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Sustainable fresh strawberry consumption: environmental, genetically modified food, and climate concerns in Europe and North Africa

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Background and gap in the literature: Seasonal strawberries are a tasty fruit with many significant health and environmental benefits. Despite these attributes, the determinants influencing strawberry consumption remain underexplored. Few existing research studies are focused on conventional factors, such as taste, freshness, and price, leaving aside some critical, current dimensions, such as consumers' environmental attitude, sustainability, genetically modified (GM) food knowledge, and climate change concerns. This article aims to explore the impact of the aforementioned factors on the purchasing behavior of strawberries among consumers.

Methodology: A designed questionnaire for a final sample of 2,378 consumers from Italy, Germany, France, Spain, Turkey, and Morocco was used to collect data about sociodemographic attributes, strawberry purchasing habits, respondents' level of knowledge on the topic of GM food, and climate change issue. The generalized ordinal logistic approach was performed deriving from the ordinal qualitative type of our two variables of interest (seasonal and non-seasonal strawberries purchase) and relaxing the assumption of parallel lines.

Main results: From the sociodemographic factors, the more educated individuals, living in urban areas and having higher income levels are more likely to purchase frequently seasonal strawberries, while older people buy less often non-seasonal strawberries. Individuals who are more aware of sustainability issues, exhibit sustainable behaviors, and have greater concerns about climate change are more likely to buy non-seasonal strawberries less frequently, which is the most important result of our analysis.

Implications: These results offer a comprehensive understanding of other drivers than the conventional ones related to seasonal and non-seasonal strawberry purchase patterns, giving significant insights for policymakers in formulating tailored interventions for other dimensions: promoting sustainable agricultural practices (following the seasonality of the fruit), increasing consumer awareness about the environmental implications of the non-seasonal fruit purchases, and shifting individual eating patterns toward more sustainable and healthy ones (fresh and seasonal fruit consumption).

KEYWORDS

seasonal strawberries, sustainability, environmental attitude, GM food, generalized ordinal logistic model

1 Introduction

In the context of dietary habits and overall individual health, the significance of daily consumption of fresh fruits is important. Beyond the physiological aspect of satiating hunger, the consumption of fresh fruits also has implications for both individual health and environmental sustainability (Edwards-Jones, 2010; Macdiarmid, 2014; Medici et al., 2020; Pem and Jeewon, 2015; Slavin and Lloyd, 2012; WHO, 2024). Research across diverse disciplines highlights the recognized role fresh fruits play in promoting human health. Several studies have highlighted health benefits associated with regular consumption of fresh fruits, spanning a broad spectrum of benefits, including bolstering the immune system, providing essential nutritional values, and mitigating the risk of chronic diseases such as cardiovascular diseases, specific cancers, and potentially not influencing obesity (Aune et al., 2017; Guyenet, 2019). Moreover, the seasonal nature of fresh fruits emphasizes their high nutritional richness, considering that they are harvested at their peak ripeness, offering the most optimal vitamin and mineral content (Gironés-Vilaplana et al., 2016). Moreover, the significance of fresh fruit consumption is extended to environmental conservation and sustainable agricultural practices. The preference for locally sourced and organic fruits not only reduces carbon emissions associated with transportation but also ensures support for small-scale farmers and indigenous agricultural practices (Food and Agriculture Organization of the United Nations, 2021). By contributing to the reduction of the carbon footprint linked to long-distance transportation, consumers can shape and align their dietary choices with environmental preservation toward a more sustainable food system.

Several scholars have explored the various drivers shaping fresh fruit consumption patterns (Briz et al., 2008; Di Vita et al., 2020; Kaur, 2013; Krølner et al., 2011; Rasmussen et al., 2006). The following major drivers were identified: the level of healthiness, taste, appearance, convenience, habit, and price. Unprocessed fresh fruit has consistently been synonymous with health, with a prevailing perception that the greater its naturalness, freshness, and minimal processing, the higher its perceived health benefits. The study by Di Vita et al. (2020) focused specifically on the citrus case in Italy, identifying the most critical product attributes (the core sensory ones) for purchasing fresh citrus fruits: sweetness, smell, size, and color. Kaur (2013) also considered sociodemographic factors, several environmental limitations, and individual and cultural preferences. Rasmussen et al. (2006), in their literature review (part I) about the determinants of fruit and vegetable consumption among children and youth, found that the considered quantitative studies in the analysis emphasized the role of consumer's attributes: sex, age, socioeconomic status (SES), individual preferences, consumption habit, and the availability and accessibility of fruits and vegetables at home. In a successive literature review, considering only the qualitative studies (part II), Krølner et al. (2011) emphasized the critical role of convenience and the trade-off between time and being healthy issues when considering the introduction of fresh, cut-into-bite-size pieces of fruits as children and youth snacks.

The present study aimed to offer a comprehensive exploration of multiple factors influencing the purchase of seasonal and non-seasonal strawberries. The motivation for this choice relies on the availability of our data, from the practical perspective, to develop a quantitative study and on the recognized properties and qualities of strawberries concerning human health, such as their bioactive components, notably phenolic compounds and vitamin C, which exhibit antioxidant, anticancer, antimutagenic, antimicrobial, anti-inflammatory, and neuroprotective characteristics (Nile and Park, 2014). Strawberries are treated widely in reports and analyses about their price fluctuations and non-seasonal imports from non-producers' countries (Arnade and Kuchler, 2015; Plattner et al., 2012). Less explored in the existing literature are consumers' perceptions and preferences regarding the purchase and consumption of fresh strawberries. A few publications are found (Almli et al., 2019; Asioli et al., 2019; Bhat et al., 2015), focusing on both the attributes of the fruit (fresh or dried) and those of the consumers. Dimensions, such as consumers' environmental attitudes, their knowledge about GM technology, climate change awareness, and sustainability are topics that have been neglected by the existing literature. Our objective is also to address these dimensions of the consumers, along with their sociodemographic and SES attributes, answering the research questions: "*Which are the non-conventional factors that influence the seasonal and non-seasonal strawberries purchase?*" Starting from the conventional analyses that focus primarily on sociodemographic determinants, our study adopts a holistic approach in six countries (both strawberry-producing regions and major markets), ensuring a diverse and heterogeneous sample. We consider this research as a more multidimensional understanding of seasonal and non-seasonal strawberry-purchasing behavior within the broader context of sustainability and environmental consciousness, shedding light on the set of determinants that shape consumer preferences, thereby informing targeted interventions aimed at promoting sustainable dietary habits.

