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Knowledge: A Factor for Acceptance of Insects as Food

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Abstract: The role that insects will play in a healthier and more sustainable diet has been highlighted in the last years, at the European level. In future, due to environmental concerns and population growth, eating insects might be a solution for many problems. However, populations without the tradition of eating insects are still reluctant in accepting such a food as part of their diet. The present observational study highlights some factors that are influencing the acceptance of insects as food in Romania, in 2022. A number of 496 Romanian adults, 433 women and 63 men, with the mean age 39.3 ± 11 years, completed a validated questionnaire analyzing food behaviors, as well as attitudes and knowledge in relation to insects, including sustainability, nutrition and food safety aspects. Only 6.3% of participants had already eaten insects, while 43.8% claimed their openness to do it in future. Insect-based products were accepted more than insects that can be perceived as such. The most frequent words associated with insects were rather deleterious: disgust, odd, nausea, not to eat, or curiosity. Investigating the factors involved in insect acceptability in Romanians' diets, we found a statistically significant correlation between openness to eat them and the knowledge about insects as being a valuable, sustainable and safe source of nutrients. Targeted education seems to be an important tool in accepting them as part of future diets.

Keywords: insects; entomophagy; proteins; food safety; consumer attitudes; sustainability

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1. Introduction

Insects have been used as food in human nutrition since ancient times, with the first "recorded" cases of entomophagy dating from 30,000 to 9000 BC. Also, the consumption of insects was present among the ancient Greeks, Romans and Algerians, among the Aboriginal Australians, and in different religions (Christian, Jewish, Islamic). Today, insects are consumed in many areas of the globe: in Asian countries, especially China, Thailand, India, Africa, America, and even Europe [1,2]. In recent years, the interest in farming insects as food and feed (over 1900 species) has grown substantially [3].

The interest in supporting the production and consumption of insects is increasing, due to the following considerations:

(a) Insects could represent one of the basic pillars of nutrition in future, due to the rapid increase of the global population and the prospect of doubling the demand for food products of animal origin in the period 2000–2050. It should be noted that insects are a good protein source with all the essential amino acids in adequate quantities, though, protein content may vary. Insects from the Gryllidae family have a large amount of protein and

sodium, while those from the Curculionidae family have a low content of both protein and sodium. Most edible insects contain small quantities of saturated fatty acids and have a representative content of iron, zinc and vitamin E [4–6]. The level of these nutrients is modulated by certain factors, such as the insects' diet, their stage of development, industrial processing, etc. [7].

(b) FAO reckons that, until 2025, a huge number of people will lack adequate water supply. Raising and processing insects involves a lower water requirement compared to that for animals. Some insects are drought-tolerant (e.g., the yellow mealworm and smaller mealworms) [4,8]. Greenhouse gas emissions are also reduced.

(c) The feed conversion ratio (FCR) is 1.7 for cricket [9], 2.5 for chicken meat, 5 for pork and 10 for beef [10]. Thus, crickets are more efficient than conventional types of meat.

Studies conducted worldwide, most of them in Europe and Africa, confirmed that consuming insects is safe, as long as preventive measures are respected. The studies in Europe were carried out on edible insects from farms, and those in Africa were carried out on wild ones [8,11]. The microbiological load for dry and powdered insects is obviously higher than for very well fried and boiled ones. Worms and beetles have been studied more intensively and therefore represent the ideal insects for growing in farms, while other insects, such as Locusta migratoria manilensis, can be grown in greenhouses. Growing insects on farms is traditional in Thailand, Laos and Vietnam [12].

Edible insects are processed for consumption in several ways, mostly by frying and boiling, followed by drying and freezing, drying in the sun and boiling, and keeping and storing in refrigerated, frozen, dry, powdered and canned form [13–15].

The production and marketing of insects in the European Union is only allowed after authorization as "novel foods", according to the provisions of Regulation 2015/2283 [16].

At the level of the European Commission, in the period 2021–2022, the following 3 insects have already been authorized to be placed on the European market as novel foods ("novel foods"), according to European legislation [16,17]:

- the dried larva of Tenebrio molitor (yellow mealworm)
- Acheta domesticus (house cricket)
- Locusta migratoria (traveling locust).

