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# Are natural and functional ingredients valued by meat consumers? From what you claim to think to what you like to taste

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**ORIGINAL ARTICLE**

## Abstract

This article evaluates consumer liking and preferences toward the use of cherries and pecan nuts in novel formulations of lamb burgers to improve their nutritional content and shelf life. Data were obtained from October to December 2021, with a sample of 149 untrained consumers. Participants completed two tasks: first, a sensory test where they tasted and rated the burgers and second, a choice experiment to study their purchasing preferences. Results showed that consumers preferred the taste of the control burger and especially disliked the cherry-added burger. However, they showed interest in the addition of natural ingredients to improve the nutritional features of lamb burgers.

*Keywords*: cherry; choice experiment; lamb burger; natural and functional ingredients; nut; preferences; sensorial studies

## Introduction

Agriculture and livestock farming are fundamental to society, providing essential food and resources for millennia. However, with the increasing level of urban development over the past decades, the relationship between consumers and the rural environment, where food is produced, has weakened as a result of the emergence of new stakeholders that deal with the final stages of food distribution and are in direct contact with consumers.

In this context, traditional food consumption trends have been changing due to the urbanization process and the emergence of new work patterns within families, or the growing concerns about the influence of food on health, among others (Godfray *et al*., 2018).

These changes have had a significant impact on how and what we eat, and consequently on food producers. Particularly, meat and meat products, whose production and consumption have been associated with various negative issues in recent years, require special attention. From an environmental perspective, livestock production systems are linked to climatic changes due to the greenhouse gas emissions from livestock farming and deforestation, as this practice opens up new pastures and crops for animals (Reisinger and Clark, 2018). Additionally, from a consumer health perspective, certain

studies have linked the consumption of meat and meat products to the increased incidence of certain diseases. Finally, ethical issues, such as animal welfare, have also emerged as strong factors contributing to fuel the controversy behind meat consumption.

However, consumers in Western countries seem reluctant to cut down on meat consumption (Tobler *et al*., 2011), although these concerns have pushed them toward alternative meat products in the hope of offsetting the aforementioned drawbacks (Weinrich and Elshiewy, 2019). Moreover, this scenario has impelled the food industry to develop new food products that benefit consumers in line with the aforementioned needs, and thus fill these gaps in demand.

Despite the shortcomings, meat consumption has remained constant in recent years in the European Union (EU), although there has been a decline in certain specific categories (European Commission, 2018). In particular, red meat consumption has decreased as a result of research findings that the higher the consumption of red meat, especially processed red meat, the higher the risk of various diseases, such as type 2 diabetes and cardiovascular disease (Larsson and Orsini, 2014; Micha *et al*., 2010).

The significant decline in lamb consumption, both in Spain and the EU (Rabadán *et al*., 2020), and substantial losses for sheep farmers, is an example of this trend. One of the reasons for the decline in its consumption is the strong flavor of the meat, which reduces the level of acceptance among unaccustomed consumers. Additionally, lamb meat is uncommon in processed meat products such as meatballs or burgers, and is mainly sold in traditional cuts, such as leg or shoulder. This fact has alienated potential new consumers and aggravated the problem.

Lifestyle changes in recent years—consumers who have less time and therefore demand more convenient or ready-to-eat food products—have forced the food industry to develop strategies to diversify products that better suit consumer demands and are more appealing. In the meat sector, this approach has led to the rise of processed products such as burgers, which have become popular worldwide due to their convenience of preparation and consumption, low cost, and pleasant taste. Consumption of burgers in Spain alone exceeded 3 million units per week (MAPA, 2018). Despite the above figures, burgers are perceived as an unhealthy food choice because of their link to red meat (Binnie *et al*., 2014), as well as their saturated fat content and lack of fiber, all of which are associated with cardiovascular diseases, colorectal cancer, and obesity prevalence (Spencer *et al*., 2005).

In this context, the use of lamb meat in burgers could have a twofold effect. First, it could lead to an increase in consumption, as it would be made available in a highly demanded type of food formulation. Second, because burgers are frequently consumed by youngsters, it could help them become familiar with the product, which in turn would contribute to building up a consumption habit. Moreover, lamb meat is regarded as a product with extraordinary sensory attributes (Linares *et al*., 2007, 2008) and a strong, sustainable reputation. For instance, in Spain, it is mainly produced sustainably and largely linked to rural and depopulated areas, as well as valuable ecosystems, thus playing a relevant role in the economy and the maintenance of the population in those areas.

Although these attributes could contribute to improving the image of burgers, their negative perception from a health perspective makes it necessary to seek additional strategies. Among these strategies, the addition of natural antioxidants and fiber obtained from natural resources could result in a healthier and attractive product for consumers (Madane *et al*., 2019).

