Future Foods 12 (2025) 100722

Contents lists available at ScienceDirect

Future Foods

journal homepage: www.elsevier.com/locate/fufo

Nudging effects on consumer preferences and willingness to pay for lycopene-enriched fresh tomatoes

Maria De Salvo [a,*], Isabella Trovato [a], Laura Giuffrida [b], Marika Cerro [b], Giovanni Signorello [b], Giuseppe Cucuzza [b]

[a] University of Messina, Department of Veterinary, Polo Universitario dell'Annunziata 98168 Messina, Italy
[b] University of Catania, Department of Agriculture, Food and Enviornment, via Santa Sofia 100 95123 Catania, Italy

ARTICLE INFO

Keywords:
Nudging
Fresh tomatoes
Nutraceutical properties
Discrete choice experiments
Attribute Non-Attendance

ABSTRACT

Using a Discrete Choice Experiment, this study examines how informational prompts about the nutraceutical properties of tomatoes influence consumers' perceptions and preferences for lycopene-enriched fresh tomatoes. The results show that such nudges effectively increase consumer interest in functional foods by raising the perceived importance of their health-related benefits. Furthermore, nudging significantly impacts Willingness To Pay (WTP), with consumers exhibiting higher WTP for tomatoes with enhanced nutraceutical attributes when exposed to the informational prompts. These findings offer valuable insights for promoting healthier dietary choices and for guiding the development of food products that align with shifting consumer values and health consciousness.

1. Introduction

In recent years, behavioural interventions such as nudging have gained increasing attention in public policy and consumer research for their potential to improve individual decision-making without limiting freedom of choice (Thaler and Sunstein, 2021). Nudging is especially effective in situations involving routine, low-engagement decisions, such as those related to food purchasing and dietary habits (Gravert and Kurz, 2021; Hansen et al., 2021; Vella et al., 2024). Within this context, informational prompts represent a non-intrusive form of nudging that can enhance awareness of nutritional or functional food attributes, potentially steering consumers toward healthier and more sustainable choices.

A growing body of literature has examined how nudges affect consumer behaviour in food-related contexts (Franceschinis et al., 2024). Systematic reviews by Čop and Njavro (2024), Lindstrom et al. (2023), Pandey et al. (2023), and Sapio and Vecchio (2024) underscore the effectiveness of nudges in guiding food choices, especially toward increased Fruit and Vegetable (F&V) consumption. More focused studies have investigated behavioural outcomes and choice architecture related to F&V intake (Almeida et al., 2024; Bauer et al., 2021; Blom et al., 2021; Ensaff, 2021; Gillebaart et al., 2023; Vecchio and Cavallo, 2019; Weimer et al., 2022; Yi et al., 2022). However, the impact of nudging on Willingness To Pay (WTP) in a Discrete Choice Experiment (DCE) setting remains relatively unexplored.

This study contributes to the literature by investigating the effect of informational nudges on consumer preferences and WTP for fresh tomatoes, with a particular focus on nutraceutical content, specifically lycopene enrichment. Tomatoes are among the most widely consumed vegetables in Italy and represent a key segment of the national agri-food system (ISMEA, 2017). They are also a significant source of lycopene, a carotenoid with demonstrated antioxidant properties and potential anticancer effects (Poojary and Passamonti, 2015). Lycopene is known for its role in reducing oxidative stress and inflammation and contributes to the prevention of cardiovascular diseases and other chronic conditions (Collins et al., 2022; Tan et al., 2018). In addition, tomatoes contain a wide range of other antioxidants, vitamins, and phenolic compounds, some of which exhibit antimicrobial effects (Ibrahim et al., 2023). The nutritional content of tomatoes is influenced by both agronomic and post-harvest practices (Giovannetti et al., 2012; Lima et al., 2022).

Despite the evidence supporting lycopene's health benefits, the European Food Safety Authority (EFSA NDA Panel, 2011) has not yet approved any official health claims for lycopene, citing insufficient

* Corresponding author.
E-mail addresses: maria.desalvo@unime.it (M. De Salvo), isabella.trovato@unime.it (I. Trovato), laura.giuffrida@unict.it (L. Giuffrida), marika.cerro@unict.it (M. Cerro), giovanni.signorello@unict.it (G. Signorello), giuseppe.cucuzza@unict.it (G. Cucuzza).

https://doi.org/10.1016/j.fufo.2025.100722
Received 26 February 2025; Received in revised form 8 May 2025; Accepted 18 July 2025
Available online 20 July 2025
2666-8335/

scientific consensus. However, consumer-oriented communication about lycopene's potential benefits could increase perceived value and promote demand for functional tomato products.

While substantial literature exists on consumer preferences for traditional tomato attributes such as colour, size, origin, packaging, and certifications (Carroll et al., 2018; De Salvo et al., 2020; Ellison et al., 2016; Joya et al., 2022; Kassas et al., 2023; Mancuso et al., 2024; Maples et al., 2018; Nishimura, 2021; Nohara, 2024; Printezis and Grebitus, 2020; Ruth et al., 2016; Shonkwiler, 2024; Tran et al., 2023; Zapata et al., 2025), only a limited number of studies explore consumer valuation of nutraceutical attributes. To date, Verneau et al. (2019) is the only study that has examined the impact of lycopene-related information on WTP, and it focused on canned rather than fresh tomatoes.

In addition, although DCEs are widely used to elicit consumer preferences, they are subject to potential biases related to Attribute Non-Attendance (ANA), wherein respondents ignore one or more attributes due to cognitive overload or strategic simplification (Alemu et al., 2013; Carlsson et al., 2018; Campbell et al., 2011; Hensher, 2006; Scarpa et al., 2009; Weller et al., 2014). Only a few recent studies (Jonker et al., 2018; Kassie et al., 2020) have attempted to measure how nudging may affect ANA, cognitive effort, or decision fatigue in DCEs.

These observations point to several research gaps. First, there is limited understanding of how nudging affects valuation of nutraceutical attributes, especially in fresh produce. Second, little is known about how nudging influences the processing of attribute information in DCE settings, particularly in relation to cognitive effort and decision consistency. Third, the literature lacks empirical evidence on whether nudging modifies the structure and distribution of marginal WTP estimates.

This study addresses these gaps using a DCE to estimate Italian consumers' preferences and WTP for fresh tomato attributes, with a special emphasis on lycopene content. A split-sample design was implemented: the control group received no informational prompt, while the treatment group was exposed to a science-based informational nudge about the health benefits of lycopene (Congiu and Moscati, 2022). This design enables causal identification of nudging effects on both preferences and cognitive processes.

The study investigates the following research questions:

- RQ1. Does nudging influence consumer preferences exclusively for the lycopene attribute, or does it also affect the valuation of other tomato characteristics?
- RQ2. Does nudging alter the correlation structure across product attributes?
- RQ3. By promoting more deliberate and rational decision-making, does nudging increase cognitive effort? If so, does this increased effort significantly affect the likelihood of ANA?
- RQ4. Does nudging lead to significant shifts in the distribution of marginal WTP, indicating changes in average valuation and/or preference heterogeneity?

By addressing these questions, the study contributes to the broader understanding of how informational nudges affect consumer behaviour in complex choice environments and provides practical insights for designing interventions that promote healthier and more sustainable food choices.

Results show that nudging significantly enhances consumer interest in functional tomato attributes, particularly lycopene content. Participants who received the informational prompt displayed a higher WTP for lycopene-enriched tomatoes compared to those in the control group. This effect extended beyond lycopene to influence other product attributes as well, suggesting a broader shift in consumer valuation once health information is provided. Moreover, results suggest that informational nudging may increase perceived cognitive load, particularly among those already engaging in simplified decision-making strategies.

The remainder of the paper is structured as follows. Section 2 presents the design and implementation of the DCE, including a description of the sampling strategy, a summary of key sample characteristics, and a statistical comparison of the two subgroups. It also details the nudging treatment and outlines the econometric models employed to estimate consumer preferences. Section 3 reports and discusses the main empirical findings. Finally, Section 4 offers concluding remarks and proposes directions for future research on nudging in food choice contexts.

2. Materials and methods

2.1. Data

Data were collected by a specialized Italian market research company that manages a national panel of over 50,000 respondents. The survey targeted a representative sample of 1,009 Italian consumers who are primarily responsible for purchasing F&V for their households and who personally consume fresh tomatoes at least once per month. The sample was stratified by gender, age, and geographical region to ensure representativeness of the Italian adult population. Data collection was carried out between June and July 2023 through an online questionnaire composed of four sections. The first section gathered information on fresh tomato consumption habits. The second section focused on the respondent's self-reported health status. The third section explored the respondent's awareness and knowledge of the nutraceutical properties of tomatoes. The final section included the DCE tasks used to elicit preferences and WTP.

Table 1 presents the list of attributes and corresponding levels used in the DCE. These were selected based on a review of the relevant literature and the results of a pilot survey involving 141 consumers, who were asked to identify the four tomato attributes they considered most important in their purchasing decisions (Mariel et al., 2022; Morejón Cabrera et al., 2022).[1] The experimental design included a relatively large number (nine) of attributes and levels to reflect the complexity of real-world decision-making contexts, where the risk of ANA naturally increases, allowing us in investigating whether the incidence of ANA is influenced by the use of nudging (Caraban et al., 2019; Collins, 2012). ANA phenomenon rate was detected by asking to each respondent ex post debriefing questions about their attendance of attributes (e.g., 'stated ANA', Balcome et al., 2015).

