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Recognizing Potential Pathways to Increasing the Consumption of Edible Insects from the Perspective of Consumer Acceptance: Case Study from Finland

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Abstract: Mitigating the sustainability challenges related to agriculture and ensuring adequate availability of nutritious food requires an increase in the use of sustainable alternative protein sources. Edible insects are considered to be a sustainable protein source and a possible substitute for meat. There are many readily available edible insect species with many competing utilization possibilities, which, from the producers' perspective, increases the complexity of the area. Through a consumer survey and expert interviews, this study recognizes four pathways to increasing the use of edible insects in Western countries and especially in Finland where the survey and interviews were conducted: (1) producing a variety of insect-based food products, especially food products where insects are not recognizable as such and the food is in a familiar form; (2) producing edible insect food products which could replace greenhouse gas emission-intensive animal proteins; (3) focusing on the price, taste, and availability of insect food; and (4) using insects as animal feed. Our findings provide information on the prospects of the studied pathways in terms of consumption and production. Technological development is expected to decrease the price of insect-based food products, but at the same time, the increased use of edible insects faces challenges related to eating habits, contradictory perceptions about the sustainability implications of insect farming, and the availability of insect-based products.

Keywords: edible insects; consumer acceptance; alternative protein; sustainability



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1. Introduction

Global population growth, with the sustainability problems arising from food systems, comprises a significant and likely increasing threat for the future [1]. Animal products currently account for approximately 83% of global farmland use and contribute 56–58% of food-product-related emissions, and yet, animal products provide a relatively small share of the global protein and caloric consumption, 37% and 18%, respectively [2]. It has been estimated that by 2050, 70% more food calories must be available for human consumption than in 2010 [3]. This greater demand, together with growing land-use pressures, is likely to increase food prices in the near future, which motivates the search for alternative protein sources, such as cultured meat, seaweed, vegetables, or edible insects [4–6].

Edible insects may have health, environmental, social, and economic features that make them a good alternative to conventional meat consumption [4,7,8]. According to the life cycle assessment studies, insect production has lower impacts on the environment than conventional meat production [9–11] and requires less land [12,13] and fresh water [14,15]. In addition, the production of edible insects has a high feed-conversion efficiency because insects are cold-blooded and able to transform low-value organic side streams into high-value protein products [4,5,7–9,13]. When considering the climate impacts, insect production has been shown to typically cause lower greenhouse gas (GHG)

emissions than animal meat production [9,11,12], but there are some uncertainties. For instance, the influence of different production practices on GHG emissions is not well known [8]. In addition to the environmental benefits, the increased use of edible insects could boost food access, support human nutrition, and facilitate new forms of income generation [16].

Interest in entomophagy, i.e., eating insects, has increased in recent years [6], but nevertheless a majority of Western consumers reject edible insects [17–20]. Food habits, culturally-bound disgust towards edible insects, the limited availability of insect-based food, and a previous lack of regulations governing insects as food and feed have been recognized as the major barriers to widespread entomophagy in Western countries [21]. To understand the prospects of entomophagy, a clarification of the reasons behind consumer acceptance or rejection of edible insects is needed [22]. The main drivers influencing consumer choices in insect eating are sociocultural and psychological in nature, and they reflect learned knowledge about the positive environmental effects [20,23–25] as well as the familiarity, flavor, palatability, and visual appearance of edible insects [25–28]. The willingness of Western consumers to test edible insects has been studied, but better understanding is needed about the distinctive features affecting regular insect consumption as food [29]. A switch from animal products to insect consumption would have a particularly positive impact on the environmental burden imposed by Western countries because of the high meat consumption rates per capita in the Western world [30].

Based on previous studies, early adopters of insect eating can be assumed in Western contexts to be young men with a high educational level who are open to trying novel foods and are interested in the environmental impact of their food choices [20,24,26,27,29,31]. It has also been presented that the consumer acceptance of insect-based food is higher when the insects are presented in a familiar form and when the consumer has had an earlier experience of eating insects [20,29,32–36]. However, incompatibility with local food culture [24,32,35,36] and other people's opinions [25] can become barriers to adopting insect consumption. Moreover, the reluctance to eat novel foods, i.e., food neophobia, has a significant effect on consumers' readiness to adopt edible insects into their diets as it can decrease the willingness to eat insects [20,27,33,37–40].

