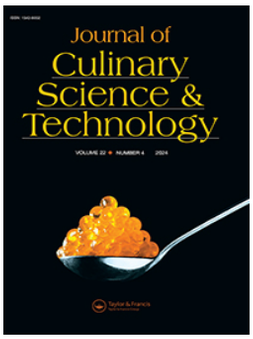

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Edible Insects – Exotic Food or Gastronomic Innovation? Study Involving 14 Countries

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ABSTRACT

This study explores the perceptions about edible insects and their usage in modern gastronomy. Data were collected through questionnaire survey in 14 countries, and 7222 responses were obtained. ANOVA and factor analysis were used, respectively to evaluate differences between groups and to analyze the scale items. The results showed that participants showed higher agreement toward insects being considered exotic foods and being associated with taboos and neophobia. Some sociodemographic factors (country, age class, education level and income) were proven to significantly influence with the perceptions. while sex and living environment did not. Factor analysis extracted three factors, one associated with the uses of insects in gastronomy, another associated with insects as foods and a third about insects not being proper for human consumption. In conclusion, the work revealed differences between countries in the perceptions about edible insects, and that these perceptions were also significantly influenced according to other sociodemographic variables.

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Introduction

In a context of fast raise of the world population, it is envisaged that by 2050 the world population reaches about 10 billion. In this scenario, the demand for food is expected to increase by approximately 50% (Lu et al., 2024). For this reason, food security is at risk and all over efforts are being made to look for more sustainable and efficient ways to feed humans (Guiné, Correia, Coelho, & Costa, 2021). The development and use of alternative food sources is highly encouraged owing to the growing demands for protein, especially from animal origin. At a global level we face serious problems of food and feed insecurity, environmental degradation and loss of biodiversity, wasteful disposal of food and resources, as well as unsustainable food production practices (Araújo, Chavez-Santoscoy, Parra-Saldívar, Melchor-Martínez, & Iqbal, 2023; Laestadius & Wolfson, 2019; Michalke et al., 2023; Roberts, Milios, Mont, & Dalhammar, 2023). The sources of protein are undoubtedly one of the main challenges and in this domain, edible insects (EI) have been suggested as protein rich alternatives to other conventional foods rich in animal protein, allied to a much lower environmental impact (Borges, da Costa, Trombete, & Câmara, 2022; Guiné, Florence, Anjos, et al., 2022; Queiroz et al., 2023).

Some EI are very nutritive foods, being rich in proteins of high biologic value, with a diversity of amino acids, such as essential amino acids, fats, especially polyunsaturated fatty acids, carbohydrates and micronutrients like vitamins and minerals (Anaduaka, Uchendu, Osuji, Ene, & Amoke, 2021; Ghosh, Lee, Jung, & Meyer-Rochow, 2017; Nolan et al., 2023). Besides, EI contain also some bioactive substances responsible for techno-functionality as well as health benefits on the human body, like for example phenolic compounds, dietary fiber (Lucas, Oliveira, Rocha, & Prentice, 2020; Mannozzi et al., 2023; Meshulam-Pascoviche, David-Birman, Refael, & Lesmes, 2022; Navarro del Hierro, Hernández-Ledesma, & Martin, 2022). Bioactivities demonstrated by some edible insects' components include antioxidant, anti-inflammatory, antimicrobial and antiviral activities, as well as protection against developing metabolic syndrome (Navarro Del Hierro, Gutiérrez-Docio, Otero, Reglero, & Martin, 2020; Siddiqui et al., 2023).

Despite the usefulness of EI as a sustainable and nutritive food, the consumption of insects is subject to several constraints, especially in the western societies where they have not been part of cultural food traditions. For this, highly variable contexts are found across cultures and world regions with respect to the utilization of edible insects as foods and their acceptance (Bisconsin-Júnior, Rodrigues, Behrens, da Silva, & Mariutti, 2022; Florença et al., 2022).

The objective of this work was to explore the perceptions of participants from 14 countries about insects as foods and their usage in modern gastronomy. Additionally, differences according to sociodemographic characteristics were

also be analyzed, and finally the 9-items scale was validated by means of statistical tools like factor analysis and internal reliability.

Materials and methods

Study design

For this research was used the data collected through a questionnaire survey in the ambit of project EiSuFood (https://raquelguine.wixsite.com/eisufood), which aimed to study various domains related to EI (Guiné, Duarte, et al., 2023). This paper focuses one of the dimensions investigated in the project, associated with the perceptions of participants in 14 different countries in relation to the gastronomic usages of EI including their potential for innovation and gourmet kitchen.

As so, this article shares some common elements with previously published work from the same team under the same project, like for example the work by Guiné et al. (2022) and Guiné et al. (2023). These two articles are from the same project, and the sample is the same, as well as the ethical approval or data collection, and therefore some data related to the sample characterization or description of the project, are similar. However, the contents of the articles is totally different, because the first is related to consumer's awareness about sustainability of edible insects, the second is about knowledge of edible insects, and this present article relates to culinary uses of insects. Although connected, the contents of the articles are totally different in terms of research results, even though sharing a common methodology for data collection and using the same questionnaire.

