

Research Article

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Edible insects: A survey about perceptions regarding possible beneficial health effects and safety concerns among adult citizens from Portugal and Romania

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Abstract: Although edible insects (EI) have been consumed for ages in many countries around the world, in most European countries, this is not a traditional practice. Still,

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it has been encouraged as a sustainable source of animal protein besides other nutrients. The Food and Agricultural Organization and the United Nations, recommend consuming EI as a way to contribute to the sustainable development goals. Hence, this research investigated how participants from Portugal and Romania perceive EI, and how these can be useful as a source of nutrients and other benefits for human health, as well as possible risks. For that, it was undertaken a questionnaire survey, with data collected online in the two countries. For the analysis of data, basis statistics and chi-square tests were used. Results showed significant differences between Portuguese and Romanian participants in six out of ten questions, namely regarding safety ($p < 0.001$), use in traditional medicine ($p < 0.001$), possible infection with parasites ($p = 0.021$), of pesticides ($p = 0.031$), their usage as therapeutics ($p = 0.001$) and being potential sources of allergens ($p < 0.001$) and aflatoxins ($p < 0.001$). Also, differences were tested for other sociodemographic variables. The results showed significant differences according to age for only three questions, gender for only two questions, and Education for most of the questions, i.e., six out of the ten. These results highlighted the greater influence of variables like country of origin and education in the perception of the effects of EI in human health.

Keywords: consumer perception, health benefits, safety risks, country differences

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1 Introduction

One of the United Nations (UN)' objectives listed in the sustainable development goals is to pursue the achievement of zero hunger together with good health and wellness by 2030. Nevertheless, global actions do not seem to be enough, particularly in some regions, for example, Sub-Saharan Africa, where food insecurity and poverty are worsening [1]. Difficulty in accessing food in quantity and quality necessary for the feeding of the human population continues to be one of the most threatening issues to the survival of humans [2].

The search for efficient sources of nutritive foods has led to the perspective of looking at traditional as well as unconventional foods that arise as good alternatives, and sustainable options to serve as sources of a diversity of food products. Many approaches have been focusing on the reutilization of agricultural residues or food waste, to extract macro and micro-nutrients, or to develop new foods with increased health benefits by incorporating a diversity of bioactive compounds, in several attempts to implement a circular economy [3–6].

One other approach, which has great relevance is to incentivize the consumption of insects, which constitute a nutritive food and an alternative source of animal protein. Edible insects (EI), are suggested as a food alternative that can help achieving the sustainable development of the planet [7]. Livestock requires high land areas, and high feed and water input ratios, when compared with insects, which require less area for production, and have a higher conversion ratio between input feed and output mass [8].

EI have been consumed as traditional foods in many regions of the globe, where eating insects is a fully accepted practice. However, in other regions, they are not so readily accepted due to many factors that lead consumers to be defensive toward unfamiliar foods such as insects, or even feel disgust or neophobia [9,10].

The possibility of utilizing insects as a novel food source is attracting much attention in Europe for being a more environmentally friendly food as compared with beef, pork, or chicken meat. Nevertheless, even though insects are highly appreciated in very different parts of the world, like in some Asian, African or South/Central American countries, it is also a fact that consumer aversion remains the strongest barrier to a fully successful introduction of EI at a large scale in Europe [11–13].

Factors such as awareness of the sustainability of EI or their value as nutritive and healthy foods can be considered drivers of a more positive attitude toward acceptance of EI as food [14,15]. EI contains relevant amounts of protein and micronutrients, and insect-based foods may have an equal

or even superior nutritional value when compared to those obtained from birds or mammals [14]. Besides macro and micro-nutrients, EI can contain bioactive compounds with a positive impact on human health. For that reason, they have been used in some regions in traditional folk medicine [16]. Nevertheless, it is also relevant to look at possible harmful effects linked with the consumption of EI [17,18].

The consumption of EI must not pose any kind of risk to human health. Some EI species can contain allergens; for example, mealworms and cricket have been reported to have arginine kinase allergens, with cross-reactivity [19,20], and therefore people prone to allergen reactions must take care when consuming EI. Research has pointed out that some EI contain anti-nutritional elements, which are compounds that reduce the absorption of other nutrients in the human body. To this matter, EI can contain oxalates, phytates, or saponins, and these can compromise the correct absorption of nutrients such as proteins or minerals. Other hazards may result from microbial contamination of EI or the presence of pesticides [21–23], although these problems arise when the insects are collected from the wild, being the problem minimized or totally eliminated in farmed insects that obey all safety regulations. Also, Mwelwa *et al.* [24] reported a possible transfer of heavy metals along the food chain (soil-plant-insect-humans), but, once again, this problem relates to insects harvested in the wild in environments polluted with heavy metals, because when they are reared in farms all the production is rigorously controlled, and in that case, they are safe for human consumption [25].

