



Towards more sustainable animal-feed alternatives: A survey on Spanish consumers' willingness to consume animal products fed with insects

Muhammad Adzran Che Mustapa, Zein Kallas^{*}

Centre for Agro-food Economy and Development (CREDA), Universidad Polit cnica de Catalu a (UPC), Castelldefels 08860, Spain

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ABSTRACT

Global meat consumption will continue to increase in response to the growth in population and demand. Numerous studies have emphasized the nutritional, economic, and environmental benefits of using insect meal as an alternative protein source for animal feed. This article analyses Spanish consumers' willingness to consume pork, chicken, eggs, and fish, and explores the effect of sociodemographic and psychometric characteristics on their willingness to consume when the animals are fed with insect protein as a sustainable feed alternative. The study used an online Spanish consumers' panel belonging to Qualtrics  (market company services) and distributed it to 1260 individuals stratified by age, gender, and region. The data were analysed using the non-parametric Kruskal–Wallis and Mann–Whitney *U* tests. Overall, the results demonstrated that most Spanish consumers expressed high uncertainty regarding their willingness to consume animal-fed insect meals. They also exhibited moderate levels of food neophobia and showed a highly ecocentric attitude. The non-parametric comparison analysis confirmed significant differences in willingness to consume sustainable animal products across sociodemographic characteristics: financial situation and gender were significant variables, with females more willing to consume sustainable animal products than males. For the psychometric traits, significant differences in willingness to consume sustainable animal products were confirmed across food neophobia, food neophilia, opinions on using insects in animal feed, and ecocentric attitude. The results also confirmed a significant difference in the effects of sociodemographic variables on psychometric attributes. Financial situation affects food neophilia, anthropocentric attitudes, and opinions on the use of insects in animal feed. Age influences food neophobia, ecocentric attitudes, and opinions on the use of insects in animal feed. Education also influences food neophilia, ecocentric attitudes, and opinions on the use of insects in animal feed. For gender, it is observed that females are more neophobic than males. This study has provided comprehensive initial insights into consumer willingness to consume insect-fed animal products in Spain, and the findings from this study will serve as a valuable resource for producers, policymakers, and governments in making informed decisions that promote more sustainable production practices.

1. Introduction

Meat consumption has become a contentious topic because of its implications for various sustainability factors, including the economy, society, environment, health, and animal welfare (Sanford et al., 2021; Willett et al., 2019). Meat contains nutrients (e.g., proteins, vitamins, and minerals) required for human health, and its production has become a source of income and employment for approximately one billion people worldwide (Parlasca and Qaim, 2022). However, meat production has large environmental impacts, such as on greenhouse gas (GHG) emissions, and agricultural land and freshwater use (Gonz lez et al.,

2020). Data at the demand level indicates that developed countries have higher per capita meat consumption than developing countries (OECD, 2017). However, in the latter, higher emissions of GHG are identified at the production level due to the low feed conversion rate and low technical efficiency of farms (Bellarby et al., 2013). In this context, putting the consumption of meat products, both at the demand and production levels, on the agenda for reducing GHG emissions has increased in relevance over the last few decades.

Food production is responsible for 26 % of global GHG emissions; for instance, 10.3 % of the EU's greenhouse gas emissions are attributable to agriculture, and the livestock sector accounts for roughly 70 % of those

^{*} Corresponding author.

E-mail addresses: adzran.mustapa@upc.edu (M.A.C. Mustapa), zein.kallas@upc.edu (Z. Kallas).

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(European Court of Auditors, 2021). Furthermore, animal feeding accounts for a high percentage of these GHG emissions, including those generated from land-use change and manure management (Herrero et al., 2011). Several alternatives are being considered to reduce GHG emissions in the livestock production system; for instance, introducing organic schemes (Halberg et al., 2004; Holka et al., 2022) and sustainability regulations with quality label scenarios, such as the red label (RL) in France (Basset-Mens and Van Der Werf, 2005). In this context, alternative protein sources for animal feeding are being explored as a means to improve the sustainability level of livestock production. Consequently, studying alternative feed sources has become a leading research topic, where the aim is to strike a balance between the demand for low-cost and high performance through alternative solutions (Dabbou et al., 2018). The feed costs in poultry and pig production account for 70–75 % of the total production costs (Raza et al., 2019), which makes improving the environmental sustainability of animal feed an essential task and an immense challenge, especially when taking into account the economic aspects of any feed alternatives.

Insect-fed animal products offer several notable benefits that make them an attractive alternative to traditional feed sources. Firstly, insects are highly efficient converters of feed, requiring fewer resources such as land, water, and feed compared to conventional livestock. This efficiency is attributed to insects' ability to convert low-value organic waste into high-quality protein and nutrients. Secondly, insect-based feed can contribute to a more sustainable and circular economy by utilising organic waste streams that would otherwise be disposed of in landfills, thereby reducing environmental pollution. Moreover, insects have a low environmental footprint, emitting fewer greenhouse gases and consuming less water compared to traditional livestock. Additionally, insect-fed animal products have the potential to offer unique nutritional advantages, such as being rich in essential amino acids, omega-3 fatty acids, and minerals. These benefits have been supported by various scientific studies (van Huis et al., 2013; Oonincx et al., 2010; Sogari et al., 2019a) and are increasingly recognised as a viable solution for sustainable animal protein production.

In this context, in May 2017 the European Commission adopted Regulation 2017/893, which authorizes the use of insect proteins originating from seven insect species in feed for aquaculture animals (European Commission, 2017). Recently, Commission Regulation (EU) 2017/1372[1] also authorized the use of Processed Animal Proteins derived from insects (insect PAPs) in poultry and pig feed. However, the inclusion of these insect protein sources is still in the initial experimental phases, where the principal limitations relate to the current high production costs of such feed alternatives and limited technical details regarding the impact of such protein on animals and product qualities. Furthermore, despite the lack of regulations obligating retailers to provide information about how animals are fed and the types of feed, uncertainty regarding the reactions and expectations of consumers towards the introduction of insect meal into animal diets may also be a limiting factor.