Since the allergenic potential of insects is known, in general, for the 3 authorized insects, proper information for consumers has to be placed on labels.

However, people in Europe remain reluctant to consume insects, due to the absent tradition in this area and the general association of insects with pests, not with food. Changing food habits and traditions can be overwhelmingly difficult and, for insects to become a potential source of nutrients and part of our daily meals, these challenges must be dealt with and resolved. Even more, some unsustainable arguments, such as the presumed health harm caused by insect consumption, have to be adequately and scientifically corrected.

In this framework, the aim of our study was to investigate some factors that can affect insect consumption in Romania, especially knowledge regarding eating insects, sustainability, and nutritional and food safety concerns linked to them.

2. Materials and Methods

2.1. Study Design

This research is part of an international study, the EISuFood (Edible Insect Survey Food) project, running simultaneously in 18 countries around the world. The project investigates attitudes regarding insect consumption, in order to identify modifiable factors linked to reluctance, by using a questionnaire that was translated in Romanian. This questionnaire was distributed, as indicated in the project, as a Google Forms document by means of the social media page of our University (on Linkedin, Twitter, Facebook), with the request to be completed as soon as possible by anyone interested in doing it. The request was accompanied by a short presentation of the study and information regarding personal data protection. The questionnaire was previously validated in a study sample of Portuguese

participants [18]. The only criteria for participation in this study was to be over the age of 18 years, without an upper age limit. The period of completion of the questionnaire was February-April 2022. We were aware that internet-distributed questionnaires generally have a bias towards people with a higher socio-economic status, from urban areas, and towards women, but financial restraints dictated this approach [19,20].

The questionnaire included several parts, covering socio-demographic elements, food-consumption behaviors, attitudes and behaviors regarding insect consumption, and specific items representative of attitudes and knowledge in relation to insects, classified in several domains (Supplementary Material File S1). For each domain, a score of accuracy of the answers was calculated. In the present article, we present results regarding just 3 domains, namely: **1. Insects in relation to sustainability**, **2. Insects in relation to human nutrition** and **3. Insects in relation to health and food safety**.

2.2. Statistical Analysis

Answers were analyzed by means of SPSS software, and descriptives, correlations (Spearman Rho), non-parametric (Kruskal Wallis) and tree classification tests (CHAID growing method) were applied. The Kolmogorov-Smirnov test was used for the evaluation of normality of distribution of continuous variables and internal consistency was verified using Cronbach alpha. Tests were considered statistically significant if p was equal to, or below, 0.05.

3. Results

3.1. Socio-Demographic Data

A total number of 510 questionnaires were completed, and 14 had to be dismissed, having incomplete answers to the three subjects analyzed in this article (sustainability, nutrition, food safety). In the end, the final number of valid questionnaires was 496. Of these questionnaires, 87.3% were completed by women, and 12.7% by men, with a mean age of respondents of 39.3 $\pm$ 11 years (minimum 19 years, maximum 84 years). According to the collected answers, 83.1% of the investigated persons are living in urban areas, 11.3% in rural regions, and 5.1% in suburbs.

Most of respondents (60%) graduated high school, 37.2% graduated university, and 2.8% of participants have a postgraduate diploma. As regards the income of participants, compared to the average income: 10% have lower income than average, 58% higher, and the rest around the average Romanian income.

3.2. Behavior, Attitudes and Knowledge Regarding Insects as Food

When asked if they already had eaten insects, only 6.3% of respondents answered that they had. From those who had not consumed insects (92.7%), 41.5% answered that they would never, 43.8% were undecided, answering "maybe", 9.8% said they would try food containing insect ingredients, and 4.8% would consume whole insects.

Asked to choose words that came to mind regarding insects, varied answers were obtained. We classified the answers in several categories, as described in Table 1.

Most frequent words were: disgust (n = 71), protein (n = 41), odd (n = 27), nausea (n = 23), not to eat (n = 22), curiosity (n = 22). This shows that, although insects are not seen as an attractive food, people who receive more information about them may be open to eating these new food products, as some associate insects with protein or nutrients. However, overcoming repulsion will be a big step in the acceptance of insect consumption, because food habits change slowly and reluctantly.

