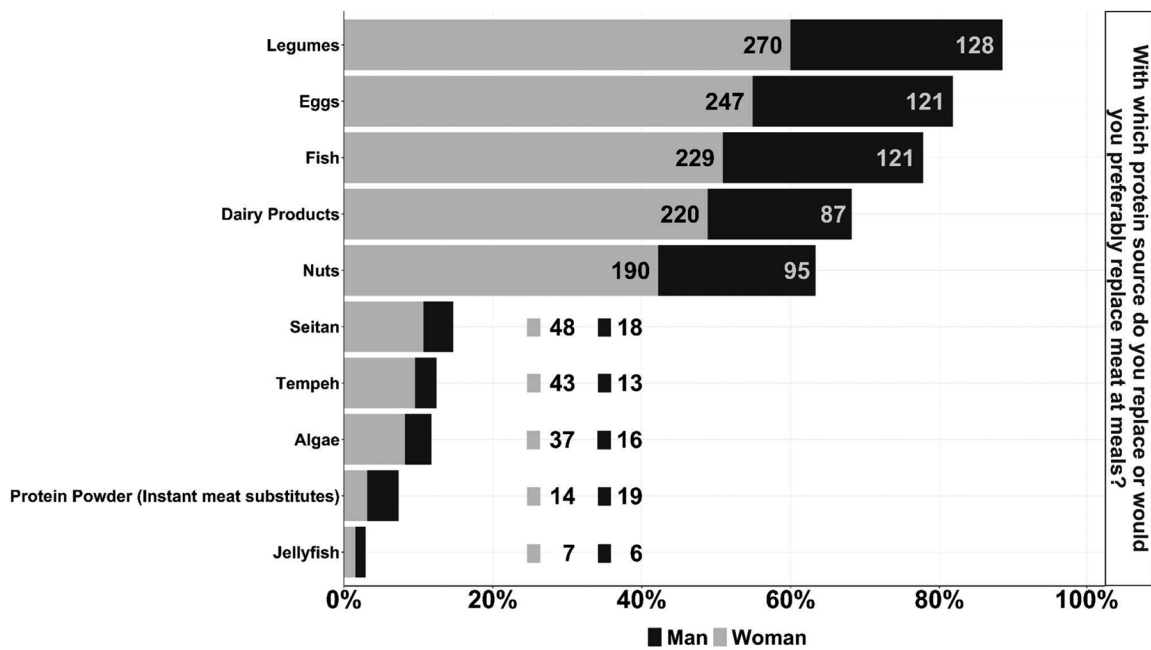

Figure 2. Frequencies and percentages, stratified by sex, of the main reasons for preventing individuals from eating more sustainably.

Considering all the above, women (mean 7.14±SD 1.13) showed a greater attitude towards sustainability than men (mean 6.59±SD 1.45, $p < 0.001$), as reported in Table S4.

Eating behaviour towards food sustainability

The respondents were asked to indicate the main reasons preventing them from eating more sustainably, and high cost ($n = 296$, 65.9%), lack of clear labels ($n = 249$, 55.5%), and lack of time ($n = 223$, 49.7%) were the tree most frequently reported. When stratified by sex, being not interested in sustainability (15.8% in men vs 8.1% in women), and unwillingness to change their own food habits (25.0% in men vs 12.1% in women) were more frequently reported by men compared to women, in a statistically significant manner ($p = 0.012$ and $p = 0.001$, respectively). Conversely, high cost was statistically significant

Figure 3. Frequencies and percentages, stratified by sex, of the main source of protein used to replace meat.

$(p = 0.032)$ more frequently indicated by women (69.4%) compared to men (59.2%). Data are shown in Figure 2. When considering meat consumption, most of the participants ($n = 276$, 61.5%) reduced the consumption of red meat, and they will eat the same amount even if all meat products comply with farm animal welfare rules ($n = 235$, 52.3%). Moreover, participants have replaced meat with alternative sources of proteins, mainly legumes ($n = 398$, 88.6%), eggs ($n = 368$, 82.0%), and fish ($n = 350$, 78.0%). Details are reported in Figure 3. Further, in the future, they intend to replace meat mainly with plant-based meat alternatives, both if only made from ingredients that are not derived from Genetically Modified Organisms (GMO) ($n = 172$, 38.3%) or also made from GMO-derived ingredients ($n = 81$, 18.0%). Insects and their derivates will be used as substitutes for meant only if they will meet the participants' taste ($n = 103$, 22.9%). Results are shown in Figure S1. Lastly, the respondents were asked for their opinions regarding using meat-related names to describe meat-free vegetarian products. In this regard, the sample was equally distributed among two options: no issue detected ($n = 174$, 38.8%), and the importance of clearly labelling their vegetable origins ($n = 157$, 35.0%).