The article is structured as follows: in Section 2, we summarize critically the related literature; in Section 3, the data and the methodological approach are described; in Section 4, we report the empirical results. Discussion and conclusive remarks are presented in Section 5.

2 Related literature

The consumption of seasonal food is promoted for a sustainable dietary approach, frequently linked with locally sourced production. Assessing the social, environmental, and economic implications of this approach is essential while comparing it with the continuous provision of year-round fresh production (Macdiarmid, 2014). The marketing of seasonal food has gained increasing attention even in developed economies and markets that usually eliminate the seasonality attribute of food consumption (Spence, 2021). In urban realities, the phenomenon of "urban agriculture" is formulated as an alternative source to supply local products in cities (Vargas et al., 2021) in several forms, such as rooftop farms, greenhouses, and plant factories. In this way, these alternative initiatives can provide a local supply of fruits (in specific strawberries), reducing the reliance on non-seasonal imports, promoting sustainable consumption patterns (consumers highly concerned about sustainability are expected to prefer purchasing locally grown fruits), extending the growing season of fruits, and providing a more consistent supply of fresh fruits throughout the year.

In this context, the literature explored for this study can be divided into two groups: (i) the group of scholars who have analyzed the determinants of local and seasonal food and, as a subgroup, the one that focuses on the consumption of fruits and vegetables, and (ii) the group of scholars who had explored specifically the determinants of fresh strawberries' consumption. While the first group also offers literature review studies, implicating a higher interest and contribution, the second group includes a few studies, giving us the potential of our study to fill this gap in the literature. The determinants of fruit and vegetable consumption, identified in the literature, are categorized as follows:

- *sociodemographic factors*: sex (Musaiger and Gregory, 1992; Shi et al., 2005), age (Warwick et al., 1999), SES (Wang et al., 2002; Xie et al., 2003), ethnicity (Burdine et al., 1984), and urbanization (Wrieden, 1996);
- *personal factors*: preferences (Bere and Klepp, 2004), nutritional knowledge (De Bourdeaudhuij and van Oost, 2000; Lytle et al., 2003), attitude (Bere and Klepp, 2005), and subjective norms (Lien et al., 2002);
- *family-related factors*: parental habits (Young et al., 2004; Williams et al., 1993), home availability and accessibility (Hearn et al., 1998; Kratt et al., 2000), family structure and size (Roos et al., 2001; Woodward, 1985), and home healthy eating habits (Young et al., 2004);
- *friends-related factors*: friends' habits (Woodward et al., 1996);
- *meal pattern*: meal frequency (Cullen et al., 2004), and eating fast food (French et al., 2001).

In a more specific context, the determinants of strawberry purchase and consumption are identified among several publications. Bhat et al. (2015) identified first, several vital determinants, such as strawberries' quality parameters (color, flavor, and acidity), texture, and firmness, that influence the German consumers' choice for seasonal strawberries since these factors are correlated with environmental factors such as temperature and time of harvest (Vlachonasios et al., 1995; Watson et al., 2002). Moreover, during summer, it was identified the price per kilo acceptable range, while during winter, 82% of the respondents stated they "do not buy them." Strawberries' perfect appearance was not important compared with their taste, which was highly preferred (Bhat et al., 2015), while freshness resulted as the main criterion of visual appeal. Finally, German consumers preferred locally grown strawberries over imported ones, oriented from their perceptions about the freshness and short storage time of strawberries along with choosing to support local farmers, which benefits the whole regional economy. Another study on the Italian strawberries market by Crescimmano et al. (2014) was formulated to trace the consumers' behavior toward berries and the determinants of their purchase in Italy. They identified the intrinsic and extrinsic attributes affecting berries' consumption and analyzed differences among the macro-areas. They found that intrinsic qualities attributes (flavor, good shape, and beneficial properties) are essential motivations, in line with Francis (1995) and James et al. (2002) related previous studies. Moreover, their perceptions about the expensive nature of berries fruits and the traceability of the product, especially in big capitals, are also significant.

Our contribution to the literature is to provide a cross-sectional study, including the leading European and non-European strawberry producers and markets, about not only conventional determinants of strawberry consumption. Along with the traditional attributes of consumers and strawberries, four critical dimensions are considered (not considered before in related previous studies): the consumer's environmental attitude, their perceptions about sustainable food and sustainability food consumption behaviors, the individual GM knowledge, and climate change issues perceptions and concerns in purchasing seasonal (and non-seasonal) strawberries.

3 Materials and methods

An online consumer survey was conducted across six European and North African countries: Italy, France, Germany, Spain, Turkey, and Morocco. The purpose of the study was to gather insights into consumer behaviors and preferences within diverse cultural and economic contexts. By targeting a broad geographic range, the study aimed to provide a comprehensive understanding of the trends and patterns shaping consumer attitudes and purchasing decisions. Respondents addressed a comprehensive range of questions covering sociodemographic characteristics, purchasing behaviors, attitudes toward sustainability, levels of understanding, and perceptions regarding GM food, as well as inquiries related to climate change awareness. The survey administration process was managed by the Qualtrics XM platform[1]. Prior to the full-scale survey deployment, a pilot study was conducted, constituting 10% of the sample size, with 50 questionnaires administered in each participating country, resulting in a total of 300 questionnaires.

