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Landscape presentation formats influence consumer's preferences for origin and botanical variety of Spanish honey

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Abstract

Context and presentation format influence behaviour and information processing. This study investigates how presenting the honey production landscape through different formats (i.e. pictures, 2D video, and immersive 3D video) affects consumer preferences and willingness to pay (WTP) for honey. A hypothetical choice experiment shows that presenting the landscape before the choice task considerably impacts WTP estimates for the geographical origin and botanical variety attributes of honey. Additionally, significant differences emerge across presentation formats, indicating that the immersive 3D video creates more pronounced variations in WTP based on the geographical origin of honey. Methodologically, our study contributes to the literature by utilising a 360°-virtual reality video, thus enhancing the realism of the experiment. Empirically, we explore how landscape visuals influence the consumer choices of honey, potentially increasing WTP for geographically sourced honey.

Keywords: Choice experiment, Virtual reality, Presentation format, Landscape, Honey

Introduction

The literature has demonstrated that context is an important marketing tool (Kotler 1973) for influencing consumer food choices. Context can create expectations about food quality and experience (Stroebele and De Castro 2004), and context matters because of the appropriateness of food for the situation (Schutz 1994; Schutz and Martens 2001). Context can be even more relevant than the product itself (Stroebele and De Castro 2004). The way that contextual information is presented has become a central element in discrete choice experiments (DCEs), a methodological approach for evaluating consumer preferences using realistic scenarios.

Presentation formats in discrete choice experiments

Several studies have incorporated contextual elements into DCEs to investigate how external information sources influence consumers' decisions (Jaeger and Porcherot 2017; Murwirapachena and Dikgang 2022). The way that information is presented affects how individuals process it (Feiereisen et al. 2008; Hibbard et al. 2002). For example, written formats are common for their simplicity, but visual and auditory stimuli can reduce cognitive effort and facilitate engagement (Jaeger and Porcherot 2017).

In choice experiments on household water-saving technologies, Murwirapachena and Dikgang (2022) found that participants showed stronger preferences for attributes presented in visual format than the ones exclusively using text, concluding that presentation format significantly influences willingness to pay (WTP). DeLong et al. (2021) also reported differences in WTP estimates depending on how attributes were presented; however, text-based estimates were determined to be greater and more significant than visual-based ones. Uggeldahl et al. (2016) provided more evidence, who found a lower variance error when alternatives were presented with images instead of simply text. They reasoned that images might clarify to participants what they are buying, resulting in more consistent choices. By contrast, Meyerhoff et al. (2021) did not find significant differences in their comparison between images and text-based choice sets, although they expressed concern that visual representations are more likely to be involved in the attribute non-attendance phenomenon.

Innovative presentation format: the case of virtual reality

Given the limitations of traditional presentation formats, virtual reality (VR) is gaining attention as a research tool due to its capacity to create realistic, three-dimensional environments that strengthen ecological validity by making the participants' behaviour more consistent with real-world actions (Birenboim et al. 2019; Cipresso et al. 2018; Mokas et al. 2021). Through the simulation of real-world environments via head-mounted displays, VR enables participants to feel disconnected from their physical surroundings and immersed in the experimental scenario (Mkedder et al. 2024). VR has been successfully applied in studies of retail, food behaviour, and mobility, allowing researchers to represent complex decision-making environments while maintaining control over variables (Bhavadharini et al. 2023; Rossetti and Hurtubia 2020). In choice experiments, VR is particularly effective for attributes that are difficult to communicate using traditional methods, such as spatial or visual characteristics, thus expanding the range of measurable preferences (Yin and Cherchi 2024). Compared to traditional approaches such as vignettes or self-reported surveys, VR provides emotionally engaging, realistic contexts that support more intuitive and reliable decision-making (Galiñanes Plaza et al. 2019; Mol 2019).

The psychological mechanisms that make VR effective include presence (the feeling of 'being inside'), engagement (focused attention), and immersion (active involvement in the environment) (Schuemie et al. 2001; Slater and Wilbur 1997; Wedel et al. 2020). These states enable users to connect with virtual environments, enhancing their emotional and cognitive responses during experiments. VR environments enhance enjoyment and curiosity, particularly in consumer contexts such as virtual shopping, where escapism can increase satisfaction and purchase intention (Branca et al. 2023; Mkedder et al. 2024). VR has also been shown to generate stronger emotional and sensory responses, supporting studies in food evaluation and wine tasting (Torrico et al. 2020; Zulkarnain et al. 2024); reduce price sensitivity (Meißner et al. 2020); and influence perception in virtual shopping through environmental elements such as greenery (Sina and Wu 2023).

Conventional formats of presenting information versus virtual reality

Comparative studies have explored the differences between conventional formats (i.e. text, pictures, 2D video) and VR. Patterson et al. (2017) found no significant difference in choices between textual and virtual presentation of neighbourhood, whereas other researchers have reported the opposite case. Farooq (2018) identified stronger preferences and consistency for autonomous vehicles when presented in VR compared to text or 2D video. Andersen et al. (2019) observed a greater appeal for beverages in a beach context in 3D simulations versus static images. Matthews et al. (2017) and Mokas et al. (2021) similarly indicated that VR and 2D video reduced error variance and randomness in choices compared to picture and text, thereby improving response reliability. Fang et al. (2021) showed that VR reduced hypothetical bias and produced more realistic WTP estimates. VR has also been validated by comparison with real-world experiments. De-Magistris et al. (2022) and Xu et al. (2021) reported no significant behavioural differences between 3D virtual supermarkets and real-choice experiments, whereas Van Herpen et al. (2016) found that VR better reproduces consumer real behaviour than pictures.

Contextual application: honey and landscape

The objective of this study is twofold: to investigate whether evoking the landscape of honey production could affect consumer preferences and WTP for Spanish honey and to test whether different presentation formats affect consumer preferences and WTP. This study focuses on honey, a traditional food (Consonni and Cagliani 2010), whereby botanical and geographical origins are central to shaping consumer perceptions and guiding purchasing decisions (Ben-Ali et al. 2022; Cela et al. 2019). These attributes are visually represented through landscapes, making them a powerful contextual tool. Geographical origin is particularly valued when associated with low population density, limited industrial activity, and abundant wild vegetation, as these conditions support high-quality honey production; by contrast, botanical origin pertains to the sensory and nutritional qualities of honey (Garrido-Fernández and Moumeh 2018).

Despite the importance of landscape, few studies have investigated its visual impact on honey preferences. Research has focused on individual–place relationships through the concept of place attachment (Balázsi et al. 2019; Garcia-Martin et al. 2017; Manzo and Devine-Wright 2013a, b) and proximity to food production, cultural identity, and traditional practices linked to food preferences (Baršytė et al. 2023; Cantarero et al. 2013; Kapelari et al. 2020; Thøgersen 2023). Only two studies have explored the influence of landscape on honey choice (Cela et al. 2019; Cosmina et al. 2016), both suggesting a preference for mountain landscapes and a perception of higher quality. However, neither of these studies used VR to present the landscape context, hence leaving a gap in methodological research. This aspect is the main methodological contribution of this work. Previous research has underscored that VR increases consumer engagement and realism in food-related choice experiments (Cinnamon and Jahiu 2023; Sinesio et al. 2019); however, a gap remains in the evaluation of the effectiveness of VR compared to more traditional formats (e.g. picture or 2D video) for traditional foods such as honey, in which origin and landscape play an important role. Hence, this study addresses this gap by investigating whether the presentation of the honey production landscape through different formats, including pictures, 2D video, and a 360º VR, affects consumer preferences and WTP for Spanish honey.

The results of this study also provide practical implications for producers, marketers, and policy makers in using immersive technologies to promote local honey, as the study reinforces the evidence that landscape can influence the choices of honey consumers. In this regard, the managerial implications are particularly relevant for beekeeper associations, honey producers, and apitourism actors. Understanding the specific presentation format that best communicates product origin can help design more engaging and emotionally relevant consumer experiences. VR landscapes that reflect the origin of honey can increase perceived value and WTP, supporting product differentiation and competitiveness. Stakeholders could use VR for immersive storytelling, showing landscapes, apiaries, and production processes, or offer virtual tastings that combine visual stimuli with real honey. VR might also be used for educational purposes, promoting the benefits of honey and the role of bees. Finally, from a policy perspective, linking honey consumption to rural landscapes might reconnect consumers with food origins and support traditional food tourism in rural areas, thus contributing to the support of rural regions confronting demographic and economic decline.

Methodology

Experimental design

This study hypothesises that choice preferences for a jar of honey can be influenced by the different information formats in which the landscape is presented to consumers before they declare their willingness to purchase (see Appendix 1). A between-subject experiment with one control and three treatment conditions was implemented in the study, with each respondent randomly assigned to participate in only one group out of the four treatments, namely control, picture, 2D video, and 3D video (Lusk and Schroeder 2004).