To adopt insects successfully into human consumption patterns, a good availability of insect-based food products in grocery stores is required [41]. Low availability and a poor selection of products leads to passive rejection and decreases the likelihood of consumers buying the products more frequently [29]. Insects should be added to a familiar dish, and the insect product should also taste good if it is going to be regularly consumed [23,32,42]. Although it has been suggested that people should be encouraged to eat insects on a regular basis, edible insects should find their own place in the food sector rather than being used as a substitute for meat or hidden in other food [17]. Caparros Megido et al. [26] show that insect integration into Western food culture could be done using a transitional phase, in which ground insects are included in familiar ready-to-eat meals. Processed insect-based food within a familiar product category or with a familiar flavour profile can be expected to reduce neophobic reactions and increase the willingness to eat insects [33]. The degree of processing that insect-based food undergoes may be a key factor in enhancing consumer acceptance [41], and the incorporation of insects in processed foods may be seen as an acceptable way to serve insects [40,43].

The perceived environmental benefits of insect-based food can also increase the interest in entomophagy [24,32]. People who try insect-based food tend to have a higher than average level of environmental concern and insect-based foods may be targeted to people who are closer to following a "flexitarian" diet than the average person [29]. On the other hand, Wendin and Nyberg [44] consider the sustainability of edible insects to not be the main factor affecting the acceptance of insect consumption. In addition, concerns about the environmental impacts of edible insects can raise challenges to their adoption into general diets. For example, the consumption of some insect-based foods, such as chocolate with insects, is not motivated by a desire to improve sustainability [32].

Nevertheless, these kinds of products can introduce consumers to the idea of eating insects [22]. According to Elorinne et al. [45], vegetarians have the most positive attitude towards edible insects, and both vegetarians and omnivores consider entomophagy as “wise and a solution to the world’s nutrition problems”, whereas vegans describe insect eating as “immoral and irresponsible”. Santaoja and Niva [46] suggest that in order to mitigate the negative environmental impact of food production, insects should replace meat or other GHG emission-intensive food products.

Sogari [25] declares that the main factors affecting increased insect consumption are curiosity and the environmental benefits. However, consumers may taste novel foods out of curiosity but may not eat them again if the food is not considered palatable or appropriate for consumption, and therefore, insect-based food products should both encourage consumers to try the different foodstuffs and should perform well in relation to the foods that are currently consumed [47]. House [29] noted that repeated use of insects in day-to-day food consumption is mainly affected by conventional eating habits and food products, such as the price, taste, availability, and suitability for a person’s diet, and if some are negatively inclined or doubtful about any of these factors, the likelihood of the repeat consumption of insects is adversely affected. Van Thienen et al. [28] sum up that improving the supply, visibility, and taste of insect-based food is the best way to expand the share of the population that eats insects.

In this work, we study potential pathways for increasing consumer acceptance of insect eating in Finland. Finland is an example of a country where the sale of edible insects as food is legal, but insect production has not scaled. This research is based on a consumer survey and expert interviews. Our findings are important beyond the Finnish context because increased knowledge of entomophagy and consumers’ reactions to insects as food may reduce insect food rejection [23,48].

2. Materials and Methods

In this research, a mixed-method approach is carried out by combining qualitative and quantitative methods. Generally, the mixed-method approach is used to combine multiple methods into a single study and to broaden the view of a research problem [49]. To gain a comprehensive understanding about attitudes to edible insects and the potential pathways towards insect eating, we used two methods in this study. First, a survey was conducted to collect quantitative data about the Finnish consumers’ acceptance and willingness to eat edible insects, and second, expert interviews were used to understand and obtain qualitative data on the possible future consumption of insects in Finland. The use of these two methods in the same study provides information on what the current state of the consumer acceptance of insect eating in Finland is and how insect eating could be promoted in the future.