There is an increasing interest in conducting studies that focus on consumers' acceptance of animal products obtained using insects' meal as an alternative sustainable source of protein in animal feed. (Sogari et al., 2019a, 2019b; Spartano and Grasso, 2021). Sogari et al. (2019a) provided a comprehensive analysis of consumer acceptance regarding the use of insects as feed in various countries. The study encompassed six European nations, namely Germany, France, Poland, Italy, the United Kingdom (UK), and Belgium, along with a global perspective. From these surveys, the authors concluded that between 53 % and 76 % expressed their willingness to eat animal products fed with insects. For example, in Germany, the authors conducted a study on 610 consumers using Discrete Choice Experiment and found that 23 % of the sample had negative attitudes towards employing insects as fish protein feed. In addition, they concluded that consumption would increase if the price were lower or other qualities, like convenience, were enhanced (Ankamah-Yeboah et al., 2018). In a study conducted by Bazoche and Poret

(2021), it was mentioned that 76 % of participants who were informed about the practice would be willing to consume fish fed with insects, compared to only 64 % of participants who were not informed. This finding highlights the significant influence of information on the acceptance of insects as fish feed among French consumers. Further, Kostecka et al. (2017) surveyed 210 Polish consumers and found favourable attitudes towards feeding insects to cattle and pigs in 41.8 % and 47.2 % of the sample, respectively. Two studies have been conducted in Italy to assess consumers' acceptance of using insects to feed animal products: Laureati et al. (2016) revealed that 53 % of consumers were willing to eat fish and livestock fed with insects; Mancuso et al. (2016), reported that nearly 90 % of consumers support the use of insect meals as animal feed, and the majority of respondents plan to buy and consume farmed fish, including fish fed with insect meals, provided that hygienic standards are satisfied. In the context of the UK, a significant portion of consumers expressed willingness to accept the use of insects in feeding salmon. Furthermore, a study conducted by Popoff et al. (2017) highlighted that taste is an important factor influencing consumer purchasing decisions. Another study by Spartano and Grasso (2021) found that a majority of UK consumers (72 %) were willing to try eggs from hens fed with insects, and a significant proportion (87 %) were willing to pay for such products. Similarly, Verbeke et al. (2015) conducted a survey in Belgium involving farmers, agricultural stakeholders, and the general public. The results indicated that the respondents exhibited generally positive attitudes and acceptance towards the utilization of insects in animal feed, particularly for fish and poultry.

However, in Spain, there has been only one study on consumers' attitudes towards using insect meal as alternative feed, focusing solely on aquaculture (Ferrer Llagostera et al., 2019). To the best of the author's knowledge, none of the previously published studies have specifically and jointly analysed Spanish consumers' expected willingness to consume (WTC) and their preferences regarding broilers, pigs, and laying hens (eggs) that have been fed using insect-based meals. Given the recent approval of regulations allowing the use of insect proteins in animal feed, it has become imperative to understand consumer perspectives on this novel approach towards sustainability. This highlights the need for a comprehensive analysis of consumer acceptance of insect-fed animal products. Furthermore, understanding the heterogeneity of consumers' acceptance across different animal types is very relevant to policy makers and producers because protein intake and insect meal needs can vary for each production system. Currently, ongoing qualitative studies are being conducted, involving 14 in-depth interviews with various stakeholders including farmers, the feed industry, insect producers, animal feed associations, consumer associations, butchery associations, individual retailers, experts in animal feeding (researchers), and public inspectors (SUSPROMO Project 2019). These studies aim to gather stakeholders' opinions and insights on the subject. Furthermore, it is worth noting that there are no current regulations on food label that force producers or retailers to disclose information about the feed they use. This lack of mandatory transparency adds another layer of importance to understanding consumer attitudes towards insect-fed animal products. In addition to addressing these gaps in knowledge, this study distinguishes itself from previous research on various levels, providing insights and contributing to the existing body of knowledge in this field. First, despite previous studies on the influence of personal determinants on willingness to accept the use of insects in animal feed (Ankamah-Yeboah et al., 2018; Ferrer Llagostera et al., 2019; Laureati et al., 2016; Mancuso et al., 2016; Onwezen et al., 2021; Verbeke, 2015), the impact of sociodemographic and psychometrics attributes on consumers' WTC food products from animals fed insect-based feed has received less attention. Exploring the effects of different characteristics and identifying consumer profiles can offer valuable insights into consumer behaviour and preferences. By examining these factors and their impact on consumer choices, researchers and marketers can gain a deeper understanding of consumer segmentation and tailor their strategies accordingly. This paper examines Spanish consumers' WTC,

attitudes, and opinions regarding animal products fed with insect meal, and explores the effects of sociodemographic and psychometric characteristics on their WTC.

The structure of this article is as follows. In [Section 2](#), we introduce the theoretical framework and provide an explanation of each scale utilized in the study. [Section 3](#) outlines the methods employed, including the statistical analyses used to elucidate the observed impact of insect meals in animal feed on WTC. Moving on to [Section 4](#), we present the empirical results, which encompass descriptive statistics and a comparative analysis, followed by a discussion of these findings. Finally, in [Section 5](#), we offer concluding remarks along with implications, limitations, and future directions for this study.

2. Literature Review

The variables utilized in this study draws upon previous research that explored attitudes towards consuming novel or unfamiliar foods. As influential factors in understanding consumers' WTC insect-fed animal products, the study incorporates variables such as food neophobia, food neophilia, anthropocentric attitudes, ecocentric attitudes, and opinions regarding the use of insects. These variables have been adapted from relevant studies in the field and are considered significant in shaping consumer attitudes and behaviours towards such products.

2.1. Food Neophobia Scale

Food neophobia is the term used to describe an individual's tendency to reject new, unknown foods; conversely, food neophilia describes an individual's tendency to accept new, novel foods ([Capiola and Raubenbush, 2012](#); [Dossey et al., 2016](#); [Giordano et al., 2018](#)). Numerous studies have included these variables to investigate consumers' acceptance of new food products. For example, studies have reported that consumers with high food neophobia are less likely to accept unfamiliar food, such as ethnic foods ([Tomić Maksan et al., 2019](#)), new food trends ([Siddiqui et al., 2022](#)), and insect food products ([Hartmann et al., 2015](#)). According to [Pliner and Hobden \(1992\)](#), people can be grouped along a continuum of food neophilia–neophobia depending on how likely they are to try new foods. [Bazoche and Poret \(2016\)](#) also included food neophobia as one of the hypotheses to assess consumers' acceptance of insect-fed animal products. [Sogari et al. \(2019b\)](#) also suggested including food neophobia as a determinant when assessing future studies on insects as feed. Therefore, in this study, ten statements make up the scale, five of which are favourable (indicating a neophilia attitude) and five of which are negative (indicative of neophobic attitude). The Food Neophobia Scale (FNS), which measures willingness to try new foods, was used to quantify food neophobia.