A D-efficient experimental design (Rose et al., 2008) was developed using priors derived from the existing literature and implemented through NGENE software version 1.2.1 to maximize the statistical efficiency of the choice tasks. The design consists of 10 blocks, each randomly assigned to respondents and containing six choice scenarios. In each scenario, participants are presented with three alternatives: two represent different options for a 500 g container of fresh tomatoes, tailored to the preferred colour and shape as reported by the respondent in the initial section of the questionnaire; the third is an opt-out option

[1] The pilot questionnaire, which included 12 questions on consumer behaviour and habits related to fresh tomatoes, was administered by the research team via social media platforms. The respondents, primarily women with an average age of 48, were mostly based in central and southern Italy. In 84% of cases, respondents reported that their households purchase and consume fresh tomatoes, at least occasionally. Participants identified the most important attributes influencing their purchasing decisions as intrinsic product characteristics—including taste, aroma, juiciness, shape or variety, pulp firmness, external integrity, colour, and texture when cut. Other highly valued attributes included product origin, production area, and price. By contrast, some intrinsic factors were considered less relevant, such as skin thickness, lycopene content, fruit size (within the same shape or type), and seed presence. Among certification types, only ethical certification was regarded as important, while others—such as environmental sustainability, nickel-free status, and nutraceutical properties—were viewed as less influential. Purchase location and packaging method were rated as moderately important. Finally, the presence of a QR code on packaging and product advertising were considered the least relevant factors in the decision-making process.

Table 1
Attributes and levels used in the DCE.

Attributes	Levels
1. Nickel-free certification	- Yes; - No.
2. Origin of the product	- Italian, same respondent's region of residence; - Italian, different respondent's region of residence; - EU country; - Extra-EU country.
3. Packaging material	- Plastic; - Paper; - 100 % biodegradable.
4. Origin Label (PGI - Protected Geographical Indication)	- Yes; - No.
5. Eco-sustainability label (products obtained while safeguarding the environment)	- Yes; - No.
6. Ethical label (products obtained while safeguarding the health and safety of workers, without employing child labour, etc.)	- Yes; - No.
7. Organic	- Yes; - No.
8. Lycopene content	- Medium; - High.
9. Price (€/500 g container)	- 2.99; - 3.29; - 3.62; - 3.98; - 4.38.

(i.e., the "no choice" alternative). This structure allows for the estimation of preferences while maintaining realism and respondent engagement. An example of a choice card is shown in Fig. 1.

Respondents were randomly assigned to one of two experimental groups: a control group, which received no nudge stimuli, and a treatment group, which was exposed to the nudge. In this study, we employed an informational nudging approach, following the typology proposed by Hansen and Jespersen (2013), and applied in subsequent work (Congiu and Moscati, 2022; Nielsen et al., 2017). Participants in the treatment group were asked to read a one-page informational card (a copy of which is provided in the Supplementary Materials) that presented concise, evidence-based content on the nutritional, nutraceutical, and health-related properties of fresh tomatoes. The card was displayed for a minimum of two minutes. The informational content emphasized that fresh tomatoes are composed of approximately 94 % water, contain low levels of macronutrients, and are rich in vitamins (including provitamin A), minerals, and organic acids. Special emphasis was placed on their antioxidant profile, which includes over 40 polyphenols and several carotenoids, with lycopene highlighted as the most abundant and functionally significant compound due to its well-documented health benefits.[2]

The informational card also included a list of key reasons explaining why tomatoes are considered a healthy food. To assess participants' a priori knowledge, we implemented different approaches for the two subgroups. In the control group (not exposed to the nudge), respondents were asked to evaluate whether a series of statements describing the nutraceutical properties of tomatoes were true or false. All of the statements reflected scientifically accurate information. In contrast, participants in the treatment group (who received the informational nudge) were asked whether they had prior knowledge of the specific nutraceutical properties listed on the informational card before participating in the survey.

The final dataset comprises 6,054 observations, derived from 1,009 respondents each completing six choice tasks in the DCE. The sample characteristics are summarized in Table 2 and detailed in the Supplementary Materials. Participants ranged in age from 18 to 80 years, with a mean age of 52.99 years (standard deviation - SD: 12.97). Men represented 55 % of the sample, with an average age of 54.00 years (SD: 12.38), average weight of 78.61 kg (SD: 12.87), and average height of 175.23 cm (SD: 7.40). Women accounted for the remaining 45%, with an average age of 51.81 years (SD: 13.49), weight of 65.70 kg (SD: 15.40), and height of 164.01 cm (SD: 6.69). Regarding socioeconomic characteristics, 54% of respondents were employed, and 32% held a university degree. In terms of household income, the largest group (27%) reported an annual income between 30,000 and €50,000, followed by 25% in the €20,000 to €29,999 bracket. The most common household size was three members, reported by 30% of participants. The majority of participants reported being non-smokers and not affected by major health conditions, including obesity, cardiovascular disease, hypertension, or cancer. Most respondents also indicated that they do not follow any specific diets and have no known allergies to Solanaceae (e. g., tomatoes) or nickel. Furthermore, only a small minority identified as vegan or vegetarian.

To ensure the validity of the experimental design, comparison tests were conducted to assess both homogeneity and heterogeneity across the two subsamples. Results confirm that the groups are statistically equivalent with respect to key demographic variables, including age, gender, educational attainment, and household size (see Table 2).

2.2. *Econometric analysis*

As part of the preliminary analysis, we estimated both a Multinomial Logit (MNL) model, which assumes fixed coefficients and homogeneous preferences across respondents, and a Mixed Logit (MXL) model, which allows for preference heterogeneity by incorporating random parameters, assuming a fixed distribution for the price coefficient.[3]

Model comparison based on the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) strongly favoured the MXL

[2] Lycopene is mainly present in the outermost part of the tomato and in the skin (epicarp). In the fresh, free-range product, the lycopene content ranges from 3 mg/kg in yellow tomatoes to 50 mg/kg in red tomatoes. The daily dose of lycopene our organism needs is between 5 and 15 mg, roughly equal to what would be found in about half a kilo of tomatoes. The protective action of tomatoes increases when cooked and seasoned with oil.

[3] A fixed-price model specification was preferred to the one based on a lognormal distribution to obtain well-defined WTP distributions for qualitative attributes, facilitate post-estimation analysis through a simple visual comparison of WTP distributions across subsamples.

	Option 1	Option 2
Nickel-free certification	No	Yes
Origin of the product	Italian, same respondent's region of residence	EU country
Packaging material	Plastic	Paper
Origin Label (PGI - Protected Geographical Indication)	No	Yes
Eco-sustainability label (products obtained while safeguarding the environment)	Yes	No
Ethical label (products obtained while safeguarding the health and safety of workers, without employing child labour, etc.)	No	Yes
Organic	No	Yes
Lycopene content	Medium	High
Price (€/500g container)	4.38	2.99

Fig. 1. Example of choice card.

Table 2
Summary statistics* and results of comparison tests.

Variables	Statistics	"Nudged" subsample	"No-nudged" subsample	Whole sample
Age (in years)	Mean	53.24	52.73	52.99
	Standard deviation	12.85	13.11	12.97
MALE (equals to one if yes)	Mean	0.57	0.54	0.55
	Standard deviation	0.50	0.50	0.50
EDU (in years)	Mean	13.90	13.98	13.94
	Standard deviation	3.33	3.18	3.25
Family size (n.)	Mean	2.94	2.87	2.90
	Standard deviation	1.07	1.13	1.10
Tests**:	F		Prob>*F*	
1. Allowing for homogeneity:				
Wilks' lambda	0.9975		0.647	
Pillai's trace	0.0025		0.647	
Lawley-Hotelling trace	0.0025		0.647	
Roy's largest root	0.0025		0.647	
2. Allowing for heterogeneity				
Multivariate Normality Test	0.62		0.647	
Likelihood Ratio test	2.50		0.647	

* Summary statistics about other variables related to the respondents' profile, habits and preferences are reported in supplementary materials.
** These comparison tests assume as null hypothesis the equality of subsamples' means.

specification, which consistently yielded lower values for both criteria. These results support the use of the MXL model for subsequent analysis.[4]

MXL model assumes that each respondent has their own parameter vector β_n. Therefore, the probability that the n-*th* respondent choices the i *th* alternative given the set *J* is:

$$P_{ni} = P(i|\beta_n) \tag{1}$$

The choice probability is conditional on β_n. Respondents are assumed to be randomly drawn from a population which is formalized by stating that the individual parameter vectors are sampled from a continuous distribution $f\ (\beta)$. This distribution is often assumed to be normal, lognormal, uniform or triangular (Train, 2009). In this study, we used the normal distribution to describe the heterogeneity of respondents' preferences for qualitative attributes, as already done in similar studies (De Salvo et al., 2020).

The unconditional probability is then calculated as the weighted average of the logit formula evaluated at different values of β, with the weights given by the density $f(\beta)$. Given that in this case of study each respondent faced more than one choice occasion, the probability of observing a particular sequence of choices for each respondent is the product of standard logit formulas. In the so-called Panel Mixed Logit, which allowed us to use a MXL specification in the context of repeated choices by respondents assuming specific taste distributions (Revelt and Train, 1998), the unconditional probability that n-*th* respondent choice the i-*th* alternative in the t-*th* choice occasion is computed using the following integral (Train, 2009):

$$P_{nit} = \int P(i|\beta_n) f(\beta) d\beta = \int \prod_{t=1}^{T} L_{nit}(\beta) f(\beta) d\beta \tag{2}$$

where:

- P_{nit} is the probability that the n-*th* respondent (with $N = 1009$) choice the i-*th* alternative (with $J = 3$) in the t-*th* choice occasion (with $T = 6$);
- $L_{nit}(\beta) = \frac{e^{V_{nit}(\beta)}}{\sum_{j=1}^{J} e^{V_{njt}(\beta)}}$ is the logit probability evaluated at parameters β;
- and $V_{njt}(\beta)$ is the observed (indirect) portion of the utility which in the case of study is assumed to be linear in attribute levels (x_{njt}) and parameters (β): $V_{njt}\ (\beta) = \beta' x_{njt}$.