Instrument

The questionnaire used for the collection of data was validated and approved by the Ethics Committee of the Polytechnic University of Viseu (Ref. 45/SUB/2021). Additionally while preparing the research and implementing the data collection and treatment, strict ethical principles, including those of the Declaration of Helsinki, were obeyed, for ensuring the rights of the participants and their data.

The nine questions included in the questionnaire to investigate this problem were as follows: Q1. Insects are considered as exotic foods; Q2. Insects are traded as treats/delicacies; Q3. Insects are not suitable for human consumption; Q4. Insects are associated with taboos and food neophobia (not wanting to eat unfamiliar foods); Q5. Some gourmet restaurants use edible insects in their culinary preparations; Q6. Insects are present in culinary events and gastronomic shows; Q7. Insects are recommended by some recognized chefs; Q8. Chefs contribute to the popularization of insects into gastronomy in

Western countries; Q9. Culinary education favors overall liking for innovative insect-based products. These questions were part of the previously validated questionnaire, as described in a previous work by the same team (Guiné, Duarte, et al., 2023).

The participants had to express their opinion to each of the nine questions using a Likert scale with five points of agreement: 1 = strongly disagree, 2 = disagree, 3 = no opinion, 4 = agree, 5 = strongly agree (Likert, 1932).

Data collection

This is a descriptive cross-sectional study undertaken on a non-probabilistic sample consisting of 7222 participants originating from 14 countries. The data collection took place between July and November 2021, by means of a computer/web-based methodology. This questionnaire was to be responded only by adults (people aged 18 years or older), and all participants had to specifically give their informed consent before they were given access to the questionnaire. Additionally, the participants could abort the response and quit without sending the responses at any moment during the process, and until they clicked the final send button. More details about the data collection performed in the ambit of the project can be found in Guiné et al. (2022).

Data analysis

The average scores for each item were calculated as a mean value between the scores given by the participants, while the average scores for each participant were calculated as a mean value based on the scores attributed by that participant to each of the nine items. These average scores were then analyzed for comparison purposes or for identification of possible differences. For data treatment, evaluation of possible differences of mean values between groups was made using the ANOVA – analysis of variance, complemented with the post-hoc test of Tukey. The level of significance considered was 5%.

For analysis of the scale items was applied Factor Analysis (FA) based on the extraction method of Principal Components Analysis. For rotation the Varimax method was chosen. The number of components to be extracted was established based on Eigenvalues greater than 1. A measure of the adequacy of the study sample was used (KMO: Kaiser-Meyer-Olkin) to confirm suitability to apply FA. Also the Bartlett's test was computed to analyze the correlations between variables (Broen et al., 2015). As reference values of the KMO measure, was used the criteria sed KMO > 0.5 for acceptable. Moreover, higher values of KMO indicated increasing suitability of the data to apply FA (Kaiser & Rice, 1974). For not being relevant statistically, cases where the factor loadings had values lower between −0.44 and +0.4 were excluded (Rohm & Swaminathan, 2004; Stevens, 2009).

Internal reliability analysis was performed using the Cronbach's alpha (α) test to assess the internal consistency of the items that composed each of the factors obtained in the FA (Broen et al., 2015; Tanaka, Akechi, Okuyama, Nishiwaki, & Uchitomi, 2000). As reference values of alpha were taken these intervals: acceptable consistency if $0.5 < \alpha < 0.7$, good consistency if $0.7 \leq \alpha < 0.8$, very good consistency if $0.8 \leq \alpha$ (Davis, 1964; Hair, Black, Babin, & Anderson, 2009; Maroco & Garcia-Marques, 2006).

Results

Sample characterization

Table 1 shows the sociodemographic characteristics of the 7222 participants. The distribution by country was relatively even, showing, however, a somewhat higher participation of Mexican citizens. Most participants were female (63.5%) and the age class less represented were the senior adults with 15.6%. The classes of education were quite even, with a percentage of participants with a post-graduate level of education around one-third (31.9%). About

Table 1. Sociodemographic characterization of the sample (N = 7222).

Variables	Groups	N	%
Country	Brazil	322	4.5
(*N* = 7222)	Croatia	686	9.5
	Greece	636	8.8
	Latvia	300	4.2
	Lebanon	357	4.9
	Lithuania	510	7.1
	Mexico	1139	15.8
	Poland	521	7.2
	Portugal	527	7.3
	Romania	492	6.8
	Serbia	344	4.8
	Slovenia	517	7.2
	Spain	575	8.0
	Turkey	296	4.1
Sex	Female	4584	63.5
(*N* = 7222)	Male	2590	35.9
	No answer	48	0.7
Age class	Young adults (18–30 years)	3415	47.4
(*N* = 7208)	Adults (31–50 years)	2665	37.0
	Senior adults (51 years or over)	1128	15.6
Education	Post-graduate (master or doctorate)	2303	31.9
(*N* = 7210)	Completed university degree	2329	32.3
	No university degree	2578	35.8
Living environment	Rural	1377	19.1
(*N* = 7221)	Urban	4739	65.6
	Suburban	1105	15.3
Household income in relation to average	Much lower	424	5.9
(*N* = 7168)	Lower	1142	15.9
	Equal	2729	38.1
	Higher	2327	32.5
	Much higher	546	7.6

The sociodemographic variables are the same of the ElSuFood Project, and the sample was common to different studies (Guiné, Florença, Anjos, et al., 2022).

one-third of the participants (38.1%) had income equal to the average income in their own countries and 40.1% had income above the average (32.5% had income higher than average and 7.6% had income much higher).