2.1. Consumer Survey

Our survey of the Finnish consumers’ acceptance of insect eating was conducted online in Finland during the summer of 2020. A link to the survey was shared on different social media (e.g., Facebook and Twitter), a local newspaper in the Päijät-Häme region, and on the mailing list and intranet for employees and students of the Lappeenranta-Lahti University of Technology LUT. The survey was shared on different platforms to reach as many respondents with different backgrounds as possible. The data were collected using the Webropol 3.0 survey and reporting tool and analysed in the statistical program SPSS 26. The survey was conducted in Finnish.

Two studies were previously conducted, in 2016–2017, on the Finnish consumers’ attitudes towards insect eating [36,50]. However, the context has changed since that time as the sale of insect food for human consumption was made legal in Finland in 2018 [51]. This survey on Finnish consumer acceptance of insect eating is the first study conducted following the legislative reform in 2018.

The survey questions addressed subjects such as the background of the respondents, their earlier knowledge and experience of edible insects, their attitudes towards novel and insect-based food, and the factors affecting insect eating and the purchase decisions of insect-based food. Different question forms were used, e.g., a 5-response Likert scale, multiple choice, order of importance, and open questions. A copy of the questionnaire translated into English is presented in Appendix A.

The total number of respondents to the survey was 212, of whom 29% were men and 67% were women, and the remaining 4% were non-binary or did not want to disclose their gender. The age of the respondents varied from 14 to 69 years. However, the majority of the respondents were within the age range of 25–44 years (55%).

The key question of the survey concerned the respondents' attitudes towards insect eating. There were five statements that measured the respondents' attitudes. The respondents assessed their attitude on a 5-point Likert scale from "strongly agree" to "strongly disagree". The Likert-scale statements were "I'm interested in eating insects"; "My attitude towards insect eating is positive"; "Insect eating does not evoke thoughts in me"; "The idea of insect eating disgusts me"; and "I don't want to use insects in my diet". Based on these statements, the sum variable of the total overall attitude towards insect eating can be measured and analyzed. By forming a sum variable from these statements, the respondents can be categorized according to how different background information affects their attitudes towards edible insects and their willingness to eat insect-based food (Table 1). Some of the statements were negative and others were positive. Negative statements were reversed and formed to the sum variable.

Table 1. Characteristics of respondents (N = 212) and cross-tabulation between respondents' characteristics and attitude towards insect eating. When the Pearson Chi-Square is less than 0.05, the crosstabulation is statistically significant.

Characteristics		The Share of Respondents (N = 212)	Negative Attitude towards Insect Eating	Neither Negative Nor Positive Attitude towards Insect Eating	Positive Attitude towards Insect Eating	Pearson Chi-Square
Gender	Male	29%	16%	12%	72%	0.006
	Female	67%	21%	30%	49%	
	Did not want to tell gender or non-binary	4%	-	-	-	
Age	<30	27%	17%	12%	71%	0.009
	30–49	50%	19%	34%	47%	
	50+	23%	25%	17%	58%	
Diet	Omnivore	70%	18%	24%	58%	0.289
	Semi-vegetarian	22%	20%	22%	59%	
	Vegetarian/Vegan	8%	38%	31%	31%	

Table 1. Cont.

Characteristics		The Share of Respondents (N = 212)	Negative Attitude towards Insect Eating	Neither Negative Nor Positive Attitude towards Insect Eating	Positive Attitude towards Insect Eating	Pearson Chi-Square
Education	Primary school or less	3%	43%	14%	43%	0.597
	Matriculation or vocational examination	24%	14%	28%	58%	
	Bachelor's degree	29%	20%	21%	59%	
	Master's degree	31%	22%	20%	59%	
	Licenciate or doctoral degree	14%	21%	35%	45%	
Previous experience	No earlier experience	35%	37%	28%	35%	0.0
	Tasted insect food once	22%	20%	30%	50%	
	Has eaten multiple times	43%	6%	18%	77%	
Attitude towards novel food (food neophobia)	Negative attitude towards novel food	6%	67%	8%	25%	0.0
	Neutral attitude towards novel food	34%	29%	36%	35%	
	Positive attitude towards novel food	60%	10%	19%	71%	
Meat consumption	Not reducing meat consumption	12%	42%	19%	39%	0.012
	Considered reducing meat consumption	27%	14%	30%	56%	
	Has reduced meat consumption	48%	16%	20%	65%	
	Do not eat meat	12%	27%	35%	39%	
	Other	1%	-	-	-	

Cronbach's alfa was used to check the reliability of the study and the sum variable [52]. In this study, it is used to understand whether all the statements about the attitudes towards insect eating could be combined into a single sum variable. Cronbach's alfa should reach 0.7 to have an acceptable level of consistency [52]. The correlation between the characteristics of the respondents and the attitudes to insect eating was analysed using the chi-square (χ^2) test. Results with $p < 0.05$ are considered statistically significant.

