CONSUMER'S KNOWLEDGE ABOUT NUTRITIONAL ASPECTS OF EDIBLE INSECTS

[1]SOFIA G FLORENÇA, [2]PAULA M R CORREIA, [3]CRISTINA A COSTA, [4]RAQUEL P. F. GUINÉ

CERNAS-IPV Research Centre, Polytechnic University of Viseu, Viseu, Portugal
E-mail: [1]sofiaflorenca@outlook.com, [2]paulacorreia@esav.ipv.pt, [3]amarocosta@esav.ipv.pt, [4]raqueguine@esav.ipv.pt

Abstract— Edible insects have been recognized as a nutritive food, rich in protein and other nutrients of value for the human body, while being a more sustainable alternative to other conventional protein-based foods. For this reason, and because edible insects are not a part of the traditional diet in Portugal, an European country of Mediterranean dietary influences, this work aimed to investigate the knowledge of the population about the nutritive value of edible insects. For that a questionnaire survey was prepared and data were collected through internet means and were treated using appropriate statistical tools and tests. The results showed that, in general, the level of knowledge was low, and most especially regarding aspects like the presence of anti-nutrients, or the fat and mineral contents. Regarding the influence of sociodemographic variables on the level of knowledge, significant differences were found between sexes or between age groups, and the same applies to the education level. Reversely, living environment was not found to significantly influence the knowledge. In conclusion, Portuguese consumers are not yet informed enough about the potential of edible insects as valuable foods.

Keywords - Edible Insect, Information, Knowledge, Sociodemographic Characteristics.

I. INTRODUCTION

Climate change and the need to significantly reduce the emission of gases with greenhouse effect, is provoking a great deal of research on the human meat consumption and its negative impacts on the environment [1]. It is estimated that emissions from livestock account for up to 70% of all agricultural, forestry, and other land use emissions of gases with greenhouse effect [2]. Contrarily, edible insects have been reported as being more sustainable, emitting less greenhouse gases, being more efficient in converting organic matter into protein, using less feed, less water and less land for their production when compared to other animal productions [3].

Recognizing the lower environmental impact of edible insects, the Food and Agriculture Organization (FAO) of the United Nations has proposed greater use of insects as an alternative source of animal protein [4]. A work by Niva and Vainio [5] investigated consumers' self-reported past changes and future intentions to alter the consumption of beef and alternative, plant- or insect-based protein products. This results indicated that nearly one third of the respondents (27%) intended to reduce in the future the consumption of beef, while 26% planned to increase the consumption of plant-based and 24% planned to increase the use of insect-based protein foods [5].

In addition to the environmental advantages, insects also provide nutritional benefits and health effects. They contain high-quality protein, relevant fat, including polyunsaturated fatty acids, minerals, and vitamins [6], [7]. Furthermore, edible insects supply amounts of protein, fat, vitamins, and minerals comparable to those of conventional meat sources [7]. Lucas et al. [8] highlight that edible insects are not only a good sources of nutrients, but they also provide bioactive compounds beneficial to the human body. Among these are included the bioactive peptides [9]. These bioactive peptides from insects have beneficial effects on human health or in food systems, including antioxidant, antimicrobial and antidiabetic properties, as well as the capacity to inhibit the angiotensin I converting enzyme. Besides, they can also be utilized as ingredients added to obtain functional foods [10].
However, some safety issues are pointed out to their consumption, including microbiological quality, zoonotic diseases, allergens, antinutrients or heavy metals [7]. According to Baiano [11] edible insects are generally considered safe for human consumption, nevertheless, particular attention must be paid to allergens.

Although insects have nutritional allied to environmental benefits, there are still many barriers to their adoption, especially in Western countries, where their consumption is unfamiliar, due to disgust and neophobia [12]–[14].

The work by Marquis et al. [15] showed that by enhancing the visual aspect of insect-based foods it is possible to positively influence consumer's emotions, expected product liking, tastiness, and purchase intentions. Additionally, the authors also reported that the efficiency of the tested arguments related with healthiness/tastiness perception and with willingness to purchase was significantly affected depending on factors like nutritional claim [15].

Considering that nutritional aspects and the presence of bioactive compounds can be one of the motivators for adopting insect consumption in non-traditional entomophagic societies [16]–[18], this work aimed to investigate the level of knowledge about nutritional

facts related to edible insects in a sample of Portuguese citizens.