There is a considerable number of studies on the use of natural ingredients in meat products, such as natural antioxidants in pork burgers (Ganhão *et al*., 2011, 2013) or extracts obtained from rose hips in cooked ham (Armenteros *et al*., 2016). Fruit or vegetable extracts and by-products have been used as ingredients in burgers to not only provide antioxidant compounds (Ganhão *et al*., 2010) but also to add dietary fiber and improve the nutritional characteristics of meat (Horrillo *et al*., 2022). Consequently, the addition of natural ingredients, such as cherry or pecan nuts, might potentially result in a healthier and more appealing product for the consumer. Cherries (*Prunus avium L.*) are an important source of antioxidants, while pecan nuts (*Carya illinoinensis*) are a source of healthy mono- and polyunsaturated fats, with both fruits also providing dietary fibers.

Pecan nuts contain numerous phenolic compounds, as well as a large amount of bioactive chemicals with functional properties (Malik *et al*., 2009). Nut intake has been found to decrease the risk of cardiovascular disease, cancer, type 2 diabetes, and obesity in several studies (Atanasov *et al*., 2018; Owen *et al*., 2000). Pecan nuts have a healthy fatty acid profile, despite being high in fat content, due to the elevated presence of unsaturated fatty acids (Atanasov *et al*., 2018). Jiménez-Colmenero *et al*. (2003) attempted the reconstruction of beef fillets with walnuts, which produced satisfactory physicochemical and sensory qualities, as well as a higher amount of heart-healthy fatty acids. The addition of nuts to meat products could turn meat into a functional food product (Jiménez-Colmenero *et al*., 2010).

The cherry, on the other hand, is a high-quality fruit widely recognized for its nutritional and organoleptic qualities. It contains considerable levels of functional compounds, such as polyphenols, anthocyanidin pigments, and indoleamines, all of which are effective antioxidants in addition to a variety of other beneficial features (Serradilla *et al*., 2011). Nowak *et al*. (2016) used polyphenolic extracts from cherry and black currant leaves as natural preservatives in meat products, which were highly accepted by consumers.

Despite the nutritional and health benefits of incorporating these ingredients in meat products in general, and in burgers in particular, consumers may still have a negative attitude toward "enhanced" foods. Neophobia, a common negative reaction to new things (Frewer *et al*., 2011), may be a reason, or the perception that meat is being overprocessed due to the addition of unusual ingredients. However, consumers are initially prone to welcome the use of plant-based ingredients and the reduction of fats and salts (Barone *et al*., 2021).

Within this framework, this research aims to analyze consumer preferences for lamb burgers enriched with pecans or cherries, compared to conventional burgers commonly found in supermarkets. The objective is to deepen our understanding of consumer attitudes and preferences toward these innovative products. Previously, the research team studied consumer perceptions on the addition of pecans and cherries to lamb burgers (Horrillo *et al*., 2022). Using the focus group technique, it was found that consumers responded positively to the idea of adding these ingredients. However, it is important to note that in that study, participants did not taste the burgers.

To address this limitation, this study used two complementary methodologies: sensory analysis and Choice Experiment (CE). Sensory analysis allows us to assess consumers' reactions during the tasting experience, while the CE examines the decision-making process at the point of purchase. This dual approach allows a comprehensive study of both consumer expectations and actual consumer preferences, providing valuable information on lamb burgers and burgers enhanced with functional ingredients such as pecans and cherries.

## Materials and Methods

### Materials

Burgers were made from Merino lamb meat (CORDEREX "Cordero de Extremadura" Protected Geographical Indication). The meat was minced and seasoned with salt (1.5%) and white pepper (0.2%) and mixed in an industrial vacuum meat mixer (CATO by Tologoni system) and then subdivided into three lots: 1) the control burger lot, which was made out of just seasoned lamb meat; 2) lamb meat enriched with 6% rehydrated cherries (w/w); and 3) lamb meat improved with 10% pecan nuts. Burgers with 10 cm diameter and 100 g weight were made using a manual burger maker. Both cherries (Pico negro variety) and pecan nuts (Osage variety) were lyophilized and ground, added to the minced seasoned lamb meat, and mixed in an industrial vacuum meat mixer (Tologoni CATO equipment).

### Subjects

The study included 149 untrained consumers who had no aversion to lamb meat and volunteered their participation. They were distributed into sessions of 20 participants each in different locations, in the region of Extremadura (SW Spain). The number of consumers included in this study was in line with that of other consumer sensorial studies (Grassi *et al*., 2024). The participants were habitual meat consumers and were recruited in Extremadura, with a total of 46% being men and 54% women, from various age groups (24% were aged 18–35 years; 31% were aged 36–50 years; 42% were aged 51–65 years; and 3% were over 65 years). The sessions were held from October to December 2021, and each consumer completed two surveys. The first one was related to the sensorial analysis or taste of the products, and the second one was the CE. Before the tasting session, participants were informed about the product they were about to taste, that is, the product type and origin of the raw materials and were given brief information on the ingredients included in the burgers. They were also warned of the potential allergens that might be included in the products to avoid allergy issues. The research was conducted in compliance with the University of Extremadura Bioethics and Biosecurity Committee regulations regarding studies with human participants and approved under Registration number 22/2022.