Adopting normal distributed β parameters, Eq. (2) became:

$$P_{ni} = \int \frac{e^{V_{nit}(\beta)}}{\sum_{j=1}^{J} e^{V_{njt}(\beta)}} f(\beta|\theta) d\beta \tag{3}$$

where $f(\beta|\theta)$ is the multivariate probability of β given the distributional parameters θ.

The vector θ represents the population-level parameters and characterizes the properties of the assumed normal distributions. It includes

[4] AIC values equal to 10,944 in the MNL model and to 9,757 in the MXL one. Similarly, BIC values respectively equal to 11,045 and 10,467.

the mean vector μ for the individual parameters β_n, the vector of standard deviations σ, and the covariances, as the analysis accout for potential correlation among the parameters in β_n. Standard deviations and covariances are summarized into the variance-covariance matrix $\mathbf{\Omega}$ which captures both the extent of individual heterogeneity and the interdependencies between preference parameters.

Since the unconditional choice probability defined in Eq. (3) has no closed-form solution, simulation-based methods are required for model estimation. In this study, we applied maximum simulated likelihood estimation, following the approach described by Train (2009), using the *mixlogit* routine in Stata (Hole, 2007).

To assess potential attribute overlap, we conducted a series of post-estimation diagnostics. First, we estimated the correlation matrix of the attribute coefficients to identify possible multicollinearity. Then, we re-estimated the model excluding attributes that appeared conceptually or statistically overlapping, in order to evaluate the stability of the remaining parameter estimates. These checks confirmed that, although some attributes shared conceptual similarities, the core parameter estimates remained stable, and the interpretability of the model was preserved.

The MXL model was estimated for both the full sample and the two sub-samples, corresponding to the nudged and non-nudged groups. Comparative analysis across subsamples was conducted by examining the significance and direction of the estimated coefficients, allowing for an assessment of how informational nudging influenced preference structures. It is not possible to compare the magnitude of the coefficients across models, as they are specified in preference space and therefore subject to scale differences.

Additionally, we estimated the Cholesky decomposition L of the full variance-covariance matrix Ω, where $\Omega = (LL')$, to derive the correlation matrix for the random parameters. This enabled an analysis of the nudging effect not only in terms of changes in coefficient significance, but also with respect to the significance of the correlation structure among attributes. Estimates of the mean vector μ for the individual parameters and the variance-covariance matrix Ω obtained for the two subsamples (nudged and non-nudged) were used to generate corresponding multivariate distributions of individual-level preference parameters. These distributions enabled the derivation of marginal WTP at the population level and facilitated visual comparisons between the two experimental groups. In addition, the estimated parameters served as the basis for behavioural inference, allowing us to construct probabilistic demand functions. We conducted simulation exercises separately for nudged and non-nudged consumers, considering products with both medium and high lycopene content. All simulations were based on 10,000 random draws, ensuring robust and stable inference.

3. Results and discussion

The data confirm that fresh tomatoes are a staple in the Italian diet. Approximately 39% of respondents reported consuming <200 g per day, while 37% indicated a daily intake between 200 and 300 g. Among these consumers, 60% stated that they consume tomatoes year-round, whereas the remaining 40% limit their consumption to the spring–summer period. Regarding frequency, 63% of participants reported eating fresh tomatoes several times per week, and 20% consume them at least once a week. In terms of product freshness, 65% of respondents reported consuming tomatoes within 2–3 days of purchase. Price sensitivity varied, but promotional offers emerged as the primary purchasing trigger for 42% of consumers. In terms of preferences, the most favoured tomato varieties were cherry tomatoes (29%), followed by date tomatoes (22%), beef tomatoes (15%), and Piccadilly (11%). A strong preference for red-coloured tomatoes was evident, with 85% of respondents indicating red as their preferred colour. The three most influential factors driving purchasing decisions were: product origin (88%), region-linked certifications such as PDO/PGI (74%), and organic (62%) or environmentally sustainable (60%) labels. These findings align with results from previous studies conducted both in Italy and internationally (De Salvo et al., 2020; Mancuso et al., 2024).[5]

Among respondents who received the informational card ($N = 505$), the overall level of prior knowledge regarding the nutraceutical properties of tomatoes appeared to be relatively low. Most participants reported being unaware of the various health-related benefits before the interview, with the exception of a few well-known aspects, such as the high lycopene content, the hydrating effect on tissues, and the digestive benefits. For the control group ($N = 504$), who did not receive the informational prompt, respondents were asked to evaluate whether the same statements included on the card were true or false. Most participants correctly identified the statements as true; however, there was noticeable uncertainty or incorrect responses regarding the claims that tomatoes should be cooked and seasoned with oil to enhance their nutraceutical properties, and that they offer benefits for visual health. These findings suggest that consumer knowledge of tomato-related nutraceutical benefits is generally limited and fragmented.

Prior to completing the DCE tasks, all respondents were asked to select the four most important attributes they consider when purchasing tomatoes, from the set included in the experiment. As illustrated in Fig. 2, the most frequently selected attributes were product origin, regional quality labels (e.g., PDO/PGI), as well as organic and environmental sustainability certifications.

Coefficient estimates of DCE-MXL model are presented in Table 3. Based on the magnitude of the estimated coefficients, it becomes evident that the order of importance stated *a priori* by the respondents was not confirmed by DCE, given that the four most important qualitative attributes, derived from the selections made across the choice tasks, are, in sequence, the regional label, the material used to packet tomatoes, the organic label and the ethical label.

The price coefficient displays the expected negative sign, indicating that utility decreases as price increases, and is statistically significant, confirming its influence on consumer choice behaviour. Moreover, estimates indicate that utility increases if the product is nickel-free, PGI-certified, eco-sustainable (*eco*), ethically produced (*etico*), organic (*bio*) and has a high lycopene content (*lico*).

Regarding the provenance of the products, compared to non-EU products, consumers prefer, in the following decreasing order, products from their own region (*same_reg*), from other Italian regions (*other_reg*) or, although to a lesser extent, from other EU countries.

In terms of packaging, compared to plastic, the use of paper (*paper*) or biodegradable materials (*degr*) increases utility, particularly in the case of biodegradable packaging.

Finally, choosing the option that does not involve purchasing, generally, results in disutility. The coefficient of the corresponding alternative specific constant (*ASC_none*) is in fact negative and highly significant ($p < 0.001$).

Heterogeneity in preferences is highlighted by significant estimates of the coefficients for the standard deviation only for some attributes, named the nickel free certification, as well as PGI and eco-sustainability, the provenience of the product from the same respondent's residence region and, finally, for the *ASC_none*.

To assess whether the estimated MXL was affected by potential attribute overlap, we computed the correlation matrix of the attribute coefficients (reported in the Supplementary Materials). We then re-estimated the model after removing attributes exhibiting moderate to high correlation with others,specifically "etico" (which showed a correlation of 0.76 with "PDO") and "bio" (which correlated at 0.49 with "lico"). Comparison of these results with those from the original model indicates that the key mean coefficients remained stable in sign, magnitude, and statistical significance. These findings suggest that the exclusion of overlapping attributes does not materially impact the main

[5] Figures and Tables related to such issues are reported in the Supplementary Materials section.

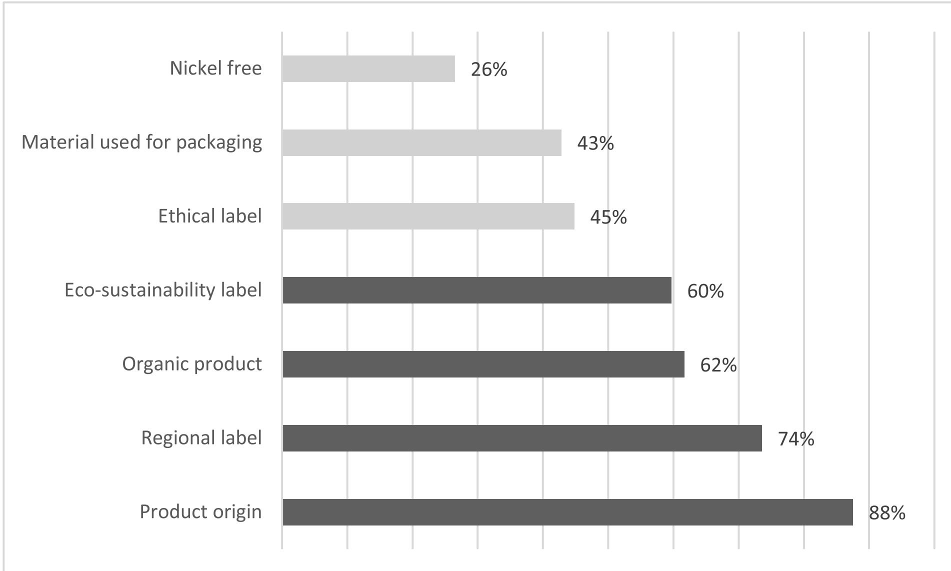

Fig. 2. *A priori* importance assigned by respondents to attributes included into the DCE.

results, thereby confirming the robustness and reliability of the model estimates. Full details of this analysis are provided in the Supplementary Materials.