3.1 The questionnaire

The first section of the questionnaire was designed to gather sociodemographic data, including variables such as sex, age, household size, educational attainment, household income, and residential location. The second section provided information about strawberry purchasing habits. Respondents were asked to answer two questions: "*How frequently do you purchase seasonal and non-seasonal strawberries?*" Respondents answered using a scale from 1 to 4[2] and had four options to select from "*less than once a month*" to "*twice or more times per week*." Another section delved into the themes of sustainability, examining both perception and behavior. Specifically, an initial inquiry aimed to assess individuals' perception of the attributes associated with sustainable food, asking respondents, "*What comes to your mind when thinking about "sustainable" food?*" For the evaluation of pro-environmental behavior, questions developed by Binder et al. (2020) were employed, where respondents were tasked with rating the frequency with which

1 Qualtrics managed all the presteps such as informing, giving consent, and responding anonymously and the post-step through registering all the submitted final answers for each respondent.

2 The used scale is: 1-less than once a month, 2-once a month, 3-once a week, 4-twice or more a week.

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TABLE 1 Covariates' description and composition.

Question	Name	Items code and description
What comes to your mind when thinking about "sustainable" food?	Sustainability food perception (score)	SF1: Low environmental impact SF2: Avoid the use of pesticides and GM SF3: Local supply chains SF4: High animal welfare standards SF5: Healthy food
The frequency of sustainable behaviors	Sustainability behaviors (index)	SB1: TV on standby for the night SB2: Switch off lights SB3: Keep the tap running SB4: Put more clothes on when you feel cold SB5: Do not buy something that has too much packaging SB6: Buy recycled paper products SB7: Your own shopping bag SB8: Separate waste SB9: Use public transport SB10: Walk or cycle for short journeys SB11: Car share SB12: Consume no meat or animal products SB13: Buy products with eco-seal SB14: Buy regional products SB15: Discard food
Please indicate what do you think of each of the following statements (true, false, and I do not know)	GM's objective knowledge (score)	GMK1: GM that has drought resistance, herbicide resistance, and pest resistance help to reduce greenhouse gas emissions and agricultural chemical use GMK2: GM can be cultivated and used only if its safety is examined GMK3: Most of the soybeans and cotton (about 80%) produced all over the world are genetically modified GMK4: Ordinary fruit does not contain genes, but genetically modified fruit does GMK5: By eating genetically modified fruit, a person's genes could also be changed
Please indicate for each of the following statements your level of agreement (strongly disagree, disagree, somewhat disagree, neither agree nor disagree, somewhat agree, agree, strongly agree)	Climate change concerns (index)	CC1: Realness of climate change CC2: Human activities cause climate change CC3: It has serious negative consequences CC4: Climate change is influencing my local area CC5: It has long-run consequences

they engage in a set of sustainable behaviors (e.g., bring your own shopping bag when shopping, use public transport, see Table 1 for total items description).

The subsequent section of the questionnaire aimed to assess respondents' level of knowledge on the topic of genetically modified food (GM): objective knowledge was evaluated using a set of five statements modified from Han (2006) (e.g., *"Ordinary fruit does not contain genes, but genetically modified fruit does."*), each with a true, false, and no-answer response option. The variable was then calculated as the sum of correct answers. Finally, the concluding section of the questionnaire aimed to estimate agreement on climate change issues. A scale adapted from van Valkengoed et al. (2021) consisting of five statements pertaining to climate change was employed (e.g., *"I believe that climate change is real."*) utilizing a Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

The first dimension considered is a score named "*Sustainability food perception*" which measures the perception of individuals about the so-called sustainable food. This is related to its environmental impact, including five components: (i) low environmental impact; (ii) avoiding the use of pesticides and GM; (iii) purchasing at local supply chains; (iv) ensuring high animal welfare standards, and (v) purchasing a healthy food. The maximum number of items to choose from was three. Additionally, an index named "*Sustainability behaviors*" measures the frequency of exhibiting sustainable behaviors (15 in total, with 3 behaviors negative, reversed). The question was to rate the frequency of conducting 15 specific behaviors with possible answers ranging in the scale: 1—barely ever to never, 2—rarely, 3 – sometimes, 4—often, and 5—almost always. This set of questions is related to the sustainability section of the questionnaire.

The second dimension is a score named "*GM's objective knowledge*" (linked with the GM food section of the questionnaire). Individuals who correctly responded to any question got 2 points per each (for a maximum of 10 points). Non-corrected answers and the "*I do not know*" type of answer were given 0 points. It was computed as the sum of scores for each of the five items, suggesting that a higher value indicates more excellent objective knowledge about GM food.

The third dimension is an index to measure the concerns about climate change issues (deriving from the Climate change section of the questionnaire). The question includes 5 items with answers on a scale from 1—strongly disagree to 7—strongly agree.

3.2 Data collection and analysis

Data was gathered in September 2022, engaging an initial sample of $N = 3{,}000$ consumers across six countries: Italy, France, Germany, Spain, Turkey, and Morocco, with 500 participants from each nation. Respondents were recruited via the Qualtrics platform using random selection methods, employing the primary criterion: "Consumers who have purchased strawberries within the last year," alongside sampling quotas based on age, sex, income, and education levels. Participants received an invitation via email to partake in the web-based survey, through which they accessed the final version in English of the questionnaire, translated into their native language (Italian, French, German, Spanish, Turkish, and Arabic). The final sample used for elaboration is $N = 2{,}378$ (after cleaning and validating the initial data) in Stata 18.0.