Considering that EI can have different effects on the human body and their consumption could eventually be associated with health benefits but also some food safety risks, the aim of this study was to compare the perceptions regarding health aspects linked with consumption of EI among participants from two distinctive European countries, one from the Atlantic coast (Portugal) and one from Central Europe (Romania). In this context, the main research hypothesis is “Are there any differences between Portuguese and Romanian consumers regarding the knowledge about the health effects of EI?”.

2 Materials and methods

2.1 Questionnaire and ethical approval

The questionnaire developed to collect the data was formulated and applied in the ambit of the international project EISuFood of the CERNAS-IPV Research Centre from the Polytechnic University of Viseu. The questionnaire was

original, purposely developed for the project, and it was validated according to the work by Guiné et al. [26]. The validation was made with structural equation modelling, producing two multifactorial models with good fit indices and internal consistency (Cronbach's $\alpha = 0.941$) [26].

One of the sections of the questionnaire was devoted to collect data regarding health aspects linked with the consumption of EI, to assess how the participants perceived these effects on the human body. This part of the questionnaire contained 10 items for which the participants expressed their agreement using a 5-point Likert scale (1 = Strongly disagree, 2 = Disagree, 3 = Indifferent, 4 = Agree, and 5 = Strongly agree) [27]:

- (1) There are appropriate regulations to guarantee food safety of edible insects.
- (2) Insects are used by some people in traditional medicine.
- (3) Eating insects poses a substantial risk to human health.
- (4) Industrial-processed insect products are hygienic and safe.
- (5) Insects and insect-based foods are often infected by pathogens and parasites.
- (6) Insects collected from the wild may be contaminated with pesticide residues.
- (7) In certain countries, insects are approved officially for therapeutic treatment.

- (8) Insects contain bioactive compounds beneficial to human health.
- (9) Insects are potential sources of allergens.
- (10) Aflatoxins, which are carcinogens, can be present in insects.

The questionnaire was translated into the native languages of the participants before being distributed. This manuscript deals with data collected from participants residing in Portugal and Romania.

All ethical considerations were taken into account when designing the questionnaire and collecting the data, including those from the American Psychological Association Ethical Guidelines for Research involving Human Subjects, and the Declaration of Helsinki. The Polytechnic University of Viseu Ethics Committee approved the ethical aspects of this study (Reference No. 45/SUB/2021).

2.2 Data collection

The survey was applied through the Google forms® online platform only to adult participants, who gave their informed consent to participate in the study. Only those who