In the *control* treatment, which represents the benchmark in the current study, the participants responded only to the DCE questions. Following previous research (Cela et al. 2019; Cosmina et al. 2016; Tempesta et al. 2010), the participants in the other treatments encountered visual information about the landscape where the honey is produced before they were asked to respond to the DCE questions. For example, in the *picture* condition, the participants viewed a set of six static images[1] before answering the DCE questions. Each image illustrated a different perspective of the production landscape (see Fig. 1). The first image shows a general view of a green mountainous area with wild flora and the hives. The second image is a medium shot capturing the beekeeper while opening a hive and spreading smoke to calm the bees and subsequently check the inside of the hive. The third image features a panoramic view of the landscape, with the beekeeper revising the inside of the hive. The fourth image is a closer shot of the beekeeper checking one of the honeycombs in the hive. The fifth image presents a distant scene of

[1] The images were generated from the screenshots of a 360º video that was used for creating the immersive 3D scenario.

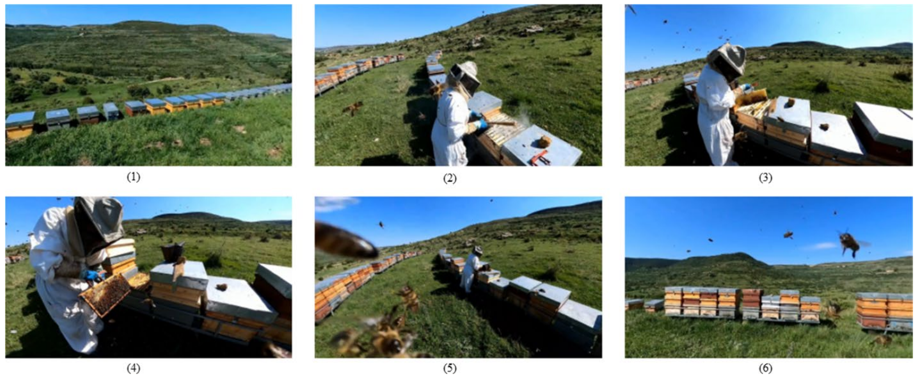


Fig. 1 Pictures of the landscape of honey production presented to participants before the choice experiment

the beekeeper closing the hive. Finally, the sixth image shows a general view of wooden beehives integrated into the natural landscape.

In the *2D-video* treatment,[2] the participants watched a video on their PC or smartphone (whereas they opened the link to the survey) with the same visual sequence as the *picture* treatment through the honey production environment (more details in Appendix 2). In the *3D-video* treatment or the VR group, the participants wore headsets with a custom APK[3] developed for the experiment (more details in Appendix 2). The *3D-video* treatment offered an immersive experience in the same mountainous environment as the other treatments, but it allowed participants to freely look in all directions; furthermore, the image added a grid to simulate the view from inside the beekeeper's suit.

Research hypotheses

Several hypotheses were developed based on the treatments, with the assumption that the information presentation format of the landscape of the production place could influence the preference for honey and its origin. The hypotheses were tested to answer the research question on whether differences exist in choices depending on the presence or absence of the production landscape information as an evoked context. The *control* group was initially compared to the *picture* format group, then to the *2D-video* and *3D-video* format groups.

H_{01}: $WTP^{Picture} = WTP^{Control}$

H_{11}: $WTP^{Picture} \neq WTP^{Control}$

H_{02}: $WTP^{2D} = WTP^{Control}$

H_{12}: $WTP^{2D} \neq WTP^{Control}$

H_{03}: $WTP^{3D} = WTP^{Control}$

$H_{13:}$ $WTP^{3D} \neq WTP^{Control}$

[2] The video included the same visual sequence as the *picture* treatment through the honey production environment. The video included the walking speed footage of the surrounding hills covered in wild vegetation, footage of the beekeeper opening the hives, checking the honeycombs as the bees fly around, and soft panoramas of the hives surrounded by the landscape. Ambient background noises accompanied the video, and no narration was included. The video was 2D in MP4 format. The 2D video is available in this link: https://youtu.be/gKloBCnsQCw.

[3] The APK was developed for Android 6.0 Marshmallow. The creation of the APK was outsourced to a specialised local company. The 3D video is available in this link: https://youtu.be/VM5xDpHEcSA.

If H_{01}, H_{02}, or H_{03} are rejected, then the assumption that evoking the production landscape through pictures, 2D, or 3D can influence consumer choices and, thus, support the idea that contextual factors in a laboratory setting can change the perception of the honey jars might be confirmed.

The role of information presentation format in influencing consumers' preferences for honey was subsequently explored. The following hypotheses comparing pictures, 2D video, and 3D video were tested:

H_{04}: $WTP^{2D} = WTP^{Picture}$

H_{14}: $WTP^{2D} \neq WTP^{Picture}$

H_{05}: $WTP^{3D} = WTP^{2D}$

$H_{15:}$ $WTP^{3D} \neq WTP^{2D}$

H_{06}: $WTP^{3D} = WTP^{Picture}$

H_{16}: $WTP^{3D} \neq WTP^{Picture}$

If H_{04}, H_{05}, and H_{06} are not rejected, then the information presentation format of the production place will not make any difference in consumers' honey preference and WTP. On the contrary, if some of the hypotheses (i.e. H_{04}, H_{05}, and H_{06}) are rejected, then the assumption that the apparent influence of the presentation format used for showing information of the production place might influence honey perception and should be considered when information on origin is utilised may be confirmed. This approach helps assess if investing in more expensive technologies that a priori are more effective in simulating contextual environments is justified.

Choice-set design

Choice experiments have been used for studying WTP for local honey and consumers' preferences for different honey attributes (Cela et al. 2019; Cosmina et al. 2016; Kallas et al. 2021; Sparacino et al. 2022). In the current study, this methodology allows the investigation of the rate at which individuals are willing to trade between attributes and their levels, the utility that respondents derive from the product or the relative utility of different attributes, and the combination of both factors (Van Loo et al. 2011).

An unlabelled hypothetical DCE was designed in the present study to assess the preferences for attributes and WTP for local honey. Three attributes were utilised to describe the different alternatives of honey, namely price, geographical origin, and botanical origin (see Table 1). Botanical variety and geographical origin are particularly the key factors that determine honey quality. The composition and sensory characteristics of honey,

Table 1 Attributes and levels used in the choice design

Attributes	Levels
Price	€3.50, €4.50, €5.50
Geographical origin	Spain
	Aragon
	Teruel
Botanical origin	Multifloral honey
	Rosemary honey
	Thyme honey

such as colour, smell, taste, aroma, and texture, largely depend on the flowers, the location, and the climate where the bees produce honey (Garrido-Fernández and Moumeh 2018).

The attribute of price allowed for the calculation of the marginal WTP. Three price levels were specified to reflect the Spanish honey prices found in supermarkets for this product in 2021; the price levels ranged from €3.50 to €5.50 for 500 g of multifloral and monofloral honey varieties. To capture all the products available in the market, the price range of €3.50 to €5.5 was chosen. To achieve a balanced design with the smaller number of scenarios, the same number of levels for each attribute was established. The division of the price range was deemed necessary to ensure that the intervals were equal, thus resulting in the use of three prices: €3.50, €4.50, and €5.50 (refer to Table 1).

Geographical origin has been identified as an essential factor that influences honey consumption. Consumer interest in locally produced honey and in the direct purchase from local producers is strong, as honey procured in such manner is often viewed as a product of higher quality (Roman et al. 2013). Additionally, the sector is confronted with growing pressure to make mandatory the specification of the exact origin of honey on labels, rather than simply the general categories required by law (i.e. European, non-European, or blends; Directive 2014/63/EU). This demand is driven by the need to be more competitive with imported honey, combat fraud, and use origin as a means of differentiating honey from small, local beekeepers by linking the product to its place of production. This study identifies three levels of origin based on the territorial divisions of Spain: national (Spain), regional (Aragon), and provincial (Teruel) (see Table 1). Teruel was selected because it is one of the most depopulated and economically depressed rural provinces; furthermore, honey is a product closely linked to the rural environment, which is a potential tool for local development.

The final attribute, botanical origin, consists of three levels. Honey is categorised into two main types: multifloral and monofloral. Multifloral honey is made from different flowers without a dominant plant, and it is the most common type of honey. By contrast, monofloral honey largely comes from a single plant species; moreover, its characteristics are defined by the variety of that plant that contains a specific amount of pollen from the same source (Garrido-Fernández and Moumeh 2018). Monofloral honey is especially valued in the market due to its higher added value compared to multifloral honey. The melliferous flora of Teruel includes rosemary, thyme, lavender, savoury, and sage plants, which define the typical landscape of the territory (Enseñat-Ortiz, 2021). For the current study, two monofloral plants—rosemary and thyme—were selected as the most representative and abundant flora, and multiflower type was included as the baseline (see Table 1).

Given the attributes and their levels, a full factorial design with two alternatives would require $(3^{3\times2})=729$ different-choice questions. Following Street et al. (2005) and Street and Burgess (2007), the present study adopted a D-optimal design, thus reducing the number of choice questions to nine with a D-optimality of 100%. D-optimal design is a unique type of sequential orthogonal design, in which the common attributes across alternatives do not take the same level, thereby maximising the differences in the attributes across alternatives and maintaining orthogonality. The choice set was designed using NGENE software (v1.2.1). An example of a choice task is presented in Fig. 2.