3.3 Generalized ordinal logistic model

The approach used is the ordinal logistic approach. The choice was justified by the type of our two dependent variables, Y_1 and Y_2, which stand for frequency of strawberries purchasing, seasonal and non-seasonal, respectively. They are ordinal variables, with 4 outcomes: 1—less than once a month; 2—once a month; 3—once a week; 4—twice or more a week.

Following the definition of the binary logistic regression model (Menard, 1995), a model that can estimate the odds of success (given a set of predictors) can be expressed formally as follows:

$$\ln(Y') = logit\left[\pi(\underline{x})\right] = \ln\left(\frac{\pi(\underline{x})}{1-\pi(\underline{x})}\right) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_p X_p$$

For an ordinal logistic regression, the outcome variable has more than two levels. This type of model, following Long (1997) and Long and Freese (2006), estimates the probability of being at or below a specific level of the dependent variable and can be expressed formally as follows:

$$\ln\left(Y_j'\right) = logit\left[\pi(\underline{x})\right] = \ln\left(\frac{\pi_j(\underline{x})}{1-\pi_j(\underline{x})}\right) = a_j + \left(-\beta_1 X_1 - \beta_2 X_2 - \ldots - \beta_p X_p\right)$$

where $\pi_j(\underline{x}) = \pi(Y \le j | x_1, x_2, \ldots, x_p)$ is the probability-, given a set of predictors $j = 1, 2, \ldots J-1$, of being at or below the category j, a_j are the cut points and $\beta_1, \beta_2, \ldots, \beta_p$ are the coefficients of the logit model. Since there are j categories, the proportional odds (PO) model provides estimates for $J-1$ cut points (with the primary assumption that underlying binary models' coefficients are the same for all cut points—the coefficients of the logit model are independent of categories of the dependent variable). This critical assumption here is called the assumption of parallel lines (the correlation between dependent and independent variables does not change for the categories of dependent variables). This assumption is assessed by the Brant test (Brant, 1990). Testing for this assumption, if the Brant test results are significant (meaning that there is a violation of this assumption), to correct for this, the generalized ordinal logistic approach is used. This model can be formalized as below:

$$\begin{aligned} &logit\left[\pi(Y > j | x_1, x_2, \ldots, x_p)\right] \\ &= \ln\left(\frac{\pi_j\left((Y > j | x_1, x_2, \ldots, x_p)\right)}{1-\pi_j\left((Y \le j | x_1, x_2, \ldots, x_p)\right)}\right) \\ &= a_j + \left(\beta_{1j} X_1 + \beta_{2j} X_2 + \ldots + \beta_{pj} X_p\right) \end{aligned}$$

where a_j are the cut points (intercepts) and $\beta_{1j}, \beta_{2j}, \ldots, \beta_{pj}$ are the coefficients of the logit model. This model estimates the odds of being beyond a certain outcome level compared to being at or below that outcome level. Interpreting the coefficient of the underlying logit model, a positive coefficient means that it is more likely to be in a higher outcome level (category) as opposed to a lower outcome level. Is essential to state that an initial ordinal logistic regression was performed for both our dependent variables (Supplementary Table S1). Since the Brant test resulted significant for both (Supplementary Table S2), meaning that the assumption of parallel lines is violated), a generalized version of the ordinal logistic regression was performed. From the methodological point of view, the utilization of a generalized ordinal logistic regression, on a large cross-sectional dataset (that relaxes the assumption of the parallel lines), produces more interpretable estimates compared to nonordinal methods used commonly in the literature.

4 Results

4.1 Descriptive results

Figure 1 provides an initial descriptive analysis of the frequency of consumption for both seasonal and non-seasonal strawberries within our sample. For the non-seasonal strawberries, 37.17% of the sample purchases strawberries relatively less frequently (once a month) while only 9.5% purchase them more regularly (twice or more a week). On the other side, for seasonal strawberries, 44.15% of the sample purchases seasonal strawberries relatively often (once a week), while 8.03% barely buy them throughout the year (less than once a month). On a weekly frequency, there are more individuals purchasing seasonal strawberries than non-seasonal ones.

In terms of the sample composition, the majority are females (53.20%), the average age is 34.96 years old, living in a household with 3.9 members on average, with a higher level of education achieved at the tertiary education (46.55%), 38.06% having the gross annual household's income in the range of medium income, with the majority living in the urban areas (78.51%), and 58.83% of them have sole responsibility for purchasing in the household. Statistical descriptive analysis for the sociodemographic attributes of the respondents is presented in Table 2.

Table 3 summarizes the initial descriptive statistics of the three considered dimensions (sustainability, GM knowledge, and climate change concerns), transformed on the same scale (0–10) for comparability of their impact amplitude.

The first dimension (sustainability) is first represented by the score of perception about sustainable food. The mean value is 1.7 out of 3, meaning that consumers link the concept of sustainable food not only

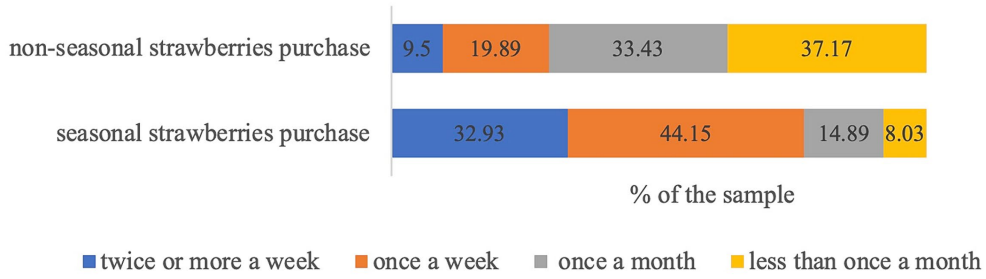

FIGURE 1
The strawberries' consumption frequency.