For a better understanding of the factors that can influence the attitudes and practices regarding edible insects and insect–based products, we investigated three domains in relation to insect consumption: knowledge about insects as a sustainable source of nutrients, nutrition provided by insects, and food safety. Regarding these areas, the internal consistency was verified for each domain, using Cronbach alpha, and the following results were obtained:

- Sustainability: internal consistency = 0.89, good internal consistency.
- Nutrition: 0.71, the internal consistency was acceptable.
- Food safety: 0.71, the internal consistency was acceptable.

Table 1. Description of insects as food.

Categories	Words and Points of View that Describe Insects as Food
Geographical areas	Asia, Thailand, China, Africa, Mexico, India, Vietnam, Myanmar, Cambodia, exotic
Types	crickets, ants, butterflies, worm, little creatures, grasshopper, cockroaches, bats, arachnids, legs (?!), dust (?!), erythema (?!)
Feelings and states of mind	curiosity, reluctance, repulsion, interest, disgust, fear, taboo, terror, reluctant, nausea, confusion, unpleasant
Organoleptic and nutritional characteristics	snack, crispy, crunchy, not to eat, no taste, inedible, gelatinous, tasty, glossy, gourmet, gastronomy, not food, smell bad, juicy, gourmet, protein, nutrients
Insects as food	money, business, extravagant, poverty, hunger, misery, new food, clean, future, challenging, alternative, odd, novelty, not for me, disease, impossible

Only 2 respondents (from 496) chose the term "sustainable", and one, "ecological".

A diagram presenting the attitudes towards insects of the participants is shown in Figure 1.

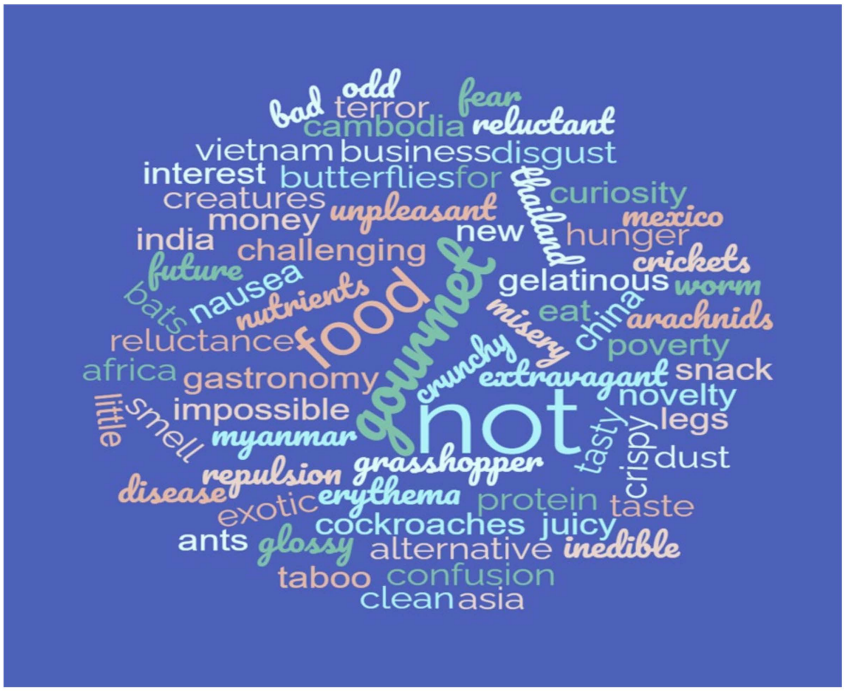

Figure 1. The view of study participants regarding insects.

As stated before, for each domain, a score was calculated. Between the scores for each domain there was a statistically significant level of correlation (Spearman Rho test: sustainability/health = 0.457, sustainability/nutrition = 0.546, health/nutrition = 0.478), showing the close relation between these 3 areas.

Furthermore, we carried out non-parametric tests between the scores of each of the three domains and different characteristics of the respondents, by means of the Kruskal Wallis test, since the distribution of values was non-normal. Statistically significant correlations were present between: (a) the level of education and sustainability knowledge score (p = 0.008), (b) income and sustainability knowledge score (p = 0.00) and (c) income and health knowledge score (p = 0.011) (see Figure 2a–c).