Fig. 2 Example of a choice set

Experimental procedure

Data collection

The Ethics Committee of the Agrifood Research and Technology Centre of Aragón (CITA), Spain, approved the research protocol and questionnaire content (no. CEISH_2021_5). Honey consumers from the north-east of Spain (Catalonia, Aragon, Madrid, Valencia, and the Basque County) comprised the target population. Following García-Madurga et al. (2019), the present study selected these cities because they represent the high-density population centres closest to Aragon. Each treatment group included 100 participants; the total sample size was 400. The participants were randomly selected and assigned to one of the four treatments using a stratified sampling procedure by age and gender. Regarding the first three treatments, the data were collected through an online experiment by a certified private company in November 2021. However, for the fourth treatment (*3D video*), data were gathered two months later (between February and April 2022) due to the restrictions of the COVID-19 pandemic and only in accordance with the anti-COVID regulations of the local health authority. Specific hygiene measures were undertaken, such as the usage of disposable eye masks, disinfection of the VR headset after each use, utilisation of plasticised choice cards to disinfect them after each use, and the proper scheduling of participants to avoid crowds. The experiment was conducted over several sessions, each with a maximum of four participants. A private company was in charge of the recruitment, offering the respondents with an incentive for participation.

Procedure

The online participants received a link on their computers to access the treatment condition to which they had been assigned. They had to provide their consent to participate in this study. The experiment consisted of the completion of the choice tasks and a survey requesting socio-demographic information. Before answering the DCE questions, the participants were exposed to visual information without written or voice-recorded descriptions; only images and the ambient sound in the video were provided. The first question on honey consumption functioned as a screening tool for selecting only honey consumers; if the answer was *'I never consume honey',* then the respondent finished the survey. In the DCE questions, the participants encountered nine choice-set scenarios, from which they had to choose between two 500-g jars of honey with different attributes and prices and a no-purchase option.

Before the presentation of choice questions, a screen appeared with instructions about the choice exercise and a script (see Appendix 3). The purpose was to remind the participants that even if they did not have to pay anything, they should be aware of their budget constraints and decide as if they were in an actual buying situation, and they were free to select the opt-out option (de-Magistris et al. 2013; Lusk 2003; Van Loo et al. 2011; Wensing et al. 2020). The participants could not proceed to the next section if they did not scroll down to the bottom of the content. Depending on the treatment, the participants were exposed to the pictures and the 2D video or directly went through the choice tasks if assigned to the *control* group. The participants could not skip the video until it played to the end.

For the *3D-video* treatment, the experiment was conducted face to face. Before beginning the 3D-video treatment sessions, the participants were asked to read and sign a consent form. They were also informed that they would receive a small gift for their participation. The tasks were subsequently explained: fill in a questionnaire, watch a video using the VR headset, and undergo the hypothetical shopping task.

Use of the virtual reality headset

When everyone had completed the survey, the participants were provided with the VR headset with a smartphone attached and the APK already running. The use of the VR glasses was explained as suggested by Song et al. (2022). First, an introduction was given, detailing the way of wearing and adjusting the VR headset (more details in Appendix 2). The participants were later given around one minute to adjust to the VR headset and visually explore the environment. They could choose whether to remain seated or stand up to turn their heads more easily. As in the online survey, the participants received the cheap talk before completing the DCE (see Appendix 3).

Econometric analyses

The analyses of the hypotheses involved specifying a utility function to calculate the marginal WTP, applying the ratio between the non-price attributes utility estimates and the price coefficient. The derivation of WTP measures across treatments requires the selection of the econometric model to be used for data analysis. Thus, different discrete choice models were explored to estimate utility parameters based on Lancaster's consumer theory of utility maximisation (Lancaster 1966) and random utility theory (McFadden 1973). Lancaster (1966) suggested that the total utility associated with a good is the result of adding the individual utility of each attribute composing that good; each consumer chooses the alternative with the highest utility.

Random utility theory posits that the researcher cannot observe the consumer's entire utility; therefore, this observed utility differs from the consumer's utility, U_{njt}. Utility functions are consequently specified as two separate components: an observable component of utility, V_{njt}, and an unobservable component, ε_{njt}, treated as a random term:

$$U_{\text{njt}} = V_{\text{njt}} + e_{\text{njt}} \tag{1}$$

where n is the individual who chooses product alternative j in the choice situation t. V_{njt} is the observable component of the utility, typically defined as the linear relationship of the attribute level x_{njt} and the corresponding coefficient β_{nj}:

$$U_{njt} = \beta_{nj}x_{njt} + e_{njt} \tag{2}$$

Given that the analyst has no information about the unobserved factor, assumptions about the way that it is distributed over the sample need to be made. Depending on these assumptions, different econometric models can then be derived.

In the empirical specification (3) of this study, the observable components of the utility function include the attributes describing the honey (origin, botanical variety, and price) with three levels each and an ASC representing the no-buy option. The ASC is a dummy variable denoting the selection of the no-buy option. $PRICE_{njt}$ is a continuous variable that takes different values depending on the level (see Table 1); meanwhile, the non-price attributes enter the utility model as dummy variables (1 = present and 0 = otherwise).

$$U_{njt} = ASC + \alpha_{price}PRICE_{njt} + \beta_{origin}ORIGIN_{njt} + \beta_{botanic}BOTANIC_{jt} + e_{njt} \tag{3}$$

The ASC of the no-buy option is expected to be negative and significant, indicating that consumers obtain a lower utility from the no-buy alternative than the product options. Following economic theory, price is also expected to negatively impact utility. For the attributes describing honey, positive signs and statistical significance are expected. Only two of the three levels for ORIGIN (Aragon and Teruel) and BOTANIC (rosemary and thyme) enter the model, as the other one is taken as the baseline for the calculation.

To estimate Eq. (3), a distribution for the error term, ε_{njt}, is needed. As previously indicated, different model specifications can depend on these assumptions. For the multinomial logit (MNL) model, presented here as a benchmark, the error term is assumed to follow a Type I extreme value distribution, and it is independently and identically distributed (iid) over time, people, and alternatives. Utility coefficients do not vary across individuals, assuming homogeneous preferences.

Second, the homogeneity assumption in utility coefficients is relaxed and a random parameter logit (RPL) model with uncorrelated coefficients is specified. The β coefficient can now be expressed as the population mean, plus the deviation of each individual from the mean preference, as this deviation is a stochastic element ($\beta = b_{mean} + \eta_{individual\ deviation}$). The coefficients associated with each attribute level are therefore allowed to randomly vary following a normal distribution. However, the price coefficient is kept fixed across individuals to ensure that the WTP estimates take the same distribution as the coefficients of the attribute (Hess and Train 2011; Revelt and Train 1998; Scarpa et al. 2008). The error term (ε_{njt}) is still assumed to follow an iid-Type I extreme value distribution.

To allow the model to capture scale heterogeneity in behavioural heterogeneity, this study specifies the generalised multinomial logit (G-MNL) model presented by Fiebig et al. (2010). The utility function (4) captures the additional layers of heterogeneity:

$$U_{njt} = [\sigma_n\beta + \gamma\eta_n + (1-\gamma)\sigma_n\eta_n]x_{njt} + \varepsilon_{njt} \tag{4}$$

where η is the specific deviation from the mean preference of each individual, σ is the scale heterogeneity, and γ is a parameter between 0 and 1. Scale heterogeneity (σ) is a correlation coefficient; thus, the G-MNL model can be considered a generalisation compared to the RPL model with uncorrelated coefficients (Hess and Train 2017).

Various samples and treatments are used in this study; hence, as stated in de-Magistris et al. (2013), the issue of whether differences in coefficients across treatments are due to the underlying preferences or variances necessitates an investigation (Louviere et al. 2000). Therefore, before estimating the model, the present study tests whether the comparison of DCE treatments is more appropriate than the use of the pooled sample. The likelihood ratio test is utilised, following Bazzani et al. (2017), de-Magistris et al. (2013), and Lusk and Schroeder (2004). The null hypothesis is that the log-likelihood of the pooled sample, LL_{PS}, equals the sum of the log-likelihood of the treatments ΣLL_T. If the hypothesis (LL_{PS} differs from ΣLL_T) is rejected, then separately modelling the treatments is expected to fit the data better than modelling the pooled sample; differences therefore exist between treatments, and comparing the marginal WTP between groups is appropriate. The likelihood ratio test is performed for the three specified models. The test statistics for equality is 2 (LL_{PS} - ΣLL_T), distributed χ^2 with K(M-1) degrees of freedom, where K is the number of restrictions and M is the number of treatments (Louviere et al. 2000).

WTP estimates are derived as the ratio of the non-price coefficients to the price coefficient and multiplied by minus one, using the coefficients from Eq. (1). To test whether differences exist in the WTP across treatments, the combinatorial test suggested by Poe et al. (2005) is used in the current study. This method initially requires deriving 1,000 WTP estimates through the bootstrapping method of Krinsky and Robb (1986), whereby a multivariate normal distribution is created using the coefficient estimates and the variance–covariance matrix from the econometric model of each treatment. The non-parametric test is performed to test the research hypotheses, as indicated in Lusk and Schroeder (2004), de-Magistris et al. (2013), and Bazzani et al. (2017).