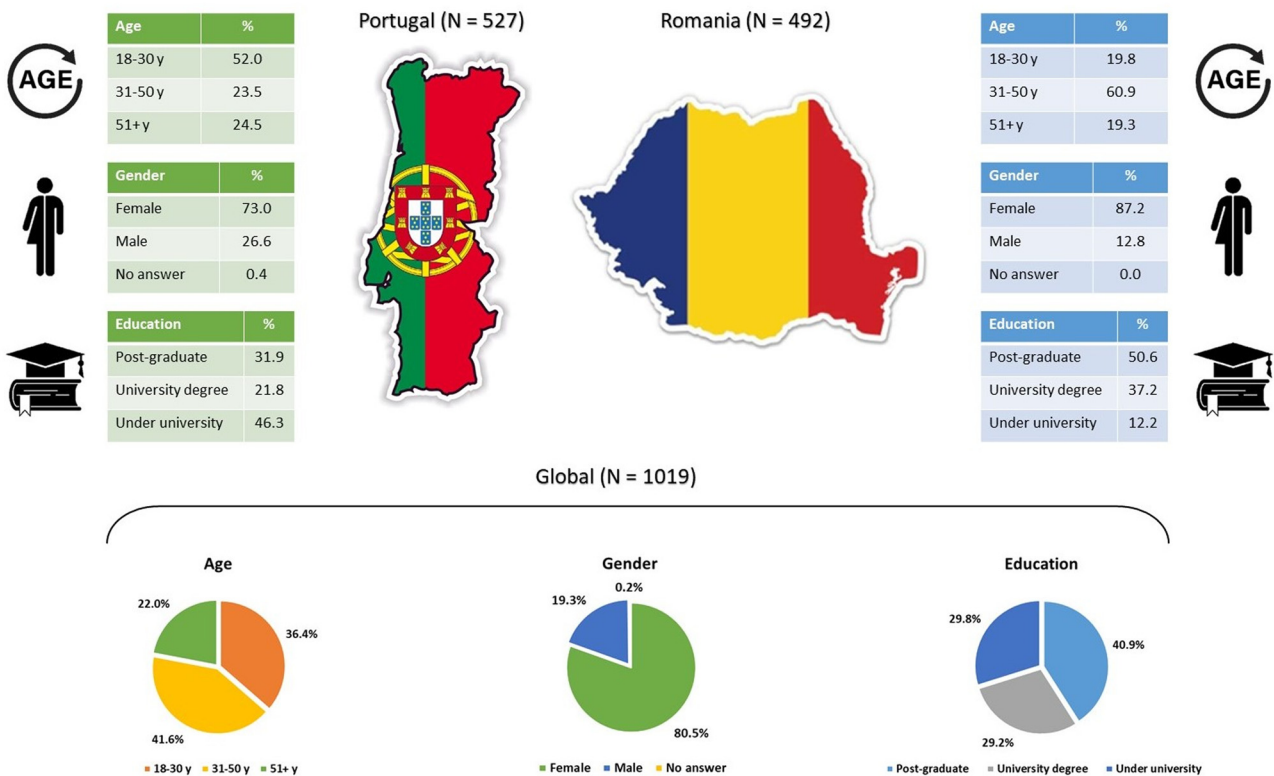


Figure 1: Sociodemographic characterization of the participants (N = 1,019 participants; N_(Portugal) = 527; N_(Romania) = 492).

manifested voluntary agreement to participate accessed the questionnaire to respond, and they were allowed to quit at any point before submitting their answers. The invitation was disseminated in social networks and by email posting the link from July to November 2021. The survey was targeted at individuals aged 18 years or more, residing in Portugal and Romania.

2.3 Data analysis

For data analysis, basic descriptive statistics tools were used. Additionally, comparison between countries was achieved through contingency tables and chi-square tests. To evaluate the strength of the associations between categorical variables, Cramer's V coefficient was used. Cramer's V varies from 0 to 1; for $V \approx 0.1$, the association is considered weak; for $V \approx 0.3$, the association is moderate; and for $V \approx 0.5$ or over, the association is strong [28].

The software used for data analysis was SPSS (Version 28) from IBM Inc. (Armonk, NY, USA), and the level of significance considered was 5% ($p < 0.05$).

Informed consent: Informed consent has been obtained from all individuals included in this study.

3 Results

3.1 Sample characterization

Figure 1 shows the sociodemographic characteristics of the participants from both countries, globally and separated by Portuguese and Romanian participants. The number of participants in both countries was similar, around 500, just with a slightly higher number of Portuguese ($n = 527$) than Romanian ($n = 492$).

Regarding the distribution according to age class (Figure 1), the percentage of young adults (aged between 18 and 30 years) was much higher in Portugal than Romania (52.0 and 19.8%, respectively), and a considerably higher percentage of Romanian adults (aged between 31 and 50 years), 60.9%, as compared with Portuguese adults (23.5). With respect to the percentages of senior adults (aged 51 years or more), the percentages were quite similar in both countries (24.5% in Portugal and 19.3% in Romania).

The distribution according to gender (Figure 1) indicated a much higher participation of women than men (80.5% and 19.35, respectively), being this discrepancy higher for the Romanian sample (87.2% female participants) than for the Portuguese (73.0% female participants).

In what concerns the level of education of the participants, the Romanian sample consisted of a higher percentage of post-graduate participants (50.6% compared to 31.9% Portuguese), and also, a higher percentage of participants who completed a university degree (37.2% as compared to 21.8% of Portuguese).

3.2 Country differences in agreement about health facts of EI

The results in Table 1 correspond to the cross-tabulation between countries and the level of agreement, for all 10 questions about the health effects of EI. The results show significant differences between Portuguese and Romanian responses for questions Q1, Q2, Q5, Q6, Q7, Q9, and Q10, but the associations were weak in all cases (values of Cramer's V between 0.102 and 0.180). In all cases, the percentage of answers in the central point of the scale (3 = indifferent) was very high, indicating that in both countries a great number of participants were not able to manifest agreement or disagreement with the statements presented. The questions with the highest level of agreement were Q2 and Q6 about EI being used in traditional medicine and the possibility of contamination with pesticides when the EI is collected from the wild. On the other hand, the highest disagreement was found for questions Q3 and Q5, about health risks associated with EI and the possibility of insect-based foods being infected by pathogens and parasites.