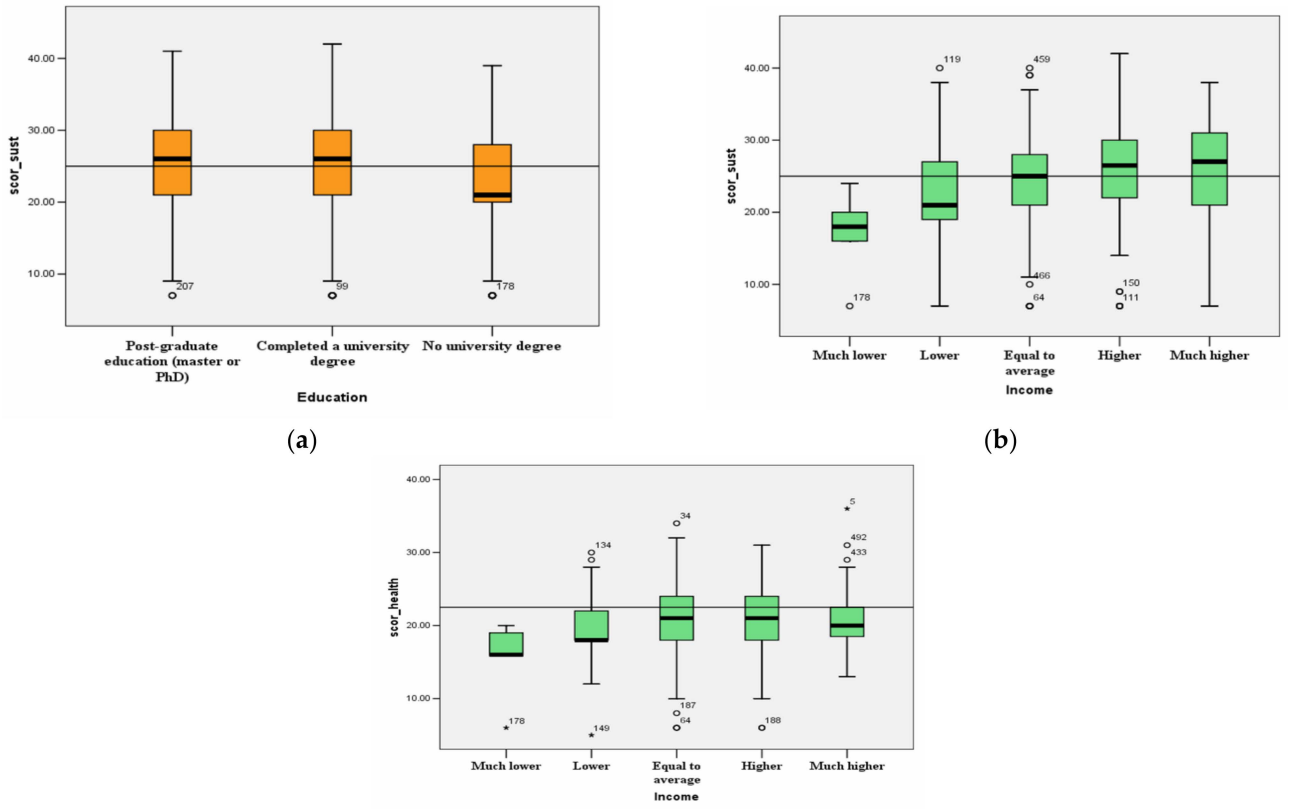

Figure 2. Factors influencing knowledge about insects, or about potential hazards in relation with eating insects: (**a**) Level of education, in relation with knowledge regarding insects as sustainable food; (**b**) Level of income, in relation with knowledge regarding insects as sustainable food; (**c**) Level of income, in relation with knowledge regarding potential health hazards raised by eating insects. The boxplots contain the median value of the score as a bold line, whiskers represent minimum and maximum values, and bullets with numbers are respondents considered as outliers (with outside values).