Perceptions about edible insects and gastronomy

Table 2 presents the mean scores calculated for each of the items, based on the scores attributed by all participants. The items with higher global level of agreement among all items are Q1 about insects being exotic foods (mean value of 3.82 ± 1.12 on a scale from 1 to 5) and Q4 about insects being associated with taboos and food neophobia (mean value of 3.79 ± 1.10). The lowest level of agreement was found for item Q3 (with a mean value closer to the lower limit of the scale, 2.41 ± 1.25) showing disagreement with the expression that insects are not suitable for human consumption.

Figure 1 presents the mean values for agreement of the participants toward items related with insects as food, separated by country. In relation to Q1, insects being considered exotic food, very high levels of agreement were found in general, and particularly for participants from Mexico (mean value of 4.20 for a maximum value of 5), Poland and Lithuania (means of 4.17 in both cases). For Q2, insects commercialized as treats or delicacies, the highest agreement was found for Brazil (mean value of 3.74) and Lithuania (mean value of 3.70), while in Poland the score was toward disagreement (mean value of 2.92, so below the central point of the scale which was 3). Regarding Q3, the perception that insects are not suitable for human consumption, in practically all the studied countries the scores were low, below the mean point of the scale (3), meaning that the participants disagreed with the statement, and therefore they consider EI are in fact suitable for human consumption. Exceptions were found only for Lebanon (mean value of 3.20), Croatia (mean value of 3.13) and Turkey (mena value of 3.11), for which the mean values were greater than 3, the central point of the scale. Finally, the results for Q4, about the taboos and neophobia associated with EI, also revealed a very expressive level of

Table 2. Mean scores for each item, considering the global sample.

Item	Mean ± s.d.[1]
Q1. Insects are considered as exotic foods	3.82 ± 1.12
Q2. Insects are traded as treats/delicacies	3.34 ± 1.10
Q3. Insects are not suitable for human consumption	2.41 ± 1.25
Q4. Insects are associated with taboos and food neophobia	3.79 ± 1.10
Q5. Some gourmet restaurants use edible insects in their culinary preparations	3.63 ± 0.98
Q6. Insects are present in culinary events and gastronomic shows	3.44 ± 1.03
Q7. Insects are recommended by some recognized chefs	3.32 ± 0.98
Q8. Chefs contribute to the popularization of insects into gastronomy in Western countries	3.36 ± 1.01
Q9. Culinary education favours overall liking for innovative insect-based products	3.40 ± 1.08

Values on a scale from 1 to 5, for which: 1 = strongly disagree, 2 = disagree, 3 = no opinion, 4 = agree, 5 = strongly agree.

Items from previously validated questionnaire (Guiné, Duarte, et al., 2023).