Results

Descriptive analysis of socio-demographic characteristics

The results across treatments are compared to test the research hypotheses; hence, the possible differences between the socio-demographic characteristics of individuals across treatments are first examined. Table 2 presents a comparison of these variables across treatments. The results from the chi-square test indicate that the null hypothesis of equality between the treatments of *control*, *picture*, *2D video*, and *3D video* cannot be rejected at the 5% significance level for gender ($\chi^{2(}$Andersen et al. 2019) = 0.240; $p = 0.971$), age (($\chi^{2(}$Balázsi et al. 2019) = 1.273; $p = 0.529$), and education level ($\chi^{2(}$Bhavadharini et al. 2023) = 3.71; $p = 0.716$). This finding signifies the absence of differences between the four treatments for the mentioned characteristics. The result suggests that the randomisation is widely successful in equalising the characteristics of participants across the four treatments, allowing for the efficient testing of the hypotheses. The socio-demographic characteristics of the Spanish population are available in Appendix 4.

Table 2 Socio-demographic characteristics of the sample

Variable Definition	Control (in %)	Picture (in %)	2D Video (in %)	3D Video (in %)
Gender				
Male	53	51	50	50
Female	47	49	50	50
Chi-square (3) = 0.2401				
p-value = 0.971				
Age				
25–35 years	25.0	23.9	25.0	26.1
35–44 years	22.6	24.5	24.5	28.3
45–54 years	27.0	26%	27.0	20.0
55–65 years	25.5	25.5	23.6	25.5
Chi-square (9) = 2.2811				
p-value = 0.986				

Table 3 Hypothesis test of equality across treatments

	Number of Observations	MNL Model	RPL Model	G-MNL Model
All treatments	10,800	− 3,026.02	− 2,850.80	− 2,706.10
Control	2,700	− 780.16	− 725.04	− 689.29
Picture	2,700	− 802.16	− 753.22	− 705.73
2D video	2,700	− 786.96	− 709.07	− 666.81
3D video	2,700	− 616.86	− 607.19	− 559.67
H_0 = *test of equality across treatments* [a]		79.75***	112.51***	169.18***

[a] Likelihood ratio test

*** Significant at the 1% level

Testing equality across treatments

To relax the homogeneity assumption of consumer preferences, Eq. (1) estimates the RPL and G-MNL models, and as the baseline model, the MNL model is estimated. First, the joint equality between the *control*, *picture*, *2D-video*, and *3D-video* estimates for the MNL, RPL, and G-MNL models is tested to check if treatments differ; the estimates are subsequently compared. The likelihood ratio test is performed after specifying three models: MNL, RPL, and G-MNL. (The estimates of the models are provided in Appendix 5.) Table 3 reports the likelihood values for the pooled and segmented samples (treatments) and the equality tests for the MNL, RPL, and G-MNL models. The results indicate that the null hypothesis of equality between the likelihood values of the pooled sample and the treatments (LR = 79.75 for the MNL model, LR = 112.5 for the RPL model, and LR = 169.18 for the G-MNL model) is rejected. Therefore, comparing the estimated parameters from the various treatments is appropriate when separately estimating the models.

Finally, if the log-likelihood values are examined, then the best values are found in the G-MNL model across the different treatments (the little value, the better). Thus, the G-MNL model is used for estimating the data for each treatment, deriving WTP, and testing the research hypotheses.

Results from the G-MNL model seem to indicate that as expected in all groups, the alternative-specific constant (no-buy) is negative and significant, denoting that the consumers' utility is lower for the no-buy alternative than for the Honey A or Honey B alternatives (i.e. consumers prefer to buy than not to buy). Similarly, price is negative and statistically significant, indicating that consumers lose utility as the price increases.

In all groups, consumers perceive more utility from regional (Aragon) and local (Teruel) origin than from national (Spain) origin. The preference is observed to be higher for the regional origin (Aragon), except in the *picture* group, in which only the local origin (Teruel) is significantly more preferred than the national origin (Spain).

With regard to the botanical origin, consumers perceive more utility for the botanical origin rosemary compared to multifloral honey, with the exception of the control group, as it is negative for thyme and not even significant for rosemary. Hence, consumers generally prefer rosemary to multifloral honey, but they prefer multifloral honey to monofloral thyme honey. The preference for rosemary is identified in groups that have visualised the landscape, in any of its formats. The model estimates are presented in Appendix 5.

Testing the research hypotheses

Tables 4 and 5 report the marginal WTP across the four treatments and the corresponding hypothesis tests using the non-parametric combinational method of Poe et al. (2005), with 1,000 Krinsky and Robb (1986) bootstrapped WTP estimates. A two-sided test is utilised in the current study to test the six hypotheses (because of the type of alternative hypothesis that is considered). Significant differences are marked in bold in Tables 4 and 5.

According to Table 4, presenting the comparison between the control group and the other treatments, the first hypothesis (H_{01}: $(WTP^{Picture} - WTP^{Control}) = 0$) is rejected in the case of the botanical variety estimate (rosemary), indicating that the marginal WTP for this botanical variety is statistically higher in the *picture* treatment than in the *control* treatment. In the *control* treatment, the WTP for the rosemary attribute presents a negative sign; by contrast, the sign is positive in the *picture* treatment. This result suggests

Table 4 Comparison of the marginal WTP (€/500-g honey jar) across treatments from the G-MNL model: Hypotheses H_{01} to H_{03}

Hypothesis Test (Poe test)	Aragon	Teruel	Rosemary	Thyme
H_{01}: $(WTP^{Picture} - WTP^{Control}) = 0$				
$WTP^{Picture}$	1.12	2.19	2.05	-0.49
$WTP^{Control}$	3.12	2.34	-0.76	-1.13
p-value (Poe test)	**0.08**	0.46	**0.01**	0.21
H_{02}: $(WTP^{2D} - WTP^{Control}) = 0$				
WTP^{2D}	3.05	2.86	0.97	-0.77
$WTP^{Control}$	3.12	2.34	-0.76	-1.13
p-value (Poe test)	0.48	0.31	**0.02**	0.30
H_{03}: $(WTP^{3D} - WTP^{Control}) = 0$				
WTP^{3D}	8.33	7.51	1.55	0.90
$WTP^{Control}$	3.12	2.34	-0.76	-1.13
p-value (Poe test)	**0.00**	**0.00**	**0.00**	**0.02**

***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively

Table 5 Comparison of the marginal WTP estimates (€/500-g honey jar) across treatments from the G-MNL model: Hypotheses H_{04} to H_{06}

Hypothesis Test (Poe test)	Aragon	Teruel	Rosemary	Thyme
H_{04}: (WTP^{2D} - $WTP^{Picture}$) = 0				
WTP^{2D}	3.05	2.86	0.97	-0.77
$WTP^{Picture}$	1.12	2.19	2.05	- 0.49
p-value (Poe test)	**0.06**	0.32	0.19	0.36
H_{05}: (WTP^{3D} - WTP^{2D}) = 0				
WTP^{3D}	8.33	7.51	1.55	0.90
WTP^{2D}	3.05	2.86	0.97	−0.77
p-value (Poe test)	**0.00**	**0.01**	0.25	**0.05**
H_{06}: (WTP^{3D} - $WTP^{Picture}$) = 0				
WTP^{3D}	8.33	7.51	1.55	0.90
$WTP^{Picture}$	1.12	2.19	2.05	−0.49
p-value (Poe test)	**0.00**	**0.01**	0.34	0.10

***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively

that evoking a natural environment through pictures can influence the WTP estimates for the botanical variety of honey and reduce the no-purchase probability.

With regard to the second hypothesis (H_{02}: ($WTP^{2D} - WTP^{Control}$) = 0), it can be rejected only for the rosemary botanical variety (rosemary). Concerning the third hypothesis (H_{03}: ($WTP^{3D} - WTP^{Control}$) = 0), the null hypothesis is rejected in all of the four analysed attributes, meaning that the WTP estimates for botanical variety (rosemary and thyme) and geographical origin (Aragon and Teruel) are higher in the *3D-video* treatment than in the *control* treatment. This result suggests that when consumers are exposed to a 360°-VR video experience, their WTP for the honey attributes increases.

Table 5 presents the results for the second set of hypotheses by comparing the effect of different levels of immersion on WTP when evoking environments. In the case of the fourth hypothesis (H_{04}: ($WTP^{2D} - WTP^{Picture}$) = 0), it is rejected for geographical origin (Aragon) and botanical origin (rosemary). This outcome suggests that the WTP estimates are higher in the *2D-video* treatment compared to the *picture* treatment for honey with an Aragon origin and from the rosemary variety.

The fifth hypothesis (H_{05}: ($WTP^{3D} - WTP^{2D}$) = 0) is rejected in both origin attributes (Aragon and Teruel) and the botanical variety (thyme). This outcome indicates that the alternative hypothesis (H_{15}: ($WTP^{3D} - WTP^{2D}$) $\neq$ 0) confirms that the WTP values for origin and thyme variety are statistically higher when evoking the environment through VR instead of 2D video before the choice task.

The last hypothesis (H_{06}: ($WTP^{3D} - WTP^{Picture}$) = 0) is rejected in the two origin attributes, suggesting that the *3D video* encourages consumers more than the *picture* treatment to pay more for honey from Aragon and Teruel.