In order to better characterize factors involved in the willingness to consume insects, we carried out, for each domain of knowledge, a tree classification test (CHAID growing method), having as a dependent variable the willingness to eat insects, and as independent variables, age, sex, education, income and the value of the score (Figure 3). Regarding the willingness, 3 categorical groups were defined, differentiated by the attitude towards eating insects: 1 = yes, they would try insect-based products, but not insects as a whole–the highest value of the score, 2 = maybe (medium value).3 = surely not (lowest value).

The values of respective scores for each group and each domain are represented in Figure 3.

1. The **sustainability knowledge score.** The 3 categories of willingness to eat insects had statistically significantly different knowledge scores, with the highest score of knowledge in the group most willing to eat insects. Also, the "maybe" category had 2 significantly different sub-categories, differentiated by income: (a) higher score for over-average income and (b) lower score in average or lower income. So, there is a statistically significant link

between the sustainability knowledge score, and the willingness to eat insects, and income. People with a high income have high knowledge about sustainability related to insects, but not enough to be clearly decided whether or not to consume insects. If they gain more knowledge, they can climb into the category of those who respond positively to the consumption of insects.

2. For the **Health knowledge score,** and for the **Nutritional knowledge score,** there were, again, statistically significant differences between the values in the three categories of willingness to eat insects. It can be seen that the willingness to eat insects is higher when the score in each domain is more important. Thus, the better knowledge the participants have in a field, the greater the openness to consume insects.

In the end, we summed up all the 3 knowledge scores (sustainability, health, and nutrition) and carried out the tree classification on a total score. The previous 3 groups of willingness are present again, with statistically different scores of knowledge. The mean scores and SD were as follows: Yes, but not as a whole = 69.9 ± 12; surely not = 57.6 ± 14, and; maybe 64 ± 9.

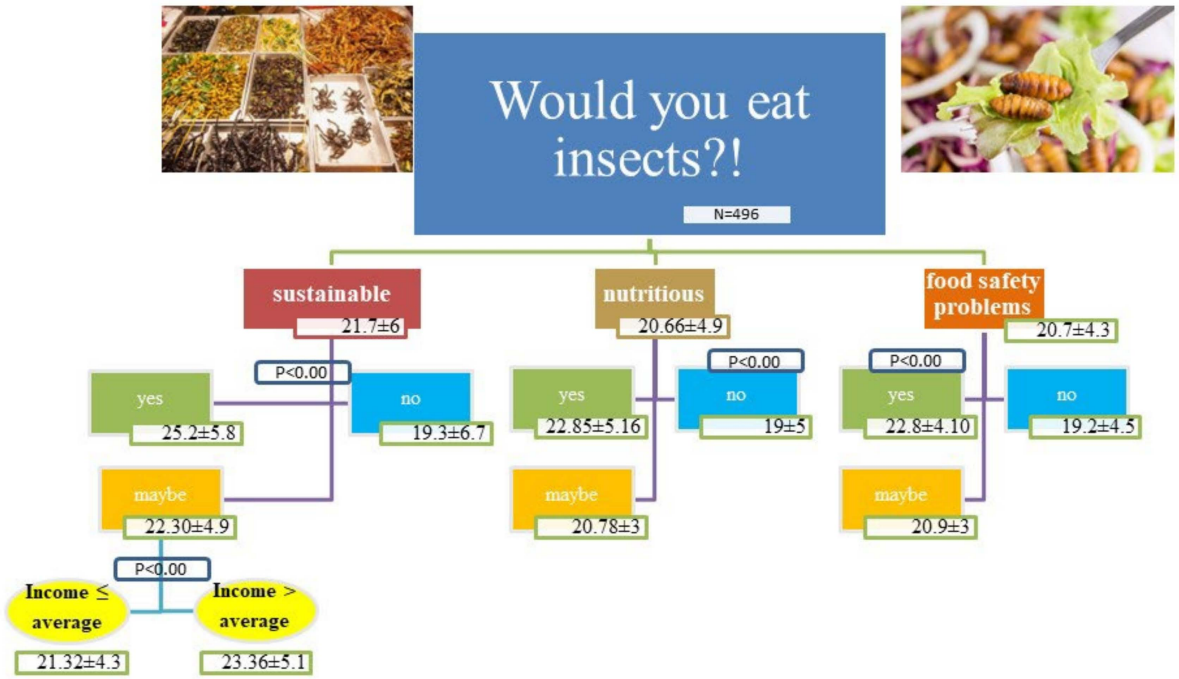

Figure 3. Sustainability, nutritional and food safety knowledge scores related with willingness of eating insects. Under each answer, average and SD of score are presented.