A comparison of the coefficient estimates from the MXL models, separately estimated for the nudged and non-nudged subsamples, reveals important differences in consumer response to lycopene content. In the non-nudged group, the coefficient for lycopene is not statistically significant, suggesting that, in the absence of the informational prompt, this attribute does not meaningfully influence choice. In contrast, in the nudged group, the lycopene attribute becomes highly statistically significant ($p < 0.001$), both in terms of the mean and the standard deviation of the random parameter. This indicates that the informational nudge not only enhances the overall importance of lycopene content in consumer preferences but also increases preference heterogeneity for this attribute. Overall, the informational nudge has a substantial impact on model estimates, resulting in notable differences in the significance of coefficients compared to the non-nudged subsample. In the non-nudged subsample, respondents appear to consider all attributes (except for lycopene content) and exhibit preference heterogeneity for several attributes, including nickel-free (*nickel)*, PGI certification (*PGI*), eco-labeling (*eco*), ethical certification (*etico*), organic (*bio*), and *ASC_none*. By contrast, in the nudged group, respondents do not assign significant importance to the nickel-free characteristic or PGI certification and perceive no meaningful difference between tomatoes sourced from EU and non-EU countries. However, preferences in this group remain heterogeneous for attributes such as nickel-free, eco-labels, lycopene content, paper packaging, and PGI, despite the latter not being statistically significant. Importantly, the signs of significant coefficients are consistent across both subsamples, indicating that the direction of preferences remains stable, even though the salience and strength of certain attributes are affected by the nudging intervention.

Fig. 3 compares the results of the two models, focusing on the significance of the variance-covariance matrix estimates derived from the nudged and non-nudged subsamples (see Supplementary Materials for full matrices). The findings reveal mixed effects of the informational nudge on preference heterogeneity, as reflected in the significance of the standard deviation coefficients. Specifically, significance increases for certain attributes, such as nickel-free, PGI certification, and lycopene content, while it decreases for others, including eco-label, ethical label (*etico*), organic (*bio*), paper packaging, and biodegradable packaging (*degr*). These results indicate that nudging does not exert a uniform influence on heterogeneity across attributes. In contrast, nudging has a more pronounced and consistent effect on the significance of the covariance coefficients, which reflect correlations between preferences for different attributes. As shown in Fig. 3, many of the covariance terms that were statistically significant in the non-nudged sample become non-significant under the nudged condition. Specifically, 25 out of 26 covariance coefficients lose significance in the nudged group. The only correlation that remains significant across both models is between lycopene content and regional origin, suggesting a persistent link in consumer valuation of these two attributes. Interestingly, in three cases, covariance coefficients that were not significant in the non-nudged sample emerge as significant in the nudged group. There are at least two plausible explanations for this finding. First, nudging may not only suppress existing correlations between preferences but also introduce new patterns of correlation, as observed in the emergence of a few significant covariance terms in the nudged sample. Second, nudging may influence the cognitive approach participants adopt when completing the DCE. As highlighted in the literature, informational nudges tend to promote more deliberate and rational decision-making, encouraging respondents to focus on explicit trade-offs between attribute levels rather than relying on heuristics or considering attributes jointly. This shift in decision strategy places greater emphasis on the evaluation of individual attributes, potentially reducing the perceived importance of attribute interactions. As a result, responses become more precise and consistent, which may explain the increased significance of the individual-level coefficients and the reduced significance of correlation terms in the nudged group. Additional findings appear to support this last interpretation. Specifically, the mean coefficient estimates show improved statistical significance in the nudged subsample, suggesting more precise estimation of preferences. Moreover, for certain attributes, such as ethical certification (*etico*), organic (bio), and *ASC status quo*, preferences appear to be more homogeneous among respondents exposed to the nudge. This further reinforces the idea that nudging promotes a more rational and consistent decision-making process. By simplifying the choice task and helping to reduce hypothetical bias, nudging appears to enhance the overall quality of respondent choices (Caputo and Scarpa, 2022).

Fig. 4 exhibits how respondents perceived the effort required to express their preferences during the DCE. It considers both the presence or absence of nudging, and whether respondents evaluated all or only some attributes in their decision-making process. Results show that 35% of respondents only partially considered all available attributes when completing the DCE, a finding that aligns with previous research in the

Table 3
Estimates of mixed logit model.

Attributes	No nudge						Nudge						All					
	Mean			Standard deviation			Mean			Standard deviation			Mean			Standard deviation		
price	−0.794	***	4.310				−0.819	***	0.153				−0.763	***	0.105			
nickel	0.469	***	4.200	0.931	***	4.890	0.135		0.087	0.822	***	0.147	0.244	***	0.062	0.750	***	0.112
PGI	0.188		1.730	0.911	***	3.480	0.138		0.087	0.661	***	0.161	0.142	*	0.060	0.513	***	0.112
eco	0.455	***	3.830	0.747	***	3.350	0.274	**	0.091	0.544	***	0.170	0.291	***	0.065	0.431	**	0.155
etico	0.398	***	3.920	0.546	**	3.100	0.314	***	0.078	0.020		0.209	0.307	***	0.055	0.187		0.147
lico	0.160		1.510	0.401		1.870	0.370	***	0.097	0.661	***	0.192	0.211	***	0.063	0.098		0.158
bio	0.469	***	3.810	0.953	***	4.780	0.293	***	0.086	0.089		0.171	0.317	***	0.061	0.033		0.169
same_reg	2.465	***	7.980	0.319		0.630	1.754	***	0.196	0.971		0.622	1.851	***	0.145	1.810	***	0.276
UE	0.521	**	2.970	0.504		1.540	0.206		0.136	0.107		0.331	0.306	**	0.097	0.236		0.200
other_reg	1.940	***	6.860	0.340		0.690	1.371	***	0.189	0.197		0.309	1.443	***	0.140	0.219		0.238
paper	0.427	*	2.540	0.151		0.420	0.417	**	0.133	0.632	*	0.296	0.376	***	0.092	0.347		0.391
degr	0.574	***	3.620	0.327		0.900	0.600	***	0.122	0.049		0.271	0.527	***	0.086	0.095		0.254
ASC_none	−6.066	***	8.140	1.046	**	3.050	−5.578	***	0.589	1.084		0.762	−5.519	***	0.408	1.001	***	0.257

. $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

field (De Salvo et al., 2020). However, a deeper analysis reveals a subtle difference between the two sub-samples: the percentage of respondents reporting the occurrence of ANA phenomena is slightly higher in the nudged group (36%) compared to the non-nudged group (34%). This suggests that nudging may have modestly increased the cognitive effort required from participants. This effect becomes more pronounced when examining self-reported cognitive effort. Among participants who acknowledged using heuristic decision strategies, such as partially considering the attributes, the proportion who found the experiment slightly tiring increased markedly in the nudged group, rising from 30% to 41%. A smaller yet notable increase was also observed in the share of participants who reported the task as moderately tiring, which rose from 39% to 41%. These shifts suggest that informational nudging may increase perceived cognitive load, particularly among those already engaging in simplified decision-making strategies. When analysing which attributes were most frequently considered under heuristic decision-making, distinct patterns emerge between the two subsamples. In the non-nudged group, respondents most commonly focused on a limited set of attributes, with the most frequent heuristics involving only origin (11%), origin and price (9%), origin and PGI certification (7%), only price (5%), and origin with organic certification (5%). In contrast, in the nudged group, the most frequent heuristic combinations were origin and price (12%), only origin (9%), only price (6%), origin, packaging, and price (4%), and origin, organic certification, and price (4%). All other attribute combinations appeared with lower frequencies in both subsamples. These results suggest that while origin and price consistently dominate simplified decision strategies, nudging may subtly shift the salience of certain attributes (e.g., packaging or organic certification) in heuristic processing.

The combined findings from Figs. 3 and 4 offer a clearer understanding of the effects of nudging in the DCE. Fig. 3 reveals that nudging influences the significance of the variance-covariance estimates. While nudging improves the significance of some standard deviation coefficients associated with individual attributes, it simultaneously leads to a decline in the significance of most covariance coefficients. This pattern suggests that nudging may prompt respondents to focus more on evaluating attributes individually, rather than considering potential interactions between them. As a result, the estimates for individual attributes become more precise and internally consistent.

Fig. 3 contributes an important behavioural insight to these findings. While nudging appears to encourage a more rational and structured decision-making process, it also seems to slightly increase cognitive burden. This is evidenced by a higher proportion of respondents in the nudged group who reported partially considering the attributes and who described the choice tasks as mentally tiring. These results support the notion that nudging helps to simplify decision-making by directing attention to key trade-offs but may also inadvertently heighten cognitive effort for some participants, particularly those already inclined to rely on heuristic processing.