Figure 3 shows a graphical representation of the mean WTP values for each honey attribute, comparing them across treatments. It illustrates the significant positive impact of the *3D-video* presentation format on WTP for geographical origin attributes and demonstrates that pictures and 3D videos have the most positive influence on WTP for botanical origin.

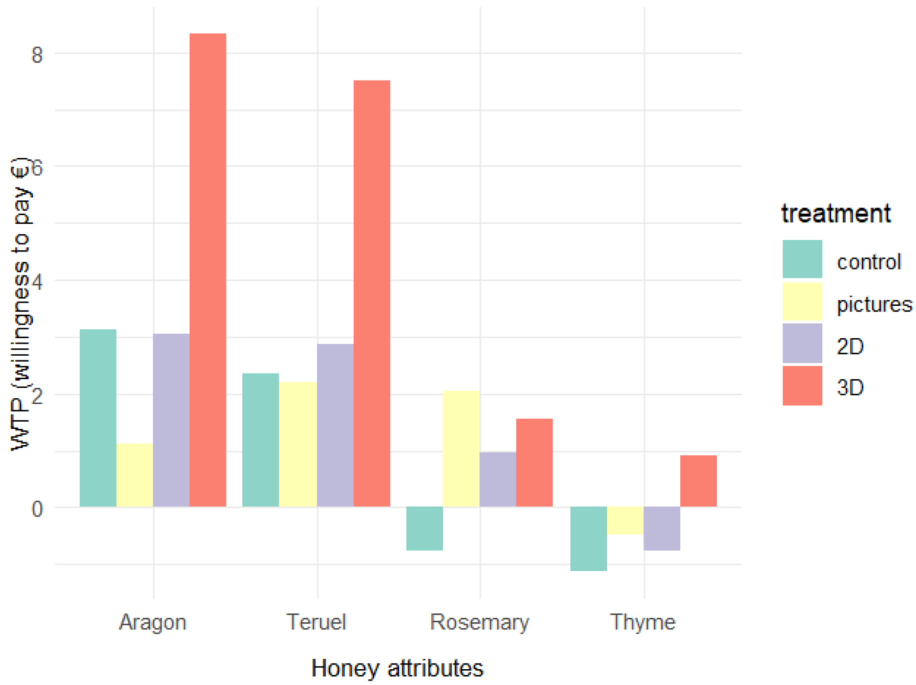


Fig. 3 Differences in WTP across treatments

Discussion

The findings of this study indicate that *3D video* is the presentation format for landscape that has the strongest impact on honey origin preferences. With regard to botanical variety, the results suggest that *picture* and *3D-video* presentation formats for landscape influence botanical variety more.

Concerning the comparison between the *control* group and the other treatments, the first (H_{01}: $(WTP^{Picture} - WTP^{Control}) = 0$) and second hypotheses (H_{02}: $(WTP^{2D} - WTP^{Control}) = 0$) are rejected for the botanical origin (rosemary) of honey. These results reveal that the marginal WTP estimates for this botanical variety are statistically higher in the *picture* and *2D-video* treatments than in the *control* treatment. The negative sign in the WTP indicates that consumers are unwilling to pay more for this attribute. The botanical variety rosemary appears with a positive WTP in all groups that visualised the landscape in any format but appears with a negative WTP in the control group. This result could be due to the fact that rosemary is more familiar to consumers, and they associate it with the visualised landscape and therefore with the territory. Therefore, by visualising the landscape, consumers associate it with a specific region with which they associate this floral variety, and this factor increases their willingness to pay for it.

Empirical evidence has confirmed the importance of the production landscape in the consumers' general quality perception of food products. For example, Cela et al. (2019) reported that consumers prefer honey produced in mountain forests and pastures because they perceived a higher guarantee of quality and medicinal properties of honey. Tempesta et al. (2010) similarly verified that the production landscape generates a significantly higher preference for the wine that consumers tasted during the experiment.

Results from the third hypothesis, which tested the differences between the *control* group and landscape *3D video* (H_{03}: $(WTP^{VID2D} - WTP^{CONT}) = 0$), confirm the significant differences in the WTP estimates for the botanical and geographical origins of honey. These results are in line with Paffarini et al. (2021), who underscored that the most important attribute affecting consumers' willingness to pay a premium price for organic lentils is the traditional rural landscape using the RPL model. However, Paffarini et al. (2021) also found that when they applied the endogenous attribute attendance model, the most vital attribute influencing the willingness to pay a premium price is the EU quality label. Several studies have shown that origin is an essential attribute in consumers' choice of honey (Blanc et al. 2021; Palmieri et al. 2022; Sama et al. 2019; Testa et al. 2019) and that the physical appearance or the ambience of the place has a vital role in place attachment, which can influence consumer choice behaviour (Carrus et al. 2013). In the present study, the landscape of production could be considered an element involved in the place attachment creation process, which could build a link between consumers and the place of production and push participants to engage with the place; their WTP subsequently increases when they see the landscape more realistically.

The acceptance of the alternative fourth hypothesis (H_{04}: $(WTP^{2D}$ - $WTP^{Picture}) = 0$; H_{14}: $(WTP^{2D}$ - $WTP^{Picture}) \neq 0$) and the alternative fifth hypothesis (H_{05}: $(WTP^{3D}$ - $WTP^{2D}) = 0$; H_{15}: $(WTP^{3D}$ - $WTP^{2D}) \neq 0$) implies significant differences in WTP. In the same line, Mokas et al. (2021) investigated whether different presentation formats change the way that people value environmental goods such as urban greenery. They found that people felt more confident about their choices when information was presented in visual forms (i.e. video and VR) than in written format (i.e. text). However, VR increased the respondents' confidence in their choices more than video. The manner by which information was presented also changed how people valued the different characteristics of urban greenery. The WTP for 'many tall trees' was higher in VR than in video, although both formats were significantly higher than in the text format. The authors suggest that the immersive nature of VR provides a more complete understanding of the scenarios, reducing uncertainty compared to video.

The last hypothesis comparing the VR (*3D video*) treatment and the *picture* treatment (H_{06}: $(WTP^{3D}$ - $WTP^{Picture}) = 0$; H_{16}: $(WTP^{3D}$ - $WTP^{Picture}) \neq 0$) confirmed significant differences in WTP for origin. Other studies have compared picture and VR as presentation formats in choice experiments. Fang et al. (2021) compared presentation formats to examine whether VR helps reduce 'hypothetical bias' (i.e. the difference between what people say they would choose or pay for in a survey and what they actually do in real life). The study compared how people made choices when given information in different formats: text on a screen, pictures on a screen, and a virtual grocery store. The results indicated that VR could help reduce hypothetical bias compared to showing choices with text or pictures on a screen, especially among people who did not feel sick from using VR. Along the same line, Matthews et al. (2017) suggested that virtual environments improved choice response reliability by decreasing the error variance. Matthews et al. (2017) compared two ways of showing information to people in a choice experiment to assess preferences for coastal management options, static images versus virtual environment videos (not interactive VR). They also observed that VR made people more interested and likely to stay engaged with the survey and found differences in WTP: the

VR group was less willing to pay for seawalls and more likely to dislike them compared to the group that saw static images. However, Andersen et al. (2019) identified some discrepancies in their results. They investigated whether using VR to create a realistic environment (e.g. a beach) could change people's desires (for drinks) and how much they preferred certain smells (e.g. sunscreen). Andersen et al. (2019) compared two ways of creating a beach environment, immersive virtual reality and a photograph condition, as well as a 'neutral' condition without a beach environment. Both beach environments (VR and picture) made people want cold drinks more than hot drinks, but their desire for cold drinks was stronger in the VR environment. Nonetheless, the different environments did not change how much people liked the smell of the skincare products.

A more general analysis of the results indicates that the most significant difference in the WTP estimates among presentation formats is between *picture* and *3D video*. This finding suggests that the level of immersion in which the images of landscape are presented to consumers affects their selections in the choice experiments. These results are in line with Jaeger and Porcherot (2018), who argue that the format of presentation and the degree of realism of contextual elements strongly influence consumer responses, particularly when evaluating food products. Their review examines the appropriateness of product use in specific contexts and the ecological validity of experiments by considering realistic consumption settings. According to Jaeger and Porcherot (2018), hedonic and sensory responses are less affected, but emotional associations and WTP are more context-dependent. They conclude that more immersive formats such as VR can enhance realism, potentially leading to greater emotional engagement and more accurate measures of consumer preferences; additionally, they contend that context matters because the more closely one's presentation simulates real-life settings, the more valid and reliable consumer responses will be.

In line with these conclusions, some authors suggested that virtual environments were comparable to real-world behaviour. Van Herpen et al. (2016) reported that a VR simulation of a grocery store could better reproduce real consumer choice behaviour than picture condition; furthermore, consistent with this finding, de-Magistris et al. (2022) found no significant differences in the results from a real-choice experiment and the results from a virtual supermarket choice experiment.

Recommendations and limitations

These findings have important methodological implications for further experiments in the field. The use of a 360º–3D video seems to bring more realism to the experiment and, therefore, may help improve the external validity of the experiment when hypothetical choice experiments are implemented. To test the robustness of the results or to become incentive-compatible with the DCE questions, the replication of the design adopted in this study by using different contexts (i.e. creating immersive environments for grocery store experiments) and various products would be an interesting direction for future research.

