CONSUMER PERCEPTION ABOUT EDIBLE INSECTS' RELATION WITH ENVIRONMENT AND SUSTAINABILITY

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Abstract - Edible insects have been suggested as a potential environmental and economic solution to replace less sustainable conventional protein sources for human nutrition. Hence, this work investigated the perceptions and knowledge of consumers in fourteen different countries towards edible insects and their relation with environment and sustainability. For that, data were collected through a questionnaire survey in the ambit of the EISuFood Project, and 7221 responses were obtained. The results showed that although participants had some difficulty in identifying wrong statements, a majority were able to express disagreement towards them (ex. comparison between poultry and insect productions for water requirements, comparison between pork and insect productions for area requirements). A great majority of respondents showed agreement with true statements, like insect production emits fewer greenhouse gases than beef production. Higher percentages of respondents that did not manifest a decisive opinion were found for insects being able to efficiently convert organic matter into protein, or for loss of biodiversity being lower for insect compared to other animal productions. Sociodemographic variables sex and education were significantly influenced knowledge on most of the questions, while age was not found so influential. Regarding the geographic variable living environment, it significantly influenced the knowledge on practically all items, and country significantly influenced knowledge in all of the questions, being the most influential of all variables studied. As a conclusion, it was fund that perception about edible insects and sustainability are influenced by sociodemographic characteristics of the participants and greatly variable according to geographical factors.

Keywords - Consumer, Edible Insects, Food Choice, Sustainability.

I. INTRODUCTION

The consumption of edible insects has a long tradition in certain countries, while being unfamiliar in others, especially western countries or even eastern countries with a recent trend for following westernized dietary patterns. The tradition of eating insects is very uneven among world regions. Entomophagy is a culturally accepted practice in a high number of countries and regions, while in most westerns countries consumers experience emotions of disgust when facing the possibility to consume insects [1].

Currently, insects are presented as a potential environmental and economic solution to replace less sustainable conventional protein productions [2]. This alternative food source is in line with sustainability goals for food production, through, for example, a reduced utilization of natural resources, allied to a reduction in the emission of gases with greenhouse effect. As example, insects emit few greenhouse gases and little ammonia and require significantly less feed, land and water, when compared with cattle production [3].

The use of insects in human nutrition has been practiced since ancient times, even for millions of years. When insects become a component of the diet, they may contribute to the development of beneficial microorganisms in the gut microbiota, enhancing the health of the intestine and the whole body, as a consequence. They have been reported also as a good source of diverse nutrients, among which essential amino and fatty acids, fibre, lipossoluble vitamins (A, D, E and K), vitamin C and those of B group, and also dietary minerals (K, Na, Ca, Cu, Fe, Zn, Mn and P), among other nutrients. However, some safety concerns must be taken into consideration, such as the monitoring of harmful microorganisms, parasites, toxins, heavy metals, veterinary drugs, hormones, and pesticide residues. In addition, some anti-nutrients can be present, which will compete with nutrients absorption on the human body. Still, edible insects have a significant nutrients' content from a nutritional point of view [2], [4].

Despite being a valuable food, with a high nutritional value and rich in some bioactive compounds, like phenolic compounds, with important health effects, edible insects are still difficult to accept for some consumers. Sustainable food alternatives can generate disgust because they typically diverge from what consumers have assumed to be "normal" food. This may lead consumers to intuitively reject these unfamiliar foods [5].

Because the interest in adopting more sustainable diets can be a driver for consumers to engage in the consumption of edible insects, even in countries where they are not culturally accepted as food, this work aimed to study the perceptions and knowledge of consumers in different countries towards edible insects and their relation with environment and sustainability.

II. MATERIALS AND METHODS

The present investigation was based on a questionnaire survey aimed to study the knowledge and perceptions about edible insects, and one of the domains studied was the sustainability of this alternative source of protein [6]. The participants had to express their agreement towards eleven statements, using a fivepoint Likert scale (1 = strongly disagree, 2 = disagree, 3 = no opinion, 4 = agree, 5 = strongly agree). While most of the items were given as true statements, some were reversed to assess whether the respondents could correctly identify false information (Table 1).