II. MATERIALS AND METHODS

This study was based on a questionnaire survey and intended to investigate the knowledge of consumers on a European country, Portugal, about edible insects. This is part of a broader study in the ambit of the international project EISuFood (https://raquelguine.wixsite.com/eisufood).

For the object of the present study, the participants had to express their agreement using a five-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = no opinion, 4 = agree, 5 = strongly agree) towards ten statements, that related with the nutritive value of edible insects, as well as possible antinutrients, as listed below:

1. Insects have poor nutritional value (False)
2. Insects are a good source of energy
3. Insects have high protein content
4. Insect proteins are of poorer quality compared to other animal species (False)
5. Insects provide essential amino acids necessary for humans
6. Insects contain group B vitamins
7. Insects contain dietary fibre
8. Insects contain minerals of nutritional interest, such as calcium, iron, and magnesium
9. Insects contain fat, including unsaturated fatty acids
10. Insects contain anti-nutrients, such as oxalates and phytic acid

This is a descriptive cross-sectional study that was undertaken on a non-probabilistic sample consisting of 527 participants from Portugal.

This research was prepared and carried out taking into account all ethical principles of the Declaration of Helsinki. Furthermore, the investigation was approved by the Ethics Committee of the Polytechnic of Viseu under reference 45/SUB/2021. Data collection took place during the year 2021 by internet tools, and only adult citizens (aged 18 year or older) were allowed to participate, and after expressing 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 or the greater the coefficient the stronger is the association. In all tests, a significance level of 5% was considered.

III. RESULTS AND DISCUSSION

A. Sociodemographic Characterization of the Sample

Table 1 shows the frequencies and percentages of the participants according to the different sociodemographic groups considered. The participants were mostly female (73.3%), and young adults (52.0%). Most of them did not complete a university degree (46.3%), and lived in urban environments (56.2%).

Variable/Group	N	%
Sex (n = 525)		
Female	385	73.3
Male	140	26.7
Age (n = 527)		
18 – 30 years	274	52.0
31 – 50 years	124	23.5
51 years or over	129	24.5
Education level (n = 527)		
Master or Doctorate	168	31.9
University degree	115	21.8
Under university	244	46.3
Living environment (n = 527)		
Rural	165	31.3
Urban	296	56.2
Sub-urban	66	12.5

Table 1. Sociodemographic characteristics of the participants (N = 527).

B. Knowledge about Nutritive Value of Edible Insects

The answers of the respondents to the ten questions presented about the nutritional facts regarding edible insects are presented in Table 2. The results express a very high percentage of participants who were not able to express an opinion, with percentages varying from a minimum of 37.6% for item #3 (Insects have high protein content) and a maximum of 77.0% for item #10 (Insects contain anti-nutrients, such as oxalates and phytic acid).

Item #	Strongly disagree	Disagree	No opinion	Agree	Strongly agree
1*	23.5%	30.0%	39.3%	4.7%	2.5%
2	4.4%	6.5%	42.7%	32.3%	14.2%
3	3.4%	2.8%	37.6%	35.1%	21.1%
4*	12.0%	25.0%	51.8%	7.4%	3.8%
5	2.8%	3.6%	60.3%	23.7%	9.5%
6	2.8%	4.2%	72.9%	14.4%	5.7%
7	3.4%	7.0%	62.2%	20.5%	6.8%
8	3.0%	4.6%	63.0%	22.6%	6.8%
9	5.1%	10.6%	67.4%	12.9%	4.0%
10	5.3%	6.1%	77.0%	8.5%	3.0%

*False statement.

Table 1. Percentage of answers given by the participants to the ten items of the questionnaire.

Edible insects are protein rich foods that can be consumed as such or alternatively, the proteins are extracted and added to other types of food [19], [20]. The review by Queiroz et al. [8] highlights that edible insects are rich in proteins and these can have functional and technological properties. Besides, edible insects contain beneficial bioactive compounds, as well as some antinutrients, like chitin, oxalates, tannins, alkaloids, phytates, and saponins, which can hinder to some extent the bioavailability of proteins and minerals [21]. Florença et al. [22] investigated the motivations for consumption of edible insects and found that nutritional value is a major determinant in Western countries.

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 facts presented were classified as "informed". Also, those who expressed disagreement/strong disagreement with false facts presented were considered "informed". All others were classified as "not informed".