### Hedonic sensory analysis

A two-phase hedonic study was conducted to determine the level of consumer satisfaction with burgers of different formulations and to analyze the product-tasting experience and preferences of regular consumers for these new products. Consumers were provided with bread and water to clean their palates between burgers. Each session was supported by two assistants.

Regarding cooking, three cooking plates were provided, one for each type of burger. The samples were placed on plates at 150°C until they reached an

internal temperature of 75°C (portable T200 thermometer, Digitron Instrumentation Ltd., Merd Lane, Hertford, UK). Both control and pecan nut burgers were cooked directly on the cooking plates, while cherry burgers were cooked using baking paper placed between the burger and the cooking plate to avoid caramelization of the sample.

The cooked burgers were cut into four pieces and immediately placed on plates, which were presented to the participants. Each participant analyzed the three types of burgers that had been coded with a randomly chosen three-digit number (MacFie *et al*., 1989). The attributes, such as visual appearance, odor, juiciness, tenderness, taste, and overall assessment, were evaluated on a 9-point hedonic scale (1 = I dislike it very much; 9 = I like it very much) using the methodology proposed by Meilgaard *et al*. (2007).

Each consumer was presented with all the samples in a random order to prevent the carryover effect, following an experimental fully balanced block design. Subsequently, consumers were asked to take the UNE-ISO 8587:2010 ranking test, to study the preference after their overall evaluation and to allocate a score from the most to least preferred (1–3).

A one-way ANOVA test was conducted to study the effects of the addition of various ingredients (control, cherry, and pecan nut samples) on the sensory attributes of manufactured lamb burgers. The mean and standard deviation values were determined. A Tukey's test at a significant level of $P \leq 0.1$ was carried out to compare the differences between pairs of groups.

Statistical analyses were also performed to study the effects of gender and age on the sensorial assessment of the burgers. A two-way ANOVA test was performed to evaluate gender (women and men) and burger type (control, and with cherries and pecan nuts), and also to analyze the effects of age range (> 65, 51–65, 36–50, and 18–35 years of age) and burger type (control, and with cherries and pecan nuts).

Statistical analyses were carried out using the SPSS version 22.0 statistical package (SPSS Inc. Chicago, IL, USA).

## Choice Experiment

In this study, the CE technique was chosen as the most appropriate method to estimate consumer preferences for an innovative noncommercialized product and to obtain a first approximation of consumer preferences toward natural and functional ingredients, which could be used to improve burgers in various aspects.

The CE technique is based on the idea that a product or service can be described by its attributes (Lancaster, 1966), and consumers can make their consumption decisions based on such attributes. In recent years, this technique has been reported to help gain insight into investor preferences and their willingness to pay for various attributes. It has been used in several studies dealing with the analysis of preferences in various fields of application, such as marketing (Louviere, 1988), evaluation of environmental goods (Hanley, 2020), culture economics (Orea-Giner *et al*., 2021), health economics (Kjaer, 2005; Wang *et al*., 2021), or meat and meat products (Altmann *et al*., 2022; Díaz-Caro *et al*., 2019).

The first step in a CE study is the selection of attributes and levels that are included in the various products to be presented to the consumers. Table 1 shows the attributes and levels selected for this study, based on the review of the literature (Akwetey and Knipe, 2012; Viana *et al.*, 2014) and an in-depth analysis of the proposed product through various focus groups (Horrillo *et al*., 2022).

The total set of hypothetical products that can be created by combining the selected attributes or levels amounts to 162 (3*2*3*3*3), which would be an excessive number of products for respondents to compare. Considering that they are presented with "choice sets" comprising two products plus a "no choice" option, the total set of potential comparisons would be 13,041 ((162 × 161)/2), which would be unmanageable in terms of cost and time. Therefore, to reduce the number of comparisons to an efficient level, a fractioned design was used instead, employing the "Dcreate" module by Stata, which allows for generating these types of designs. This module uses Fedorov's modified algorithm to create an efficient

**Table 1. Attributes and levels used in the Choice Experiment.**

| Attributes | Levels | Codification |
|---|---|---|
| Type of meat | Beef | Tern |
| | Mixed (beef and pork) | Mix |
| | Lamb | Cord |
| Packaging format | Pack 2 | Pack2 |
| | Pack 4 | Pack4 |
| Functional ingredients | Cherries | Cer |
| | Pecan Nuts | Nuec |
| | No functional ingredients | Nothing |
| Origin | Regional | Reg |
| | Spain | Esp |
| | Imported | Impo |
| Price | € 0.70 | Price |
| | € 1 | |
| | € 1.3 | |

**Table 2. Example of the Choice Set presented to the participants in the study.**

| Choice card | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| Type of meat | Lamb | Mix | None of the above |
| Packaging format | Pack 2 | Pack 4 | |
| Functional ingredients | No functional ingredients | Cherries | |
| Origin | Regional | Imported | |
| Price | € 1 | € 1.30 | |
| Selection | ☐ | ☐ | ☐ |

design (Carlsson and Martinsson, 2003). Finally, eight choice sets were created and used for the survey. Table 2 shows an example of a choice set.