Predictors of the high level of attitude

Considering results of logistic regression, with adjustments made for sex, age, and educational level,

only using public transport, biking, or walking was significantly associated with higher odds of having a higher Overall Attitude Score [aOR= 1.77 (95%CI= 1.12-2.80) $p = 0.015$]. All the other socio-demographic characteristics assessed were not significantly associated (Table 2). However, the Overall Knowledge Score was a strong predictor of high Overall Attitude Score [aOR (95% CI = 2.11 (1.68 − 2.64), $p < 0.001$] (Table 2). When considering every single knowledge-related item, almost all of them appear to be significantly associated with a higher level of Knowledge, apart the items 1.2 and 12.1 ("When compared to car use, food habits have only little impact on the environment" and "Emissions from aircraft, trains, cars, trucks and ships"), as reported in Table 2.

Discussion

In this manuscript, we explored the complex interplay between knowledge, attitudes, and behaviours among Italian consumers regarding food sustainability, encompassing environmental, social, and economic dimensions. Our primary finding indicates that less than half of the sample demonstrated a high understanding of food sustainability. Notably, a majority identified three key themes - low environmental impact, a local supply chain, and high animal welfare standards - as central to the concept of food sustainability. These findings align with recent research indicating a

Table 2. Logistic regression analysis of socio-demographic characteristics and knowledge-related items predicting higher overall attitude score, adjusted for sex, age, and educational level.

Variable	aOR* (95% CI)	p-value
Socio-demographic characteristics		
BMI		
Norm weight	Ref.	−
Underweight	0.87 (0.30 − 2.53)	0.804
Overweight	0.69 (0.39 − 1.21)	0.195
Obesity	0.61 (0.20 − 1.91)	0.399
Number of family members		
1	Ref.	−
2	1.53 (0.65 − 3.63)	0.333
≥ 3	0.90 (0.40 − 2.01)	0.794
Smoking habit		
Never Smoker	Ref.	−
Former Smoker	1.02 (0.57 − 1.83)	0.945
Smoker	0.89 (0.51 − 1.56)	0.681
Urban Mobility		
Private car	Ref.	−
Public transports, biking, walking	1.77 (1.12 − 2.80)	0.015
Physical Activity		
Non Active	Ref.	−
Active	0.87 (0.55 − 1.36)	0.544
Knowledge-related items		
Food and environment interaction		
My food habits negatively affect the environment	1.13 (1.02 − 1.24)	0.018
When compared to car use, food habits have only little impact on the environment◇	1.00 (0.92 − 1.10)	0.949
Meat knowledge		
Eating meat is necessary to have a complete diet◇	1.25 (1.15 − 1.36)	<0.001
I need meat to have energy◇	1.29 (1.16 − 1.43)	<0.001
Eating meat allows me to have a balanced diet◇	1.25 (1.14 − 1.36)	<0.001
Meat is irreplaceable in my diet◇	1.39 (1.24 − 1.55)	<0.001
Replacing meat with plant − based protein sources doesn't provide me with the same energy◇	1.16 (1.06 − 1.27)	0.001
Activities which contribute to climate change		
Emissions from aircraft, trains, cars, trucks and ships	1.11 (0.97 − 1.26)	0.135
The production of meat and dairy products, which we eat and drink	1.59 (1.37 − 1.85)	<0.001
The felling of trees and forests	1.15 (1.01 − 1.30)	0.038
Summary Score		
Overall Knowledge Score	2.11 (1.68 − 2.64)	<0.001

*Adjusted by age, sex and educational level.
◇Reverse scoring.

growing consumer sensitivity and awareness, particularly concerning animal welfare (Liang et al.2023). For example, examining the psychological aspects influencing consumers' choices about animal welfare, Ling et al. (Liang et al.2023) identified three distinct categories: "emotionally intuitive", "quality-oriented", and "quality-emotion balanced". Remarkably, all groups exhibited significant preferences for animal welfare, with the "emotionally intuitive" group displaying the strongest inclination and emphasising greater ethical awareness. The "quality-oriented" group prioritised protein content alongside animal welfare, while the "quality-emotion balanced" group struck a balance between quality and ethical considerations. We also observed a significant gender disparity in the willingness to adopt sustainable food practices, with women consistently exhibiting a higher propensity, including more willingness to pay a premium for improved animal welfare. This trend confirms previous studies involving consumers aged 18–65 and beyond, further

emphasising women's propensity towards prioritising animal welfare in their food choices (Clark et al.2017).