2.2. Expert Interviews

Six Finnish experts were selected for interview based on their expertise in the areas of insect eating, sustainable food systems, and food technology. The experts were found by searching different insect-eating projects in Finland, and based on these findings, the experts were contacted by e-mail. Nine people were asked for an interview and six of them agreed. In this study, they are called Expert 1, 2, 3, 4, 5, and 6. Expert 1 is a researcher who has studied sustainable nutrition and the relations between humans and insects. Expert 2 works in the restaurant industry and has experience of insect food. Expert 3 is a professional in future food technology and has experience in eating insects. Expert 4 is a researcher in the field of the marketing of edible insects and has experience in designing packaging for insect-based food. Expert 5 is a lecturer who has been involved in many insect-related projects. Expert 6 is a researcher who has experience in the areas of sustainability transitions, sustainable food production, and the impact of law and regulation on insect food production.

The collection of data, i.e., the interviews, was held remotely in the summer of 2020. The interviews were semi-structured thematic interviews, and the average duration of one interview was approximately 40–50 min. The interviews were conducted anonymously so that the interviewees had the opportunity to talk about the topic as freely as possible. All the interviews were recorded with the permission of the participant and the recorded interviews were then transcribed. The interviews were conducted in Finnish. The themes of the interviews addressed general attitudes to insect eating and the challenges and opportunities of entomophagy in Finland. The questions were prepared thematically, but their order was changed depending on the situation. Additional questions were also asked. Each transcribed interview was read several times and coded manually by a researcher. For analysis of the results, themes were formed from the transcribed material of the interviews. A copy of the interview questions translated into English is presented in Appendix B.

3. Results

The results of the survey and interviews are presented and analyzed in this section. The section considers the degree of consumer acceptance of insect eating, the acceptable insect-based food products, the challenges and opportunities of insect eating, and the future role of insect eating.

3.1. Attitudes and Consumer Acceptance of Entomophagy

Based on the results of the survey, the respondents' knowledge of entomophagy was quite high as 81% of the respondents ($N = 171$) answered that they had heard of entomophagy and knew what it was. Only 2% of the respondents ($N = 4$) answered that they had not heard of eating insects before. The survey was conducted online, and it was introduced as "a survey about insect eating". It can be assumed that people who have heard of insect eating are more likely to notice and respond to the survey.

Attitudes towards insect eating were gathered using the formed sum variable, and the reliability of the sum variable was checked using Cronbach's alfa. In this case, the condition was fulfilled as Cronbach's alfa was 0.872 (over 0.7). More than half of the respondents (56%) had a positive attitude towards insect eating; 24% of the respondents had neither a negative nor a positive attitude towards insect eating, i.e., a neutral attitude; and 20% of the respondents had some level of negative feelings towards insect eating. Different factors affecting the respondents' attitudes towards insect eating were considered using cross-tabulations. By analysing the correlations between the different factors and the attitudes towards eating insects, it is possible to find which aspects impact the respondents' interest in using insects as food (Table 1). The correlation between the characteristics of the respondents and the attitudes to insect eating was analysed using the chi-square (χ^2) test. The results with $p < 0.05$ are considered statistically significant, i.e., there is a correlation between the respondents' characteristics and their attitudes towards insect-based food.