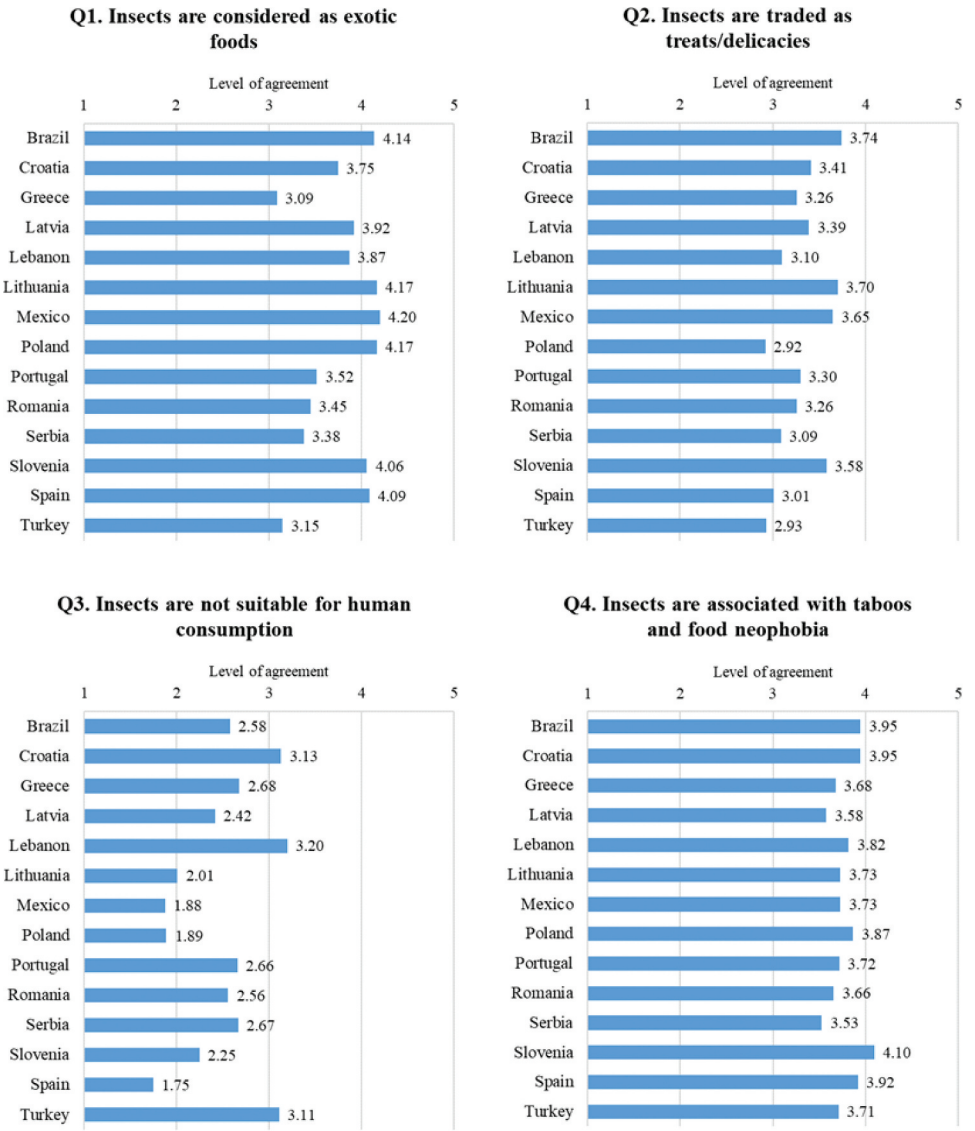

Figure 1. Perceptions of participants towards issues related with insects as food, by country.

agreement in all the 14 countries, being highest in Slovenia (mean value of 4.10 for a maximum possible of 5).

Figure 2 shows the mean values of agreement toward items related with gastronomic usages of insects, also by country. In what concerns Q5, about some gourmet restaurants using EI, very high levels of agreement were found in all studied countries (i.e., with mean values closer to the upper limit of the scale, which was 5), and the mean value was particularly high in Mexico (4.12). Also Q6, about insects being part of culinary events, gathered a very high agreement for the participants from a high number of countries, especially