Exploring potential associations between socio-demographic factors and knowledge levels, we noted that none of the included variables, except for gender, exhibited a significant association. This suggests that other influential factors play a crucial role in shaping individuals' understanding of food sustainability. Among these factors, exposure to educational interventions emerges as a promising strategy to enhance knowledge and contributes to the development of a heightened awareness of food sustainability. However, for an educational intervention to be genuinely effective, it must be tailored to the target population, and it should address identified knowledge gaps. In this perspective, the economic impact on the agri-food sector and the level of food processing emerged as the two least-known topics in our sample of Italian consumers. Moreover, according to the literature, an educational intervention based

on a mixed method including both theoretical and practical classes, might be much more effective, especially when food topics are treated. More in detail, interventions including cooking classes were found to enhance knowledge (Nucci et al.2020), food behaviour (Gianfredi et al.2021), cooking confidence, and to improve health (Silva 2023).

Our focus also extended to examining the attitudes shaping consumer choices, encompassing factors like values, beliefs, and perceptions related to sustainable food practices. Within this context, only a quarter of the sample showed a high level of positive attitude towards food sustainability. Notably, our sample was more willing to reduce food waste at home and increase the consumption of more fruits and vegetables, paying attention to the seasonality. However, regarding household food waste, the literature emphasises that it is primarily a result of unconscious decision-making (Quested et al.2013). Particularly, while eating behaviour is largely influenced by social norms and culture, household food waste remains largely invisible and is less affected by others' opinions. Additionally, evidence indicates a gap between knowledge and food management, significantly contributing to household food waste (Aschemann-Witzel et al.2015). Lastly, household food waste is largely influenced by the type of food consumed. Specifically, fruits and vegetables constituted about 48% of the total food waste by weight. (Ananda et al.2022) As a result, the willingness to increase the consumption of fruits and vegetables, observed in our sample, is certainly an important factor in the sustainability theme. This is even more true when considering seasonality (Régnier et al.2022). The latter is associated with a higher likelihood that the product is local, greater availability, and consequently, lower prices (Ladaru et al.2020). Moreover, increased consumption of fruits and vegetables is linked to numerous health benefits (Gianfredi et al.2021; Nucci et al.2021a; 2021b). However, consumers should be informed about all aspects of the shopping journey, such as planning, execution, and reflection on their food shopping experiences, including household food waste (Ran et al.2022).

Concerning regulatory aspects, the most commonly mentioned preferences included more stringent sustainability standards and the compulsory presence of food labels providing sustainability information. These data are in line with previous research, which suggests that food labels providing information on sustainability are considered essential for easily and effectively identifying food sustainability (Régnier et al.2022). However, according to Aprile and Punzo the appreciation and understanding of sustainable food labels are higher among consumers who are knowledgeable about their meaning (Aprile and Punzo 2022). Moreover, information about the product's domestic origin was significant for all consumers, irrespective of their education, suggesting that the importance of knowing where a product originates is more widespread. Considering that Aprile and Punzo conducted their study among the Italian population, it is plausible that the significance placed on knowing a product's origin might be linked to the "made in Italy" effect. This effect is possibly associated with factors such as supporting the local economy, perceived freshness, or trust in domestic production standards. Although the latter consideration, food labels should be easy to understand and well explained to the whole population to become effective tools able to simplify communication about sustainable food issues (Ladaru et al.2020).

When exploring the association between socio-demographic factors and a high level of attitude, only opting for greener transportation methods was found to be significantly associated. This is an interesting aspect that confirms the theory that sustainable food consumption is supported by a series of sequential steps that guide individuals in engaging in behaviours contributing to the achievement of the desired goal, acting consistently across different levels, and priming environmental values (Vermeir et al.2020). This theoretical model finds a counterpart even when more generally considering the lifestyles adopted by individuals. Healthy lifestyles often go hand in hand. For example, those who follow a healthy diet often engage in regular physical activity (Ferravante et al.2020).

However, the overall level of knowledge and each knowledge-related item were significantly associated with attitude, emphasising the importance of knowledge in shaping attitude. Consequently, educational interventions might yield significant outcomes in terms of both knowledge and attitude. This is an aspect that policymakers should consider when making decisions regarding the allocation of resources on such an important issue as food sustainability. Furthermore, educational interventions on these topics could contribute to developing greater consumer awareness and, consequently, lead to more sustainable food choices. A previous study showed that individuals with higher knowledge of sustainable food exhibit a greater ability to assemble lunch menus with a reduced environmental footprint (Hartmann et al.2021). In our study, a notable proportion of participants reported an inclination to reduce meat consumption. However, a pronounced gender difference

emerged, with women consistently demonstrating a greater willingness to cut down on red meat and dairy while increasing vegetable consumption. This aligns with existing literature highlighting women's proactive roles in adopting sustainable behaviours (Zhao et al.2021; Bannò et al.2023). Additionally, participants exhibited a clear preference for plant-based alternatives like legumes, eggs, and fish, indicative of a growing acceptance of alternative protein sources in line with the global shift towards plant-based diets for environmental sustainability.