Interestingly, the analysis of heuristic patterns reveals that respondents in both the nudged and non-nudged subsamples tended to prioritize similar key attributes, most notably, *origin* and *price*. However, in the nudged group, heuristic combinations involving these attributes (e.g., *origin* and price) were more frequently observed, suggesting that the nudge effectively guided respondents' attention toward specific, salient dimensions of the choice task. This finding supports the interpretation that nudging may encourage more deliberate and attribute-focused decision-making, while simultaneously reducing reliance on attribute interactions or more complex trade-offs. Taken together, these results point to a dual effect of nudging. On one hand, it enhances the significance and internal consistency of individual attribute estimates, thereby improving the quality of the data and robustness of preference inference. On the other hand, it appears to increase cognitive effort, as indicated by a higher incidence of self-reported fatigue and partial attribute processing. This trade-off is critical when designing nudging interventions. While nudges can support more thoughtful decisions, they

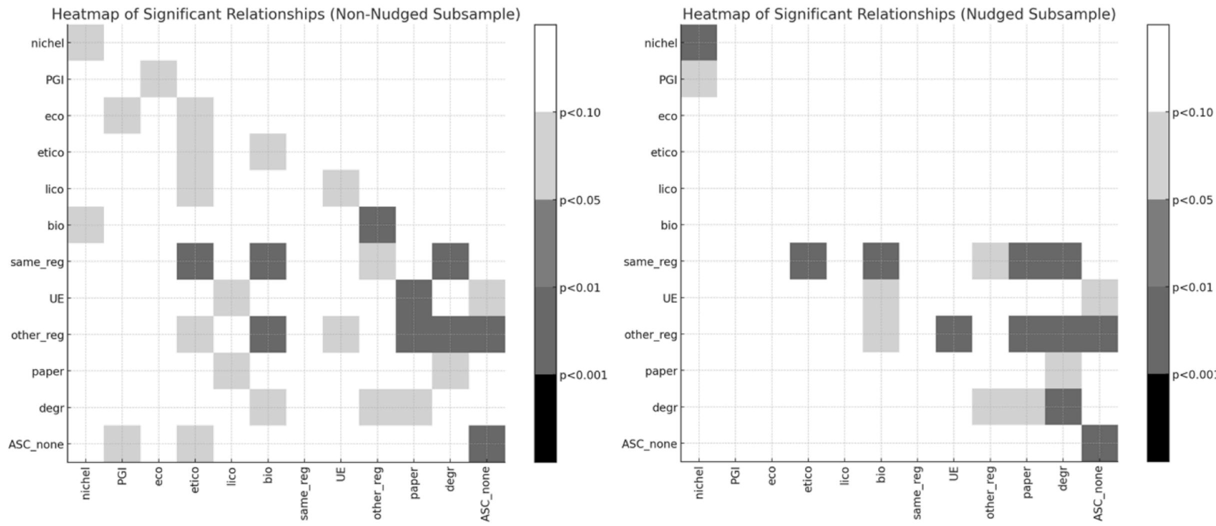

Fig. 3. Changes in the significance levels of variance–covariance coefficient estimates between non-nudged and nudged subsamples.

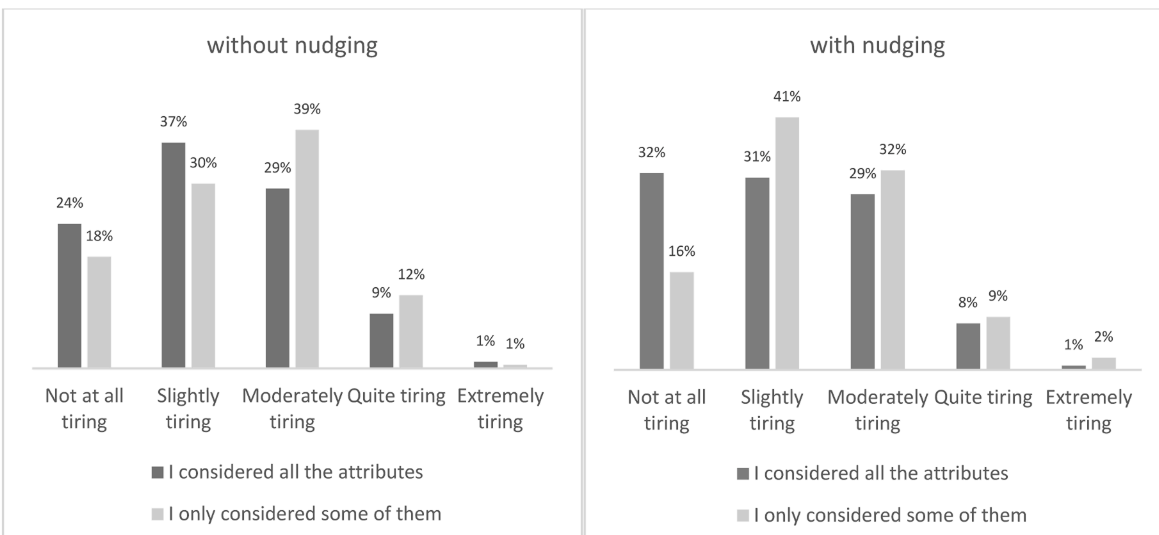

Fig. 4. Self-reported cognitive effort during the DCE and declared onset of Attribute Non-Attendance (ANA).

Table 4
Summary statistics of marginal WTP estimates.

Attributes	No-nudged sub-sample		Nudged sub-sample	
	Mean	Standard Deviation	Mean	Standard Deviation
nichel	0.59	1.17	0.19	1.01
PGI	0.23	1.16	0.17	0.87
eco	0.57	1.30	0.33	0.71
etico	0.49	0.98	0.38	0.41
lico	0.19	1.05	0.46	0.91
bio	0.60	1.60	0.36	0.50
same_reg	3.11	4.54	2.14	2.92
UE	0.63	1.78	0.27	0.77
other_reg	2.44	4.27	1.67	2.58
paper	0.51	1.74	0.49	1.07
degr	0.67	1.86	0.73	0.76

may also raise the risk of participant fatigue or disengagement, particularly in complex choice environments.

Table 4 summarizes the marginal WTP distributions for both non-nudged and nudged respondents. The results indicate that the informational nudge has a significant effect on mean WTP estimates. Notably, the marginal WTP for lycopene content increases markedly, rising from €0.19 per package in the non-nudged group to €0.43 per package in the nudged group, highlighting the impact of the nudge in elevating the perceived value of this functional attribute. However, the nudge also appears to influence WTP for competing attributes. Specifically, average marginal WTP values for characteristics such as nickel-free, PGI certification, eco-sustainability, product origin, organic production, and ethical certification are consistently lower among nudged respondents compared to their non-nudged counterparts. This suggests a reallocation of attention and perceived value toward lycopene at the expense of other health- or sustainability-related attributes. By contrast, the marginal WTP for packaging-related attributes, such as paper-based and 100% biodegradable materials, shows less pronounced differences between the two groups, indicating that nudging had a more limited impact on preferences related to environmental packaging.

Fig. 5 displays the marginal WTP distributions for nudged and non-nudged respondents. The shape of the distributions clearly illustrates that the nudging intervention significantly alters their form, making them systematically leptokurtic in the nudged group across all attributes. This result suggests that marginal WTP values among nudged participants are more tightly concentrated around the mean, with fewer extreme values

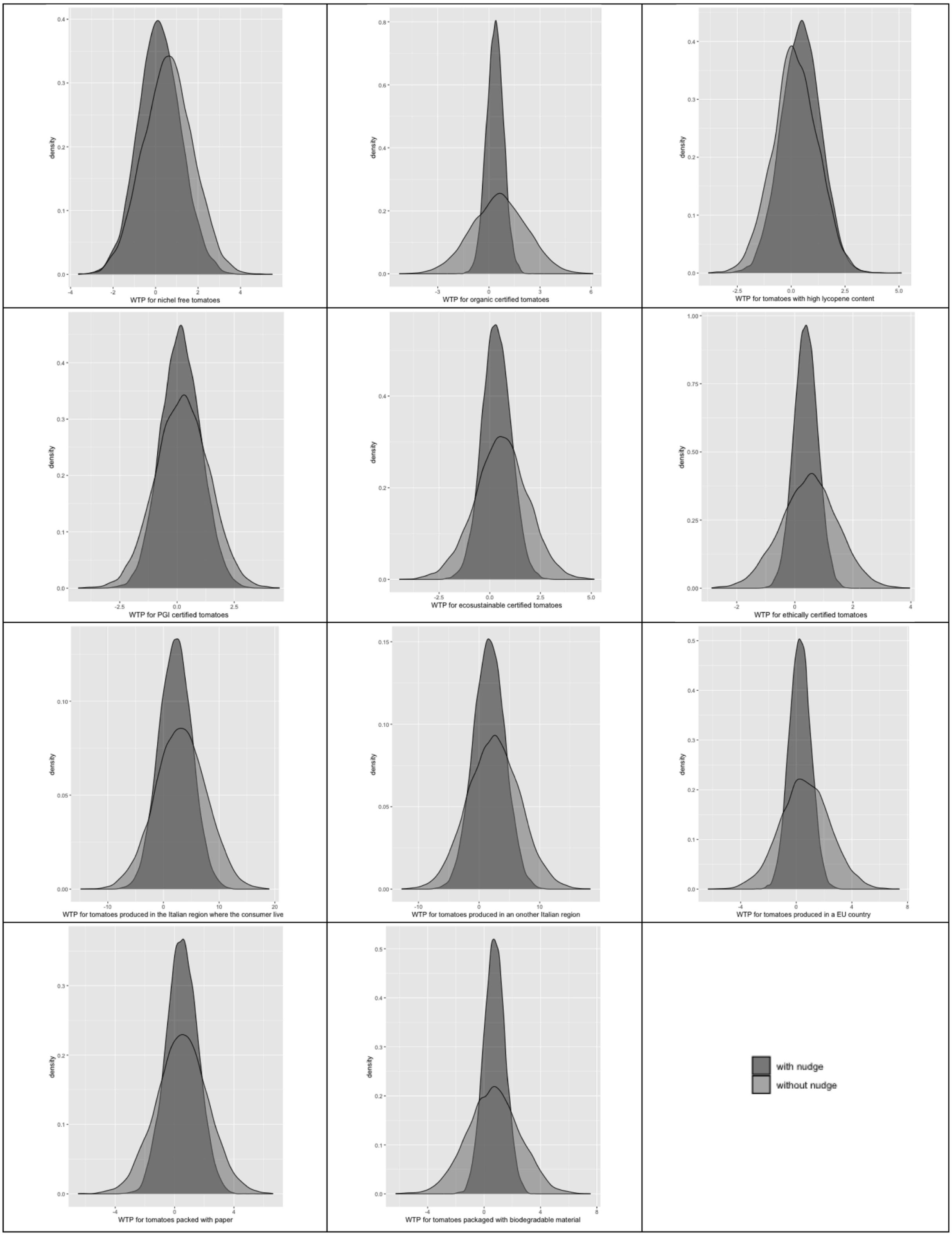

Fig. 5. Marginal WTP distributions.

compared to those in the non-nudged group. These findings reinforce the notion that nudging promotes more consistent and focused decision-making. By reducing the dispersion of WTP estimates, the nudge appears to encourage respondents to engage in a more structured and systematic evaluation of attribute trade-offs, thereby reducing behavioural noise and improving the reliability of preference inference.