2.2. New Ecological Paradigm Scale

Consumers today are aware that their purchase decisions can impact the environment, which has led them to act conscientiously and buy goods which cause no environmental harm ([Esmailpour and Bahmiary, 2017](#)). The majority of studies tend to ignore the significance of consumers' environmental attitudes, which can be a key predictor of acceptability ([Byrka et al., 2016](#)). [Esmailpour and Bahmiary \(2017\)](#) concluded that strong environmental attitudes significantly influenced consumers' decisions to purchase green products. Furthermore, [Baldi et al. \(2022\)](#) found that environmental attitudes significantly affect young consumers' acceptance of insect-fed fish in Italy. Environmental attitudes can be seen through psychological inclinations that indicate favourable or unfavourable opinions of the natural environment. Because these tendencies cannot be directly seen, they must be inferred ([Hawcroft and Milfont, 2010](#)). Accordingly, the most commonly used tool for measuring general views about how people and their environments interact is the New Ecological Paradigm (NEP) scale. The scale is a reflection of how people conceptualize and engage with nature ([Dunlap](#)

[et al., 2000](#); [Lezak and Thibodeau, 2016](#)). In this study, consumers' WTC regarding animal products fed with insects was analysed in relation to their environmental beliefs, as measured through the NEP Scale. The first component found through factor analysis is the ecocentric dimension, which was assessed using five statements highlighting the unbalanced conditions humans have brought about in nature. Similarly, the other five statements that emphasize human superiority over nature were used to measure the second component, known as anthropocentrism.

2.3. Opinions on the Use of Insects in Animal Feed

Insects are increasingly being considered as an alternate protein source to balance the future food security equation ([Bazoche and Poret, 2021](#)). Previous studies also reported that people with more favourable attitudes towards using insects as animal feed were more willing to accept new food products ([Hartmann et al., 2015](#); [Verbeke et al., 2015](#); [Vidigal et al., 2015](#)). Based on the research conducted by [de F Domingues et al. \(2020\)](#), it was found that consumer acceptance of insect-based feed in Brazil is greater for fish, compared to poultry, cattle, or pigs. The study also suggests that consumers' attitudes towards insect farms and insect-based feed play a significant role in determining their level of acceptance. Similarly, another study conducted among Belgian citizens reported that people are generally open to eating meat from animals that were fed with insects, with a preference for fish and poultry over pigs and cattle ([Verbeke, 2015](#)). Five items were used to assess consumers' opinions on the use of insects in animal feed with their WTC.

Therefore, to test the effects of sociodemographic and psychometric variables on consumers' WTC, the authors proposed the following hypotheses:

H1. *Sociodemographic characteristics influence consumers' WTC insect-fed animal products.*

H1.1. *Financial situation significantly influences consumers' WTC insect-fed animal products.*

H1.2. *Age significantly influences consumers' WTC insect-fed animal products.*

H1.3. *Education significantly influences consumers' WTC insect-fed animal products.*

H1.4. *Gender significantly influences consumers' WTC insect-fed animal products.*

H2. *Psychometric characteristics influence consumers' WTC insect-fed animal products.*

H2.1. *Food neophobia significantly influences consumers' WTC insect-fed animal products.*

H2.2. *Food neophilia significantly influences significantly influence consumers' WTC insect-fed animal products.*

H2.3. *Ecocentric environmental attitude significantly influences consumers' WTC insect-fed animal products.*

H2.4. *Anthropocentric environmental attitude significantly influences consumers' WTC insect-fed animal products.*

H2.5. *Opinions on the use of insects in animal feed significantly influence consumers' WTC insect-fed animal products.*

H3. *Sociodemographic characteristics influence consumers' psychometric characteristics.*

H3.1. *Financial situation significantly influences consumers' psychometric characteristics.*

H3.2. *Age significantly influences consumers' psychometric characteristics.*

H.3.3. Education significantly influences consumers' psychometric characteristics.

H.3.4. Gender significantly influences consumers' psychometric characteristics.

3. Methods

This section provides a detailed account of the methodologies and procedures employed in the research. It encompasses the methods of data collection, the design of the survey, and the techniques used for data analysis.

3.1. Data Collection

A total of 1306 adult respondents were collected in the study. However, only 1260 complete and valid responses were retained for analysis. A sample of Spanish adults was recruited by a market research company (Qualtrics©) using a semi-structured questionnaire. A semi-structured questionnaire is one in which the questions are presented to participants with a predefined set of answer options, but also includes the option "other type of answer" for which the participant can write his/her own response. By doing this, researcher will be able to capture all types of information (quantitative and qualitative) to ensure the quality of data collection and avoid information loss. The participants were required to be at least 18 years of age and primarily responsible for household purchases. The survey was conducted and completed over a period of one month, i.e., July 2022.

The questionnaire used in this study is divided into four parts (see Appendix 1). The first part of the questionnaire asks the consumers who is responsible for purchasing food products in their household. In this part, if the participants answered anything other than "exclusively me", "mostly me", or "me and someone else", they were not eligible to participate in this survey and did not proceed to the following questions. The next part of the questionnaire collected participants' sociodemographic characteristics (i.e., age, gender, education, household income, and financial situation). The third part, representing the core of our study, featured questions on consumers' WTC insect-fed animal products. The final part featured questions on psychometric variables (i.e., food neophobia scales, environmental attitudes, and opinions on the use of insects in animal feed).

A quota sampling procedure was used to guarantee a representative sample in terms of gender, age and region. According to [Nikolopoulou, 2023](#), among non-probability sampling methods, quota sampling is most commonly used in research studies and is most likely to represent the population being studied accurately. In addition, the sampling technique makes the method quicker and easier, creates a sample more likely to match the studied population, and allows for easier comparison between subgroups. It can also lead to bias if certain groups are over- or under-represented ([Omair, 2014](#)).

The sample size was calculated with a confidence level of 95 %, error margin of 2.71 %, and population proportion of 50 %, assuming a maximally heterogeneous population ([Singh and Masuku, 2014](#)). The results indicated that this study only required 385 respondents. Accordingly, this study also considers the total Spanish population in 2022, recorded as 41,923,039 ([National Statistics Institute, 2023](#)). Hence, the total sample of respondents involved in this study is considered sufficient.

Several empirical studies have shown the importance of the age variable in understanding consumer preferences ([Koehler and Leonhaeuser, 2008](#)). [Septianto and Kemper \(2021\)](#), on the basis of psychological reactance theory, showed the importance of age in understanding consumers preferences regarding sustainable foods (such as organic food). In this study, the participants were categorized into three baseline groups (18–24 years, 25–44 years, and 45 years and above) following the distribution of age in Spain ([National Statistics](#)

[Institute, 2023](#)). Educational levels were assessed by grouping participants into three ranges, namely basic education (primary school), intermediate level (vocational training), and university level (university, higher vocational training).

A brief, unbiased introduction to the purpose of the study was presented to the respondents before they started answering the questions. Respondents participated in our survey voluntarily, and we explained to them the purpose of the study and that their information would not be disclosed. This approach was recommended by [Kelley \(1995\)](#) as a means of assessing public attitudes. Moreover, according to [Sturgis et al. \(2010\)](#), the information provided before the survey did not affect public perceptions. Ethical approval for this study was obtained from the Centre for Agro-Food Economy and Development's (CREDA) Ethics Committee with approval number PID2019-111716RB-I00.