4. Discussions

Analyzing the study results, it can be seen that the number of people who are willing to taste insects is higher than those who say they will never eat these products (43.8% vs. 41.5%). Still, "disgust", "odd" and "nausea" are among the most frequent words related to insects.

The factors involved in consumers' acceptance of insects are varied and have been investigated in several countries, some of which do not traditionally consume insects. The results of these studies are summarized in Table 2.

In our study, income was statistically significant, correlated with the knowledge regarding insects as sustainable food. However, over 50% of our respondents have a higher, or much higher, income than average, so this might be a bias. We are still far from reaching the entire population when it comes to knowledge regarding insects.

Table 2. Consumers' acceptance of insects as food in different countries/regions.

Country/Region	Study Participants	Main Findings	Reference
Germany	516 adults, mean age	The willingness to consume an insect burger was higher than that of the buffalo worms; sensation-seeking the most important	[21]
Germany	718 children and adolescents	70.9% had already heard that insects could be used as food; A percent of 38.6% of young people and children are ready to eat an insect burger	[22]
Australia	601 adults	35.4% reported previously consuming insects; 56.2% would be "likely" to eat insects in the future. Among hindrances for consumption, disgust and safety aspects are mentioned	[23]
The Netherlands	adults	Respondents are curious regarding insects as food, mainly because they consider insect products as being more positive towards the environment and far more sustainable compared with meat	[24]
Japan	adults, mean age 41 years	Eating with friends and consumption at food festivals play an important role in the anticipated acceptance of insect-based foods	[25]
Hungary	400 adult meat-consumers	Food based on insects is mainly of interest for people seeking more environmentally friendly foods, in parallel with reducing meat consumption	[26]
United States of America	241 students	A predictor of reluctance towards insect consumption is neophobia and a sentiment of disgust	[27]
Denmark	2461 adults, mean age 46 years	Affective factors have significant predictive values for accepting foods involving novel proteins from seaweed and insects	[28]
Denmark	181 children, 9–13 years old	Danish children were moderately willing to try insect-based foods; positive aspects regarding insect consumption towards health and environment did not boost their eagerness to consume such foods	[29]
Belgium	159 university students	Presentation form of the insect-based product (burger), a previous knowledge of entomophagy, and a previous experience decrease the insect food neophobia. In term of overall liking: beef burger > mealworm/beef burger > mealworm/lentil burger > lentil burger	[30]
Portugal	303 adults	Food neophobia affect acceptance of insects as food	[31]
Norway	363 adults	Respondents accepted use of insects as feed, but much less as food	[31]
Italy	1043 respondents, average age 49.4 years	Willingness of eating insect is related to the level of visible appearance and types of food preparations	[32]
Chile	483 respondents	In terms of acceptability: indirect entomophagy > products involving processed insects > whole insects	[33]

Moreover, we found a statistically significant level of correlation between the 3 fields investigated in this study: sustainability, nutrition, and food safety in relation to insects. Therefore, there is a close connection between the willingness to eat insects and knowledge in all three domains. Better education can raise the acceptability of insects in diets, and affect the openness to eat them. Knowledge in one domain will probably lead to knowledge in any other.

The role of information and education levels was also highlighted in other research [34,35]. A subject that has to be taken into consideration is that even those already willing still have a degree of repulsion in relation to insects and want to eat without really seeing them, so the stealth use of insects in food, as stealth as it can be, since the ingredient list will show them, is an alternative better tolerated by consumers.