Fig. 6 illustrates the predicted demand curves for nudged and non-nudged consumers, focusing on tomatoes with medium and high lycopene content. The behaviour of the demand functions indicates that increasing lycopene levels shifts the demand curves upward and, in some cases, causes them to rotate, depending on both the type of tomato and whether the consumer was exposed to the informational nudge. As

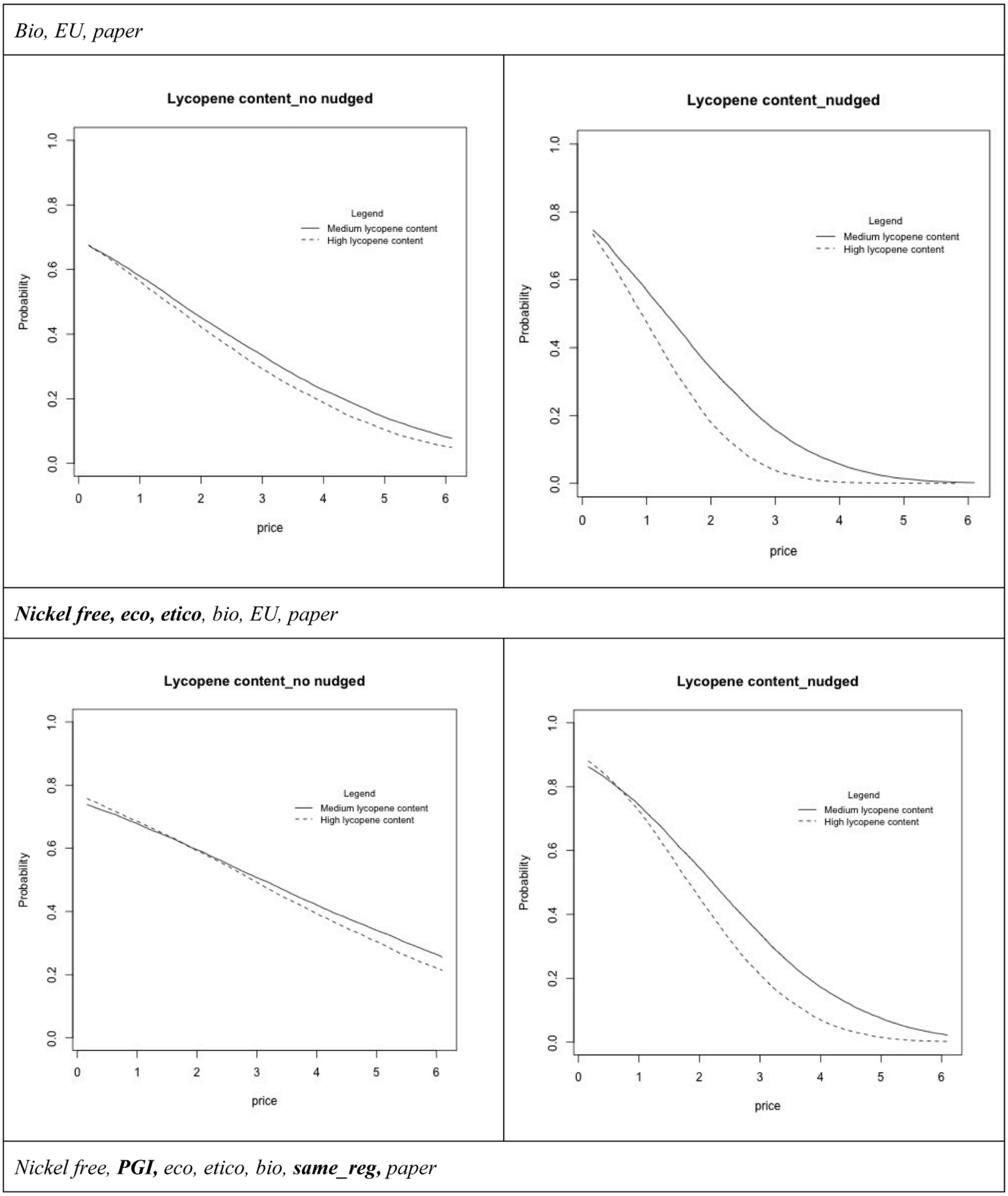

Fig. 6. Predicted demand functions in response to lycopene content across tomato types for nudged and non-nudged consumers.

expected, non-nudged consumers exhibit relatively low sensitivity to changes in lycopene content, with minimal variation in demand across scenarios. In contrast, nudged consumers respond more strongly, particularly for European-sourced, organic tomatoes packaged in paper materials, regardless of the presence or absence of additional value attributes such as nickel-free, eco-sustainable, or ethical certifications.

Across all simulated conditions, nudged consumers demonstrate more elastic demand curves compared to their non-nudged counterparts, indicating a greater responsiveness to price and attribute changes. However, demand responses to lycopene content are less pronounced for locally produced tomatoes, even among nudged participants, suggesting that local origin may act as a dominant cue, reducing the marginal influence of other health-related attributes.

4. Conclusions

This study employed a DCE to investigate the effect of nudging on consumer behaviour regarding fresh tomatoes, with a particular focus on its impact on cognition, preference heterogeneity, and marginal WTP for lycopene content and other intrinsic and extrinsic product attributes. Although the nudge was designed to provide information about the nutraceutical properties of tomatoes, its influence extended beyond lycopene. The results show that nudging significantly affected preferences for a range of attributes, not just the one directly highlighted in the informational prompt.

One key finding relates to the Cholesky decomposition of the variance–covariance matrix, where nudging improved the significance of the variance coefficients for several attributes (e.g., lycopene, nickel-free, and PGI certification) while reducing the significance of many covariance terms. This pattern suggests that nudging encouraged respondents to focus more on individual attributes, diminishing attention to potential interactions among them.

In addition, results indicate that nudging slightly increased cognitive effort. This was evidenced by a higher share of participants in the nudged group reporting partial attribute processing and greater mental fatigue. While nudging supported a more rational, trade-off-based decision-making process, it was also associated with a modest increase in ANA and heuristic-based behaviour, as more participants simplified their choices by ignoring certain characteristics.

Nudging also had a substantial impact on marginal WTP distributions, particularly for lycopene content. The average WTP for lycopene rose from €0.19 to €0.43 per package in the nudged group. However, WTP for other attributes, such as nickel-free, PGI, eco-sustainability, origin, organic, and ethical certification, tended to be lower among nudged respondents, suggesting a reallocation of perceived value towards the attribute emphasized by the nudge. Moreover, the WTP distributions for nudged participants appeared more concentrated around the mean, indicating greater consistency and reduced variability, consistent with more systematic and focused decision-making.

In summary, the findings highlight a dual effect of nudging. On the one hand, nudging enhances preference consistency and improves the statistical significance of individual-level estimates. On the other, it introduces slightly greater cognitive demands, as participants become more focused on trade-offs but may also experience decision fatigue. Additionally, nudging tends to narrow attention toward certain attributes, reducing consideration of more complex attribute interactions. Overall, while nudging improves decision quality, its potential cognitive cost must be carefully weighed.

While this study offers valuable insights, several limitations must be acknowledged. First, phenomena such as ANA and cognitive effort were measured through self-reported debriefing questions after the DCE. As is well documented in the literature, self-reports are not always reliable in capturing actual cognitive processes. Future studies should complement this approach with objective measures, such as eye-tracking, response time analysis, or neurophysiological tools, which offer direct insight into attention allocation and cognitive load. However, such methods often involve higher costs and smaller sample sizes, posing practical constraints. Second, the design of the DCE may have introduced some conceptual or perceived overlap among attributes, especially given the complexity of real-world tomato purchasing decisions. This overlap could lead to multicollinearity, which, although typically handled well by MXL models, may still affect the separation and interpretation of effects. To address this, we conducted robustness checks by examining attribute correlations and re-estimating models excluding highly correlated attributes. Nevertheless, some residual confounding effects may remain. Third, the analysis focuses exclusively on information-based nudging, which appeals to rational, cognitive pathways. Other forms of nudging such as emotional cues, visual prompts, or choice architecture interventions, may produce different behavioural effects. As such, the generalizability of our findings is limited to informational nudges, and caution is advised when extrapolating to other types of behavioural interventions. Finally, the study is based on stated preference data, which reflect hypothetical choices rather than real market behaviour. Although stated preference methods are widely accepted in the literature and offer robust insights, they remain subject to hypothetical bias, whereby respondents may overstate or misrepresent their true preferences. Future research should seek to validate these findings using incentivized experiments or real-world behavioural data to confirm the reliability of the WTP estimates.