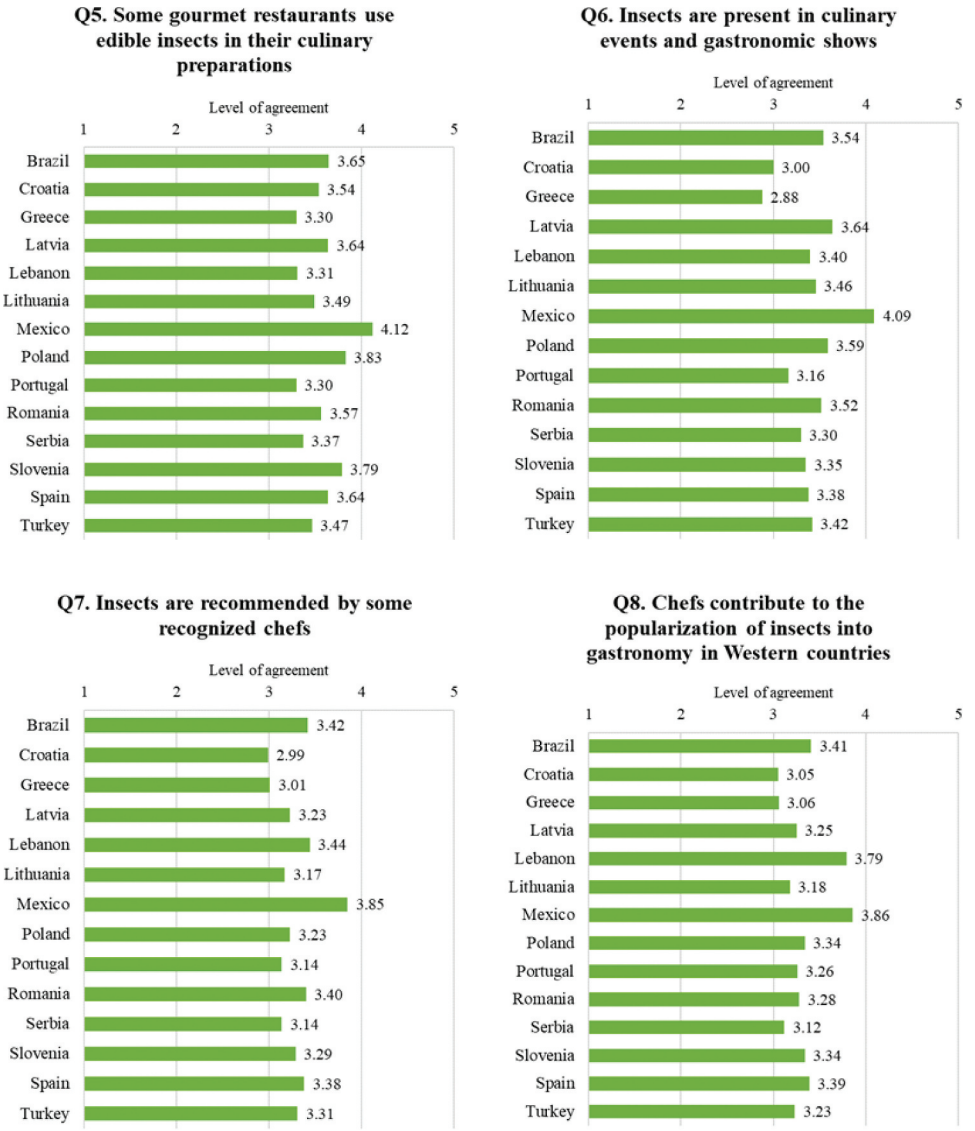

Figure 2. Perceptions of participants about gastronomic usages of insects, by country.

Mexico (mean value of 4.09), but not in Greece (where the mean value of 2.88 stood below the central point of the scale). With respect to Q7, related with the recommendation of chefs, Mexico is highlighted with a score much higher than other countries (mean value of 3.85), being Croatia the country where the agreement was lower (mean value of 2.99 on the scale from 1 to 5). In relation to Q8, about the role of chefs in making EI more popular, some agreement was found for all studied countries, especially Mexico (3.86) and Lebanon (3.79), since in these two countries the mean values were higher than in the other countries.

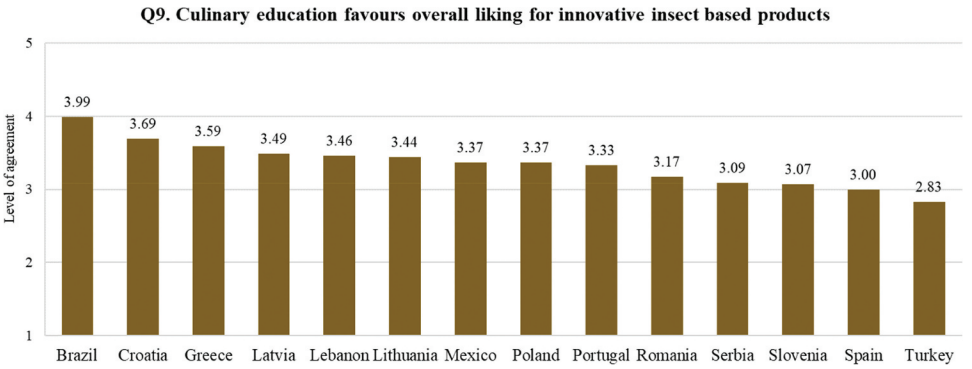

Figure 3. Perceptions of participants about the role of culinary education in acceptance of insects, by country.

According to the results presented in Figure 3, which are related to the role of culinary education in acceptance of insects, higher agreement was found for participants from Brazil (mean value of 3.99), Croatia (mean value of 3.69) and Greece (mean value of 3.59). On the other hand, lower level of agreement was obtained for participants from Turkey (mean value of 2.83) or Spain (mean value of 3.00).

Influence of sociodemographic variables on the perceptions about edible insects and gastronomy

Based on the average scores obtained for each participant, the results were analyzed for possible differences according to the six sociodemographic variables, being the results presented in Table 3. These results indicate significant differences for the perceptions according to country ($p < .001$), age class ($p < .001$), education ($p = .043$) and income ($p = .003$), but not according to sex or living environment. Higher level or perception was found for participants from Mexico (3.71 ± 0.64), for young adults (3.41 ± 0.60), for those who completed a university degree but did not pursue further studies (3.41 ± 0.61), and with an income lower (3.42 ± 0.61) or higher (3.42 ± 0.57) than the average income.

Scale validation through factor analysis and reliability

According to the correlation analysis there were some associations between the variables, with seven values above 0.5; the highest correlation was $r = 0.656$ (between Q7 and Q8). The Bartlett's test was significant ($p < .0005$), rejecting the null hypothesis "H0: The correlation matrix is equal to the identity matrix." According to the reference values for the KMO (Kaiser & Rice, 1974), the value obtained of 0.865 is considered good. The anti-image matrix showed that all the

Table 3. Perceptions according to sociodemographic variables.