According to the chi-square test, gender, previous experience of eating insects, attitude towards novel foods, age, and consideration of reducing meat consumption have a statistically significant effect on attitudes towards eating insects (Table 1). People who are interested in eating novel foods, have eaten insects before, and have considered reducing meat consumption and people under the age of 30 and men have the most positive attitudes towards insect eating, i.e., they can be assumed to be potential consumers of insect-based foodstuffs. On the other hand, diet and education did not have statistical significance for insect eating ($p > 0.05$). Attitudes towards the ethics of insect eating was examined in the survey because edible insects are commonly assumed to be sentient beings [53], especially among vegetarians and vegans [45]. We found that attitudes towards the ethics of eating insects depends on whether the respondent is a semi-vegetarian, a vegetarian, or a vegan. The majority of semi-vegetarians accepted insects as a part of their diet (72%), whereas most vegetarians (56%) and vegans (71%) found the eating of insects unacceptable from an ethical point of view.

One aim of the survey was to find out what factors influence the consumer acceptance of entomophagy, and this aspect was examined by asking what factors affect the respondents' decision to eat insect-based food products. The respondents were asked to prioritize factors increasing the likelihood that they would eat insects, and the results were analyzed using mean numbers, where 1 is the most affecting factor and 9 is the least affecting factor. The factors affecting the respondents' willingness to eat insects, in order of importance, were found to be: (1) taste (mean 3.67); (2) environmental reasons (3.80); (3) affordable price (4.23); (4) diet diversification (4.91); (5) domestic production (4.94); (6) good availability in stores (5.06); (7) ethical reasons (5.14); (8) novelty (6.42); and (9) other people's recommendations (6.84). Taste was one of the main important factors affecting the willingness to eat insects. In addition, the possible environmental benefit of edible insects compared to meat products was mentioned as an important factor, whereas affordable price was not as important as the environmental perspective. Diet diversification, domestic production, and good availability in stores had almost the same average results. The ethics of insect eating, the novelty, and other people's recommendations had the least impact on the acceptance of insect eating. These results are in line with the open question of the survey about the reasons for eating edible insects. In response to the open question, the respondents answered that if the insect-based food tasted good, insects were an environmentally friendly food option, the price was affordable, and the food was produced domestically, they could eat insects.

3.2. Acceptable Insect Food Products

To increase the share of people in Western countries willing to eat insects, it is necessary to find acceptable preparation methods for insect-based food [32]. In the survey, the respondents were able to choose in what form they could eat insects (Figure 1) and what kinds of insect-based foods are acceptable (Figure 2).

The majority of the respondents to the survey were prepared to eat insect-based food if the food was ground, the insects were invisible, and someone else had prepared the food. Furthermore, the food should taste and look like familiar food. The least preference was given to options where the food would look like something new, and the insects were whole or visible in the food. Approximately 12% of the respondents answered that they could not eat any insect-based food. Based on these results, it can be concluded that consumers want to eat insect-based food which looks and tastes like familiar food, where the insects are ground and invisible in the food, and they do not taste the insect in the food.

Comparing the survey respondents' results to the opinions of the experts interviewed on the future of insect food products, it can be seen that there is a notable overlap. The opinions of the experts interviewed can be grouped based on how they see the future of insect food products. Some of the experts think that insects should be ground and added to familiar foods because consumers are not ready to eat whole insects. The separation of insect fats and proteins would be a solution to presenting insect food to people with

doubts about eating whole insects. In addition, the healthy nutrients of edible insects could be utilized in this way. For instance, ground insects could be added to plant-based foods to increase the nutrients often missing from the vegetarian diet. On the other hand, if authentic insect food is desired and the insects are prepared traditionally, they may be served whole. Insect food production should have different strategies for different uses; for instance, there should be products on the market for both daily use and for experimental insect meals.