Despite these limitations, this study provides compelling evidence that nudging can meaningfully influence consumer preferences, especially in relation to functional food attributes like lycopene content. By promoting more consistent, rational decision-making, nudges can be a powerful tool for aligning consumer behaviour with public health and sustainability goals. From a policy and marketing perspective, the findings suggest that strategically implemented informational nudges can enhance the perceived value of health-related attributes, improve the quality of consumer decision-making, and potentially support the adoption of healthier, more sustainable diets. However, it is crucial to balance these benefits against the risk of cognitive overload, ensuring that nudging interventions remain effective without overwhelming consumers.

Funding

This research was funded by Italian Ministry of University and Research (MUR), Project AGRIFOOD ARS01_00640, "POFACS - Conservabilità, qualità sicurezza dei prodotti ortofrutticoli ad alto contenuto di servizio" (*Preservability, quality safety of fruit and vegetable products with high service content*), PON R&I 2014–2020.

Declaration of generative AI and AI-assisted technologies in the writing process

During the writing process, the authors used ChatGPT 4° to enhance grammar, improve readability, and refine the language of the manuscript. All content generated by the tool was critically reviewed and edited by the authors, who take full responsibility for the accuracy, integrity, and originality of the final publication.

Ethical statement

The study was explained to consumers in the online questionnaire. They were informed that all data will be de-identified and only reported in the aggregate. All participants acknowledged an informed consent statement in order to participate in the study.

CRediT authorship contribution statement

Maria De Salvo: Validation, Methodology, Conceptualization, Writing – original draft, Writing – review & editing, Software, Formal analysis. **Isabella Trovato:** Writing – original draft. **Laura Giuffrida:** Visualization, Data curation. **Marika Cerro:** Visualization, Data curation. **Giovanni Signorello:** Methodology, Writing – original draft, Writing – review & editing, Conceptualization. **Giuseppe Cucuzza:** Funding acquisition, Supervision.

Declaration of competing interest

The authors declare that they have no conflicts of interest to disclose.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.fufo.2025.100722.

Data availability

Data will be made available on request.

References

Alemu, M.H., Mørkbak, M.R., Olsen, S.B., et al., 2013. Attending to the reasons for attribute non-attendance in choice experiments. Environ. Resour. Econ. 54, 333–359. https://doi.org/10.1007/s10640-012-9597-8.

Almeida, C., Azevedo, J., Fogel, A., Lopes, E., Vale, C., Padrao, P., 2024. Effectiveness of nudge interventions to promote fruit and vegetables' selection, purchase, or consumption: a systematic review. Food Qual. Prefer. 116, 105122. https://doi.org/10.1016/j.foodqual.2024.105122.

Balcombe, K., Fraser, I., McSorley, E., 2015. Visual attention and attribute attendance in multi-attribute choice experiments. J. Appl. Econ. 30, 447–467. https://doi.org/10.1002/jae.2383.

Bauer, J.M., Bietz, S., Rauber, J., Reisch, L.A., 2021. Nudging healthier food choices in a cafeteria setting: a sequential multi-intervention field study. Appetite 160, 105106. https://doi.org/10.1016/j.appet.2021.105106.

Blom, S.S., Gillebaart, M., De Boer, F., van der Laan, N., De Ridder, D.T., 2021. Under pressure: nudging increases healthy food choice in a virtual reality supermarket, irrespective of system 1 reasoning. Appetite 160, 105116. https://doi.org/10.1016/j.appet.2021.105116.

Campbell, D., Hensher, D.A., Scarpa, R., 2011. Non-attendance to attributes in environmental choice analysis: a latent class specification. J. Environ. Plan. Manag. 54 (8), 1061–1076. https://doi.org/10.1080/09640568.2010.549367.

Caputo, V., Scarpa, R., 2022. Methodological advances in food choice experiments and modeling: current practices, challenges, and future research directions. Annu. Rev. Resour. Econ. 14 (1), 63–90. https://doi.org/10.1146/annurev-resource-111820-023242.

Caraban, A., Karapanos, E., Gonçalves, D., Campos, P., 2019. 23 ways to nudge: a review of technology-mediated nudging in human-computer interaction. In: Proceedings of the 2019 CHI conference on human factors in computing systems, pp. 1–15. https://doi.org/10.1145/3290605.3300733.

Carlsson, F., Kataria, M., Lampi, E., 2018. Dealing with ignored attributes in choice experiments on valuation of Sweden's environmental quality objectives. Environ. Resour. Econ. 47, 65–89. https://doi.org/10.1007/s10640-010-9365-6.

Carroll, K.A., Samek, A., Zepeda, L., 2018. Food bundling as a health nudge: investigating consumer fruit and vegetable selection using behavioral economics. Appetite 121, 237–248. https://doi.org/10.1016/j.appet.2017.11.082.

Collins, A., 2012. Attribute Nonattendance in Discrete Choice models: Measurement of bias, and a Model For the Inference of Both Nonattendance and Taste Heterogeneity. Univ. Sydney Aust. PhD Diss., Inst. Transp. Logist. Stud., Bus. Sch.

Collins, E.J., Bowyer, C., Tsouza, A., Chopra, M., 2022. Tomatoes: an extensive review of the associated health impacts of Tomatoes and factors that can affect their cultivation. Biology 11 (2), 239. https://doi.org/10.3390/biology11020239.

Congiu, L., Moscati, I., 2022. A review of nudges: definitions, justifications, effectiveness. J. Econ. Surv. 36, 188–213. https://doi.org/10.1111/joes.12453.

Čop, T., Njavro, M., 2024. Nudge research in agricultural economics: two-decade retrospective of empirical evidence. China Agric. Econ. Rev. 16 (4), 731–746. https://doi.org/10.1108/CAER-10-2023-0277.

De Salvo, M., Scarpa, R., Capitello, R., Begalli, D., 2020. Multi-country stated preferences choice analysis for fresh tomatoes. Bio-Based Appl. Econ. 9 (3), 241–262. https://doi.org/10.13128/bae-7928.

EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA), 2011. Scientific opinion on the substantiation of health claims related to lycopene and protection of DNA, proteins and lipids from oxidative damage (ID 1608, 1609, 1611, 1662, 1663, 1664, 1899, 1942, 2081, 2082, 2142, 2374), protection of the skin from UV-induced (including photo-oxidative) damage (ID 1259, 1607, 1665, 2143, 2262, 2373), contribution to normal cardiac function (ID 1610, 2372), and maintenance of normal vision (ID 1827) pursuant to article 13(1) of Regulation (EC) No 1924/2006. EFSa J. 9 (4), 2031. https://doi.org/10.2903/j.efsa.2011.2031 [28 pp.].

Ellison, B., Bernard, J.C., Paukett, M., Toensmeyer, U.C., 2016. The influence of retail outlet and FSMA information on consumer perceptions of and willingness to pay for organic grape tomatoes. J. Econ. Psychol. 55, 109–119. https://doi.org/10.1016/j.joep.2016.05.002.

Ensaff, H., 2021. A nudge in the right direction: the role of food choice architecture in changing populations' diets. Proc. Nutr. Soc. 80 (2), 195–206. https://doi.org/10.1017/S0029665120007983.

Franceschinis, C., Scarpa, R., Thiene, M., 2024. Nudging consumers' choices for niche milk: a real purchase experiment. Food Policy. 128, 102729. https://doi.org/10.1016/j.foodpol.2024.102729.

Gillebaart, M., Blom, S.S.A.H., Benjamins, J.S., de Boer, F., De Ridder, D.T.D., 2023. The role of attention and health goals in nudging healthy food choice. Front. Psychol. 14, 1270207. https://doi.org/10.3389/fpsyg.2023.1270207.

Giovannetti, M., Avio, L., Barale, R., Ceccarelli, N., Cristofani, R., Iezzi, A., Mignolli, F., Picciarelli, P., Pinto, B., Reali, D., Sbrana, C., Scarpato, R., 2012. Nutraceutical value and safety of tomato fruits produced by mycorrhizal plants. Br. J. Nutr. 107 (2), 242–251. https://doi.org/10.1017/S000711451100290X.

Gravert, C., Kurz, V., 2021. Nudging à la carte: a field experiment on climate-friendly food choice. Behav. Public Policy. 5 (3), 378–395. https://doi.org/10.1017/bpp.2019.11.

Hansen, P.G., Jespersen, A.M., 2013. Nudge and the manipulation of choice: a framework for the responsible use of the nudge approach to behaviour change in public policy. Eur. J. Risk. Regul. 4 (1), 3–28.

Hansen, P.G., Schilling, M., Malthesen, M.S., 2021. Nudging healthy and sustainable food choices: three randomized controlled field experiments using a vegetarian lunch-default as a normative signal. J. Public Health (Bangk.) 43 (2), 392–397. https://doi.org/10.1093/pubmed/fdz154.

Hensher, D.A., 2006. Revealing differences in willingness to pay due to the dimensionality of stated choice designs: an initial assessment. Environ. Resour. Econ. 34, 7–44. https://doi.org/10.1007/s10640-005-3782-y.

Hole, A.R., 2007. Fitting mixed logit models by using maximum simulated likelihood. Stata J. 7 (3), 388–401. https://doi.org/10.1177/1536867X070070030.