The willingness to eat insects and repulsion avoidance are very important in consumers' acceptance of these products. The low acceptance of insects in European countries is due to the lack of tradition of consumption. This attitude is shown also by the participants in the current study, with disgust being the most frequent word associated with insect consumption. Romania is a traditional society and most Romanians are driven by principles that promote tradition, with a low degree of tolerance for diversity, including when it comes to food. For this reason, the participants in the study are not willing to eat insects, experiencing, most of the time, disgust or repulsion in relation to insect consumption. Also, a systematic review conducted in 2022 by Florença et al. revealed that willingness to consume insects depends on the traditions of each country. If, in a country, there was some tradition of eating insects, even a minor one, the population was more determined to be open to insect consumption than to oppose (60% vs. 40%). However, in Western countries where tradition was lacking, the ratio was almost inverse (one third of the respondents are favorable, versus two-thirds against), for reasons similar to what we found in our study: (neophobia, aversion, tradition and aspect [36]).

Apparently, a previous taste experience of both whole and processed insects has been shown to improve the attitude toward insect consumption [37,38]. However, it seems that products containing insect parts are more easily accepted by consumers, thus interfering with their visibility in food products [39,40]. Products such as insect flour and bakery products, biscuits or hamburgers improve their acceptance [21,31,41].

Previous research has shown that insect acceptance depends on place of food consumption and companions (e.g., friends and family, in food festivals, restaurants, cafes or pubs [25,42]).

Due to nutritional value and organoleptic properties, insects are starting to be among the culinary choices, not only in the areas where they are traditionally consumed [43–45]. The nutritional value of edible insects is different depending on species, processing and cooking methods applied [46,47]. For their protein and unsaturated fat content and other valuable micronutrients, such as iron, magnesium, copper, riboflavin and biotin, edible insects could represent a good alternative to meat products, or in situations of undernutrition [48,49]. Nutrients like those mentioned before can positively influence gut microbiota, this action being enhanced by the presence of some antioxidant and antimicrobial peptides. Interaction with gut microbiota will lead to better digestive health and, potentially, better management of chronic diseases, such as cardiovascular ones, by reducing blood triglycerides levels [36,50–53].

Safety aspects of insect consumption that consumers must be aware of include the presence of some toxic chemicals, such as pesticides, aflatoxins, or microbial contamination of non-edible insects [54]. Thereby, it is important to choose common edible insect species in order to prevent all these health risks [55].

Insect authorization as a novel food by European Regulations will stimulate the use and the acceptance of similar novel ingredients, and thus will encourage innovation in this area of research [56].

From the perspective of sustainability and environmental protection, insect farming has some advantages: lower economic investment, lower greenhouse gas emissions, a lower quantity of water and less space is needed. Overall, insects bring a higher rate of feed conversion compared to traditional animal husbandry [57,58]. These aspects are the more important in the context of saving resources and assuring food safety security throughout the globe. The need to find alternatives to conventional meat products in the context of the increase in the population of the Globe, but also in order to limit the climate change

effects, could be an opportunity for increasing the demand of the insect-based products market [59].

5. Conclusions

The findings of the present study emphasize the idea that people would rather consume products containing insect ingredients than whole insects.

They also underline the role of education in insect acceptance and the part played by a higher economic status. There is a close connection of the willingness to eat insects with the knowledge about sustainability, nutrition provided by insects, and food safety; hence, better education can raise the acceptability of insects in diets. Insects are valuable and sustainable nutrient sources and, even though food habits are hard to change, there is hope that in future, with proper education, they will become a normal ingredient in our daily meals.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su15064820/s1, Supplementary File S1: Survey on edible insects.

Author Contributions: Conceptualization, C.Z., M.T. and M.N.; methodology, C.Z. and M.T.; software, C.Z.; validation, R.P.F.G. and C.C.; formal analysis, C.Z.; investigation, M.T.; resources, M.T.; data curation, C.C.; writing—original draft preparation, C.Z., M.N. and D.N.; writing—review and editing, M.T. and C.C.; visualization, C.Z.; supervision, C.Z. and M.T.; project administration, R.P.F.G.; funding acquisition, R.P.F.G. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: This research was implemented taking care to ensure all ethical standards and followed the guidelines of the Declaration of Helsinki. The development of the study by questionnaire survey was approved on 25 May 2020 by the ethics committee of Polytechnic Institute of Viseu (Reference No. 45/SUB/2021).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data are available from the corresponding authors upon request.

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Conflicts of Interest: The authors declare no conflict of interest.

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