The results also have practical implications for beekeepers and marketers of honey. The study confirms that using a 360º–3D video increases the WTP of honey for geographical origin. This communication tool provides consumers with valuable product information in a lively manner, and it may generate a more profound memory of the product. The beekeeping sector could adopt more immersive marketing strategies by combining existing labelling tools such as QR codes and visual information collected in a 360°−3D-video format. In this particular case, a QR code could contain the 360°−3D video, and customers could have a head-mounted display available at the place of purchase in such a way that they could use their smartphone to visualise the landscape where the honey was produced.

Finally, the proposed communication tool has relevant implications for policymakers, as it would benefit the beekeepers and the territory where the honey is harvested. Linking the product to the territory could raise customer interest in the production area, benefitting the tourist sector of the territory.

However, some limitations should be acknowledged, offering opportunities for future research. This study merely deals with hypothetical experiments; additionally, aside from the cheap talk, the experience of being in front of researchers is known to engender social desirability bias. Therefore, future research must validate the results of this study with non-hypothetical experiments such as experimental home-grown action or no-hypothetical choice experiments. Future research should also confirm whether differences exist between the control group and information treatment without any relationship with the product object of investigation (in the case of this study, honey products). For example, future research could include control conditions with a neutral video or images.

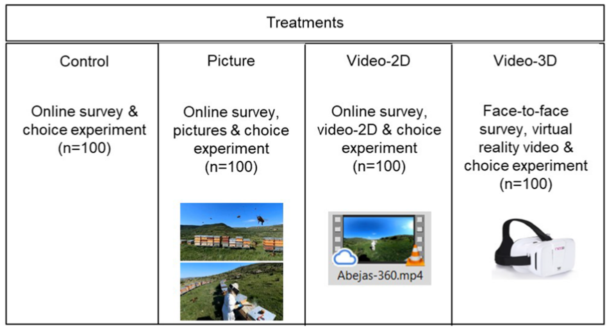
Finally, this study has some methodological limitations. First, the data for the first three treatments were collected online, but the VR (3D video) condition required in-person participation due to equipment constraints. Second, although procedures were carefully standardised across settings, the differing environments may have introduced subtle variations in participant engagement or response behaviour. This aspect should be considered a potential limitation of the study.

Moreover, an interesting research direction would be the assessment of the sense of presence for this 360°−3D video, for example, using the ITC–sense of presence inventory that analyses the four dimensions of presence (spatial presence, engagement, naturalness, and negative effects) and compares them to a real environment.

Conclusion

This study explores production landscape as contextual information for food choice and the way that immersive technologies such as VR can enhance consumer engagement and preference in food marketing. By focusing on honey and its connection to landscape, this study addresses how the use of different presentation formats of production landscape could affect consumers' preferences. The findings identify 3D video as the presentation format for landscape that has the strongest impact on honey origin preferences. However, the results for botanical variety suggest that the picture presentation format for landscape influences botanical variety more. The integration of VR into marketing strategies represents a promising direction for promoting traditional foods. Linking honey consumption to rural landscapes might reconnect consumers with food origins and increase perceived value, contributing to product differentiation and competitiveness.

Appendix 1



Appendix 2

Treatments description

In video 2D treatment, participants watched a 3:22-min HD video on their PC or smartphone (whereas they open the link to the survey) with the same visual sequence as the Pictures treatment through the honey production environment.

In the VR group, participants wore Woxter Neo Vr1 headsets with a RedMi Note 4 attached and equipped with a custom APK developed for the experiment. The VR content consisted of a 360° stereoscopic video of the same duration as the 2D video (3 min and 33 s). The sequence of images was the same as in the Video 2D treatment. The video was non-interactive (no navigation or controls), but created a strong sense of presence through depth, movement, and ambient audio (e.g. birds, bees buzzing, wind). No text or verbal instructions were given during the experience.

Use of virtual reality headset

When participants put on the glasses, they saw an empty environment with the logo of the research centre. Here, they could start moving their head and eyes to familiarise themselves with the device, and we asked them to look for a video window. To start the video, the APK had a pointer controlled by head movement; the video-3D started to play when the pointer was placed on the video for 3 s. The participants could not interact with the video, only watch it in 360º and 3D perspective.

Appendix 3

Cheap talk script.

Now, you are going to do a shopping simulation. This is a hypothetical exercise where you do not have to pay anything. However, we ask you to answer each scenario as if it were a real purchase. You will answer 9 shopping scenarios.

Imagine you are in a supermarket or a shop and you are making this decision. Buying this product would mean that you would have less money available for other purchases.

In each scenario, you are presented with 2 different honey alternatives and the option to buy none. The 3 honey alternatives are different in price (3.5, 4.5, 5.5 euros), in place *of origin (Spain, Aragon, Teruel) and in the type of flower they come from (multiflower, thyme, rosemary).*

In each scenario, choose the alternative you prefer to buy at the price indicated. You can also choose not to buy any of the alternatives offered. Please consider each option carefully before making a decision.

Select only 1 alternative or the option not to buy at all.

The features that are not specified for these jars are identical for all the alternatives presented.

Once you have made your choice and moved on to the next scenario, you cannot go back. The choices you make are independent of each other, so ignore the choices you have already made. Make each decision based only on the information given in each scenario.

Thank you for your participation.

Appendix 4

Socio-demographic characteristics of the Spanish population for gender and age.

Gender	%
Male	49
Female	51
Age	
25–34	20
35–44	27
45–54	29
55–64	24

Appendix 5

Estimated coefficients of MNL, RPL, GMXL models for treatments and pooled sample.

	ALL	CONTROL	PICTURES	2D	3D
MNL					
β Aragon	0.74***	0.57***	0.55***	0.66***	1.19***
β Teruel	0.76***	0.66***	0.62***	0.74***	1.05***
β Rosemary	0.19***	0.16	0.26**	0.10	0.25**
β Thyme	− 0.11**	− 0.17	− 0.13	− 0.16	0.04
β Price	− 0.52***	− 0.56***	− 0.47***	− 0.51***	− 0.56***
β None	− 3.60***	− 3.76***	− 3.23***	− 3.45***	− 4.42***
RPL					
β Aragon	1.15***	0.91***	0.80***	1.18***	1.45***
β Teruel	1.16***	0.98***	0.89***	1.29***	1.29***
β Rosemary	0.19**	0.23	0.18	0.11	0.30***
β Thyme	− 0.24**	− 0.34	− 0.24	− 0.29	− 0.01
β Price	− 0.84***	− 0.87***	− 0.72***	− 0.93***	− 0.71***
β None	− 5.22***	− 5.30***	− 4.48***	− 5.57***	− 5.12***
GMXL					
β Aragon	5.72***	3.49***	0.91	3.06***	7.59***
β Teruel	3.96***	2.62***	1.75*	2.89***	6.84***
β Rosemary	0.87***	− 0.86	1.61**	0.98*	1.39**
β Thyme	− 0.80**	− 1.26**	− 0.37	− 0.79	0.86

	ALL	CONTROL	PICTURES	2D	3D
β Price	− 1.01***	− 1.13***	− 0.78***	− 1.01***	− 0.91***
β None	− 6.19***	− 6.97***	− 5.32***	− 6.22***	− 6.18***

***, **, * Significance at 1%, 5%, 10% level

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Author contributions
PU. contributed to conceptualisation, methodology, acquisition, visualisation, formal analysis, writing—original draft preparation, writing—reviewing and editing, and provided software. MTM was involved in reviewing and editing, Td-M contributed to conceptualisation, methodology, acquisition, validation, writing—reviewing and editing, resources, supervision, project administration, funding acquisition and provided software and PU, MTM, and T.d-M have approved the submitted version (and any substantially modified version that involves the author's contribution to the study) and to have agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Competing interests
The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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References

Andersen INSK, Kraus AA, Ritz C, Bredie WLP (2019) Desires for beverages and liking of skin care product odors in imaginative and immersive virtual reality beach contexts. Food Res Int 117:10–18. https://doi.org/10.1016/j.foodres.2018.01.027

Balázsi Á, Riechers M, Hartel T, Leventon J, Fischer J (2019) The impacts of social-ecological system change on human-nature connectedness: a case study from Transylvania. Romania Land Use Policy 89:104232. https://doi.org/10.1016/j.landusepol.2019.104232

Baršytė J, Ruzeviciute R, Neciunskas P, Schlegelmilch BB (2023) When "Global" becomes a challenge: the role of freshness in food brand preference formation. J Int Mark 31(4):23–35. https://doi.org/10.1177/1069031X231179149

Bazzani C, Nayga RM Jr, Kim AH, Atallah SS (2017) Willpower depletion: Can it influence responses and attribute non-attendance in choice experiments? Agric Appl Econ Assoc 106:467–467. https://doi.org/10.22004/ag.econ.258261

Bhavadharini B, Monica V, Anbarasan R, Mahendran R (2023) Virtual, augmented, and mixed reality as a versatile tool in food consumer behavior evaluation: recent advances in aroma, taste, and texture incorporation. Compr Rev Food Sci Food Saf 22(6):4925–4956. https://doi.org/10.1111/1541-4337.13248