### Econometric Model

Mixed logit was used to evaluate consumers' preferences. This model is based on random utility (McFadden, 1974; Train, 2009), which presumes that the utility function of each consumer is the sum of two components, that is, a deterministic part that can be obtained from the factors impacting consumer utility and a random part, which is not directly identified and is deemed to be stochastic. Thus, utility $U_{njt}$ for consumer $n$ who selects choice $j$ for comparison $t$ is:

$$U_{njt} = \beta_n' x_{njt} + \varepsilon_{njt} \quad (1)$$

Where $\beta_n'$ is the vector for the individual's specific coefficients; $x_{njt}$ is the vector for the identifiable attributes of individual $n$; and $\varepsilon_{njt}$ is the random term, which is presumed to be an extreme value distributed independently and identically. One of the limitations of the conditional logit model is that it presumes preferences are equal for everyone. In this sense, the mixed logit model corrects this limitation by allowing different coefficients for each person. In particular, the mixed logit choice can be estimated as follows:

$$SLL(\theta) = \sum_{n=1}^{N} \ln\left\{ \frac{1}{R} \sum_{r=1}^{R} \prod_{t=1}^{T} \prod_{t=1}^{J} \left[ \frac{\exp\left(x_{njt}' \beta_n^r\right)}{\sum_{j=1}^{J} \exp\left(x_{njt}' \beta_n^r\right)} \right]^{y_{njt}} \right\} \quad (2)$$

Basic levels have been selected for each of the qualitative attributes to set a reference (zero utility) for the remaining attribute levels. The basic levels selected were "Mixed" (for attribute Type of meat), "Pack 2" (for Packaging format), "No functional ingredients" (for Functional ingredients attribute), and "Imported" (for attribute Origin). Attribute Price has been unified into one continuous single "no dummy" variable instead of disaggregating it into several variables, to monetize each of the above attributes later, where applicable. Therefore, the econometric specification used for this piece of research can be defined as follows:

$$U_{njt} = \beta_0 ASC + \beta_1 Tern_{njt} + \beta_2 Cord_{njt} + \beta_3 Pack4_{njt} + \beta_4 \mathrm{Cer}_{njt} + \beta_5 Nuec_{njt} + \beta_6 Reg_{njt} + \beta_7 Esp_{njt} + \beta_8 Price_{njt} + \varepsilon_{njt} \quad (3)$$

Where $\beta_0$ refers to the current situation (ASC), that is, choosing none of the two proposed products, and $\beta_k$ is the marginal utility associated with each attribute provided by the specific product.

## Results and Discussion

First, we present the results of the sensory evaluation. Second, we provide the results of the CE, which are a prepurchase assessment of the product, and finally, all identified preferences are analyzed to obtain a comparative and global assessment, and study the heterogeneity of the consumer sample.

### Sensory analysis

Participants were required to assess various characteristics of the three types of cooked lamb burgers with different added ingredients (control burger vs cherry-added or pecan nuts-added burgers). As stated, they were provided with information about the lamb burgers being seasoned with salt and pepper and containing a third ingredient, which was different in each burger.

As consumers were informed about the three types of lamb burgers with different formulations, the differences in ratings are presumed to result from the addition or not of the ingredient. Sensory attributes were evaluated using a previously described methodology, with the results presented in Figure 1.

Results show that the participating consumers were able to identify significant differences among burgers in terms of appearance ($P \leq 0.05$), taste ($P \leq 0.01$), and overall assessment ($P \leq 0.05$). For these three attributes, the control sample received the highest score, especially for "taste." The most prominent differences were between control burgers and burgers with functional ingredients ($P \leq 0.001$). Consumers were unable to distinguish between pecan-added and cherry-added burgers by taste ($P > 0.05$).

The participating consumers' first choice of preference was the control burger, followed by the pecan nut burger.