Variables	Groups	Perceptions Mean ± s.d.[1]	Significance[2]
Country	Brazil	3.53 ± 0.65^{f}	$p < .001$
	Croatia	3.30 ± 0.59^{bcd}	
	Greece	3.11 ± 0.57^{a}	
	Latvia	3.38 ± 0.35^{de}	
	Lebanon	3.51 ± 0.53^{f}	
	Lithuania	3.38 ± 0.43^{cde}	
	Mexico	3.71 ± 0.64^{g}	
	Poland	3.66 ± 0.49^{cde}	
	Portugal	3.25 ± 0.61^{bc}	
	Romania	3.34 ± 0.62^{cd}	
	Serbia	3.19 ± 0.70^{ab}	
	Slovenia	3.48 ± 0.57^{ef}	
	Spain	3.34 ± 0.62^{cd}	
	Turkey	3.26 ± 0.61^{bcd}	
Sex	Female	3.40 ± 0.60^{a}	$p = .442$
	Male	3.38 ± 0.62^{a}	
	No answer	3.39 ± 0.71^{a}	
Age class	Young adults (18–30 years)	3.41 ± 0.60^{b}	$p < .001$
	Adults (31–50 years)	3.40 ± 0.61^{b}	
	Senior adults (51 years or over)	3.30 ± 0.60^{a}	
Education	Post-graduate (MSc or PhD)	3.40 ± 0.56^{b}	$p = .043$
	Completed university degree	3.41 ± 0.61^{b}	
	No university degree	3.37 ± 0.64^{a}	
Living environment	Rural	3.37 ± 0.65^{a}	$p = .311$
	Urban	3.40 ± 0.61^{a}	
	Suburban	3.39 ± 0.57^{a}	
Household income in relation to average	Much lower	3.39 ± 0.69^{ab}	$p = .003$
	Lower	3.42 ± 0.61^{b}	
	Equal	3.36 ± 0.62^{a}	
	Higher	3.42 ± 0.57^{b}	
	Much higher	3.39 ± 0.65^{ab}	
Global sample		3.39 ± 0.61	

[1]Values on a scale from 1 to 5, for which: 1 = strongly disagree, 2 = disagree, 3 = no opinion, 4 = agree, 5 = strongly agree.
[2]ANOVA with post hoc test of Tukey at a level of significance of 5% ($p < .05$). Mean values with different superscript are significantly different.
The sociodemographic variables are the same of the EISuFood Project (Guiné, Florença, Anjos, et al., 2022).

values of MSA (Measure of Sampling Adequacy) were over 0.5, confirming that all items were adequate to include in the analysis. The lowest MSA was 0.789 for item Q4, and the highest was 0.892 for items Q5 and Q9.

The solution obtained by FA with PCA and Varimax rotation explains 66.1% of the variance and retained three components. All communalities were higher than 0.5, so none of the nine variables shall be excluded. The item with higher communality was Q3 (explaining 78.0% of variance), and the item with the lowest variance explained by was Q2 (52.1% variance explained). Rotation converged in 4 iterations. Table 4 shows the results of the solution obtained with FA, which was validated by the Cronbach's alpha (α) test, confirming internal consistency of each factor (Broen et al., 2015).

According to the obtained results, one factor (F1) included all items related to the gastronomic usages of insects plus the role of culinary education, the other factor (F2) included items related to the use of insects as food, and a third factor (F3) included only one item, which

Table 4. Solution obtained through factor analysis.

Factor	%VE[1]	Item	Loading	Alpha[2]
F1	35.3%	Q5. Some gourmet restaurants use edible insects in their culinary preparations	0.706	0.860
		Q6. Insects are present in culinary events and gastronomic shows	0.788	
		Q7. Insects are recommended by some recognized chefs	0854	
		Q8. Chefs contribute to the popularization of insects into gastronomy in Western countries	0.829	
		Q9. Culinary education favours overall liking for innovative insect based products	0.706	
F2	18.8%	Q1. Insects are considered as exotic foods	0.794	0.553/
		Q2. Insects are traded as treats/delicacies	0.628	0.594[3]
		Q4. Insects are associated with taboos and food neophobia	0.656	
F3	11.9%	Q3. Insects are not suitable for human consumption	0.853	N.A.[4]

[1]VE = Variance explained.
[2]Cronbach's alpha.
[3]The value of alpha increases from 0.553 to 0.594 if item Q4 is deleted.
[4]N.A. = not applicable, single item in the factor.
Items from previously validated questionnaire (Guiné, Duarte, et al., 2023).

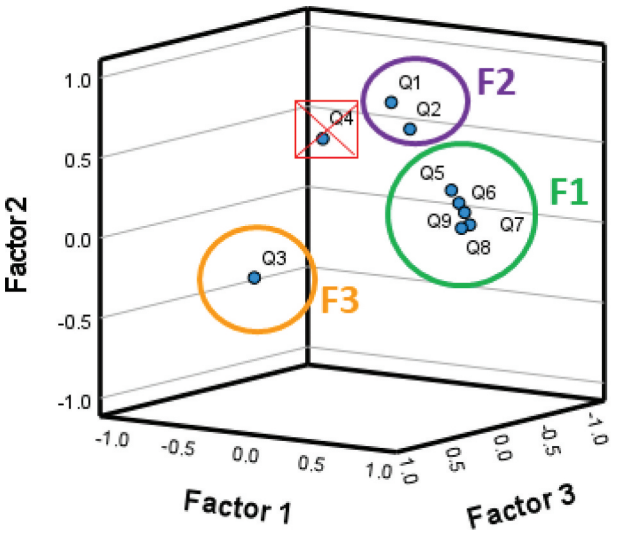

Figure 4. Component graph resulting from the factor analysis with varimax rotation.

was Q3, the item from the nine that was given as a negative statement. The internal consistency of factor F2 could improve if item Q4 was excluded from the analysis. The final values of alpha are acceptable (for factor F2, $\alpha = 0.594$) and very good (for factor F1, $\alpha = 0.860$).