3.3 Age differences for agreement about health facts of EI

Table 2 presents the results for the cross-tabulation between age class and the answers of the respondents. The results evidence significant differences only for three questions, Q1, Q2, and Q3, and even in these cases, the association was weak. These are about the safety of EI for human consumption (Q1), or constituting a risk for human health (Q3), and EI being used in folk medicine (Q2). For all other questions, age was not found to significantly influence how people responded to the questions.

3.4 Gender differences for agreement about health facts of EI

For the treatment of data regarding gender the cases that answered Female or male were only considered, since the number of participants who did not want to answer was

Table 1: Crosstabs and chi-square tests for country differences for the responses to the questions about health effects of EI

Country	Level of agreement ¹ (% of answers)					Chi-square test ²	
	1	2	3	4	5	<i>p</i> -value	<i>V</i>
<i>Q1. There are appropriate regulations to guarantee food safety of edible insects</i>							
Portugal	7.0	9.7	47.2	27.8	8.3	<0.001	0.164
Romania	8.7	19.3	47.0	19.3	5.7		
<i>Q2. Insects are used by some people in traditional medicine</i>							
Portugal	3.4	4.4	43.2	40.8	8.2	<0.001	0.180
Romania	2.2	4.7	27.5	52.0	13.6		
<i>Q3. Eating insects poses a substantial risk to human health</i>							
Portugal	12.7	29.3	43.5	12.0	2.5	0.979	—
Romania	11.6	29.9	43.9	11.8	2.8		
<i>Q4. Industrial-processed insect products are hygienic and safe</i>							
Portugal	4.7	8.2	52.4	26.9	7.8	0.198	—
Romania	4.7	11.8	47.6	29.7	6.3		
<i>Q5. Insects and insect-based foods are often infected by pathogens and parasites</i>							
Portugal	8.2	16.9	58.8	13.3	2.8	0.021	0.106
Romania	9.8	21.3	48.4	17.5	3.0		
<i>Q6. Insects collected from the wild may be contaminated with pesticide residues</i>							
Portugal	3.6	5.7	41.0	37.7	12.0	0.031	0.102
Romania	4.3	11.0	40.2	32.9	11.6		
<i>Q7. In certain countries insects are approved officially for therapeutic treatment</i>							
Portugal	3.0	4.0	60.0	26.8	7.2	0.001	0.132
Romania	2.4	3.5	48.2	35.8	10.1		
<i>Q8. Insects contain bioactive compounds beneficial to human health</i>							
Portugal	3.0	4.0	63.4	23.9	5.7	0.260	—
Romania	3.7	4.5	57.1	26.4	8.3		
<i>Q9. Insects are potential sources of allergens</i>							
Portugal	2.7	8.3	68.9	15.9	4.2	<0.001	0.179
Romania	2.8	7.3	53.9	28.7	7.3		
<i>Q10. Aflatoxins, which are carcinogens, can be present in insects</i>							
Portugal	4.7	6.5	76.3	9.1	3.4	<0.001	0.144
Romania	5.5	12.2	66.7	14.0	1.6		

¹Five-point Likert scale: 1 = Strongly disagree, 2 = Disagree, 3 = Indifferent, 4 = Agree, 5 = Strongly agree.

²Significance of the chi-square test is 5% ($p < 0.05$); *V* = Cramer's coefficient, only if the *p* is significant.

very diminished, only two. Based on this principle, the results are presented in Table 3, revealing that gender only influenced the responses of the participants for questions Q4 and Q6, but again with low associations between the variables (Cramer's *V* varying between 0.113 and 0.123). The two questions that showed gender differences were about industrial processing of EI guaranteeing that the products are hygienic and safe (Q4) and about the possible contamination with pesticides of insects collected from the wild.

3.5 Education differences for agreement about health facts of EI

Table 4 shows the results of cross-tabulation between the answers of the participants and their level of education, revealing significant differences for most of the questions.

In general, it was observed that people with higher education showed higher levels of agreement with items Q2 (use of EI in traditional medicine), Q4 (hygiene and safety of industrially processed EI), Q6 (contamination of wild EI with pesticide residues), Q7 (therapeutic use of EI), Q8 (bioactive compounds in EI), and Q10 (presence of aflatoxins in EI). Nevertheless, in all cases, the associations were weak (values of *V* varying from 0.088 to 0.1499).

4 Discussion

This study identified differences between participants from Portugal and Romania in relation to knowledge about the health effects of EI. This result may be explained by differences in the sociocultural environments in both countries.