TABLE 2 Respondents' sociodemographic characteristics ($N = 2,378$).

	Italy	France	Germany	Spain	Morocco	Turkey	Overall
Sex							
Male	51.90%	51.01%	45.56%	52.13%	68.00%	51.88%	53.20%
Female	48.10%	48.99%	54.44%	47.87%	32.00%	48.12%	46.80%
Age	37.04 (10.72)	34.46 (10.79)	36.98 (12.29)	35.19 (10.16)	30.66 (9.89)	34.95 (9.83)	34.96 (10.85)
Household size	3.68 (1.28)	3.62 (1.57)	3.28 (1.44)	3.99 (1.32)	4.59 (2.25)	4.18 (1.51)	3.90 (1.64)
[a]Education							
Primary	0%	0.67%	0.23%	0.89%	2.13%	1.33%	0.88%
Secondary	24.18%	19.46%	46.01%	26.40%	24.80%	20.62%	27.46%
Vocational	25.54%	26.17%	34.17%	26.40%	41.87%	0%	25.11%
Tertiary	50.27%	53.69%	19.59%	46.31%	31.20%	78.05%	46.55%
[b]Household income							
Low	27.17%	24.83%	29.16%	29.75%	34.67%	28.16%	29.10%
Medium	38.32%	40.94%	29.84%	43.62%	39.20%	37.47%	38.06%
High	34.51%	34.23%	41.00%	26.62%	26.13%	34.37%	32.84%
Area of living							
Rural area	19.57%	45.30%	35.08%	14.54%	19.73%	2.44%	21.49%
Urban area	80.43%	54.70%	64.92%	85.46%	80.27%	97.56%	78.51%
Food shopping routine							
Sole responsibility	56.52%	55.03%	61.96%	59.96%	42.93%	72.28%	58.83%
Shared responsibility	43.48%	44.97%	38.04%	40.04%	57.07%	27.72%	41.17%
Observations	368	298	439	447	375	451	2,378

[a]Since the educational systems and income categories are different among countries, the presented scale is a common, aggregated scale post-data collection.
[b]It refers to the gross annual household income in local currency (LC). For categorical variables, the percentages are provided, and for the continuous ones, the mean and standard deviation are in brackets.

with one item from the list SF1–SF5 (Table 1), and they are aware of the multidimensionality of the sustainability issue. Second, it is represented by the index of sustainability behaviors (SBI) with a Cronbach's α of 0.7026. Its mean value for the overall sample is 6.97 out of 10, suggesting a high level of self-reported sustainable behavior in our sample. The respondents reported exhibiting several sustainable behaviors in their daily lives, which means that they are not only aware of the concept of sustainability and its multidimensional nature but also taking individual actions to prevent or minimize the negative consequences of their behaviors in the everyday familiar environment and future. The second dimension (GM knowledge) is represented with a score of up to 10 points as a maximum, reflecting the objective understanding of consumers about GM food. The score reflects a below-average knowledge about GM food in our sample, meaning that, on average, in our sample, there is a low level related to the science behind and the level of awareness and information about GM food. The third dimension (climate change concerns) is represented by an index with the respective Cronbach's α of 0.7561 to measure the individual perception of issues related to climate change, with a mean value of 7.575 out of 10, giving us a different picture about climate awareness: there is a high level of understanding in our sample, concerning implications of climate change.

TABLE 3 Covariates' descriptive statistics.

Code	Name	Overall Mean	SD	Minimum	Maximum	Mean ITA	Mean FRA	Mean DEU	Mean ESP	Mean MAR	Mean TUR
SP	Sustainability perception score	1.689	0.863	0	3	1.799	1.792	1.993	1.714	1.336	1.509
SBI	Sustainability behaviors index	6.964	1.074	3.33	10	7.077	6.885	6.949	7.078	6.742	7.014
GMK	GM objective knowledge score	4.28	2.54	0	10	4.625	4.651	3.927	4.367	4.336	3.960
CCI	Climate change concerns index	7.575	1.615	1.428	10	7.478	7.441	7.185	7.649	7.657	7.959
Observations		2,378	2,378	2,378	2,378	368	298	439	447	375	451

DEU, Germany; ESP, Spain; FR, France; IT, Italy; MAR, Morocco; SD, standard deviation; TUR, Turkey.

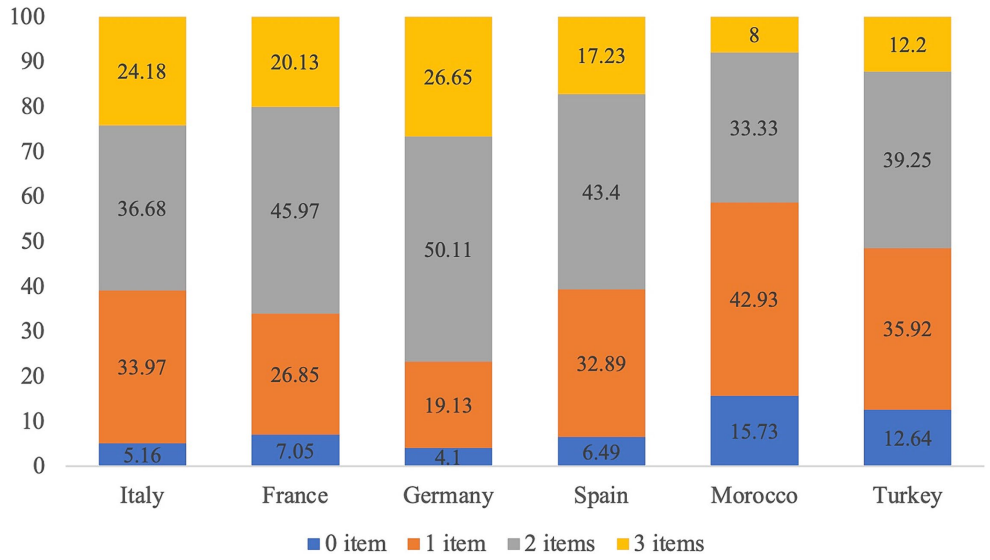

FIGURE 2
The sustainability perception score for each country.