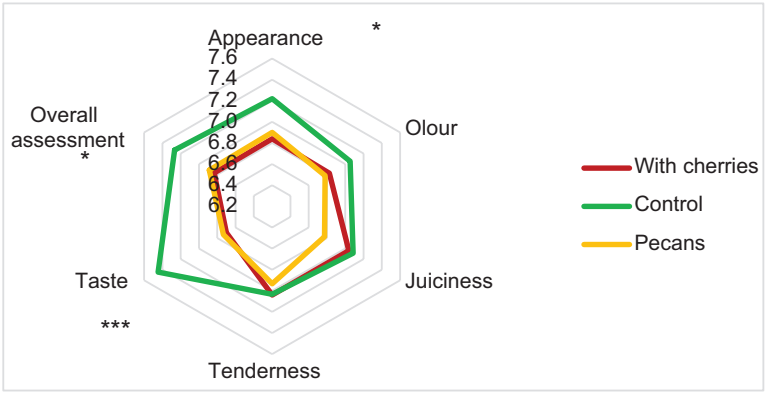


**Figure 1. Consumers' sensory assessment of lamb burgers with different functional ingredients versus control lamb burger. *P ≤ 0.05; ***P ≤ 0.001.**

The cherry burger, apart from scoring poorly during the tasting session, was the least preferred. This finding is in line with the trend identified in the CE, where the mean value of the coefficients for the cherry attribute was negative.

Fruits such as cherries or pecan nuts might not be accepted by Spanish consumers to be included in a traditional meat product such as burgers, since such ingredients do not belong to the meat product family, as is the case in other gastronomic cultures, where fruits are common in meat dishes (Yilmaz and Yalcin, 2024).

The "appearance" attribute and "overall assessment" of the pecan nut-added burgers obtained intermediate scores somewhere between the control and the cherry-added burgers; however, the cherry-added lamb burger received the lowest score.

The results of the sensory evaluation were in line with the findings of López-Parra *et al.* (2024) and could not identify differences between lamb control burgers and cherry-added burgers for attributes such as odor and juiciness when assessed by trained panelists. Martín-Mateos *et al.* (2023) found similar results between control lamb burgers and pecan nut-added burgers for the same attributes, also using trained panelists.

"Taste" is the most important attribute in terms of food choice (Malone and Lusk, 2017), and despite the fact that consumer interest in products with new flavors continues to increase, the sensory aspects still govern much of consumers' perception of meat products (Tomasevic *et al.*, 2018). The consumers in our study strongly preferred the taste of control burgers versus burgers enriched with cherries or pecan nuts, thus suggesting a need for technological improvements in these products to be more acceptable to consumers.

López-Parra *et al.* (2024) assessed enriched lamb burgers with different cherry contents and observed that, regarding the attribute "Intensity of meat flavor," related to the sense of taste, lamb burgers with 2% cherries obtained the same score as control burgers, while the meat flavor assessment was lower as the cherry content increased. Our study assessed burgers with 6% cherry content, and in view of the results obtained by López-Parra *et al.* (2024), the low scores obtained by burgers with cherries compared to the control burgers and the burgers with pecan nuts could be potentially explained because the cherry content decreases the flavor of lamb meat.

The "appearance" attribute mainly depends on the sense of sight, which is activated before consumption. When consumers see the product's appearance, they perceive certain physical properties that together make up the product. These are color, shape, and texture (Blijlevens *et al.*, 2009). Taking into account the importance of color in meat and meat products from a consumer's perspective (de Araújo *et al.*, 2022), in our case, the control burgers were the most highly valued, which is in contrast with the results obtained by López-Parra *et al.* (2024), where lamb burgers with cherries were highly valued than control burgers on account of their color. The same results were obtained in beef burgers with added cherries versus control burgers (Martín-Mateos *et al.*, 2022).

The results of the sensory evaluation analysis by gender of the participating consumers are shown in Table 3.

There were no differences in the assessment of the sensory attributes of the control burger based on gender, which was in line with other authors (Font i Furnols *et al.*, 2003; Grasso *et al.*, 2022). However, women gave higher scores than men (P ≤ 0.05) in the assessment of attributes such as "juiciness" and "tenderness," both in cherry and pecan-added burgers. Additionally, this fact was also identified

**Table 3. Sensory assessment by gender of lamb burgers with different functional ingredients.**

| | | Control | With cherries | With pecan nuts | P-value by types of burger |
|---|---|---|---|---|---|
| Appearance | Men | 7.03 | 6.70 | 6.60 | ns |
| | Women | 7.38 | 6.95 | 7.15 | ns |
| P-value by gender | | 0.097 | 0.29 | 0.02 | |
| Odor | Men | 7.10[a] | 6.59[b] | 6.47[b] | * |
| | Women | 7.01 | 7.02 | 7.04 | ns |
| P-value by gender | | 0.698 | 0.086 | 0.03 | |
| Juiciness | Men | 6.99 | 6.71 | 6.46 | ns |
| | Women | 7.17 | 7.32 | 7.04 | ns |
| P-value by gender | | 0.42 | 0.017 | 0.02 | |
| Tenderness | Men | 6.90 | 6.71 | 6.60 | ns |
| | Women | 7.15 | 7.32 | 7.21 | ns |
| P-value by gender | | 0.30 | 0.016 | 0.02 | |
| Taste | Men | 7.53[a] | 6.57[b] | 6.45[b] | ** |
| | Women | 7.38 | 6.80 | 6.96 | ns |
| P-value by gender | | 0.57 | 0.505 | 0.10 | |
| Overall assessment | Men | 7.25[a] | 6.60[b] | 6.69[ab] | * |
| | Women | 7.28 | 7.02 | 7.05 | ns |
| P-value by gender | | 0.896 | 0.14 | 0.13 | |