Table 2: Crosstabs and chi-square tests for age differences for the responses to the questions about health effects of EI

Age ¹	Level of agreement ² (% of answers)					Chi-square test ³	
	1	2	3	4	5	p-value	V
<i>Q1. There are appropriate regulations to guarantee food safety of edible insects</i>							
Young adults	4.3	12.9	45.0	28.6	9.2	0.004	0.106
Adults	10.4	14.4	48.0	20.3	6.9		
Senior adults	8.5	16.5	49.1	21.9	4.0		
<i>Q2. Insects are used by some people in traditional medicine</i>							
Young adults	3.0	6.5	41.2	38.0	11.3	0.005	0.103
Adults	2.6	4.3	31.7	50.3	11.1		
Senior adults	3.1	1.8	33.5	52.2	9.4		
<i>Q3. Eating insects poses a substantial risk to human health</i>							
Young adults	8.3	27.5	46.6	14.6	3.0	0.005	0.104
Adults	15.6	28.4	42.8	11.6	1.6		
Senior adults	12.1	35.7	40.2	8.0	4.0		
<i>Q4. Industrial-processed insect products are hygienic and safe</i>							
Young adults	5.4	12.4	52.0	25.3	4.9	0.142	—
Adults	4.0	9.5	49.2	28.8	8.5		
Senior adults	4.9	6.7	48.7	31.7	8.0		
<i>Q5. Insects and insect-based foods are often infected by pathogens and parasites</i>							
Young adults	6.7	17.8	54.7	18.1	2.7	0.385	—
Adults	10.9	19.6	52.0	14.4	3.1		
Senior adults	8.9	20.1	55.8	12.1	3.1		
<i>Q6. Insects collected from the wild may be contaminated with pesticide residues</i>							
Young adults	4.0	6.7	44.2	34.0	11.1	0.805	—
Adults	3.8	8.7	39.5	35.7	12.3		
Senior adults	4.0	9.8	37.1	37.1	12.0		
<i>Q7. In certain countries, insects are approved officially for therapeutic treatment</i>							
Young adults	3.2	4.6	59.6	25.3	7.3	0.093	—
Adults	2.1	3.3	49.9	34.3	10.4		
Senior adults	3.1	3.1	54.0	32.1	7.7		
<i>Q8. Insects contain bioactive compounds beneficial to human health</i>							
Young adults	3.5	5.1	62.0	23.5	5.9	0.508	—
Adults	2.6	3.1	61.5	25.2	7.6		
Senior adults	4.5	4.9	55.8	27.2	7.6		
<i>Q9. Insects are potential sources of allergens</i>							
Young adults	2.2	6.5	62.3	22.5	6.5	0.829	—
Adults	2.8	8.3	61.9	22.2	4.8		
Senior adults	3.6	9.4	60.3	20.5	6.2		
<i>Q10. Aflatoxins, which are carcinogens, can be present in insects</i>							
Young adults	4.3	7.0	73.9	11.9	3.0	0.329	—
Adults	4.7	10.2	71.9	11.6	1.7		
Senior adults	7.1	11.2	67.4	10.7	3.6		

¹Age classes: Young adults (18–31 years), Adults (31–50 years), and Senior adults (51 years or older).

²Five-point Likert scale: 1 = Strongly disagree, 2 = Disagree, 3 = Indifferent, 4 = Agree, 5 = Strongly agree.

³Significance of the chi-square test is 5% ($p < 0.05$); V = Cramer's coefficient, only if the p is significant.

Portugal and Romania, although being two European countries have different geographic locations, and different food and cultural influences. While Romania is situated in Central Europe, Portugal is situated in the Iberian Peninsula on the Atlantic coast and under the influence of the Mediterranean Sea, being one of the initial seven subscribers of the proposal to consider the Mediterranean Diet as intangible heritage of

the UN, together with Cyprus, Croatia, Spain, Greece, Italy, and Morocco [29].

The work by Ribeiro et al. [30] focused on eating insects in Portugal and compared with a Northern Europe, Norway. Their findings indicated that the acceptability of EI was lower among Portuguese participants, and that acceptance was negatively influenced by disgust, while

Table 3: Crosstabs and chi-square tests for gender differences for the responses to the questions about health effects of EI