Q#	Question	True/ False
Q1	Insects are a more sustainable alternative when compared to other sources of animal protein	True
Q2	Insect production for human consumption emits much less greenhouse gases than beef production	True
Q3	Insects efficiently convert organic matter into protein [7]	True
Q4	The production of insect protein uses considerably less feed than beef protein	True
Q5	Insects are a possibility to respond to the growing world demand for protein	True
Q6	The production of poultry protein requires much less water than insect protein	False
Q7	The ecological footprint (impact) of insects is smaller when compared to other animal proteins	True
Q8	The production of insect protein requires much more area than pork protein	False
Q9	Insects are collected as a means of pest control for some cultivated crops	True
Q10	Loss of biodiversity is lower with insect production compared to other animal food production	True
Q11	Energy input needed for the production of insect protein is lower than for the production of other proteins from animal origin	True

Table 1. Questions used to assess knowledge of the participants about sustainability of edible insects.

This descriptive cross-sectional study was carried out on a non-probabilistic sample of 7221 participants from 14 countries, as indicated in Figure 1.

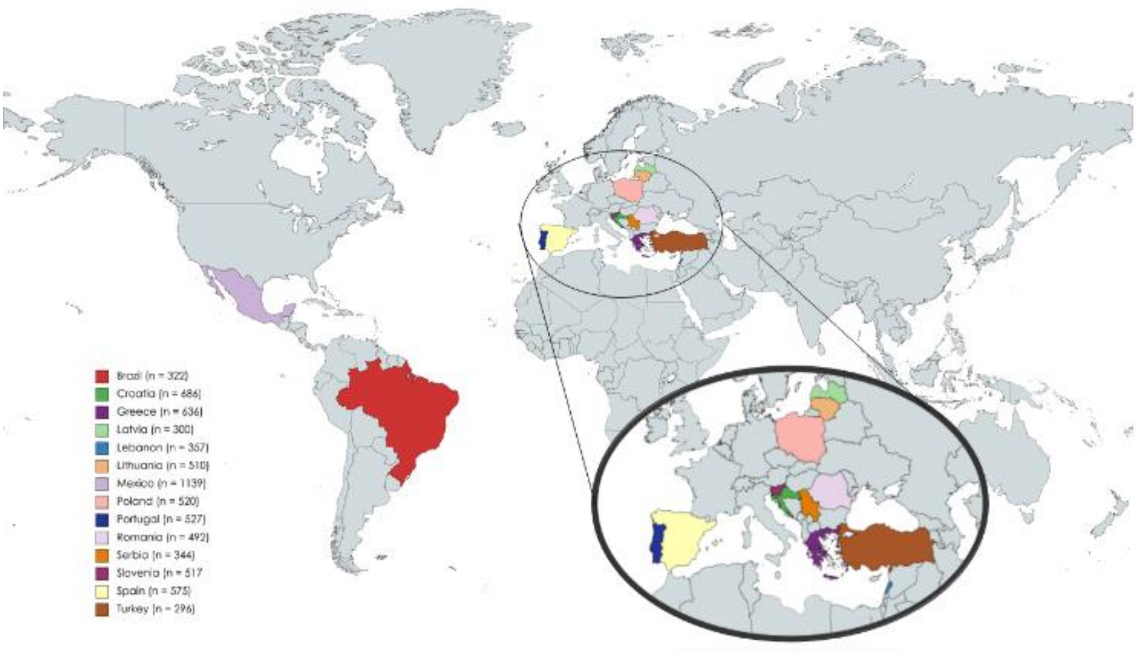

Figure 1. Distribution of participants by country.

All ethical principles of the Declaration of Helsinki were followed in the investigation. The Ethics Committee of the Polytechnic University of Viseu approved this survey with reference 45/SUB/2021. Data collection took place during 2021 using on-line tools, only to adult citizens (≥18 years old) and after they expressed their informed consent.

Statistical analysis was made with SPSS Version 28 from IBM, Inc. (Armonk, NY, USA). Basic descriptive statistics were used, complemented with Chi-square tests to assess the relations between variables. The Cramer's coefficient V was used to evaluate the strength of the associations between variables. For V= 0 there is no association and the greater the coefficient the stronger is the association. In all tests, a significance level of 5% was considered.

III. RESULTS AND DISCUSSION

A. Presentation of the Results

The answers of the respondents to the eleven questions formulated about the relation of edible insects with environment and sustainability are presented in Table 2. For question Q1 most participants agreed (31.0%) or strongly agreed (20.2%). A similar trend, i.e., majority of expressed opinions being in category agree followed by strongly agree, was observed for questions Q2 (31.3% agreed, 24.7% strongly agreed), Q3 (31.2% agreed, 17.9% strongly agreed), Q4 (32.9% agreed, 23.4% strongly agreed), Q5 (35.2% agreed, 22.5% strongly agreed), Q7 (31.7% agreed, 19.2% strongly agreed), Q9 (32.0% agreed, 15.3% strongly agreed), Q10 (27.6% agreed, 13.2% strongly agreed), Q11 (32.2% agreed, 18.5% strongly agreed). For questions Q6 and Q8 the majority of responses were disagree followed by strongly disagree, which is coherent with the fact that these are wrong statements. To note also that there was a high percentage of participants that did not express an opinion, with percentages varying from a minimum of 29.1% in the case of question Q1 to a maximum of 50.8% for question Q6, which is false.