ns, P > 0.05; *P ≤ 0.05; **P ≤ 0.01; Values with the same letters (a, b) indicate uniform subsets for P = 0.05 according to Tukey's test.

in attributes "appearance" and "odor" in the case of pecan burgers. Some authors (Bureš *et al*., 2024; Talens *et al*., 2022) also noticed higher sensitivity in women than in men, although this seemed controversial in the scientific literature, and some findings reported no differences based on gender (Gómez-Llorente *et al*., 2022).

It is worth noting that men discriminated between the types of burgers under study for some sensory attributes, such as odor (P ≤ 0.05), taste (P ≤ 0.01), and overall assessment (P ≤ 0.05), and gave a higher score to the control burgers, while women did not find significant differences among them. This coincides with the findings of García-Torres *et al*. (2016) that gender is one of the discriminating factors between types of meat consumers. Also, Font i Furnols *et al*. (2011) found that different groups of Spanish lamb consumers differed significantly based on gender.

The age of the consumers was also analyzed, and differences were found (Figure 2) for the attribute "tenderness" in respondents >65 (P ≤ 0.05), who found the control burger to be more tender than the pecan burger, while the cherry burgers obtained an intermediate value. The same age range gave the control burger the highest score on the "overall assessment" attribute (P ≤ 0.01).

Consumers within the age range of 51–59 scored the taste of control burgers the highest, whereas the burgers with cherries obtained an intermediate score between control and pecan burgers (P ≤ 0.05). The youngest consumers (18–35 years) gave the highest score to control burgers and the lowest to burgers with cherries (P ≤ 0.05). Fořtová *et al*. (2022) noticed that older consumers were more sensitive to finding differences between beef samples.

## Choice experiment

Table 4 shows the results obtained by applying the mixed logit model to the answers that participants provided in the CE task.

The relative importance of each attribute is obtained through comparison of the coefficients and the z-value parameter. The higher the value, the higher the relative importance of the attribute level. As shown, respondents placed the most relative importance on product origin, followed by the type of meat and the type of added functional ingredient. The least important attributes are price and packaging format, although they are not significant.

As shown, regarding the type of meat, beef has a positive influence, whereas lamb has a negative influence compared to mixed meat, with both coefficients being significant. These findings were in line with other studies that found processed beef products were more popular in