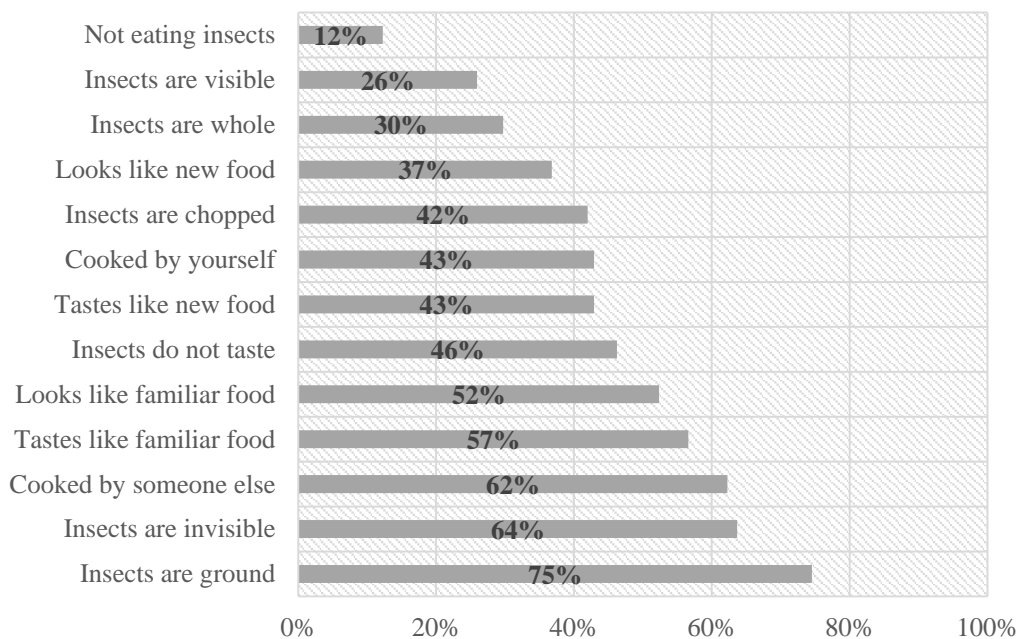


Figure 1. Survey respondents' readiness to eat different kinds of insect-based foods depending on the form of the insects and the cooking method. Respondents had the possibility to choose as many options as possible. The total share of each option is 100% (N = 212).

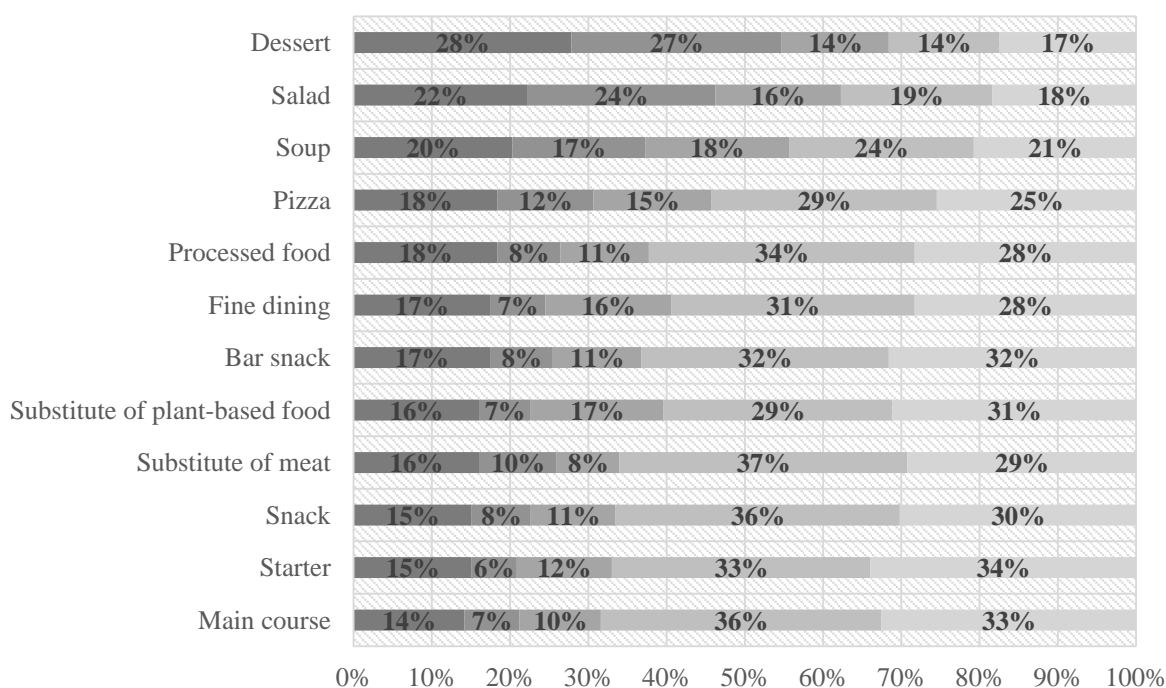


Figure 2. Food dishes that survey respondents felt could acceptably contain insects (N = 212).