3.2. Survey Design and Measures

Based on previous studies, a survey instrument to measure WTC animal products fed with insects was developed. The instrument incorporated five variables: food neophobia, food neophilia, ecocentric environmental attitude, anthropocentric environmental attitude, and opinions on the use of insects. All the scales used in this study are well-known from previous studies: the FNS ([Fernández-Ruiz et al., 2013](#); [Pliner and Hobden, 1992](#); [Sogari et al., 2019b](#)), NEP scale ([Dunlap et al., 2000](#); [Orduño Torres et al., 2020](#)) and use of insects in animal feed ([Weinrich and Busch, 2021](#)). All items were measured and given an ordinal ranking on a 1 to 9-point Likert-type scale (1 = "strongly disagree", 2 = "disagree", 3 = "moderately disagree", 4 = "slightly disagree", 5 = "neutral: do not agree nor disagree", 6 = "slightly agree", 7 = "moderately agree", 8 = "agree", and 9 = "strongly agree").

The FNP scale adopted in this study originally used a 7-point Likert scale, while the NEP scale also used a 9-point Likert scale. [Finstad \(2010\)](#) concluded that 7-point Likert items provide a more accurate measure of a participant's true evaluation. However, in this study, we decided to standardize the scale for all variables used in the study because we wanted to homogenize our criteria in using identical scale points throughout the questionnaire. Following [Jones et al. \(1955\)](#) who showed that longer scales tend to be more discriminating, we expect to achieve a better heterogeneity analysis. As also observed in [Damsbo-Svendensen et al. \(2017\)](#), the scales with 7 and 10 response categories result in more reliable results compared to shorter ones; this accords with earlier findings in [Preston and Colman \(2000\)](#). Furthermore, according to [Wu and Leung \(2017\)](#), an increased number of Likert-type scale points will result in a closer approach to the underlying distribution, and hence normality and interval scales. We also hypothesized that this change would not systematically damage the scale reliability, as concluded by [Cummins and Gullone \(2000\)](#) in their review. They suggested that choice-points beyond 7-points may even increase the scale sensitivity. [Leung \(2011\)](#), in his comparison of different Likert scales, mentioned that there was no major difference in the internal structure of the different scales (factor loadings or Cronbach's alpha). He also indicated that having more points on the scale seems to reduce skewness and increase the likelihood of variable following a normal distribution. According to [Peryam and Girardot \(1952\)](#), data collected using a 9-point scale can be effectively analysed using parametric methods. This is due to the fact that the data adheres to the statistical assumption of normality, enabling the estimation of preference levels.

The content validity of the survey instrument was assessed by a panel of experts in the areas of consumer behaviour, measurement, animal feeding (researchers), and public inspection. The questionnaire was developed using a back-translation technique, following the method proposed by [Green and White \(1976\)](#). To ensure accurate interpretation in both languages. The first stage involved translating the English version into Spanish. To ensure consistency between the two versions, the translated version was then retranslated back into the original language, which means the Spanish version was translated back into

English. This is the second phase in the back-translation process. The questionnaire must be prepared in Spanish because it is the lingua franca, and Spanish people are more familiar with this language than with English. Certified translators validated the two-way translation.

3.3. Data Analysis

The latest SPSS software, version 29.0 for macOS, was used to measure the validity and reliability of the constructs. Before carrying out the factorial analysis, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett’s sphericity test were applied. The KMO test is used to measure how well suited the data is for factor analysis and takes values between 0 and 1, with values above 0.5 considered satisfactory for a principal component analysis (PCA). In this study, the KMO value was 0.870, indicating an adequate sample size. Bartlett’s test of sphericity was performed to assess the adequacy of the correlation matrix for factor analysis. In this study, Bartlett’s test of sphericity yielded a value of 0.001, which is considered significant as it is <0.05 (Gerbing and Anderson, 2018; Kaur et al., 2021).

To identify the attitudinal dimensions, an exploratory principal component factor analysis was conducted, followed by varimax rotation. During the analysis, items that exhibited cross-loading on more than two factors and had factor loadings below 0.50 were eliminated due to difficulty of interpretation. As indicated in Table 1, the value of all items was >0.5, indicating good validity (H et al., 2010; Heale and Twycross, 2015; Kaur et al., 2021). H et al. (2010) suggest that a factor loading value of >0.5 is considered acceptable, indicating a reasonable level of association between the observed indicator and the underlying latent construct. Additionally, a factor loading of 0.7 or higher is considered good for a single indicator, indicating a strong relationship between the indicator and the latent construct. Likewise, the Cronbach’s alpha value for each construct was considered good as it exceeded 0.7 (Table 1) (H et al., 2010; Kaur et al., 2021).

Descriptive statistics of the sample were analysed using the non-parametric Kruskal-Wallis H test to compare variables with more than two categories, such as WTC, financial situation, age, and education. On the other hand, the non-parametric Mann-Whitney U test was used to compare samples with only two categories, such as gender. Additionally, pairwise comparisons analysis was conducted to identify significant differences between levels of independent variables.

4. Results

In this section, we present the research findings. The results include the sociodemographic sample, the percentages of WTC insect-fed animal products, and the mean score values for attitudes and personality traits.

4.1. Sample Description

The descriptive statistics of the representative sample (n = 1260) indicate that there were slightly more females than males (50.8 % and 49.2 %, respectively), and most respondents were aged 45 years and above (Table 2). The average age of the sample was 37.70 years. In addition, the sample was well educated, with 49.8 % having received higher education (university degree or above) and 43.4 % having received intermediate education (college or vocational training) (Table 2). With respect to household income, more than half of the respondents (61.5 %) agreed that it sometimes covers their household expenses and 70.5 % considered their financial situation adequate (Table 2).

4.2. Willingness to Consume Insect-Fed Animal Products, Attitudes, and Personality Traits

As shown in Table 3, a majority of Spanish consumers expressed higher percentages of uncertainty when it came to consuming each

Table 1
Measurement scales and reliability.