At a country level, slight differences emerge. The lowest sustainability perception (SP) mean score is registered among consumers in Morocco and the highest in Germany (Figure 2). Descriptively, Moroccan consumers are less informed about sustainability issues than German ones. Spain registers the highest mean value in SBI and the lowest in Morocco, confirming that Moroccan consumers in our sample are exhibiting less sustainable behaviors due to the low level of sustainability score perception. Consumers in France have the highest mean value of GMK, while Germany registers the lowest, probably due to the strict regulation on GM food with extensive risk assessment, label requirements, and restrictions on the cultivation of GM crops in France, along with the French media that frequently addresses GMs, contributing to higher objective knowledge among French consumers (Figure 3). In contrast, despite the strict regulation also in Germany, the strong public opposition and skepticism (Severin and Hogan, 2024) and the orientation toward organic agriculture probably divert attention away from GM food. Finally, consumers in Turkey have the highest mean value for the CCI, while those in Germany have the lowest. Turkey is highly vulnerable to the impacts of climate change, including droughts and extreme weather condition events. In this line, the Turkish government has made significant policy shifts, such as committing to the Paris Agreement with ambitious climate goals (Elgendy and Tastan, 2022), while in Germany, the strong economic infrastructure and implemented climate policies can make climate change seem like a less pressing personal issue compared to other concerns (Table 3).

4.2 Empirical results

Table 4 summarizes the results from the generalized ordinal logistic regression for the dependent variable Y_1, the seasonal strawberry purchases. For the first panel, consisting of individuals who barely purchase seasonal strawberries compared with the rest ($Y_1 > 1$ vs. $Y_1 \leq 1$), the profile of the consumer is an educated woman, with medium and higher household income, living in larger families, having a higher objective knowledge about GM food with respect to their counterpart, holding other variables constant. Meanwhile, they are less likely to buy (even rarely) seasonal strawberries, individuals who share responsibility for food purchasing with other family members and reside in Germany or Morocco, in that order (with respect to Italy). For the third panel, consisting of individuals who often purchase seasonal strawberries compared with the rest ($Y_1 > 3$ vs. $Y_1 \leq 3$), the profile of the consumer is a woman with a higher income, living in a larger family, in urban areas, and have concerns about climate change issues. Meanwhile, those who share purchase responsibility and residing in

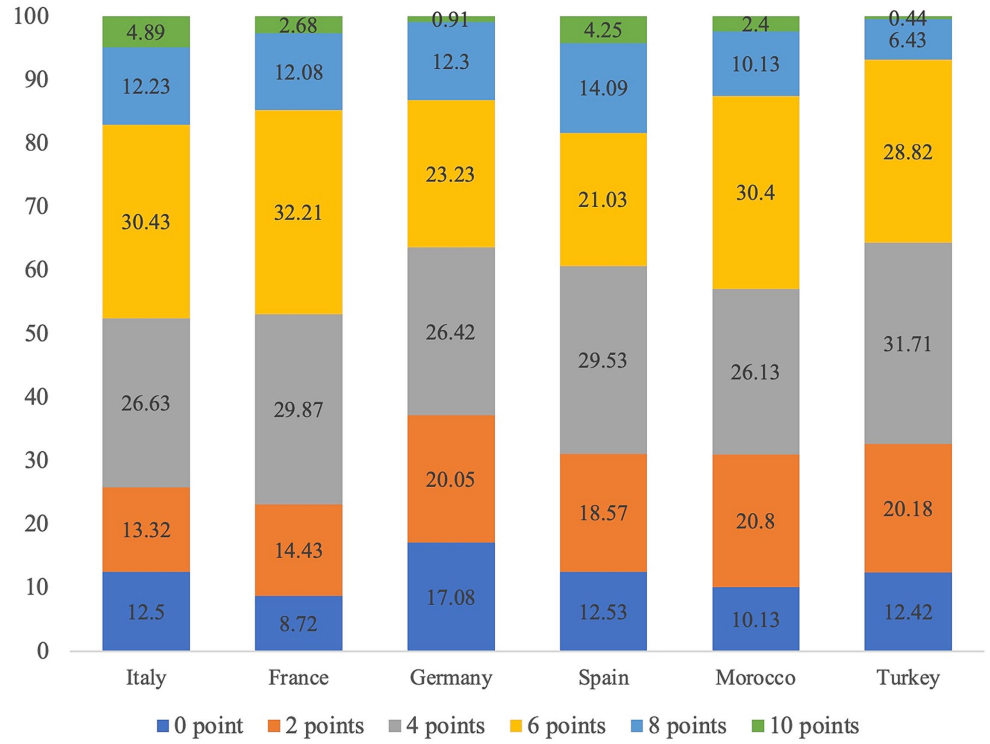

FIGURE 3
The genetically modified (GM) objective knowledge score for each country.

Germany, Spain, Turkey, and France, in that order (with respect to Italy), are less likely to purchase often seasonal strawberries.

In synthesis, across all three panels, factors including sex, education, income, household size, and objective knowledge regarding GM foods display a decreasing influence, while concerns related to climate change show an increasing impact on the frequency of purchasing seasonal strawberries. This first summarized result gives more importance to the dimension of climate change concerns, compared with the sociodemographic factors. Individuals are linking their personal roles to big concepts such as climate change issues.