Q#	% of answers (in row)				
	Strongly Disagree	Disagree	No opinion	Agree	Strongly Agree
Q1	7.6	12.1	29.3	31.0	20.0
Q2	4.3	6.4	33.3	31.3	24.7
Q3	3.7	5.8	41.5	31.2	17.9
Q4	3.8	6.0	34.0	32.9	23.4
Q5	5.2	8.0	29.1	35.2	22.5
Q6*	13.2	18.8	50.8	12.1	5.1
Q7	4.3	8.3	36.6	31.7	19.2
Q8*	18.2	21.1	43.6	11.8	5.1
Q9	4.4	8.2	40.1	32.0	15.3
Q10	4.2	8.9	46.1	27.6	13.2
Q11	3.6	6.7	39.0	32.2	18.5

*False state

Table 2. Distribution of the percentage of answers given by the 7221 participants to each of the questions.

For each of the questions, was created a new variable about information, corresponding to two possibilities: "informed" and "not informed". The participants who expressed agreement/strong agreement with the true statements and disagreement/strong disagreement with the false statements were classified as "informed". All other were classified as "not informed". Figure 2 shows the percentages of participants according to information for each of the questions. Higher percentages, over 50%, of informed participants were found for questions Q5 (57.7%), Q4 (56.3%), Q2 (56.0%), Q1 (51.0%), Q7 (50.9%) and Q11 (50.7%). These statements where people showed higher knowledge were related with insects being a more sustainable option for human diets when compared to other protein foods, having less impact on the environment due to lower ecological footprint, lower emission of greenhouse gases and fewer use of resources like feed or energy. On the other hand, questions with lower percentage of informed participants, below 40%, were Q6 (32.0%) and Q8 (39.5%). These questions were given as false statements, and this might have created additional difficulties for a significant number of respondents.

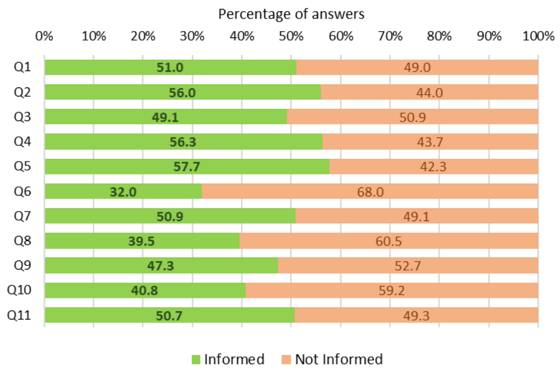

Figure 2. Percentage of participants informed or not informed for each of the questions.

Tables 3 to 5 show the results obtained from the cross tabulation of some sociodemographic variables with the variable Information for each of the eleven questions. With respect to sex, significant differences ($p < 0.05$) were observed for all questions, except for Q4 ($p = 0.211$), Q7 ($p = 0.414$) and Q9 ($p = 0.158$). In all cases, the results revealed that men were more informed about the sustainability of edible insects than women (corresponding to higher values of percentage of informed participants) (Table 3).

Concerning age class (Table 4), no significant differences ($p \geq 0.05$) were found for most of the questions. Questions where significant differences were found are Q1 ($p = 0.008$), Q2 ($p = 0.002$), Q7 ($p = 0.016$), Q8 ($p = 0.0014$) and Q11 ($p = 0.008$). With respect to age, there was a trend for younger participants (18 – 30 years) to be more informed than participants in other age classes, just except for questions Q3, Q5, and Q9, for which the more informed are in the age group 31 – 50 years.

In what concerns the education level (Table 5), statistically significant differences were found for practically all questions, except for Q6 ($p = 0.087$) and Q9 ($p = 0.080$). For all questions except Q10, the higher percentage of informed participants was always observed for participants with higher level of education, post-graduate, i.e., with a Master degree or PhD. Even in those cases where significant differences were found, the Cramer coefficients, V, were very low (under 0.1), meaning that the association between the variables was weak. The association between Q5 and education had the greater value of Cramer's coefficient ($V = 0.114$) among all relations between the eleven questions and the sociodemographic variables, but even in this case the association was weak.