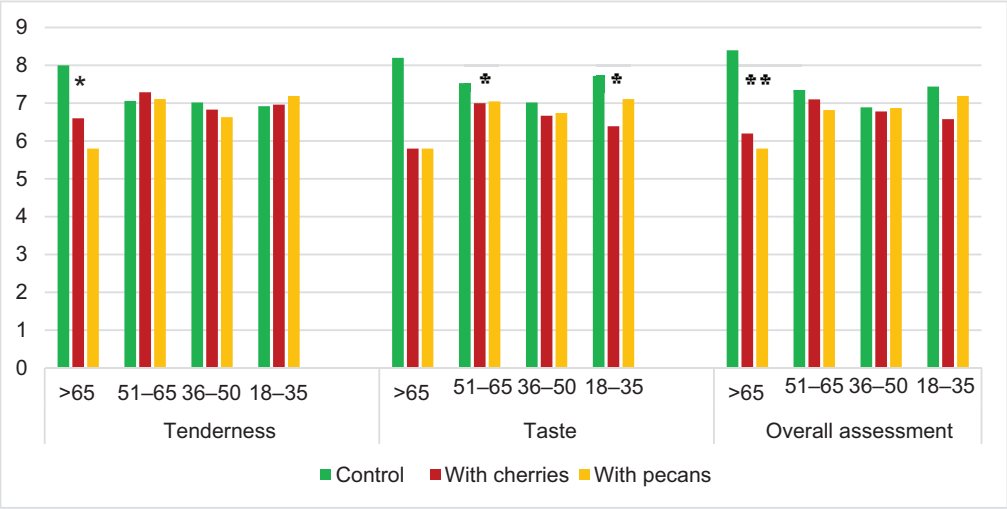


**Figure 2. Sensory attributes with significant differences by age range. *p≤0.05; **p≤0.01.**

**Table 4. Choice Experiment mixed logit results.**

| | Attribute level | Coefficient Mean | Standard error | z | P |
|---|---|---|---|---|---|
| Type of meat | Beef | 1.070 | 0.299 | 3.59 | *** |
| | Lamb | −1.434 | 0.264 | −5.42 | *** |
| Packaging format | Pack4 | −0.107 | 0.115 | −0.93 | ns |
| Functional ingredients | Cherries | −0.226 | 0.298 | −0.76 | ns |
| | Nuts | 0.498 | 0.185 | 2.69 | *** |
| Origin | Regional | 1.924 | 0.321 | 5.99 | *** |
| | Spanish | 1.740 | 0.234 | 7.43 | *** |
| Price | Price | −0.14 | 0.475 | −0.30 | ns |
| Alternative specific constant | Asc | −1.66 | 0.515 | −3.22 | ** |

ns, P > 0.05; **P ≤ 0.01; ***P ≤ 0.001.
The results show the coefficient mean values for each of the different attribute levels. The higher the coefficient, the greater the utility of the attribute level for the consumer.

Spain than lamb products (MAPA, 2023). This fact was also identified by Horrillo *et al.* (2022), where consumers stated that they preferred beef burgers over other types of burgers. The trend toward beef can be associated with consumer perception of this meat as a healthier choice when compared to other meats (Grunert *et al.*, 2004).

In terms of packaging format, as attribute Pack4 is not significant, it can be concluded that there are no differences among the preferences for both formats. Packaging is consistently the least relevant attribute for Spanish lamb consumers throughout time (Rabadán *et al.*, 2021).

Regarding the attribute "Functional ingredients," cherries have revealed a negative coefficient, although this is not statistically significant. This would mean that consumers do not perceive a difference between control burgers (burgers without functional ingredients) and cherry-enhanced burgers. On the other hand, the use of nuts prove to be a positive influence, and it is statistically significant, which indicates that the interviewed consumers prefer it to a greater extent. These results are in disagreement with a preliminary qualitative piece of research carried out by Horrillo *et al.* (2022), where burgers enriched with cherries or pecan nuts were highly accepted. Also, the addition of cherries seemed to be more accepted, because it added a nice flavor to the burger and masked the lamb flavor.

Origin is also statistically significant, with a positive preference for regional or national products against imported produce. Overall, origin is a relevant factor in the food purchase decision, as demonstrated by previous studies (Rabadán *et al.*, 2021; Sama *et al.*, 2018). In terms of lamb meat, these results are in line with studies carried out by other researchers (Bernabéu and Tendero, 2005;

Font i Furnols *et al*., 2011), who found that the origin was one of the most important attributes in the preference structure for this type of food product.

Finally, price shows a negative coefficient, although this is not statistically significant. This reveals the lack of importance of this attribute, which aligns with the finding of Font i Furnols *et al*. (2011), although the study carried out by Horrillo *et al*. (2022) revealed that consumers found price to be one of the most relevant attributes in their decision to buy lamb meat.

The mixed logit model estimation allows us to obtain the standard deviations (SDs) of the previously analyzed coefficients and quantify the heterogeneity of consumers' preferences (Table 4S). These results show that SDs show the same level of significance as the CE coefficients. The most prominent variation can be identified in the attribute "Type of meat," through the coefficients "beef" and "lamb." This is followed by the attribute "Origin" and finally the "Functional ingredients."

Regarding the origin, the research by Díaz-Caro *et al*. (2019) found that preferences for this attribute are not uniform and vary depending on certain characteristics such as socioeconomic factors. On the other hand, nutrient-enhanced meat products, like the ones in our research paper, attract consumers who are more aware of health issues (Dolgopolova and Teuber, 2018; Jiménez-Colmenero *et al*., 2010). Therefore, a higher level of consumer awareness could help improve the commercialization of these products, especially when preference heterogeneity regarding enriched burgers has been found.

These results reveal that preferences vary in terms of meat products, which are in line with the trend in the existing literature on the analysis of preferences for these types of products (Díaz-Caro *et al*., 2019; Dolgopolova and Teuber, 2018; Pouta *et al*., 2010). We therefore must consider the fact that there are groups of consumers whose taste for these innovative products varies. This is a crucial result to consider before engaging in marketing strategies for such products.

Innovation tends to face a certain degree of resistance from consumers and especially in the case of more traditional products. Therefore, the provision of information for the consumer, for example, nutritional and comparative product information, could be positive (Yang *et al*., 2020). This could contribute to the new enhanced burgers analyzed in this research to gain a higher level of acceptance in the market as such, as several other studies indicate (Barreiro-Hurlé *et al*., 2009; Van Wezemael *et al*., 2014).