From Table 5, for the first panel, consisting of individuals who barely purchase non-seasonal strawberries compared with the rest ($Y_2 > 1$ vs. $Y_2 \leq 1$), the emerging consumer profile is an older woman, who has shared responsibility for purchasing, which links sustainable food concept with low environmental impact and exhibit frequently pro-environmental behaviors, who have climate change issues concerns, and residing in France (with respect to Italy). Meanwhile, those who live in larger families with high incomes and have a higher GM food objective knowledge, residing in Turkey (with respect to Italy) are more likely to buy rarely non-seasonal strawberries. For the third panel, consisting of individuals who purchase often non-seasonal strawberries compared with the rest ($Y_2 > 3$ vs. $Y_2 \leq 3$), the consumer profile emerged was older individuals with medium income, with a shared responsibility to purchase, which links sustainable food concept with low environmental impact and exhibit frequently sustainable behaviors, residing in France, Germany, in that order (with respect Italy), while those who reside in Morocco with regard to Italy, are more likely to purchase often non-seasonal strawberries.

When comparing all three panels for non-seasonal strawberries purchases, it is observed that variables, such as shared responsibility for purchasing and concerns regarding climate change, exhibit an increasing impact, whereas factors, such as age, household size, and demonstration of sustainable behaviors, show a decreasing effect on the odds of frequently purchasing non-seasonal strawberries. This second summarized result is in line with the first result: climate change concerns are prevailing among other considered factors, both for seasonal and non-seasonal strawberry purchases.

When comparing seasonal and non-seasonal strawberry purchase main drivers, what emerges is that education and area of living have a significant impact on seasonal strawberry purchase. The more educated an individual is, the more he can understand the multiple importance of buying seasonal strawberries. Individuals living in urban areas, as they have limited accessibility, are more likely to purchase seasonal strawberries since their availability is greater. Age seems to be significant for non-seasonal strawberry purchases: older consumers buy rarely non-seasonal strawberries. Income levels have a positive considerable effect on seasonal strawberry purchases with a lower impact on more frequent seasonal strawberry purchases. The dimension "sustainability" resulted in significant for the non-seasonal strawberries purchase: individuals who have higher knowledge about sustainable food and exhibit sustainable behaviors are more likely to buy them less frequently. The climate change concerns effect is another significant result: it emerges that the more concerned and aware individuals are about climate change issues, the less frequently they buy non-seasonal strawberries. This is linked with interaction among individual higher education and higher knowledge about sustainable food: the production of non-seasonal strawberries or other food has a highly recognized

TABLE 4 Generalized ordinal logistic regression model results, seasonal strawberries.

Seasonal strawberries	Y > 1 vs. Y ≤ 1	Y > 2 vs. Y ≤ 2	Y > 3 vs. Y ≤ 3
	Coefficients	Coefficients	Coefficients
Sex			
Male	–	–	–
Female	0.430***	0.270***	0.170*
Age	0.002	0.007	0.006
Education	0.281***	0.143**	0.017
Household income			
Low	–	–	–
Medium	0.646***	0.243**	−0.086
High	0.613**	0.503***	0.256**
Household size	0.129***	0.124***	0.098***
Area of living			
Rural area	–	–	–
Urban area	0.123	0.265**	0.208*
Food shopping routine			
Sole responsibility	–	–	–
Shared responsibility	−0.702***	−0.642***	−0.428***
Sustainability perception#Sustainable behaviors	0.012	0.026***	0.007
GM food objective knowledge	0.097***	0.047**	0.019
Climate change concerns	−0.027	0.039	0.068**
Region			
Italy	–	–	–
France	−0.428	−0.336*	−0.683***
Germany	−0.652**	−0.818***	−0.980***
Spain	−0.273	−0.491***	−0.841***
Morocco	−0.635**	−0.312	−0.127
Turkey	0.149	−0.202	−0.802***
_cons	0.761	−0.636	−1.63***
Pseudo R^2	0.0505		
LR $\chi^2(48)$	291.42***		
Observations	2,378		

$Y = 1$ "less than once a month"; $Y = 2$ "Once a month"; $Y = 3$ "Once a week"; $Y = 4$ "Twice or more a week".
Interaction between the two variables.
***$p < 0.01$, **$p < 0.05$, * $p < 0.1$.
LR, Likelihood Ratio.

negative impact on the environment. In terms of country effect, German consumers consume less seasonal strawberry purchases with respect to Italy, as one of the important producers. This result stands since Germany is not a producer, but a big strawberry market. French consumers buy less non-seasonal strawberries, and Moroccan and Turkish consumers buy more. One possible reason could be the differences in geographic location and climate. Morocco and Turkey have warmer temperatures compared to France, allowing for longer growing seasons and the production of strawberries outside of the typical seasonal window. This means that Moroccan and Turkish consumers May have access to locally grown strawberries for a larger portion of the year, reducing their reliance on imported or seasonal varieties.

5 Discussion and conclusion

Fruits are acknowledged in the literature for their health benefits (Angelino et al., 2019; Mazzoni et al., 2021). Moreover, the consumption of seasonal, fresh fruits emphasizes the benefits compared to dried or canned ones in terms of health and environmental sustainability (Macdiarmid, 2014; Rickman et al., 2007). There is a vast amount of literature available on the dual benefits of seasonal fruits and exploring the consumers' determinants of purchasing them. Strawberrys, in specific, are less treated. Furthermore, the reports related to it are more concerned about the prices' volatility and the sociodemographic factors that influence the

TABLE 5 Generalized ordinal logistic regression model results, non-seasonal strawberries.