Q#	% of informed participants			
	Female	Male	p-value	Cramer's V
Q1	48.9	54.3	<0.001	0.056
Q2	54.9	57.7	0.009	0.036
Q3	47.2	52.4	<0.001	0.05
Q4	56.1	56.4	0.211	0.021
Q5	56	60.7	<0.001	0.047
Q6	30.8	34.3	<0.001	0.045
Q7	50.8	50.9	0.414	0.016
Q8	38.1	41.8	0.009	0.036
Q9	47.8	46.6	0.158	0.023
Q10	38.7	44.2	<0.001	0.06
Q11	48.8	54.3	<0.001	0.053

Table 3. Cross tabulation and chi-square test for the association between the questions and sex.

Q#	% of informed participants				
	18 - 30 y	31 – 50 y	≥ 51 y	P value	Cramer V
Q1	51.9	51.4	46.7	0.008	0.037
Q2	57.3	56.2	51.2	0.002	0.042
Q3	48.6	50.1	47.9	0.36	0.017
Q4	56.8	56.7	53.5	0.119	0.024
Q5	57.7	58.6	55.5	0.202	0.021
Q6	32.4	31.5	32.2	0.773	0.008
Q7	52	50.9	47.1	0.016	0.034
Q8	41.3	38.2	37.3	0.014	0.034
Q9	46.5	48	47.5	0.492	0.014
Q10	41.2	40	40.5	0.618	0.012
Q11	52.6	49	48.8	0.008	0.036

Table 4. Cross tabulation and chi-square test for the association between the questions and age.

In what concerns the education level (Table 5), statistically significant differences were found for practically all questions, except for Q6 ($p = 0.087$) and Q9 ($p = 0.080$).

Q#	% of informed participants				
	Post-grad.	Complete Univ.	Under Univ.	P value	Cramer V
Q1	53.9	53	46.4	<0.001	0.068
Q2	59.2	57.3	52.1	<0.001	0.062
Q3	53.8	48.3	45.6	<0.001	0.068
Q4	59.7	57	52.6	<0.001	0.06
Q5	64.2	59	50.6	<0.001	0.114
Q6	33.7	31.6	30.8	0.087	0.026
Q7	53.3	52	47.6	<0.001	0.049
Q8	41.4	37.5	39.4	0.025	0.032
Q9	49.1	46.7	46	0.08	0.026
Q10	40.3	43.5	38.5	0.002	0.042
Q11	52.7	51.2	48.5	0.013	0.035

Table 5. Cross tabulation and chi-square test for the association between the questions and education.

For all questions (Table 5) except Q10, the higher percentage of informed participants was always observed for participants with higher level of education, post-graduate, i.e., with a Master degree or PhD. Even in those cases where significant differences were found, the Cramer coefficients, V, were very low (under 0.1), meaning that the association between the variables was weak. The association between Q5 and education had the greater value of Cramer's coefficient ($V = 0.114$) among all relations between the eleven questions and the sociodemographic variables, but even in this case the association was weak.

In Table 6, the results of cross tabulation between the questions and living environment are presented. A trend was observed for the rural areas to have the lowest percentage of informed participants, while those living in urban or suburban areas were mostly informed. These differences were significant ($p < 0.05$) for most of the questions, with exception of Q6 ($p = 0.794$), Q8 ($p = 0.926$), Q10 ($p = 0.241$) and Q11 ($p = 0.149$).

Q#	% of informed participants				
	Rural	Urban	Suburban	P value	Cramer V
Q1	47.9	52.2	49.8	0.013	0.035
Q2	53.5	56.1	58.7	0.033	0.031
Q3	43.5	51.1	47.6	<0.001	0.059
Q4	51.8	57.4	57.3	<0.001	0.044
Q5	53.7	59.1	56.9	0.001	0.043
Q6	32	31.8	32.9	0.794	0.008
Q7	47.3	52.1	50.1	0.006	0.037
Q8	39.1	39.5	39.8	0.926	0.005
Q9	44.4	48.4	46.2	0.022	0.032
Q10	38.8	41.2	41.4	0.241	0.02
Q11	48.4	51.2	51.9	0.149	0.023

Table 6. Cross tabulation and chi-square test for the association between the questions and living environment.