The items with lowest percentage of correct answers were item #10 (Insects contain anti-nutrients, such as oxalates and phytic acid) with only 12% of informed participants, and item #9 (Insects contain fat, including unsaturated fatty acids), with 17% of informed participants, revealing a highest percentage of participants with incorrect perceptions about these topics.

Edible insects have fats and a wide diversity of fatty acids. For example, mealworms, locusts, termites, crickets, and flies are rich in polyunsaturated fatty acids, which are beneficial for the human body, although processing operations can alter the lipid and fatty acid profiles of edible insects. Besides, insect oils are viable alternatives to vegetable oils for human consumption [23].

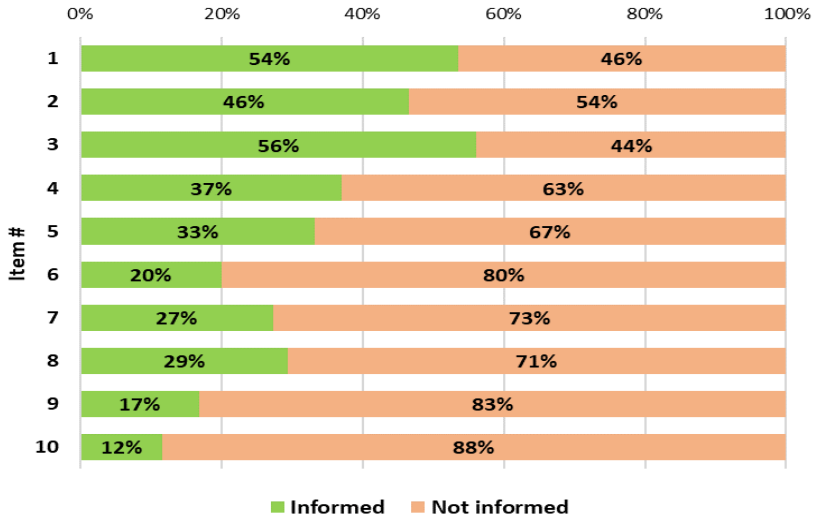

Figure 1. Percentage of participants informed or not informed about each of the questions.

C. Chi-square Tests between Sociodemographic Variables and Knowledge

Table 2 shows the results obtained with cross tabulation of the variable Information with sex, for each of the ten questions. Significant differences were found between sex groups for half of the items, item #1 (Insects have poor nutritional value), item #2 (Insects are a good source of energy), item #3 (Insects have high protein content), item #4 (Insect proteins are of poorer quality compared to other animal species) and item #5 (Insects provide essential amino acids necessary for humans), and in all these, a higher percentage of

informed was observed for male participants. Although showing significant differences, the associations between variables for these items were low, given the low values of Cramer's coefficient (V). The work by Guiné et al. [24] investigated the knowledge about edible insects in 14 countries and found significant differences between sex groups regarding clusters for knowledge, defined as 'fearful', 'farming' and 'ecological' participants. The work by Florença et al. [25] highlighted the relative importance of sociodemographical variables on knowledge about edible insects, and sex was the first discriminating variable identified through tree classification.

Item #	% Informed		Chi-square test[1]	
	Female	Male	p-value	V
1	49.4	65.0	0.006	0.139
2	42.9	56.4	0.022	0.120
3	52.2	67.1	0.009	0.133
4	33.2	47.9	0.005	0.142
5	30.6	40.7	0.058	0.104
6	21.0	17.9	0.562	—
7	26.8	28.6	0.708	—
8	29.1	30.0	0.798	—
9	16.9	17.1	0.813	—
10	12.5	9.3	0.528	—

[1]Chi-square test p- value (significance of 5%) and Cramer's V coefficient (indicated only when the p-value was significant).

Table 2. Cross tabulation and chi-square test for the association between information and sex.

Table 3 presents the results obtained for the cross tabulation of the variable Information with age class. Significant differences were found between age groups for most of the items, item #1 (Insects have poor nutritional value), item #2 (Insects are a good source of energy), item #3 (Insects have high protein content), item #4 (Insect proteins are of poorer quality compared to other animal species), item #5 (Insects provide essential amino acids necessary for humans), and item #8 (Insects contain minerals of nutritional interest, such as calcium, iron, and magnesium).