Factors/items	Mean score	Factor loading	Cronbach’s α
Food neophobia (FNP scale)			
1. I don’t trust new foods	4.70	0.69	0.74
2. If I don’t know what’s in a food, I don’t try it	5.70	0.64	
3. Ethnic food seems too weird to eat	4.80	0.63	
4. I am afraid of trying foods that I have never tried before	4.50	0.70	
5. I am very particular about the food I eat	5.14	0.56	
Food neophilia (FNP scale)			
1. I am constantly trying new and different foods.	5.23	0.63	0.82
2. I like foods from different countries.	6.46	0.77	
3. At parties where there is food, I try new foods	6.22	0.71	
4. I would eat almost anything.	5.90	0.64	
5. I like to try new ethnic restaurants	6.05	0.83	
Ecocentric environmental attitude (NEP scale)			
1. Plants and animals have as much right as humans to exist	7.60	0.78	0.81
2. The balance of nature is very delicate and easily upset	6.92	0.63	
3. If things continue on their present course, we will soon experience a major ecological catastrophe.	7.27	0.72	
4. Despite our special abilities, humans are still subject to the laws of nature.	7.41	0.76	
5. To achieve sustainable development requires a balanced economic situation	7.01	0.73	
Anthropocentric environmental attitude (NEP scale)			
1. The balance of nature supports the impacts of industrialized countries.	4.15	0.71	0.75
2. Humans will eventually learn enough about how nature works to be able to control it.	5.33	0.76	
3. Human ingenuity will ensure that we do not make the Earth unliveable.	5.09	0.75	
4. Humans were meant to rule over the rest of nature.	3.67	0.59	
5. Human have the right to modify the natural environment to suit their needs.	3.92	0.52	
Opinions on the use of insects in animal feed			
1. It seems natural to me that animals feed on insects.	6.54	0.54	0.71
2. The idea of eating meat from animals fed on insects is not disgusting.	5.45	0.63	
3. I believe that eating meat from animals fed with insects-based feed is good for the environment	5.96	0.69	
4. I believe there are no other ways to improve environmental sustainability in animal production than introducing insects	4.28	0.53	
5. I would be willing to eat meat from animals fed on insect meal as long as the food is not expensive	5.94	0.75	

animal product fed with insects. Specifically, 52.9 % of them expressed hesitancy about consuming pork fed with insect meal, followed by chicken (53.5 %), chicken eggs (51.9 %), and fish (54.5 %) (Table 3). However, favourable percentages were also observed with regard to the “yes answer” for WTC insect-fed animal products, with 39 % for pork, 40 % for chicken, 41.5 % for chicken eggs, and 37.4 % for fish. In terms of the attitudes and personality traits, the results in Table 4 revealed that consumers have a moderate level of food neophobia and food neophilia (\bar{x} = 4.97 and 5.96, respectively). They expressed a high ecocentric

Table 2
Summary of sociodemographic characteristics.

Description	n	Sample (%)	Population (%)
Age			
- 18–24	174	13.8	8.0
- 25–44	477	37.9	29.1
- ≥ 45	609	48.3	43.7
Gender			
- Male	620	49.2	48.9
- Female	640	50.8	51.1
Education			
- Basic	85	6.7	28.0
- Intermediate	547	43.4	23.0
- High	628	49.8	49.0
Description	n	Sample (%)	
Household income			
- Never cover household expenses	21	1.7	
- Sometimes cover household expenses	774	61.5	
- Always cover household expenses	465	36.9	
Financial situation			
- Very difficult	181	14.4	
- Adequate	888	70.5	
- Good	176	14.0	

Table 3
Percentages of consumers' willingness to consume insect-fed animal products.

Animal Products	n	Sample (%)
Willingness to consume pork meat		
- Yes sure	491	39.0
- Uncertain	665	52.9
- No	102	8.1
Willingness to consume chicken meat		
- Yes sure	498	40.0
- Uncertain	666	53.5
- No	82	6.6
Willingness to consume chicken eggs		
- Yes sure	520	41.5
- Uncertain	650	51.9
- No	82	6.5
Willingness to consume fish		
- Yes sure	468	37.4
- Uncertain	683	54.5
- No	102	8.1

Table 4
Attitudes and personality traits.

Factors	Mean score ± standard deviation	Interpretation
Food neophobia	4.97 ± 1.47	Moderate
Food neophilia	5.96 ± 1.57	Moderate
Ecocentric environmental attitude	7.24 ± 1.38	High
Anthropocentric environmental attitude	4.43 ± 1.65	Moderate
Opinions on the use of insects in animal feed	5.63 ± 1.37	Moderate

Mean score interpretation: 1.00–3.00 = low; 3.01–6.00 = moderate; 6.01–9.00 = high.

attitude ($\bar{x} = 7.24$) and moderate anthropocentric attitude ($\bar{x} = 4.43$). Meanwhile, overall mean scores for opinions on the use of insects in animal feed was also moderate ($\bar{x} = 5.63$).

5. Discussion

This section will present and discuss a comparative analysis of the relationship between the variables WTC, sociodemographic characteristics and psychometric characteristics. Additionally, we will compare our findings with those of previous studies.

5.1. Sociodemographic Characteristics Influence on consumers' Willingness to Consume Insect-Fed Animal Products

Numerous studies have highlighted the effects sociodemographic characteristics on consumers' acceptance of new foods (Khalil et al., 2021; Kraus et al., 2017; Ozen et al., 2013; Szendrő et al., 2020; Van Thielen et al., 2018). According to the study's findings, sociodemographic characteristics significantly influenced consumer WTC insect-fed animal products (Table 5). First, the results revealed that consumers with difficult financial situations show a higher mean rank and differ from consumers with good financial situations, which is only observed in their WTC pork and fish products. These results are somewhat in line with De Faria Domingues et al. (2020), who reported that fish was the animal product for which use of insects as animal feed was most widely accepted among 600 Brazilian consumers. Such findings could be explained by the fact that fish already consume insects in their natural habitat (Verbeke, 2015). The popularity of pork as Spain's most consumed animal product can shed light on the prevailing attitude towards meat consumption in the country (ICEX, 2021). Consequently, this openness among consumers may pave the way for the acceptance of insects as a viable food source for pigs.

Interestingly, there were significant differences between males and females in terms of WTC all animal products, with females showing a higher mean rank than males. That is, females had significantly higher WTC insect-fed animal products than males, despite their high level of food neophobia. However, these results contradicted previous studies reported by several authors, such as Menozzi et al. (2021), who concluded that males expressed a more favourable attitude and stronger intention to purchase a farmed duck fed with an insect-based meal than females. In addition, Bazoche and Poret (2021) also found that males were more likely to accept insect-fed fish than females. Nonetheless, Naranjo-Guevara et al. (2021) conducted a study involving German and Dutch students, which revealed that gender does not play a role in determining the willingness of individuals to accept insects as animal feed and human food. This could be explained by the fact that women are more concerned with environmental problems and engage more in conservation behaviours than men (Desrochers et al., 2019; Li et al., 2022).