The respondents' attitudes towards food dishes that could contain insects were examined on a Likert 5-point scale in the survey (Figure 2). The main course and starter are the most acceptable food dishes as 69% and 66% of the respondents partly or strongly agreed that insects were acceptable in the main course and starter, respectively. Insects could also be accepted as snacks (66%), such as protein bars. Insects as a substitute for meat and plant-based food, bar snacks, fine dining, and processed food had nearly same results with regard to acceptance. However, most respondents do not want to eat insects in desserts (55%) or in salads (46%).

3.3. Challenges and Opportunities for Increasing the Use of Edible Insects

All the experts interviewed had eaten insect-based food, but in general, the food has not remained in their ordinary diet. They all agreed that insect eating has reached its peak in Finland and that the curiosity and novelty of insect eating no longer attracts consumers as much as earlier. The next steps in the insect industry should thus be considered.

According to the interviews, the main challenges to the greater eating of insects in Finland is the disgust of consumers and a lack of suitable insect-based food products on the market. Another problem is the contradiction between the perceived sustainability of insect-based food and the current insect products. Present-day insect food products on the market do not replace other emission-intensive animal protein products; rather, edible insects are added to foods that are already vegan or plant-based. In addition, the high price of insect-based food products affects the desire to eat insects regularly. Insect-based food products should be inexpensive and easy to prepare, should replace other animal protein food, and should taste as good as the replaced food.

The experts felt that insects were a good food ingredient because many insect species contain high-quality proteins. If legislation allows the separation of the fats, proteins, and chitins, edible insects can be used in new ways in the future. On the other hand, some consumers may be more interested in authentic and traditional insect food culture than eating an unidentified insect mass made with separation technology. Insect production is also seen as strengthening the security of the food supply in the domestic market as insects could be produced locally on a small scale.

The experts considered edible insects as one of the possible ways of reducing meat production. They also thought that the features of edible insects, such as low land use requirements and a high feed-conversion efficiency, made their production more sustainable than that of other animal proteins, especially when insects are compared to livestock. Future technologies and the automation of insect production were believed likely to increase the use of insect-based food products and to decrease their price.

To better understand the effect of price and environmental considerations in the acceptance of eating insects, beef, soybean meal, and insect-based food products were compared in the survey. There were fictitious prices and carbon footprints for a beef meal, a soybean meal, and insect-based food, and the respondents had an opportunity to choose which product they would buy (Figure 3).

When comparing the price and carbon footprint of the beef meal, the soybean meal, and the insect-based food, 37% of the respondents chose the soybean meal at a price of 6 EUR kg⁻¹ and the carbon footprint of 1 kg CO₂eq. A slightly smaller share of the respondents (28%) chose the insect meal when its price was cheaper than the soybean meal (4 EUR kg⁻¹), and its carbon footprint was bigger than that of the soybean meal (4 kg CO₂eq). Twenty-four percent of the respondents chose beef when its price and carbon footprint were bigger than those of the soybean or insect food meal (8 EUR kg⁻¹ and 17 kg CO₂eq). These results show that most of the respondents give a higher consideration to the environmental impact of food than the price. This concern for the emissions generated by food production indicates that an insect-based food product could be marketed as a substitute for high-emission food products, such as beef. However, the finding can only be considered as tentative as the results may have been different if the price of beef had been lower than that of the soybean or insect-based meal, and further research is required.