Figure 4 shows the rotated component plot resulting from the factor solution, clearly indicating the spatial distribution of the three factors, and also highlighting the exclusion of item Q4 from factor F2, as indicated by the reliability analysis.

Discussion

Science has demonstrated that EI are good sustainable alternatives to other animal proteins, containing proteins (and essential amino acids), fat (particularly unsaturated fatty acids), dietary fiber, and micronutrients like vitamins and minerals Besides, they contain bioactive molecules such as phenolic compounds with biological activities (Aguilar & Ribeiro, 2023; Anusha & Negi, 2022; Sogari et al., 2023; Zielińska, Baraniak, Karaś, Rybczyńska, & Jakubczyk, 2015). For being nutritive foods with a lower environmental impact, EI have been suggested as part of the solution to fight world food insecurity and have been recommended by the FAO – Food and Agriculture Organisation of the United Nations Food and Agriculture Organisation (FAO, 2021; Huis et al., 2013). The participants in this study showed a disagreement with the expression that insects are not suitable for human consumption, therefore revealing that they were aware of the fact that some insects can be consumed as food, even though most countries involved in the study are European, and therefore with a poor tradition of insect consumption.

The motivations and obstacles to consumption of EI are highly variable across countries, namely between those who are traditionally entomophagous and those where EI are not part of the traditional food heritage, such as most western countries. The review by Florença et al. (2022) highlighted factors such as nutritional value, sensory characteristics, sustainability aspects, tradition and culture, food disgust and neophobia, as well as familiarity or past experiences as the principal motivations associated with the consumption of EI. The authors further noticed that, in insect eating countries, a greater emphasis was posed on the sensorial aspects of EI, their availability, and affordability, besides personal preferences or traits. On the other hand, in western countries, consumers attributed higher value to determinants such as the sustainability aspects, nutritional composition of EI, benefits for human health, while also considering tradition/culture, familiarity/past experience, and food neophobia/disgust. Another review by Mancini, Moruzzo, Riccioli, and Paci (2019) exploring how European consumers accept insects as food, concluded that the level of acceptability of EI among European populations is still very low in general, although certain groups were identified as early adopters and more easily prone to start entomophagy, like for example the students attending Gastronomy courses at university. A great majority of the participants of this study tend to consider insects as exotic foods and recognize that insects are associated with taboos and food neophobia, again this results from the lack of tradition in the consumption of insects in most European countries included in the study. Nevertheless, in countries like Brazil, or Mexico, insects are reported by the participants as being traded as food delicacies, and interestingly also this happens in some European counties, namely Lithuania and Slovenia. Looking closely at country differences,

participants from Mexico, Lithuania and Poland manifested stronger agreement with insects being exotic foods. In Brazil and Lithuania, insects are strongly considered as treats/delicacies. Participants from Lebanon Croatia and Turkey were the only ones in agreement with the statement that insects are not suitable for human consumption, while in all countries included in this study insects were considered associated with taboos and neophobia. In Mexico the highest level of agreement was found compared to other countries for insects being used in gourmet restaurants, for them being a part of culinary events, for being recommended by some recognized chefs and these chefs contribute to the utilization of insects in gastronomy. Culinary education was found to contribute to the increase in acceptance of innovative foods containing insects, particularly in Brazil, Croatia and Greece. Additionally, the role of chefs is also acknowledged, because even in western countries they started to use insects as delicacies and produce appealing culinary preparations based on insects that captivate the public's attention and acceptance.

Although there are many obstacles to eating insects, especially in western societies, a recent review by van Huis and Rumpold (2023) pointed out some strategies to incentivize consumers to adopt them. Some of these strategies include to properly inform the consumers about the nutritional value and adequateness of edible insects, their safety for human consumption, their quality and their sustainability, since modern consumers are more alert to environmental issues. Another strategy is to incorporate insects as food ingredients, rather than presenting them whole to consumers who are unaccustomed to eating them. Finally, the same authors also highlight the role of tasting experiences, linked with gastronomic preparations and gourmet kitchen allied to the incentives provided by celebrities. Also Mishyna, Chen, and Benjamin (2020) emphasize the role of sensory attributes of edible insects and insect-based foods as determining factors for increasing consumer appeal.