Birenboim A, Dijst M, Ettema D, De Kruijf J, De Leeuw G, Dogterom N (2019) The utilization of immersive virtual environments for the investigation of environmental preferences. Landsc Urban Plan 189:129–138. https://doi.org/10.1016/j.landurbplan.2019.04.011

Blanc S, Zanchini R, Di Vita G, Brun F (2021) The role of intrinsic and extrinsic characteristics of honey for Italian millennial consumers. Br Food J 123(6):2183–2198. https://doi.org/10.1108/BFJ-07-2020-0622

Branca G, Resciniti R, Loureiro SMC (2023) Virtual is so real! Consumers' evaluation of product packaging in virtual reality. Psychol Mark 40(3):596–609. https://doi.org/10.1002/mar.21743

Cantarero L, Espeitx E, Gil Lacruz M, Martín P (2013) Human food preferences and cultural identity: the case of Aragón (Spain). Int J Psychol 48(5):881–890. https://doi.org/10.1080/00207594.2012.692792

Garrido-Fernández D, Moumeh B (2018) Características fisicoquímicas y sensoriales de la miel. In: Recuperar la miel para recuperar el territorio: análisis del sector apícola de Teruel, Eds: de-Magistris T. & López-Galán B. Z 2081–2018. CITA, Zaragoza

Carrus G, Scopelliti M, Fornara F, Bonnes M, Bonaiuto M (2013) Place attachment, community identification and pro-environmental engagement. In: Manzo L, Devine-Wright P (eds.) Place Attachment: Advances in Theory, Methods and Applications (1st ed.). Routledge, London, New York. https://doi.org/10.4324/9780203757765

Cela A, Zhllima E, Imami D, Skreli E, Canavari M, Chan C (2019) Analysis of urban consumer preferences for honey in the context of a transition economy – A case study for Albania. Die Bodenkultur: J Land Manage Food Environ 70(4):237–248. https://doi.org/10.2478/boku-2019-0021

Cinnamon J, Jahiu L (2023) 360-degree video for virtual place-based research: a review and research agenda. Comput Environ Urban Syst 106:102044. https://doi.org/10.1016/j.compenvurbsys.2023.102044

Cipresso P, Giglioli IAC, Raya MA, Riva G (2018) The past, present, and future of virtual and augmented reality research: a network and cluster analysis of the literature. Front Psychol 9:2086. https://doi.org/10.3389/fpsyg.2018.02086

Clément H (2012) Tratado de apicultura: El conocimiento y el cuidado de la abeja. Las técnicas apícolas y los productos de la colmena, Omega, Barcelona

Consonni R, Cagliani LR (2010) Nuclear Magnetic Resonance and Chemometrics to Assess Geographical Origin and Quality of Traditional Food Products. En Advances in Food and Nutrition Research (Vol. 59, pp. 87–165). Elsevier. https://doi.org/10.1016/S1043-4526(10)59004-1

Cosmina M, Gallenti G, Marangon F, Troiano S (2016) Reprint of "Attitudes towards honey among Italian consumers: a choice experiment approach." Appetite 106:110–116. https://doi.org/10.1016/j.appet.2016.08.005

De-Magistris T, Gracia A, Nayga RM (2013) On the use of honesty priming tasks to mitigate hypothetical bias in choice experiments. Am J Agric Econ 95(5):1136–1154. https://doi.org/10.1093/ajae/aat052

De-Magistris T, López-Galán B, Ballco P (2022) Do virtual reality experiments replicate projection bias phenomena? Examining the external validity of a virtual supermarket. J Agric Econ 73(1):20–34. https://doi.org/10.1111/1477-9552.12443

DeLong KL, Syrengelas KG, Grebitus C, Nayga RM (2021) Visual versus text attribute representation in choice experiments. J Behav Exp Econ 94:101729. https://doi.org/10.1016/j.socec.2021.101729

Fang D, Nayga RM, West GH, Bazzani C, Yang W, Lok BC, Levy CE, Snell HA (2021) On the use of virtual reality in mitigating hypothetical bias in choice experiments. Am J Agr Econ 103(1):142–161. https://doi.org/10.1111/ajae.12118

Feiereisen S, Wong V, Broderick AJ (2008) Analogies and mental simulations in learning for really new products: the role of visual attention. J Prod Innov Manag 25(6):593–607. https://doi.org/10.1111/j.1540-5885.2008.00324.x

Fiebig DG, Keane MP, Louviere J, Wasi N (2010) The generalized multinomial logit model: accounting for scale and coefficient heterogeneity. Mark Sci 29(3):393–421

Galiñanes Plaza A, Delarue J, Saulais L (2019) The pursuit of ecological validity through contextual methodologies. Food Qual Prefer 73:226–247. https://doi.org/10.1016/j.foodqual.2018.11.004

García-Madurga M-Á, Esteban-Navarro M-Á, Delgado-de Miguel J-F, Buil-López Menchero T (2019) Positioning axes of sustainable tourist destinations: the case of aragón. Sustainability 11(18):18. https://doi.org/10.3390/su11184885

Garcia-Martin M, Fagerholm N, Bieling C, Gounaridis D, Kizos T, Printsmann A, Müller M, Lieskovský J, Plieninger T (2017) Participatory mapping of landscape values in a Pan-European perspective. Landscape Ecol 32(11):2133–2150. https://doi.org/10.1007/s10980-017-0531-x

Van Herpen E, Van Den Broek E, Van Trijp HCM, Yu T (2016) Can a virtual supermarket bring realism into the lab? Comparing shopping behavior using virtual and pictorial store representations to behavior in a physical store. Appetite 107:196–207. https://doi.org/10.1016/j.appet.2016.07.033

Hess S, Train KE (2011) Recovery of inter- and intra-personal heterogeneity using mixed logit models. Transp Res Part B Methodol 45(7):973–990. https://doi.org/10.1016/j.trb.2011.05.002

Hess S, Train K (2017) Correlation and scale in mixed logit models. J Choice Model 23:1–8. https://doi.org/10.1016/j.jocm.2017.03.001

Hibbard JH, Slovic P, Peters E, Finucane ML (2002) Strategies for reporting health plan performance information to consumers: evidence from controlled studies. Health Serv Res 37(2):291–313. https://doi.org/10.1111/1475-6773.024

Porcherot C, Delplanque S, Gaudreau N, Ischer M, De Marles A, Cayeux I (2018) Immersive techniques and virtual reality. In: Ares, G., and Varela, P. (Eds.), Methods in Consumer Research Alternative: approaches and Special Applications, Part I: Doing Consumer Research, 2, (pp.69–83). Woodhead Publishing Series in Food Science, Technology and Nutrition https://doi.org/10.1016/b978-0-08-101743-2.00003-0

Jaeger SR, Porcherot C (2017) Consumption context in consumer research: methodological perspectives. Curr Opin Food Sci 15:30–37. https://doi.org/10.1016/j.cofs.2017.05.001

Kallas Z, Alba MF, Casellas K, Berges M, Degreef G, Gil JM (2021) The development of short food supply chain for locally produced honey: understanding consumers' opinions and willingness to pay in Argentina. Br Food J 123(5):1664–1680. https://doi.org/10.1108/BFJ-01-2019-0070

Kapelari S, Alexopoulos G, Moussouri T, Sagmeister KJ, Stampfer F (2020) Food heritage makes a difference: the importance of cultural knowledge for improving education for sustainable food choices. Sustainability 12(4):1509. https://doi.org/10.3390/su12041509

Kotler P (1973) Atmospherics as a marketing tool. J Retail 49(4):48–64

Krinsky I, Robb AL (1986) On approximating the statistical properties of elasticities. Rev Econ Stat 68(4):715. https://doi.org/10.2307/1924536

Lancaster KJ (1966) A new approach to consumer theory. J Polit Econ 74(2):132–157

Van Loo EJ, Caputo V, Nayga RM, Meullenet J-F, Ricke SC (2011) Consumers' willingness to pay for organic chicken breast: evidence from choice experiment. Food Qual Prefer 22(7):603–613. https://doi.org/10.1016/j.foodqual.2011.02.003

Louviere JJ, Hensher DA, Swait JD (2000) Stated choice methods: analysis and applications. Cambridge University Press. Second Edition, Cambridge

Lusk JL (2003) Effects of cheap talk on consumer willingness-to-pay for golden rice. Am J Agr Econ 85(4):840–856. https://doi.org/10.1111/1467-8276.00492

Lusk JL, Schroeder TC (2004) Are choice experiments incentive compatible? A Test with quality differentiated beef steaks. Am J Agr Econ 86(2):467–482. https://doi.org/10.1111/j.0092-5853.2004.00592.x

Manzo L, Devine-Wright P (eds) (2013a) Place Attachment. Routledge. https://doi.org/10.4324/9780203757765