Ibrahim, M.S., Mujtaba, A., Hassan, I., Nadeem, M., Sohail, A., Abbasi, K.S., Samee, A., Azeem, W., Waqar, W., Fatima, I., 2023. Antioxidant and nutraceutical potential of tomato for health and life quality: a review: tomato as functional fruit. Food Sci. Appl. Microbiol. Rep. 2 (1), 8–25.

ISMEA. (2017). I Numeri Della Filiera del Pomodoro da Industria (https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://www.ismea.it/flex/cm/pages/ServeAttachment.php/L/IT/D/8%25252Fd%25252Fb%25252FD.f7b5a2e810dad283d1a1/P/BLOB:ID%3D10110/E/pdf&ved=2ahUKEwjale_krJGNAxUy_rsIHWowKLoQFnoECBwQAQ&usg=AOvVaw3J3N6paDEI-asWQIxfMZiT).

Jonker, M.F., Donkers, B., de Bekker-Grob, E.W., Stolk, E.A., 2018. Effect of level overlap and color coding on attribute non-attendance in discrete choice experiments. Value Health 21 (7), 767–771. https://doi.org/10.1016/j.jval.2017.10.002.

Joya, K., Ramli, N.N., Shamsudin, M.N., Kamarulzaman, N.H., 2022. Consumers' willingness to pay for food safety attributes of tomato. Br. Food J. 124 (3), 701–717. https://doi.org/10.1108/BFJ-02-2021-0164.

Kassas, B., Cao, X., Gao, Z., House, L.A., Guan, Z., 2023. Consumer preferences for country-of-origin labeling: bridging the gap between research estimates and real-world behavior. J. Choice Model. 48. https://doi.org/10.1016/j.jocm.2023.100429.

Kassie, G.T., Zeleke, F., Birhanu, M.Y., Scarpa, R. (2020). *Reminder nudge, Attribute nonattendance, and Willingness to Pay in a Discrete Choice Experiment*, Selected Paper prepared for presentation at the 2020 Agricultural & Applied Economics Association, Annual Meeting, Kansas City, MO, July 26-28, 2020. DOI: 10.22004/ag.econ.304208.

Lima, G.P.P., Gómez, H.A.G., Seabra Junior, S., Maraschin, M., Tecchio, M.A., Borges, C.V., 2022. Functional and nutraceutical compounds of tomatoes as affected by agronomic practices, postharvest management, and processing methods: a mini review. Front. Nutr. 9, 868492. https://doi.org/10.3389/fnut.2022.868492.

Lindstrom, K.N., Tucker, J.A., McVay, M., 2023. Nudges and choice architecture to promote healthy food purchases in adults: a systematized review. Psychol. Addictive Behav. 37 (1), 87. https://doi.org/10.1037/adb0000892.

Mancuso, T., De Cianni, R., Di Vita, G.A., Spada, E., Brun, F., Spadaro, D.C., Zanchini, R., 2024. Understanding Italian consumers' perceptions of tomato agricultural innovation: exploring the nexus between sustainability, health and consumer beliefs. J. Clean. Prod. 435, 140528. https://doi.org/10.1016/j.jclepro.2023.140528.

Maples, M., Interis, M.G., Morgan, K.L., Harri, A., 2018. Southeastern consumers'willingness to pay for environmental production attributes of fresh tomatoes. J. Agric. Appl. Econ. 50 (1), 27–47. https://doi.org/10.1017/aae.2017.18.

Mariel, P., Khan, M.A., Meyerhoff, J., 2022. Valuing individuals' preferences for air quality improvement: evidence from a discrete choice experiment in South Delhi. Econ. Anal. Policy. 74, 432–447. https://doi.org/10.1016/j.eap.2022.03.006.

Morejón Cabrera, G., Mariel, P., Abadía, L.K., 2022. Postgraduate study preferences of business administration and economics students from Colombia, Ecuador, and Spain. Int. J. Educ. Res. 112. https://doi.org/10.1016/j.ijer.2022.101935.

Nielsen, A.S.E., Sand, H., Sørensen, P., Knutsson, M., Martinsson, P., Persson, E., Wollbrant, C., 2017. Nudging and Pro-Environmental Behaviour. Nordisk Ministerråd. https://doi.org/10.6027/TN2016-553.

Nishimura, T., 2021. The effect of greenhouse pollination methods on consumers' willingness to pay for tomatoes in Japan. J. Agric. Appl. Econ. 53 (2), 186–208. https://doi.org/10.1017/aae.2020.33.

Nohara, K., 2024. Willingness to pay for pesticide-free vegetables in Hokkaido, Japan: the relationship between appearance and pesticide use. Humanit. Soc. Sci. Commun. 11 (1), 1–12. https://doi.org/10.1057/s41599-023-02515-y.

Pandey, S., Olsen, A., Perez-Cueto, F.J., Thomsen, M., 2023. Nudging toward sustainable food consumption at university canteens: a systematic review and meta-analysis. J. Nutr. Educ. Behav. 55 (12). https://doi.org/10.1016/j.jneb.2023.09.006.

Poojary, M.M., Passamonti, P., 2015. Extraction of lycopene from tomato processing waste: kinetics and modelling. Food Chem. 173, 943–950. https://doi.org/10.1016/j.foodchem.2014.10.127. Epub 2014 Oct 29. PMID: 25466110.

Printezis, I., Grebitus, C., 2020. College-age millennials' preferences for food supplied by urban agriculture. Front. Sustain. Food Syst. 4, 48. https://doi.org/10.3389/fsufs.2020.00048.

Revelt, D., Train, K., 1998. Mixed logit with repeated choices: households' choices of appliance efficiency level. Rev. Econ. Stat. 80 (4), 647–657. https://doi.org/10.1162/003465398557735.

Rose, J.M., Bliemer, M.C., Hensher, D.A., Collins, A.T., 2008. Designing efficient stated choice experiments in the presence of reference alternatives. Transp. Res. Part B 42 (4), 395–406. https://doi.org/10.1016/j.trb.2007.09.002.

Ruth, C., Lakshmi, T.N., Gopal, K., 2016. Studies on epidemiology of major diseases of horticultural crops. Plant Arch. 16 (1), 65–70.

Sapio, S., Vecchio, R., 2024. The effect of nudges on healthy food choices of individuals with a low socio-economic position: a systematic literature review. Trends. Food Sci. Technol. https://doi.org/10.1016/j.tifs.2024.104475.

Scarpa, R., Gilbride, J., Campbell, D., Hensher, D.A., 2009. Modelling attribute non-attendance in choice experiments for rural landscape valuation. Eur. Rev. Agric. Econ. 36 (2), 151–174. https://doi.org/10.1093/erae/jbp012.

Shonkwiler, V.P., 2024. Exploring Co-labeling strategies in local food markets: insights from a choice experiment on Southern buyers' Preferences for cherry tomatoes. HortScience 59 (6), 736–742. https://api.semanticscholar.org/CorpusID:269403437.

Tan, B.L., Norhaizan, M.E., Liew, W.P., Sulaiman Rahman, H., 2018. Antioxidant and oxidative stress: a mutual interplay in age-related diseases. Front. Pharmacol. 9, 1162. https://doi.org/10.3389/fphar.2018.01162. PMID: 30405405; PMCID: PMC6204759.

Thaler, R.H., Sunstein, C.R., 2021. Nudge: The final Edition. Yale University Press.

Tran, L., McCann, L., Su, Y., 2023. Consumer preferences for produce grown with reduced pesticides: a choice experiment in Missouri. Renew. Agric. Food Syst. 38, e49. https://doi.org/10.1017/S1742170523000418.

Train, K.E., 2009. Discrete Choice Methods With Simulation. Cambridge university press. https://doi.org/10.1017/CBO9780511805271.

Vecchio, R., Cavallo, C., 2019. Increasing healthy food choices through nudges: a systematic review. Food Qual. Prefer. 78. https://doi.org/10.1016/j.foodqual.2019.05.014.

Vella, F., Migliore, G., Schifani, G., Vecchio, R., 2024. Nudging interventions to foster the reduction of pesticides in viticulture. Insights from Italian winegrowers. Environ. Dev., 101120 https://doi.org/10.1016/j.envdev.2024.101120.

Verneau, F., La Barbera, F., Furno, M., 2019. The role of health information in consumers' Willingness to pay for canned crushed tomatoes enriched with lycopene. Nutrients. 11 (9), 2173. https://doi.org/10.3390/nu11092173. PMID: 31510086; PMCID: PMC6770788.

Weimer, K., Ahlström, R., Esteves, F., 2022. The effect of nudging in promoting the consumption of organic fruits and vegetables. Front. Physiol. 13, 720606. https://doi.org/10.3389/fpsyg.2022.720606.

Weller, P., Oehlmann, M., Mariel, P., Meyerhoff, J., 2014. Stated and inferred attribute non-attendance in a design of designs approach. J. Choice Model. 11, 43–56. https://doi.org/10.1016/j.jocm.2014.04.002.

Yi, S., Kanetkar, V., Brauer, P., 2022. Nudging food service users to choose fruit-and vegetable-rich items: five field studies. Appetite 173. https://doi.org/10.1016/j.appet.2022.105978.

Zapata, S.D., Villavicencio, X.A., Marconi, T.G., Avila, C.A., 2025. Using sensory analysis and stated preference valuation to assess the willingness to pay for fresh tomato attributes. Agribusiness. https://doi.org/10.1002/agr.21977.