Many studies have supported the use of processed insects into traditional or innovative food products as a more beneficial strategy to achieve higher consumer acceptance when compared to the use of whole insects, since by being not visible the consumers' rejection is greatly reduced (Baiano, 2020; Lombardi, Vecchio, Borrello, Caracciolo, & Cembalo, 2019; Orsi, Voege, & Stranieri, 2019; Zielińska, Zieliński, Karaś, & Jakubczyk, 2020). Many food products containing insects, for example, in the form of insect flour, have been successfully tested for consumer acceptance, such as energy bars, sandwiches, snacks, energy shakes, soups, burgers, and bakery products (bread, cookies) or pasta, among others (Bartkiene et al., 2023; Biró, Fodor, Szedljak, Pásztor-Huszár, & Gere, 2019; Tedjakusuma, Linggadiputra, Cahya, & Surya, 2022; van Thielen, Vermuyten, Storms, Rumpold, & van Campenhout, 2019). The use of insect-based food items where the insects are not fully visible is a way to incentive their acceptance and consumption. The participants in the present study recognize that culinary education can be beneficial to increase

acceptance of insect-based food products. The study's findings reveal significant differences in perceptions of edible insects and gastronomy based on a variety of sociodemographic characteristics. Participants from Mexico, for example, had significantly higher awareness levels than peers from other countries, highlighting the influence of cultural contexts on the acceptance of edible insects. Furthermore, young adults displayed a more hopeful attitude, consistent with the current trend of increased receptivity among younger cohorts to novel nutritional options. Education also played an impact, as those who finished university degrees without going on to pursue their education demonstrated higher levels of perception. This could be attributed to their exposure to other points of view and a better understanding of the possible benefits of eating insects. Income levels were particularly interesting, as both lower and higher income brackets had higher perception levels than the average income category. This finding shows that economic concerns may not be the only factors influencing views toward edible insects, with cultural and educational factors also having an impact.

Moreno, Reyes-Prado, and Nonaka (2022) discusses the gastronomic usage of some common edible insects in Mexico. In fact, the use of insects in gastronomy is a trend that contributes to their dissemination as a gourmet food item. Halloran, Flore, and Mercier (2015) in their notes from the workshop titled "Insects in a gastronomic context," that took place in in Bangkok, Thailand, report that four innovative dishes were prepared purposely for the event aimed to be evaluated by the participants, that included chefs, among other professionals. The reported results highlighted that all participants considered the menu as well as the presentations fascinating, and after the event, 93% of the participants assumed that they would be willing to eat insects again in the future. Additionally, they all manifested the interest in repeat participation in such events in the future. It is notable that the participants in this research recognize that activities promoted by recognized chefs can be a way to make insects or insect-based foods more popular in countries where they are not part of the traditional gastronomic culture.

Conclusions

This work revealed that participants in the 14 countries of the study have higher agreement toward insects being considered exotic foods and being associated with taboos and neophobia. Culinary education was found to contribute to the increase in acceptance of innovative foods containing insects, especially taking into account that most countries of the present study are European, where entomophagy is not traditional.

Sociodemographic variables like country, age, education, and income were confirmed as significantly related with the perceptions of the participants in the study, while sex and living environment were not influential. The study's

discovery that these judgments vary significantly depending on criteria such as country of origin, age group, educational achievement, and income level is revealing of the cultural and gastronomic diversity of the participants and their countries' specificities.

Factor analysis revealed three factors that explain two thirds of the variance, one associated with the uses of insects in gastronomy, another associated with insects as foods and a third about insects not being proper for human consumption. Finally, reliability analysis showed appropriate internal consistency of the sub-scales.

Gastronomic value

The results in this study are relevant from the gastronomic point of view because they highlight some perspectives that consumers have about the utilization of EI in gastronomic preparations and culinary recipes. Moreover, because the study includes participants form 14 countries it gives a wide perspective of consumer perceptions across variable sociodemographic and cultural disparities. Strong perceptions were found toward EI being considered exotic foods, but on the other hand quite associated with taboos and neophobia. However, it is recognized by the participants the role of culinary shows and gastronomic events as ways to promote a better familiarization with EI. Also, it is acknowledged that famous chefs can successfully recommend the consumption of EI by using them in gourmet preparations, thus contributing to the popularization of EI into gastronomy, particularly in non-entomophagous communities.

Limitations and future work

Although this study included many different countries, the results may have some bias due to the lower participation of people from countries where EI are part of the gastronomic tradition. In fact, when designing of the EISuFood project, more countries were selected as having a tradition of consuming insects Countries such as Colombia, Cape Verde, Nigeria or Morocco were invited to participate in the study, but they were not able to deliver a minimum number of responses to be acceptable for inclusion in the multinational study. That is a limitation of the study. However, this was somehow minimized by the inclusion of a very expressive participation of Mexican participants, two or three times as that of other countries, and Mexico has many regions where entomophagy is traditional.

Another limitation may be linked with unequal group representation, namely more female participants than male, but this is very common in surveys where a non-probabilistic convenience sample is used, due to facility of recruitment and normally higher disposition of female participants to participate in questionnaire

surveys. The uneven group representation can, however, be to some extent compensated by the very high number of participants globally, more than 7 thousand (Guiné et al., 2020).

The study focuses on perceptions rather than real consumption behavior. There could be differences in what people perceive and what they eventually do. External influences, such as media coverage or societal trends, could influence participants' perspectives, which the study may not have completely explored. Perceptions of participants may change over time because of changing social, cultural, and economic factors. As a result, it would be interesting to revisit the findings over time. Finally, sociodemographic characteristics can alter throughout time. If there are changes in age distribution, education levels, income patterns, and so on, the findings may no longer be applicable in the future.

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