Gender	Level of agreement ¹ (% of answers)					Chi-square test ²	
	1	2	3	4	5	p-value	V
<i>Q1. There are appropriate regulations to guarantee food safety of edible insects</i>							
Female	7.5	14.1	48.0	23.6	6.8	0.660	—
Male	9.4	15.3	42.9	24.1	8.3		
<i>Q2. Insects are used by some people in traditional medicine</i>							
Female	3.1	4.8	35.4	46.4	10.3	0.681	—
Male	2.0	3.4	36.0	45.8	12.8		
<i>Q3. Eating insects poses a substantial risk to human health</i>							
Female	11.7	28.3	45.8	11.7	2.5	0.090	—
Male	14.3	35.0	35.0	12.7	3.0		
<i>Q4. Industrial-processed insect products are hygienic and safe</i>							
Female	5.0	10.7	51.7	26.4	6.2	0.004	0.123
Male	3.4	6.9	43.3	35.5	10.9		
<i>Q5. Insects and insect-based foods are often infected by pathogens and parasites</i>							
Female	8.2	18.1	54.7	15.7	3.3	0.136	—
Male	11.8	22.7	50.2	13.8	1.5		
<i>Q6. Insects collected from the wild may be contaminated with pesticide residues</i>							
Female	4.3	8.2	42.9	33.7	10.9	0.011	0.113
Male	2.5	7.9	31.5	42.9	15.2		
<i>Q7. In certain countries, insects are approved officially for therapeutic treatment</i>							
Female	3.2	3.9	52.6	31.4	8.8	0.186	—
Male	1.0	3.0	60.6	27.6	7.9		
<i>Q8. Insects contain bioactive compounds beneficial to human health</i>							
Female	3.6	4.5	60.6	24.4	6.9	0.640	—
Male	2.5	3.0	59.1	28.0	7.4		
<i>Q9. Insects are potential sources of allergens</i>							
Female	3.1	8.4	60.1	22.4	6.0	0.274	—
Male	1.5	5.9	67.5	20.7	4.4		
<i>Q10. Aflatoxins, which are carcinogens, can be present in insects</i>							
Female	5.0	10.0	70.1	12.4	2.5	0.166	—
Male	5.4	6.4	77.3	7.9	3.0		

¹Five-point Likert scale: 1 = Strongly disagree, 2 = Disagree, 3 = Indifferent, 4 = Agree, 5 = Strongly agree.

²Significance of the chi-square test is 5% ($p < 0.05$); V = Cramer's coefficient, only if the p is significant.

being positively influenced by curiosity. Furthermore, this study [30] revealed that sociodemographic factors like education, sex, and age, exerted a variable influence depending on the country. The study by Florença et al. [31] revealed that the Portuguese tend to be informed about the sustainability of EI, but not about their nutritive value. Also, the same study [31] revealed gender differences in the knowledge about the sustainability of EI.

The study by Zamfirache [32], which focused on entomophagy in Romania, revealed that four factors are critical to shape food choices. The most important were found to

be taste, perception of healthiness, and price. Knowledge was also identified as a key feature, and it must be increased, given the lack of information detected among the Romanian participants regarding the benefits associated with consuming insects. In another study by Andronoiu et al. [33] it was found that the most important factor impeding Romanians from consuming insects was disgust. The work by Zugravu et al. [34] showed the role of knowledge as a positive influencing factor for the consumption of EI.

In our work, differences were observed according to sociodemographic variables age, gender, and education. It is expected that people with different levels of education might have different attitudes toward being informed about certain topics. In the case of EI, since these are not part of the traditional gastronomic patrimony in both countries, it might be expected that the older people might not be so well informed about a new trendy food such as EI. Sociodemographic differences have been observed in many studies conducted with human subjects investigating their level of knowledge about a number of subjects. These sociodemographic characteristics influence the degree of knowledge, and they can include age, gender, education, or country of origin, among others [35–37].

Focusing on the items of the questionnaire, for the first item, differences were observed according to country and age group: Q1 – “There are appropriate regulations to guarantee the food safety of edible insects.” This item deals with laws and regulations, and these can differ immensely between countries or regions of the globe. For example, European legislation has approved some insects to be used as novel foods within the European Union (EU), and so they are inscribed in the EU Novel Food Status Catalogue [38]/Union List of Novel Foods [39]. These insects were allowed following the European Food Safety Authority prior evaluation for safety. The EU also established rules for their production [40]. Fuso et al. [41] highlight the problematics of the EI market and value chain being vulnerable to fraud, thus posing risks for the consumer, as well as the economic impact.