In what concerns the country differences (Table 7), significant differences were observed for all the eleven questions. For question Q1 highest percentage of informed participants was observed for Lebanon (74.5%) and lowest for Greece (30.3%). For Q2, the highest percentage of informed participants was observed for Lebanon (68.9%) and lowest for Serbia (32.0%). For Q3, the highest percentage of informed participants was observed for Mexico (65.9%) and lowest for Croatia (35.3%). For Q4, the highest percentage was observed for Poland (75.2%) and lowest for Serbia (34.0%). For Q5, the highest percentage was observed for Poland (78.1%) and lowest for Croatia (29.0%). For Q6, the highest percentage was observed for Spain (49.7%) and lowest for Latvia (15.3%). For Q7, the highest percentage was observed for Mexico (65.6%) and lowest for Serbia (34.6%). For Q8, the highest percentage was observed for Spain (54.1%) and lowest for Turkey (20.3%). For Q9, the highest percentage was observed for Spain (74.3%) and lowest for Lebanon (25.5%). For Q10, the highest percentage was observed for Lebanon (66.4%) and lowest for Serbia (23.2%). For Q11, the highest percentage was observed for Mexico (64.4%) and lowest for Serbia (30.5%). With respect to the values of Cramer's coefficients, for the associations between the questions and the living environment the values were all very low, meaning very weak associations. In the case of the variable country, some associations had values of V close to 0.3, meaning moderate associations between the variables (values of V equal to 0.291 and 0.270, respectively for questions Q5 and Q1).

Country	Q1	Q2	Q3	Q4	Q5
Brazil	51.6	56.2	44.1	49.4	55.0
Croatia	31.8	40.1	35.3	41.0	29.0
Greece	30.3	44.5	41.2	51.1	44.0
Latvia	53.7	52.0	46.0	51.7	58.7
Lebanon	74.5	68.9	37.8	46.8	68.3
Lithuania	52.9	67.5	48.8	64.3	72.4
Mexico	68.0	64.2	65.9	65.7	74.4
Poland	56.0	65.2	61.7	75.2	78.1
Portugal	52.9	56.0	47.1	49.0	56.5
Romania	39.2	53.5	48.0	62.6	50.6
Serbia	32.8	32.0	36.3	34.0	38.1
Slovenia	53.6	62.9	48.2	64.2	56.9
Spain	64.5	66.8	56.7	64.0	65.2
Turkey	36.8	37.8	40.5	43.6	41.6
p-value	<0.001	<0.001	<0.001	<0.001	<0.001
Cramer V	0.27	0.219	0.199	0.218	0.291

Table 7. Continuation

Country	Q6	Q7	Q8	Q9	Q10	Q11
Brazil	36.0	55.0	43.8	51.9	45.0	53.7
Croatia	29.6	35.7	40.4	42.3	30.7	37.2
Greece	23.0	45.8	29.7	33.6	30.3	40.9
Latvia	15.3	44.0	31.7	31.7	28.0	41.7
Lebanon	24.1	45.4	22.1	25.5	66.4	47.1
Lithuania	29.2	49.4	49.4	57.3	54.9	61.2
Mexico	34.9	65.6	39.5	54.7	53.4	64.4
Poland	44.4	51.9	49.2	48.7	38.8	57.7
Portugal	36.1	52.9	39.3	44.8	34.0	49.1
Romania	26.6	53.3	33.9	55.1	39.0	51.2
Serbia	23.0	34.6	30.5	40.1	23.2	30.5
Slovenia	36.8	50.7	50.5	36.9	33.7	51.8
Spain	49.7	61.2	54.1	74.3	45.7	56.5
Turkey	19.9	42.6	20.3	43.2	32.8	43.6
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cramer V	0.183	0.184	0.188	0.233	0.222	0.192

Table 7. Cross tabulation and chi-square test for the association between country and the questions.