In most of these, a higher percentage of informed was observed for participants aged between 31 and 50 years old, with two exceptions, for item #4, in which case the highest percentage of informed was found for young adults, aged between 18 and 30 years old, and item #1 for which the most informed were those aged 51 years or older. Based on the values of the Cramer's coefficient, a moderate association was found for item #3 (V = 0.221), while in all other cases, the associations were weak. According to Orsi et al. [14] age is an influential variable in the regression model for edible insect's acceptance in Germany. Fernandes da Silva et al. [26] explores the impact of information on entomophobia, and identifies some factors that differentiate the 'flexible' from the 'inflexible' consumers.

Item #	% Informed			Chi-square test[1]	
	18-30 y	31-50 y	51+ y	p-value	V
1	45.6	59.7	64.3	<0.001	0.168
2	41.2	53.2	51.2	0.040	0.110
3	45.6	67.7	67.4	<0.001	0.221
4	29.2	41.9	48.8	<0.001	0.175
5	26.3	41.1	40.3	0.002	0.153
6	16.1	24.2	24.8	0.053	—
7	28.1	27.4	25.6	0.869	—
8	25.2	37.1	31.0	0.049	0.107
9	16.4	13.7	20.9	0.296	—
10	12.0	8.9	13.2	0.530	—

[1]Chi-square test p- value (significance of 5%) and Cramer's V coefficient (indicated only when the p-value was significant).

Table 3. Cross tabulation and chi-square test for the association between information and age class.

Table 4 shows the results of the cross tabulation of variable Information with education level. Significant differences were found between age groups for practically all items, except in three cases: item #7 (Insects contain dietary fibre), item #9 (Insects contain fat, including unsaturated fatty acids) and item #10 (Insects contain anti-nutrients, such as oxalates and phytic acid). In all these, a higher percentage of informed was observed for participants who completed post-graduate studies, Master or Doctorate degrees. The associations were in general weak, but for items #3 and #5, they can be considered moderate. The work by Ribeiro et al. [13] identified the sociodemographic variable 'higher education' as one of the predictor variables for acceptance of edible insects in Norway.

Item #	% Informed			Chi-square test[1]	
	MSc or PhD	Univ. degree	Under Univ.	p-value	V
1	64.9	53.9	45.5	<0.001	0.169
2	56.0	47.0	39.8	0.005	0.141
3	72.6	55.7	45.1	<0.001	0.241
4	45.2	35.7	32.0	0.022	0.120
5	48.2	30.4	24.2	<0.001	0.224
6	29.8	16.5	15.2	<0.001	0.165
7	28.6	26.1	27.0	0.892	—
8	37.5	30.4	23.4	0.008	0.135
9	19.0	15.7	16.0	0.662	—
10	10.1	13.0	11.9	0.736	—

[1]Chi-square test p- value (significance of 5%) and Cramer's V coefficient (indicated only when the p-value was significant).

Table 4. Cross tabulation and chi-square test for the association between information and education.

In Table 5 are presented the results obtained for the cross tabulation between variables information and living environment. For these tests, none of them showed significant differences between living environment groups, revealing that this variable does

not influence knowledge.

Item #	% Informed			Chi-square test[1]	
	Rural	Urban	Suburban	p-value	V
1	51.5	56.8	43.9	0.139	—
2	48.5	45.9	43.9	0.790	—
3	51.5	58.1	59.1	0.344	—
4	32.7	39.2	37.9	0.382	—
5	32.7	33.8	31.8	0.942	—
6	19.4	21.3	16.7	0.673	—
7	28.5	26.4	28.8	0.850	—
8	30.3	29.7	25.8	0.778	—
9	17.6	16.9	15.2	0.906	—
10	15.2	10.5	7.6	0.179	—

[1]Chi-square test p- value (significance of 5%) and Cramer's V coefficient (indicated only when the p-value was significant).

Table 5. Cross tabulation and chi-square test for the association between information and living environment.

IV. CONCLUSIONS

The obtained results showed that a great percentage of the participants were not able to express an opinion about the ten nutritional facts regarding edible insects presented to them in the questionnaire. The participants showed more difficulty in answering correctly to questions related to the presence of anti-nutrients, such as oxalates and phytic acid, the content of fat, including unsaturated fatty acids, or the mineral content, including group B vitamins. Contrarily, highest level of correct perceptions was found for the rich nutritive value of edible insects, constituting a good source of energy and having high protein content. Regarding the effect of sociodemographic variables on knowledge, it was observed that the most influential variables were education, age class and sex, while living environment does not significantly influence the level of knowledge.

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