5.2. Psychometric Characteristics Influence on consumers' Willingness to Consume Insect-Fed Animal Products

The results showed that both food-neophobia and food-neophilia have significant effects on consumers' WTC (Table 6). These results are unsurprising, broadly supporting those of other studies linking food neophobia/neophilia with consumer acceptance of new food technologies. For instance, the acceptability of jellyfish among Italian consumers was found to be negatively correlated with high food neophobia (Torri et al., 2020). According to the study by Siddiqui et al. (2022), people with high food neophobia are picky and cautious when exploring new foods. Soucier et al. (2019) investigated a group of 250 older adults (≥65 years) living in Canada to examine the impact of food neophobia. The study revealed that participants with a notable level of food neophobia showed a decreased willingness to explore novel foods or food products. Meanwhile, another study also concluded that people with low

Table 5
Comparative analysis between sociodemographic characteristics and willingness to consume.

	Financial situation	Mean Rank	Kruskal - Wallis H	df	p – Value	Age	Mean Rank	Kruskal - Wallis H	df	p – Value
Willingness to consume pork	Difficult	665.45 ^a	6.348	2	0.042*	18–24	589.08	3.267	2	0.195
	Adequate	621.41				25–44	639.70			
	Good	580.30 ^b				≥45	633.08			
Willingness to consume chicken meat	Difficult	637.46	2.606	2	0.272	18–24	592.70	2.324	2	0.313
	Adequate	619.16				25–44	635.82			
	Good	585.02				≥45	622.59			
Willingness to consume chicken eggs	Difficult	643.49	6.376	2	0.041	18–24	597.57	1.694	2	0.429
	Adequate	625.29				25–44	633.69			
	Good	565.60				≥45	629.19			
Willingness to consume fish	Difficult	663.07 ^a	12.597	2	0.002*	18–24	653.36	1.714	2	0.424
	Adequate	625.52 ^a				25–44	629.27			
	Good	565.60 ^b				≥45	617.64			

	Education	Mean Rank	Kruskal - Wallis H	df	p – Value	Gender	Mean Rank	Wilcoxon W	Z	p – Value
Willingness to consume pork	Basic	622.16	0.151	2	0.927	Male	589.20 ^b	364,717.500	-4.350	<0.001*
	Intermediate	633.30				Female	668.53 ^a			
	High	627.19								
Willingness to consume chicken Meat	Basic	611.11	0.584	2	0.747	Male	585.39 ^b	358,260.00	-4.150	<0.001*
	Intermediate	631.13				Female	660.29 ^a			
	High	618.58								
Willingness to consume chicken Eggs	Basic	624.42	0.280	2	0.869	Male	586.85 ^b	361,501.00	-4.301	<0.001*
	Intermediate	631.94				Female	664.90 ^a			
	High	622.05								
Willingness to consume fish	Basic	629.97	3.462	2	0.177	Male	589.56 ^b	364,348.00	-4.077	<0.001*
	Intermediate	645.53				Female	663.44 ^a			
	High	610.56								

*p < 0.05; **p < 0.01.

Table 6
Comparative analysis between psychometric characteristics and willingness to consume.

Factors	Willingness to consume pork	Mean Rank	Kruskal - Wallis H	df	p – Value	Willingness to consume chicken meat	Mean Rank	Kruskal - Wallis H	df	p – Value
Food neophobia	Yes sure	542.77 ^c	51.071	2	<0.001**	Yes sure	537.70 ^b	51.910	2	<0.001**
	Uncertain	670.66 ^b				Uncertain	669.45 ^a			
	No	765.86 ^a				No	764.38 ^a			
Food neophilia	Yes sure	708.25 ^a	40.642	2	<0.001**	Yes sure	702.63 ^a	42.038	2	<0.001**
	Uncertain	585.78 ^b				Uncertain	575.09 ^b			
	No	528.87 ^b				No	527.96 ^b			
Ecocentric environmental attitude	Yes sure	650.63	4.107	2	0.128	Yes sure	660.95 ^a	9.065	2	0.011*
	Uncertain	621.99				Uncertain	597.52 ^b			
	No	576.74				No	607.04			
Anthropocentric environmental attitude	Yes sure	642.85	1.230	2	0.541	Yes sure	637.57	2.370	2	0.306
	Uncertain	619.02				Uncertain	618.98			
	No	633.54				No	574.82			
Opinions on the use of insects in animal feed	Yes sure	785.35 ^a	193.060	2	<0.001*	Yes sure	780.00 ^a	209.461	2	<0.001**
	Uncertain	563.93 ^b				Uncertain	552.58 ^b			
	No	306.75 ^c				No	249.04 ^c			

Factors	Willingness to consume chicken eggs	Mean Rank	Kruskal - Wallis H	df	p – Value	Willingness to consume fish	Mean Rank	Kruskal - Wallis H	df	p – Value
Food neophobia	Yes sure	542.26 ^b	49.710	2	<0.001**	Yes sure	532.96 ^b	53.367	2	<0.001**
	Uncertain	679.20 ^a				Uncertain	673.34 ^a			
	No	736.00 ^a				No	742.49 ^a			
Food neophilia	Yes sure	701.01 ^a	38.551	2	<0.001**	Yes sure	717.32 ^a	48.251	2	<0.001**
	Uncertain	574.33 ^b				Uncertain	577.32 ^b			
	No	559.30 ^b				No	538.64 ^b			
Ecocentric environmental attitude	Yes sure	667.49 ^a	11.821	2	<0.003**	Yes sure	677.13 ^a	14.653	2	<0.001**
	Uncertain	600.21 ^b				Uncertain	599.72 ^b			
	No	574.94				No	579.67 ^b			
Anthropocentric environmental attitude	Yes sure	643.20	1.923	2	0.382	Yes sure	635.70	0.447	2	0.800
	Uncertain	613.93				Uncertain	621.21			
	No	620.18				No	625.87			
Opinions on the use of insects in animal feed	Yes sure	776.80 ^a	200.219	2	<0.001**	Yes sure	798.15 ^a	228.168	2	<0.001**
	Uncertain	551.91 ^b				Uncertain	563.76 ^b			
	No	264.62 ^c				No	265.21 ^c			

*p < 0.05; **p < 0.01.

levels of food neophobia are more likely to consume foods they are unfamiliar with; by contrast, people with higher food neophobia tend to avoid or reject novel foods (Tomić Maksan et al., 2019).

With regards to the NEP scale, it is interesting to observe that consumers who were willing to consume animal products (i.e., chicken, eggs, and fish) fed with insects differed significantly with uncertain group in terms of ecocentric attitude (Table 6). This shows that consumers are willing to consume these insect-fed animal products when they adopt a more ecocentric attitude, that is, one which places a high value on nature. The explanation for this attitude might be that consumers with an ecocentric attitude may have a greater openness to trying innovative and sustainable food options. Insect-fed animal products represent a novel and eco-friendly approach to food production, which may align with their values and desire to explore alternative food sources. Consumers with an ecocentric attitude may appreciate the reduced environmental impact of insect farming and be more open to supporting such practices. Several studies have reported that green consumers will refuse to buy products that are harmful to the environment. For instance, Hartmann and Siegrist (2017) discovered that consumers with an ecocentric attitude, i.e., those who place a high value on environmental sustainability, are more willing to experiment with novel foods. These individuals, driven by their concern for the environment, are more likely to explore food products that are marketed as being environmentally friendly, even if these foods are unfamiliar to them. Further, Bangsa and Schlegelmilch (2020) shed light on the connection between sustainable product characteristics and consumer decision-making. They identified sustainability attributes as key influencers on consumers' decisions when purchasing food.