For item Q2 “Insects are used by some people in traditional medicine,” differences were found according to country, age, and education. In fact, this item can be perceived differently, depending on the geography, in particular, since it is true in some regions, while not in others. This item showed a higher agreement among Romanians, older people, and those with higher education. This shows that older people are more familiar with traditional medicine than the young ones, because they used to have influences on traditional healing strategies received from ancient family members. The work by Devi et al. [16]

Table 4: Crosstabs and chi-square tests for education differences for the responses to the questions about health effects of EI

Education	Level of agreement ¹ (% of answers)					Chi-square test ²	
	1	2	3	4	5	p-value	V
<i>Q1. There are appropriate regulations to guarantee food safety of edible insects</i>							
Post-graduate	8.6	15.8	46.0	21.8	7.8	0.069	—
University degree	9.1	16.4	48.0	21.1	5.4		
Under-university	5.6	10.2	47.7	28.6	7.9		
<i>Q2. Insects are used by some people in traditional medicine</i>							
Post-graduate	1.7	2.6	31.2	53.0	11.5	<0.001	0.149
University degree	2.7	4.0	31.5	48.7	13.1		
Under-university	4.6	7.6	45.7	34.5	7.6		
<i>Q3. Eating insects poses a substantial risk to human health</i>							
Post-graduate	13.7	30.5	41.7	11.0	3.1	0.465	—
University degree	13.8	28.9	44.3	11.0	2.0		
Under-university	8.6	29.3	45.7	13.8	2.6		
<i>Q4. Industrial-processed insect products are hygienic and safe</i>							
Post-graduate	2.4	7.9	48.7	31.2	9.8	<0.001	0.119
University degree	5.0	10.1	48.7	29.5	6.7		
Under-university	7.6	12.5	53.3	23.0	3.6		
<i>Q5. Insects and insect-based foods are often infected by pathogens and parasites</i>							
Post-graduate	9.4	22.5	51.1	14.4	2.6	0.349	—
University degree	9.4	18.8	53.0	15.8	3.0		
Under-university	7.9	14.5	58.2	16.1	3.3		
<i>Q6. Insects collected from the wild may be contaminated with pesticide residues</i>							
Post-graduate	2.2	8.2	37.6	37.6	14.4	0.047	0.088
University degree	4.4	8.4	41.3	33.9	12.0		
Under-university	5.9	8.2	44.1	33.9	7.9		
<i>Q7. In certain countries, insects are approved officially for therapeutic treatment</i>							
Post-graduate	1.7	2.2	53.5	33.8	8.8	0.001	0.111
University degree	2.0	4.0	50.4	32.9	10.7		
Under-university	4.9	5.6	59.2	24.0	6.3		
<i>Q8. Insects contain bioactive compounds beneficial to human health</i>							
Post-graduate	2.9	2.2	60.7	25.9	8.3	0.015	0.096
University degree	2.3	4.4	61.1	24.2	8.0		
Under-university	4.9	6.9	59.2	25.1	3.9		
<i>Q9. Insects are potential sources of allergens</i>							
Post-graduate	2.2	7.4	59.0	25.4	6.0	0.142	—
University degree	1.7	8.4	62.4	20.8	6.7		
Under-university	4.6	7.9	64.5	18.8	4.2		
<i>Q10. Aflatoxins, which are carcinogens, can be present in insects</i>							
Post-graduate	4.1	12.0	68.5	12.7	2.7	0.047	0.088
University degree	5.0	10.1	71.8	11.1	2.0		
Under-university	6.6	4.6	75.6	10.2	3.0		

¹Five-point Likert scale: 1 = Strongly disagree, 2 = Disagree, 3 = Indifferent, 4 = Agree, 5 = Strongly agree.

²Significance of the chi-square test is 5% ($p < 0.05$); V = Cramer's coefficient, only if the p is significant.

highlights the usefulness of EI in traditional healing, based on knowledge passed on from generation to generation in some regions of the world, focusing also particularly on India. In areas like Asia, South and Central America, and Africa, insects have been used to cure several diseases. These are also a basis for studying new ways to treat human diseases based on traditional knowledge [42,43]. Regarding item Q7 “In certain countries insects are approved officially

for therapeutic treatment,” differences were found depending on country and education. This is true evidence in some countries, like in Asia, where insects are used as therapeutics with long success, while also being used in modern cancer therapy [44].

Only age differences were observed for item Q3 – “Eating insects poses a substantial risk to human health.” In this case, the more informed are the older generations,