Manzo L, Devine-Wright P (eds) (2013b) Place Attachment: Advances in Theory, Methods and Applications, 1st edn. Routledge. https://doi.org/10.4324/9780203757765
Matthews Y, Scarpa R, Marsh D (2017) Using virtual environments to improve the realism of choice experiments: a case study about coastal erosion management. J Environ Econ Manag 81:193–208. https://doi.org/10.1016/j.jeem.2016.08.001
McFadden D (1973) Conditional Logit Analysis of Qualitative Choice Behavior. In: Zarembka P (ed) Frontiers in Econometrics. Academic Press, pp 105–142
Meißner M, Pfeiffer J, Peukert C, Dietrich H, Pfeiffer T (2020) How virtual reality affects consumer choice. J Bus Res 117:219–231. https://doi.org/10.1016/j.jbusres.2020.06.004
Mkedder N, Jain V, Salunke P (2024) Determinants of virtual reality stores influencing purchase intention: AN interpretive structural modeling approach. J Retail Consum Serv 78:103757. https://doi.org/10.1016/j.jretconser.2024.103757
Mokas I, Lizin S, Brijs T, Witters N, Malina R (2021) Can immersive virtual reality increase respondents' certainty in discrete choice experiments? A comparison with traditional presentation formats. J Environ Econ Manag 109:102509. https://doi.org/10.1016/j.jeem.2021.102509
Mol JM (2019) Goggles in the lab: economic experiments in immersive virtual environments. J Behav Exp Econ 79:155–164. https://doi.org/10.1016/j.socec.2019.02.007
Murwirapachena G, Dikgang J (2022) The effects of presentation formats in choice experiments. Environ Econ Policy Stud 24(3):421–445. https://doi.org/10.1007/s10018-021-00328-4
Paffarini C, Torquati B, Tempesta T, Venanzi S, Vecchiato D (2021) Rural sustainability and food choice: The effect of territorial characteristics on the consumers' preferences for organic lentils. Agric Food Econ 9(1):29. https://doi.org/10.1186/s40100-021-00200-9
Palmieri N, Stefanoni W, Latterini F, Pari L (2022) Italian consumer preferences for eucalyptus honey: an exploratory study. Sustainability 14(13):13. https://doi.org/10.3390/su14137741
Patterson Z, Darbani JM, Rezaei A, Zacharias J, Yazdizadeh A (2017) Comparing text-only and virtual reality discrete choice experiments of neighbourhood choice. Landsc Urban Plan 157:63–74. https://doi.org/10.1016/j.landurbplan.2016.05.024
Poe GL, Giraud KL, Loomis JB (2005) Computational methods for measuring the difference of empirical distributions. Am J Agr Econ 87(2):353–365
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
Roman A, Popiela-Pleban E, Kozak M, Roman K (2013) Factors influencing consumer behavior relating to the purchase of honey part 2. Product quality and packaging. J Apic Sci 57(2):175–185. https://doi.org/10.2478/jas-2013-0027
Rossetti T, Hurtubia R (2020) An assessment of the ecological validity of immersive videos in stated preference surveys. J Choice Modell 34:100198. https://doi.org/10.1016/j.jocm.2019.100198
Sama C, Crespo-Cebada E, Díaz-Caro C, Mesías FJ (2019) Análisis de las preferencias de los consumidores españoles hacia la miel de producción social y ambientalmente responsable frente a la de Comercio Justo. Archivos De Zootecnia 68(264):264. https://doi.org/10.21071/az.v68i264.4988
Scarpa R, Thiene M, Train K (2008) Utility in willingness to pay space: a tool to address confounding random scale effects in destination choice to the alps. Am J Agr Econ 90(4):994–1010. https://doi.org/10.1111/j.1467-8276.2008.01155.x
Schuemie MJ, Van Der Straaten P, Krijn M, Van Der Mast CAPG (2001) Research on presence in virtual reality: a survey. Cyberpsychol Behav 4(2):183–201. https://doi.org/10.1089/109493101300117884
Schutz HG, Martens M (2001) Appropriateness as a Cognitive-Contextual Measure of Food Attitudes. In: Frewer LJ, Risvik E, Schifferstein H (eds) Food, People and Society. Springer, Berlin, Heidelberg
Schutz HG (1994) Appropriateness as a measure of the cognitive-contextual aspects of food acceptance. In H. J. H. MacFie & D. M. H. Thomson (Eds.), Measurement of Food Preferences (pp. 25–50). Springer US. https://doi.org/10.1007/978-1-4615-2171-6_2
Sina AS, Wu J (2023) The effects of retail environmental design elements in virtual reality (VR) fashion stores. Int Rev Retail Distrib Consu Res 33(1):1–22. https://doi.org/10.1080/09593969.2022.2049852
Sinesio F, Moneta E, Porcherot C, Abbà S, Dreyfuss L, Guillamet K, Bruyninckx S, Laporte C, Henneberg S, McEwan JA (2019) Do immersive techniques help to capture consumer reality? Food Qual Prefer 77:123–134. https://doi.org/10.1016/j.foodqual.2019.05.004
Slater M, Wilbur S (1997) A framework for immersive virtual environments (FIVE): speculations on the role of presence in virtual environments. Presence Teleoperators Virtu Environ 6(6):603–616. https://doi.org/10.1162/pres.1997.6.6.603
Song X, Pérez-Cueto FJA, Bredie WLP (2022) Food desires and hedonic discrimination in virtual reality varying in product-context appropriateness among older consumers. Foods 11(20):20. https://doi.org/10.3390/foods11203228
Sparacino A, Merlino VM, Blanc S, Borra D, Massaglia S (2022) a choice experiment model for honey attributes: Italian consumer preferences and socio-demographic profiles. Nutrients 14(22):22. https://doi.org/10.3390/nu14224797
Street DJ, Burgess L (2007) The construction of optimal stated choice experiments: Theory and methods. Wiley
Street DJ, Burgess L, Louviere JJ (2005) Quick and easy choice sets: constructing optimal and nearly optimal stated choice experiments. Int J Res Mark 22(4):459–470. https://doi.org/10.1016/j.ijresmar.2005.09.003
Stroebele N, De Castro JM (2004) Effect of ambience on food intake and food choice. Nutrition 20(9):821–838. https://doi.org/10.1016/j.nut.2004.05.012
Tempesta T, Giancristofaro RA, Corain L, Salmaso L, Tomasi D, Boatto V (2010) The importance of landscape in wine quality perception: an integrated approach using choice-based conjoint analysis and combination-based permutation tests. Food Qual Prefer 21(7):827–836. https://doi.org/10.1016/j.foodqual.2010.04.007
Testa R, Asciuto A, Schifani G, Schimmenti E, Migliore G (2019) Quality determinants and effect of therapeutic properties in honey consumption. An exploratory study on Italian consumers. Agriculture 9(8):8. https://doi.org/10.3390/agriculture9080174
Thøgersen J (2023) How does origin labelling on food packaging influence consumer product evaluation and choices? A systematic literature review. Food Policy 119:102503. https://doi.org/10.1016/j.foodpol.2023.102503

Torrico DD, Han Y, Sharma C, Fuentes S, Gonzalez Viejo C, Dunshea FR (2020) Effects of context and virtual reality environments on the wine tasting experience, acceptability, and emotional responses of consumers. Foods 9(2):191. https://doi.org/10.3390/foods9020191

Uggeldahl K, Jacobsen C, Lundhede TH, Olsen SB (2016) Choice certainty in discrete choice experiments: Will eye tracking provide useful measures? J Choice Modell 20:35–48. https://doi.org/10.1016/j.jocm.2016.09.002

Farooq B (2018) Virtual immersive reality for stated preference travel behaviour experiments: a case study of autonomous vehicles on urban roads

Meyerhoff J, Klefoth T, Arlinghaus R (2021) Visual versus text-based choice sets: Investigating differences in validity and value estimates

Wedel M, Bigné E, Zhang J (2020) Virtual and augmented reality: advancing research in consumer marketing. Int J Res Mark 37(3):443–465. https://doi.org/10.1016/j.ijresmar.2020.04.004

Wensing J, Caputo V, Carraresi L, Bröring S (2020) The effects of green nudges on consumer valuation of bio-based plastic packaging. Ecol Econ 178:106783. https://doi.org/10.1016/j.ecolecon.2020.106783

Xu C, Demir-Kaymaz Y, Hartmann C, Menozzi M, Siegrist M (2021) The comparability of consumers' behavior in virtual reality and real life: a validation study of virtual reality based on a ranking task. Food Qual Prefer 87:104071. https://doi.org/10.1016/j.foodqual.2020.104071

Yin H, Cherchi E (2024) Preferences for automated taxis. A comparison between immersive virtual reality and screen-based stated choice experiments. Transp Res Part C Emerg Technol 163:104628. https://doi.org/10.1016/j.trc.2024.104628

Zulkarnain AHB, Cao X, Kókai Z, Gere A (2024) Self-assessed experience of emotional involvement in sensory analysis performed in virtual reality. Foods 13(3):375. https://doi.org/10.3390/foods13030375

Ben-Ali, S., Taghouti, I., & University of Carthage, INRGREF, Laboratory of Management and Valorization of Forest Resources. Rue Hédi El Karray El Menzah IV, 1004 Tunis BP 10 Ariana 2080, Tunisia / Center for Agro-Food Economics and Development (CREDA-UPC-IRTA). Parc mediterrani de la tecnologia. Edifici ESAB, carrer esteve terradas 8. Castelldefels 08860, Spain (2022) Tunisian consumer preferences for local forest honey attributes: a market segmentation analysis. Span J Agric Res 20(1):e0101–e0101. https://doi.org/10.5424/sjar/2022201-18411

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