Consumers who indicated a positive WTC such animals have positive opinions towards the use of insects in animal feed and they differed

significantly from others (Table 6). Consumer perceptions of the safety of insect-fed animal products are influenced by their attitudes towards using insects in animal feed. If consumers are supportive of the idea of insects as a safe and viable feed source, they are more likely to perceive insect-fed animal products as safe for consumption. This positive perception can increase their willingness to try and consume such products. Similar results are also reported by Mancuso et al. (2016), who revealed that a favourable opinion of insect meal as a feed influences Italian consumers towards farmed fish even if it has been fed with insects. Another study conducted in Brazil found that customers' willingness to accept the use of insects in animal feed is consistently influenced by their positive attitude (de F Domingues et al., 2020). Further, a favourable attitude among UK consumers was found towards acceptance of Scottish salmon fed with insects (Popoff et al., 2017).

5.3. Sociodemographic Characteristics Influence on consumers' Psychometric Characteristics

The results uncovered a significant difference in food neophobia across age and gender (Table 7). Firstly, regarding the effect of age, middle-aged respondents (25–44 years) reported a higher mean rank levels of food neophobia and significantly differ from those of younger respondents (18–24 years). A possible reason for this might be that, over time, individuals develop strong preferences for the foods they are familiar with and have consumed throughout their lives. Older people have had more years to establish their eating habits and food preferences, making them more resistant to trying new foods. This familiarity bias can lead to a higher degree of food neophobia as individuals become less willing to venture beyond their comfort zone. This observation is consistent with the conclusions drawn by other studies, which indicate

Table 7
Comparative analysis between sociodemographic characteristics and psychometric characteristics.

Factors	Financial situation	Mean Rank	Kruskal - Wallis H	df	p - Value	Age	Mean Rank	Kruskal - Wallis H	df	p - Value
Food neophobia	Difficult	639.69	2.600	2	0.273	18–24	586.18 ^b	10.897	2	0.004**
	Adequate	611.93				25–44	671.32 ^a			
	Good	654.76				≥45	608.19			
Food neophilia	Difficult	521.89 ^c	24.431	2	<0.001**	18–24	615.35	5.027	2	0.070
	Adequate	625.30 ^b				25–44	611.87			
	Good	708.83 ^a				≥45	622.23			
Ecocentric environmental attitude	Difficult	593.89	2.295	2	0.317	18–24	496.45 ^b	29.523	2	<0.001**
	Adequate	623.30				25–44	669.79 ^a			
	Good	651.44				≥45	638.02 ^a			
Anthropocentric environmental attitude	Difficult	554.14 ^b	25.639	2	<0.001**	18–24	684.63	5.617	2	0.060
	Adequate	613.99 ^b				25–44	635.16			
	Good	739.27 ^a				≥45	611.38			
Opinions on the use of insects in animal feed	Difficult	557.55 ^b	7.016	2	0.030*	18–24	533.77 ^b	14.517	2	<0.001**
	Adequate	634.88 ^a				25–44	638.26 ^a			
	Good	626.88				≥45	651.06 ^a			

Factors	Education	Mean Rank	Kruskal - Wallis H	df	p - Value	Gender	Mean Rank	Wilcoxon W	Z	p - Value
Food neophobia	Basic	662.85	2.521	2	0.283	Male	603.41 ^b	372,909.000	-2.369	0.018*
	Intermediate	641.50				Female	651.85 ^a			
	High	613.59								
Food neophilia	Basic	514.82 ^b	17.639	2	<0.001**	Male	631.32	398,610.500	-0.272	0.786
	Intermediate	604.56 ^b				Female	625.76			
	High	666.66 ^a								
Ecocentric environmental attitude	Basic	465.45 ^b	20.237	2	<0.001**	Male	622.49	385,320.500	-0.675	0.500
	Intermediate	628.86 ^a				Female	636.29			
	High	654.27 ^a								
Anthropocentric environmental attitude	Basic	669.31	1.141	2	0.565	Male	628.12	388,807.500	-0.133	0.895
	Intermediate	631.33				Female	630.83			
	High	624.52								
Opinions on the use of insects in animal feed	Basic	551.15 ^b	14.274	2	<0.001**	Male	644.63	391,625.00	-1.506	0.132
	Intermediate	599.82 ^b				Female	613.83			
	High	666.91 ^a								

*p < 0.05; **p < 0.01.

that neophobia tends to increase as individuals grow older (Jeżewska-Zychowicz et al., 2021; Meiselman et al., 2010; Predieri et al., 2020; Siegrist et al., 2013). However, several studies have observed a decline in food neophobia as individuals grow older, particularly during the transition from childhood to adulthood. For instance, Mustonen and Tuorila (2010) revealed a reduction in food neophobia scores among children after participating in a sensory education program. The study suggested that through education and increased exposure, the negative effects of food neophobia can be alleviated as children age. Next, previous studies have highlighted the influence of gender on food neophobia. However, there are inconsistencies in these findings. Our study indicated that females were more food neophobic than males (Table 7), which was also confirmed in previous studies (Frank and Van Der Klaauw, 1994; Olabi et al., 2009). However, other studies have suggested men are more neophobic than women (Siegrist et al., 2013; Tuorila et al., 2001), while others reported no gender-related differences (Jeżewska-Zychowicz et al., 2021; Knaapila et al., 2015; Okumus et al., 2021). The disparities in the results can be explained by the fact that food neophobia can be inherited and acquired through environmental factors, leading to cultural distinctions in the context of food between genders (Jeżewska-Zychowicz et al., 2021; Knaapila et al., 2011). It is important to note that generalisations about gender differences can be misleading, as there is significant variation within each gender. While this study has suggested that females may exhibit higher levels of food neophobia than males on average, it is essential to recognize that individual differences and cultural factors play a significant role in shaping food preferences and behaviours.