The expressed intention to substitute meat with plant-based alternatives reflects openness to diverse and technologically advanced options. While a smaller percentage showed receptiveness to using insects as meat substitutes, it indicates a willingness to explore unconventional protein sources, contingent on meeting participants' preferences and standards. Notably, divergent opinions on using meat-related names for vegetarian products underscore the need for clear and standardised labelling. While a substantial portion is comfortable with current practices, a significant number underscores the importance of transparent communication, emphasising the vegetable origins of meat-free products.

Limitations and strengths

Some limitations should be considered when interpreting our results. First, despite the relatively wide sample size, our data might be biased by representativeness. Most of our respondents were highly educated with relatively healthy lifestyles (half of the sample was physically active and never smokers). However, our analyses were adjusted by educational level which might contribute to controlling for this aspect. Moreover, in this cross-sectional study data were collected using a questionnaire and therefore, it might be prone to information bias. Actually, all data were self-reported, and recall bias or social desirability bias might not be excluded. However, the questionnaire was administered online which has been proven to be less prone to social desirability bias when compared to in-person interviews (Bowling 2005). Despite the above-mentioned limitations, the current study has also some strengths. Firstly, we used validated tools adapted for the Italian population. Secondly, the statistical analyses we used, including correlations and regression models, ensure a good understanding of a complex interplay between knowledge, attitudes, and behaviours.

Implications for policies, practices and future research

The findings of our study hold significant implications for public health policies, providing valuable insights for the scientific community, policymakers, and practitioners involved in promoting sustainable food systems. By comprehending the factors influencing consumer choices and behaviours, we can develop targeted interventions and educational campaigns to foster a more sustainable and ethical food culture among Italian consumers. This research aims to bridge the gap between knowledge and action, facilitating positive changes in consumer behaviour towards a more sustainable and resilient food future. With a majority of our sample expressing support for mandatory food labels, there is an opportunity for public health policies to advocate for stricter sustainability standards and the inclusion of comprehensive sustainability information on labels. Policies and interventions promoting ethical production practices should prioritise animal welfare considerations, while detailed origin information can empower consumers to identify local products, aligning with interests in bolstering the local economy and sustainability efforts.

Understanding how individuals acquire, perceive, and act upon information related to sustainable food practices is essential for developing effective strategies to promote ethical and sustainable food choices. Further research can explore various dimensions highlighted in our study. Firstly, a deeper investigation into the influence of socio-demographic factors beyond gender on knowledge, attitudes, and behaviours regarding food sustainability could offer valuable insights. Factors like education level, income, and geographic location warrant exploration to tailor interventions more precisely to specific demographic groups. Secondly, understanding the impact of cultural factors on attitudes and behaviours towards sustainability, including food choices and waste reduction practices, could inform culturally sensitive interventions and communication strategies. Moreover, examining the long-term effects of sustainable food interventions on consumer behaviour and environmental outcomes through longitudinal studies would provide valuable insights into their sustainability impact. Finally, investigating consumer perceptions and preferences regarding emerging sustainable food technologies, such as cultured meat, plant-based alternatives, and insect-based proteins, could shed light on future trajectory of sustainable food systems. Furthermore, another important issue related to food sustainability is the matter of water sustainability, particularly water intended for human consumption. In this regard, future studies should aim to examine the factors associated with sustainable behaviours in water resource usage, as well as to understand usage patterns and the impacts such behaviours could have socially,

economically, and environmentally. Such data would be crucial in understanding which effective strategies and actions could be adopted to achieve greater sustainability of water resources. Understanding consumer acceptance barriers and motivators for adopting these alternative protein sources can inform product development and marketing strategies aimed at promoting more sustainable dietary choices.

Conclusions

In conclusion, our data provide a comprehensive assessment of the knowledge, attitudes, and behaviours of Italian consumers regarding food sustainability. Our findings underline a complex scenario where consumers' awareness and perception highly influence the applicability of sustainable food choices. Thus, our results might inform decision-makers as well as consumers. For policymakers, they can serve as a foundation for evidence-based strategies aimed at promoting sustainable food practices in Italy. For consumers, our data can directly contribute to enhancing awareness, fostering a critical understanding of the impact of their dietary choices on sustainability.

Disclosure statement

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