with higher percentages of disagreement toward a statement that is not true. In fact, the perception of risks of human health lacks some support if the EI are commercialized within the EU, given the need to obey the regulations established by the EU [25]. Nevertheless, there is the possibility of allergen potential, which can be a problem to some people, but no more or no less than the allergen potential of other foods, like shellfish or nuts, for example. The review by Verhoeckx and den Heijer [17] focuses on the allergen potential of EI and they confirm that consumption of insects can have some allergenic risks, but these risks are unlikely to be higher when compared to other allergenic foods. In this context, in our work, we observed only country differences for item Q9 – “Insects are potential sources of allergens.” The work by Imathiu [45] alerts us to the need to establish food safety and hygiene practiced throughout the EI chain from production to consumption. This is particularly relevant in regions where regulations are not as strict as within the EU. Baiano [25] refers that EI are generally safe from a microbiological point of view but can pose risks in terms of chemical contaminants, such as residues of pesticides and heavy metals. A differentiation must be, however, made when the EI are collected from the wild or processed in controlled food environments. Regarding item Q4, “Industrial processed insect products are hygienic and safe,” differences were observed according to gender and education. This aspect, as previously discussed, is rather important, since most contamination problems come from the environment for EI that is collected from the wild, and not from those which are reared in insect farms [46]. It is also the EI collected from the wild that have the possibility of being contaminated, either with chemical harmful substances or with microbiological hazards. To this matter, country differences were observed for item Q5 – “Insects and insect-based foods are often infected by pathogens and parasites,” while for item Q6 – “Insects collected from the wild may be contaminated with pesticide residues,” differences were observed for variables country, gender, and education. The work by Traynor et al. [47] analyses the novel risks from both perspectives, food safety, and fraud, within the novel supply chains. Regarding item 10, “Aflatoxins, which are carcinogens, can be present in insects,” different responses were observed according to the country as well as education level. It is referred to in the scientific literature that EI can contain aflatoxins, and these are detrimental to human health. The work by Bisconsin–Junior et al. [48] refers that some insects can contain mycotoxins like aflatoxin B1, zearalenone, ochratoxin A, deoxynivalenol, fumonisin B1, and T-2, in both forms: isolated or combined.

For item Q8 – “Insects contain bioactive compounds beneficial to human health,” only differences were observed

according to education level. More educated people tend to search for information and increase their levels of knowledge. Many studies report bioactive compounds in EI, with beneficial effects on human health, for example antioxidant, antidiabetic, antilipidemic, antihypertensive, and anti-inflammatory effects. The review by Sánchez-Estrada et al. [49] explores these biological activities of EI. Also, the review by Zhang et al. [50] refers to the same effects previously described and adds the anti-obesity, anti-cancer, protection of the liver and the gastrointestinal system, and immunomodulatory effects. These effects are provided by various bioactive compounds present in EI, such as phenolic compounds, peptides, polysaccharides or fatty acids, especially the polyunsaturated fatty acids, among others.

5 Conclusions

The results obtained in this work showed that for questions about regulations that guarantee the safety of EI, significant differences were found according to country and age. For questions about EI being used by some people in traditional medicine, there were significant differences according to country, age, and education. For the third question, about EI's risks to human health, significant differences were found for age class only. For questions about hygiene and safety of industrially processed insect products, significant differences were found between genders and education levels. For the fifth question, about insects and insect-based foods being often infected by pathogens and parasites, significant differences were found only according to country. In what concerns question about insects collected from the wild possibly being contaminated with pesticide residues, significant differences were found for country, gender, and education. For questions about insects being approved officially in some countries for therapeutic treatment, significant differences were found according to country and education. For question eight, about insects containing bioactive compounds beneficial to human health, significant differences were observed only according to education level, and for the question about insects being potential sources of allergens, only differences were found according to country. Finally for the question about carcinogenic aflatoxins might be present in insects, significant differences were found for variables country and education.

In sum, it was found that country of origin, as well as education level, was the most influential sociodemographic variables in the perceptions regarding the effects of consuming EI on human health. Additionally, higher differences were found for items related to the use of EI in

folk medicine and their possible contamination with residues of pesticides, when collected from the wild. The obtained results confirm our research hypothesis; i.e., there are differences between Portuguese and Romanian consumers regarding the knowledge about the health effects of EI.

The results obtained provide new insights into the level of knowledge among the Portuguese and Romanians about how consumption of EI can influence one's health status, either in a positive or negative way. As so, they are valuable to help build effective strategies to better plan dissemination policies aimed at informing consumers toward a novel type of food that has been recently approved under the Novel Foods Regulation within the EU. Informed consumers will be more prone to accept EI as food, if they are aware of the positive health effects they carry. On the other hand, informed consumers might be aware that, although there are some safety concerns regarding EI, they do not apply within the EU Markets, where all the safety measures must be obeyed to produce, transform, and commercialize such products.

Some limitations of this study can be pointed out, namely concerning the data collection, than followed a snowball methodology with invitations sent by internet tools. For that reason, the sample obtained was a convenience sample and not a probabilistic one. As so, although there is a similar number of responses in the two countries (around five hundred), there is not an even distribution according to the sociodemographic variables, with a lower representativeness of people older than 50 years and a much higher representativeness of women than men.

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