Based on this study's findings, significant differences in food neophilia were observed across financial situation and educational level (Table 7). Consumers in a good financial situation tended to have a more positive attitude towards food neophilia than those in difficult and adequate situations. One possible reason why people in a good financial situation might have a more positive food neophilia is that they have greater access to a wide variety of food options. This exposure to diverse culinary experiences and interactions with others who have positive attitudes towards food neophilia can influence their own openness to trying new foods. There are limited data on the relationship between financial situation and food neophilia. However, some authors have concluded that consumers with good and high income decrease their food neophobia and increase their willingness to try new foods (Meiselman et al., 2010; Siddiqui et al., 2022). In terms of education, consumers with high education levels have a higher mean rank for food neophilia and differ from other groups. This suggests a positive effect of education level on consumers' willingness to try new food. A potential reason why individuals with higher education may be more likely to exhibit this trait is that higher education often involves exposure to diverse cultures and perspectives. Individuals with higher education levels may thus be more inclined to explore and experiment with new experiences, including trying different types of food. A similar finding was also reported by Helland et al. (2023), who found that respondents with low levels of education had high levels of food neophobia and were less willing to try new food. Another survey of attitudes towards organic foods among Swedish consumers reported that those with high levels of education had more positive attitudes and were more interested in organic foods (Magnusson et al., 2001).

The current results showed a statistically significant effect of age and education on ecocentric environmental attitude (Table 7). Specifically, younger respondents with less education had a less positive ecocentric attitude. A possible explanation for this is that young people with lower levels of education may have limited exposure to information about environmental issues and the importance of ecocentrism. They may not have been exposed to educational programs, campaigns, or media that emphasize environmental conservation and sustainability, and this can contribute to a less positive ecocentric attitude. In accordance with the present results, previous studies have demonstrated that young people's environmental attitudes start to develop at an early age and improve as

they get older (Bradley et al., 2010; Media Subasi and Serap Gökbel, 2019). Aminrad et al. (2011) also found that older age and higher education level both positively correlated with a positive attitude towards the environment among Iranian students in Malaysian universities. Conversely, another study by Schindler et al. (2011) reported that young people tended to have a more positive attitude towards the environment in Austria, but nonetheless supported the finding that highly educated people have a more positive attitude.

Furthermore, the results revealed that consumers in good financial situations differed significantly from other groups in anthropocentric attitude (Table 7). This means that consumers with a good financial background support the idea of valuing nature for its usefulness to humans. People with higher incomes may be more focused on economic growth, financial success, and material possessions. This focus on economic pursuits can sometimes lead to a mindset that prioritizes human needs and desires above environmental concerns. However, it is not accurate to generalize that people with good financial situations inherently have a more anthropocentric attitude, as attitudes towards the environment and nature can vary widely among individuals regardless of their financial circumstances. Prior studies have not gone into great detail regarding the impact of income on environmental attitudes, indicating further research is necessary.

In regard to opinions towards the use of insects in animal feed, the study's results revealed significant difference across financial situations, age, and education (Table 7). First, consumers with adequate financial situations have a higher mean rank and expressed more favourable opinions towards using insects in animal feed than those with financial difficulties. Financial stability can provide individuals with the capacity to consider long-term sustainability issues. They may be more aware of the environmental impacts of traditional animal feed sources and recognize the potential of insect-based feed to address these concerns. This finding is consistent with that of Orkusz et al. (2020) in Poland who found that those with stable incomes are more likely to consume insects and are more inclined to incorporate them into their diets than those with lower incomes. Similar findings were also observed by Liu et al. (2019), which denoted high and stable incomes among Chinese consumers influence their willingness to accept insects as food. However, this finding contradicts the results of De Faria Domingues et al. (2020) in Brazil, which explained how consumers with more stable financial situations are less likely to accept the use of insects as fish food. However, a study conducted in Hungary found that consumer acceptance of animal products fed with insect meal was not influenced by income levels (Szendrő et al., 2020).

Increasing age of respondents (middle-aged and older) was found to align with a more favourable attitude towards using insects in animal feed. This could be because as people age they may develop a stronger sense of environmental responsibility. They have witnessed environmental changes and may be more aware of the need for sustainable practices. Consistent with the current results, previous studies in Australia have also demonstrated that older consumers differ slightly from younger consumers in having higher levels of acceptance of insects as food (Wilkinson et al., 2018). However, other studies have produced contradictory findings regarding how age affects a consumer's willingness to eat insects. For example, several studies have reported that younger age groups are more likely to accept insects as an alternative to meat (Schösler et al., 2012; Verbeke, 2015).

Consumers with a high education level were found to be more positive towards the use of insects in animal feed than those with only basic and intermediate levels of education. This could be explained by their exposure to scientific knowledge and research on the topic. Higher education often involves more exposure to scientific literature, discussions, and critical thinking. As a result, highly educated consumers may have a better understanding of the potential benefits of using insects as animal feed, and consequently more inclined to support insect-based animal feed as a means of addressing sustainability concerns. In line with the present results, previous studies have proven that higher education is a

significant factor in the acceptance of insects as food (Bryant and Barnett, 2020; Onwezen et al., 2021). By contrast, several studies have reported that education is irrelevant when it comes to accepting insects as food (Kulma et al., 2020; Lammers et al., 2019; Schäufele et al., 2019; Woolf et al., 2019).

6. Conclusions

In summary, most Spanish consumers have expressed considerable uncertainty regarding their WTC insect-fed animal products. However, a favourable majority has shown WTC such products, with only a small proportion expressing their reluctance. These findings suggest the potential for introducing insect-fed animal products into the Spanish market. These findings provide a solid foundation of evidence from the consumer side that can assist governments, policymakers, and producers in developing effective strategies for the successful integration of insect meal as alternative protein source in Spain's livestock feed industry and for farmers. The research emphasized that individuals with higher levels of education displayed more food neophilia traits and higher WTC insect meal in animal feed. This underscores the importance for governments to implement informative and practical communication strategies that effectively inform consumers about the advantages of using insects as an alternative protein source for animal feed, and probably to highlight that in the wild state of these animals, the insect is considered their normal and natural diet. Secondly, according to the results of this study, young people and those with lower education levels differ in their ecocentric attitude, which suggests the need for appropriate strategies which adopt environmental awareness programs for the early stages of the education system, which may lead to positive WTC among these groups.

The current study has limitations, which might also reflect opportunities for future research. First, the results are valid only in relation to Spanish consumers. In future research, by comparing the findings with other countries, especially in Europe, it will be interesting to see the similarities or differences in their WTC in order to see a broad picture of the overall acceptance of insects as alternative protein feed. In addition, given that consumers' WTC regarding insect-fed animal products was high at the uncertain level, it would be useful to explore how much consumers are willing to pay (WTP) for each animal product to increase profitability and gain a deeper understanding of consumers. Next, previous studies have demonstrated the impact of information on consumer acceptance of food products; hence, assessing consumers' awareness of information related to insect-fed animal products would be valuable. Moreover, understanding levels of acceptance on the production side is also an important aspect in the successful implementation of any new agricultural practices or technologies, including insect-fed animal products. Lastly, how and to what extent these factors are associated with consumers' acceptance can also be explored.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.spc.2023.07.027>.

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