Non-seasonal strawberries	$Y > 1$ vs. $Y \leq 1$	$Y > 2$ vs. $Y \leq 2$	$Y > 3$ vs. $Y \leq 3$
	Coefficients	Coefficients	Coefficients
Sex			
Male	–	–	–
Female	−0.199**	−0.109	−0.224
Age	**−0.019*** **	**−0.017*** **	**−0.021*** **
Education	**−0.043**	**−0.032**	**−0.002**
Household income			
Low	–	–	–
Medium	0.170	−0.087	−0.423**
High	0.276**	0.196	0.013
Household size	0.118***	0.082***	−0.006
Area of living			
Rural area	–	–	–
Urban area	0.015	0.155	−0.152
Food shopping routine			
Sole responsibility	–	–	–
Shared responsibility	−0.692***	−0.615***	−0.638***
Sustainability perception#Sustainable behaviors	−0.010*	−0.025***	−0.018**
GM food objective knowledge	0.055***	0.012	0.015
Climate change concerns	−0.101***	−0.064**	−0.029
Region			
Italy	–	–	–
France	−0.445***	−0.334*	−0.713**
Germany	−0.187	−0.183	−0.532*
Spain	0.167	0.226	0.023
Morocco	−0.137	0.254	0.621**
Turkey	0.493***	0.157	0.274
_cons	1.742***	0.284	−0.618
Pseudo R^2	0.0442		
LR $\chi^2(48)$	268.66***		
Observations	2,378		

$Y = 1$ "less than once a month"; $Y = 2$ "Once a month"; $Y = 3$ "Once a week"; $Y = 4$ "Twice or more a week".
Interaction between the two variables.
***$p < 0.01$, **$p < 0.05$, *$p <$ 0.l.
LR, Likelihood Ratio.

purchase and consumption of it. We aimed to fill this gap in the literature by considering both seasonal and non-seasonal strawberry purchases by including an additional four dimensions left aside: consumers' environmental awareness and attitude, their knowledge about GM technology, and climate change awareness.

From our results, several trends emerge. Education and urban living significantly influence seasonal strawberry purchases, with higher education levels leading to a better understanding of the importance of buying seasonal strawberries. Urban areas, facing limited accessibility, are more inclined to purchase seasonal strawberries due to their greater availability. Both these results are in line with Bui et al. (2016) and Stadlmayr et al. (2023). Age impacts non-seasonal strawberry purchases, with older consumers buying them less frequently in line with Warwick et al. (1999). Income positively affects seasonal strawberry purchases (in line with Wang et al., 2016), particularly for more frequent buyers, while sustainability awareness plays a significant role in non-seasonal strawberry purchases, with individuals knowledgeable about sustainable food being less likely to buy them frequently (in line with Frankowska et al., 2019). Climate change concerns also influence non-seasonal strawberry purchases, with individuals more aware of climate change buying them less frequently. Additionally, country-specific effects reveal differences in consumption patterns, with German consumers buying fewer seasonal strawberries compared to Italy and French consumers purchasing fewer non-seasonal strawberries (warmer climate conditions

in Morocco and Turkey compared to France, which allows for longer strawberries growing seasons). If for sociodemographic factors impact and partial sustainability effect, we had similar studies to compare our results with, the dimension of sustainability in terms of perception and action (exhibiting individual daily sustainable behaviors), GM food objective knowledge and climate change concerns, to the best of our knowledge, there are no similar studies to compare our results.

Our findings have several policy implications, particularly concerning individuals who demonstrate a higher frequency of purchasing fresh seasonal strawberries, as opposed to less frequent consumers of non-seasonal strawberries, especially within countries that are major producers or markets of strawberries. These implications are indicative of a strong correlation between sustainable behaviors, knowledge about GM food, perceptions about climate change, and specific consumer preferences. One valid instrument is the promotion of sustainable production practices, meaning that governments and agricultural bodies in strawberry-producing countries should emphasize and promote sustainable agricultural practices, particularly those related to the production of fresh seasonal strawberries. Encouraging farmers to adopt eco-friendly cultivation methods can enhance the overall sustainability of the strawberry production industry. Governments can introduce incentives for both producers and consumers to choose and promote sustainable agricultural practices. This might include subsidies for sustainable farming methods, tax incentives for businesses adopting environmentally friendly practices, or even consumer-facing initiatives that reward sustainable choices.

In terms of educational initiatives, policymakers should prioritize initiatives aimed at enhancing public awareness and knowledge about sustainable food concepts. This could include educating consumers about the environmental benefits associated with choosing seasonal production, such as lower carbon footprints and reduced environmental impact. Moreover, since our results reflected the association between frequent consumers of fresh seasonal strawberries and concerns about climate change, policymakers should focus on implementing measures to address climate-related challenges in agriculture. This could involve supporting climate-resilient farming practices and implementing policies to reduce greenhouse gas emissions in the agricultural sector. Given that individuals with higher knowledge about GM show a preference for fresh seasonal strawberries and less frequently for non-seasonal strawberries, policymakers should ensure transparent communication and effective regulation regarding genetically modified organisms in food. Stricter labeling requirements and clear information dissemination can empower consumers to make informed choices aligned with their preferences.

Finally, in terms of international cooperation, by aligning policies with these implications, strawberry producing countries can work toward fostering a more sustainable strawberry industry, addressing environmental concerns, and promoting informed consumer choices.

The limitation of our study is that the time dimension is not included, which consists of a future research line to assess any changes in consumer behaviors regarding fresh seasonal and non-seasonal strawberries. Moreover, we are planning to explore factors such as cultural differences, availability of strawberries, and economic factors, specific to each country, partially considered in this study through the proxy of region. Other additional factors, such as the role of regulatory changes and educational campaigns, could be considered. A choice experiment is projected to explore how product labels influence purchasing decisions regarding seasonal strawberries.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the [patients/participants OR patients/participants legal guardian/next of kin] was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

FZ: Conceptualization, Data curation, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. VV: Formal analysis, Investigation, Supervision, Validation, Writing – review & editing. DF: Funding acquisition, Investigation, Project administration, Resources, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

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