### Heterogeneity in consumers' preferences

With the purpose of analyzing the heterogeneous preferences of consumers stated in the CE ratings and in the sensory analysis, the distribution of the CE coefficient for the pecan nut (Additive attribute) versus each of the items rated in the tasting is shown using Kernel density plots (Figures 3 and 3S). To compare the values

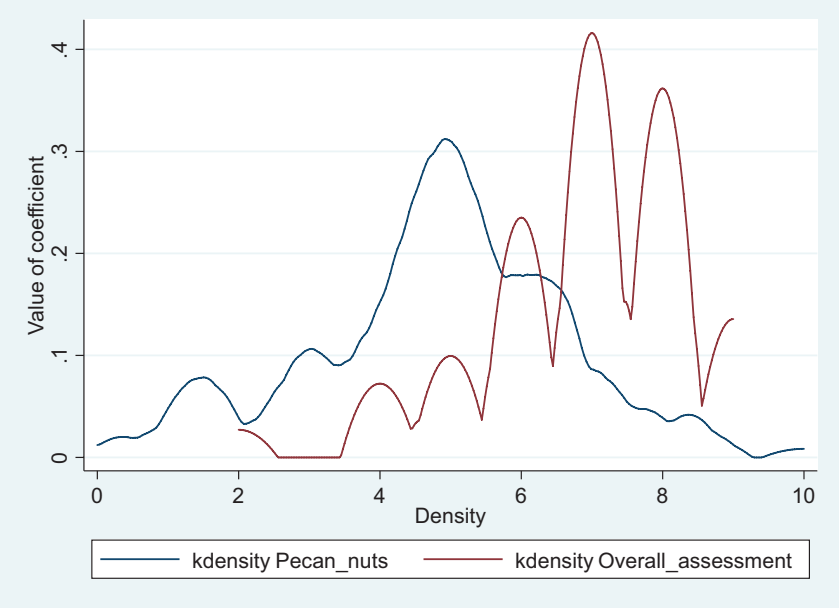


**Figure 3. K-density for pecan nuts and overall assessment.**

of both methodologies, the EC coefficient values were normalized between 0 and 10. Pecan nuts have been chosen for these comparisons as it was the level of the attribute "Functional ingredients," which showed positive preferences.

Figure 3 shows that the estimated coefficients of the CE (once they are standardized to the scale of the tasting sessions) present a percentage of approximately 30% of consumers with a 5-point score, and higher numbers of the population for higher scores than for lower scores.

The overall assessment shows that respondents give a higher score at the tasting session than before tasting (CE), which seems to indicate that even though the product is given scores of 7–8 by above two-thirds of the population after tasting, scores are not the same before tasting, as they are lower. This means that there are several groups of consumers interested in new products improved with the addition of ingredients, an issue that could be a novelty and positive, given the traditional nature of the product under assessment, as identified by Boncinelli *et al.* (2021) for the case of burgers with added Omega-3.

One of the available approaches to attract a variety of preferences is providing information on the nutritional values and their components; therefore, an available strategy for the purpose of commercialization and acceptance of the product could be along these lines, as mentioned before.

The overall analysis of preference before and after purchase helps find certain similarities and differences, as previous studies implementing similar methodologies have shown (Díaz-Caro *et al.*, 2019; García-Torres *et al.*, 2016). In the first place, we can highlight that preferences in overall terms show a high degree of product acceptance for the overall sample, although the distribution shows certain groups that accumulate a greater percentage of consumers, and these prove to be different before and after purchase. These results help deduce that the level of information and knowledge consumers have of the product, among other factors, is relevant. The provision of information results in a positive assessment by the majority of consumers, who, in general terms, value the product more once they have tasted it, which leads them to consume the product to a greater extent.

## Conclusions

This piece of research is a quantitative assessment of consumer preferences and a sensory assessment using a consumer panel for the evaluation of lamb burgers with added fruits, such as cherries and pecan nuts, as natural and healthy ingredients.

The combination of two complementary methodologies, that is, assessment by tasting sessions and CE, allowed for obtaining of in-depth knowledge of the preferences and tastes of consumers. Additionally, the analysis of the variety of opinions allowed us to identify differences among groups, a relevant issue that needs to be considered when it comes to analyzing an innovative product like the one in question.

The participating consumers showed a clear preference for the control burger when they carried out the blind taste test, and especially disliked the cherry-added burger. However, they expressed their interest in the addition of natural ingredients, such as cherries or pecan nuts, to improve burgers when they were asked about this before the tasting session. Therefore, the study identified a need to spread information on these new products with the purpose of improving lamb meat consumption, given the current market situation for this type of meat.

This research also highlights the importance of the sensory value of a product to the consumer and the relevance that a suitable product informative campaign may have, given that consumers could potentially have an initial preference for an innovative product they have never consumed. In this sense, the provision of suitable key information on the product over its potential sensory features becomes necessary for the success of the product, on top of all the nutritional benefits it may provide.

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## Authors' Contributions

All authors contributed equally.

## Conflicts of Interest

None.

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