B. Discussion

Insect-based foods have been used since ancient times and are widely accepted in many world cultures. The use of insects as food nowadays is attracting a great deal of attention for being pointed out as an alternate protein rich food source able to overcome food insecurity[8]. Understanding entomophagy and related livelihoods of indigenous and rural populations provides insights on sustainability of local livelihoods, vulnerabilities, food culture and ecology.[9] The participants in the present survey revealed higher knowledge about the sustainability issues related with edible insects as food, in regards to aspects such as: they are a more sustainable alternative when compared to other sources of animal protein, their ecological footprint is smaller when compared to other animal proteins, and they can be a possibility to respond to the growing world demand for protein. Additionally, their production emits much less greenhouse gases than beef, requires less feed than beef protein, and lower energy input than other proteins from animal origin. All these facts are scientifically validated [3], [10]–[12] and are of public knowledge not only being known by the scientific community, as a way to positively influence consumers towards more sustainable dietary practices. Insect-meat constitutes an excellent source of nutrients relevant for the human body, and therefore their consumption becoming a popular trend in non-traditionally entomophagic cultures, like in Western countries[13]. Perhaps that is why these aspects are more widely disseminated among communication media, reaching the general consumer, and helping them to make more informed food choices. The consumer acceptance is definitely a factor to take into consideration when analysing the desire to try new foods, either out of curiosity, or because they perceive the foods as good for their health or also because they consider them a less impacting solution to the health of the planet [12]. However, the cultural differences as pivotal in this matter, when it comes to eating insects. The review by Florença et al. [14] highlights the motivations that influence consumers positively and negatively towards edible insects, and especially focusing on the comparison between insect-eating countries and western countries. They concluded that in insect eating countries, the focus is set on sensory attributes, availability, affordability and preferences, while in western countries there is a bigger emphasis on sustainability allied to the nutritional value and the perceived benefits, as positive factors, but also familiarity/past experience, tradition/culture, food neophobia and disgust, as negative influential factors.

Concerning the influence of sociodemographic variables on the level of information about the sustainability of edible insects, the results indicated that education, sex and age are influential variables, by decreasing order of importance. Education is, from the sociodemographic factors considered in the study, the one that produces higher frequencies of significant differences, with the more educated participants being better informed that those with lower levels of education. Increased education has been associated with higher level of knowledge in various domains, as people with higher level of academic formation tend to be more instructed people in all domains of life and society as well [15]–[17].

One other very influential factor was age, with younger participants being, in general, better informed that older people. The young generation, in particular, is vividly concerned with the preservation of the planet and what the future will hold for their life on Earth. We assist to various actions, from the initiative of young generations, throughout the whole planet, destined to alert politicians and the general society for the problematic of climate change, pollution, use of resources and destruction of biodiversity, posing deadly threats for human life on planet Earth in the future. One of such mobilizers or activists is Greta Thunberg, that has mobilized young people all over the world: the so called Greta effect. As example, in the UK in 2019–20, the prevailing visual representation of climate protest in the media was "being young and being a female" [18]–[20].

In what concerns living environment, participants living on urban or suburban areas revealed to be better informed than those living on rural areas. Similar observations have been reported for diverse areas of knowledge, with urban residents having generally better knowledge than rural residents. This has been reported by Zhang et al. [21] and by Njingu et al. [22] for knowledge about convid-19, by Guiné et al. [23] for knowledge about edible insects or Moreira da Silva et al. [24] for knowledge about berries, for example.

Finally, when comparing countries, statistically significant differences were observed for all questions, making this the most important predictor for information about sustainability of edible insects. This is expected, having in mind that cultural influences are highly variable among the set of countries included in the study, with a high number of European countries, but also with Latin American countries like Mexico or Brazil, or Middle East countries like Turkey or Lebanon. As previously reported the cultural attitudes towards edible insects are variable according to country, as highlighted in the work by Florença et al. [14], above mentioned. Nonetheless, other studies reported differences between countries in what concerns various aspects related with edible insects, like for example the work by Raheem et al. [25] comparing the consumption of insects in Africa, Asia and Europe, or the work by Sogari et al. [26] about edible insects as food in western and eastern societies.

I. Conclusions

The results allowed concluding that participants had some difficulty in identifying wrong statements like "The production of poultry protein requires much less water than insect protein" and "The production of insect protein requires much more area than pork protein", with less than half of them being able to express a correct opinion. Contrarily, most of the respondents were able to manifest agreement with the true statements in que questionnaire, with percentages varying from 40.8% to 57.7%, de-pending on the question. Nevertheless, a relatively high percentage of respondents did not manifest a decisive opinion on many items, with percentages varying from 29.1% to 50.8%, showing their lack of knowledge about the facts mentioned in the questions.

The sociodemographic variables sex and education were found to significantly influence the knowledge of respondents towards most of the questions (respectively 8 and 9 out of the 11 items), while age was not found so influential (significant differences only for 5 out of the 11 items. Regarding the geographic variable living environment, it was found to significantly influence the knowledge on practically all the items (7 out of the 11 items). Finally the last geographical variable considered, country, was found to significantly influence the knowledge in all of the 11 questions, being the most influential of all variables studied.

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