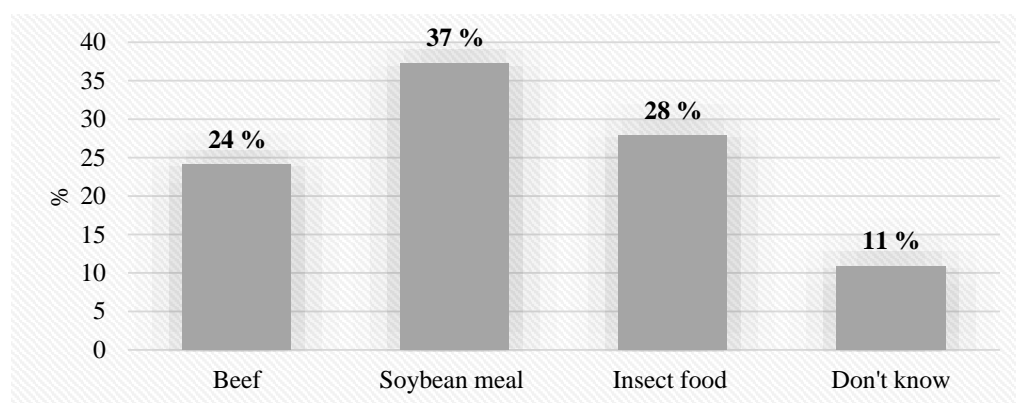


Figure 3. Effect of price and carbon footprint on consumers' purchase decisions (N = 212). The figure shows how many respondents would choose a beef meal, a soybean meal, or insect food when the purchase decision is affected by the price and carbon footprint. Fictitious prices and carbon footprints are used for the different meals. The price of the beef meal is 8 EUR kg⁻¹, the price of the soybean meal is 6 EUR kg⁻¹, and the price of the insect-based meal is 4 EUR kg⁻¹. The carbon footprint of the beef is 17 kg CO₂eq, the carbon footprint of the soybean meal is 1 kg CO₂eq, and the carbon footprint of the insect food is 4 kg CO₂eq.

3.4. Future Role of Edible Insects in Western Countries

The question of the extent to which insect eating will become a part of Western diets is an important one from the point of view of investors and other industry actors. In the expert interviews, almost all the experts agreed that insect eating will not become mainstream in Western countries in the near future. They believed, rather, that insect eating would be a niche market and that it would continue at a small level. In Finland, insect eating reached its peak a couple of years ago, but the product did not disappear completely from the market. However, regular consumption of insects failed to gain a significant foothold on the Finnish food markets. The experts agreed that increasing insect eating is not an easy task and that it will take time and a change of attitude among consumers. The experts, furthermore, considered that the way the media write about insect production will have an effect on general attitudes towards insect eating.

Based on the expert interviews, the taste and appearance of insect meals should be taken into account when considering efforts to increase insect eating. Some of the experts have personally found that beautifully displayed and served insect food increases the desire to eat insects, and some have eaten good insect food prepared by a restaurant professional, or they have prepared tasty insect food meals for others. To increase high-quality insect-based food in restaurants, restaurant kitchens need cooks who can prepare insect-based food properly. For this reason, some experts suggest that learning to prepare insect-based food should be part of restaurant industry training and education. Furthermore, the role of chain restaurants in increasing the popularity of insect eating should be considered.

In addition to their use as a foodstuff, insects can be utilized for other purposes as well, such as for animal feed and pet food. The experts almost unanimously agreed that in the future, the use of insects as animal feed should also be taken into account in the insect-industry development. Thus, insects that are suitable for human consumption, such as house crickets, mealworm larvae, and honeybee larvae, which are easy to farm, could be utilized for human consumption, and the insects that humans cannot consume for neophobic or regulation reasons, such as black soldier flies, could be used as animal feed.

Finally, although insects have not yet become a significant part of the Finnish food industry, none of the experts believes that edible insects will disappear entirely from the Finnish food-production chain. Due to the need for a change to a more sustainable food system, they agree that insect eating will bring benefits in the future. Different solutions are needed in the transition to a more sustainable food system, and insects can be one of the solutions in Finland and other Western countries. In the future, the human

consumption of insects is a convincing option, if it is truly ethical and sustainable. Moreover, insect-based products should replace other GHG emission-intensive animal proteins, and insect-based food should have notably lower environmental impacts compared to the animal protein it replaces.

3.5. Potential Pathways for Increasing the Use of Insects as Food

Based on the survey, the expert interviews, and the previous scientific literature, we created a graph of possible pathways for increasing the use of insects as food (Figure 4). In this section, the pathways are described with reference to the results of the survey and the interviews.

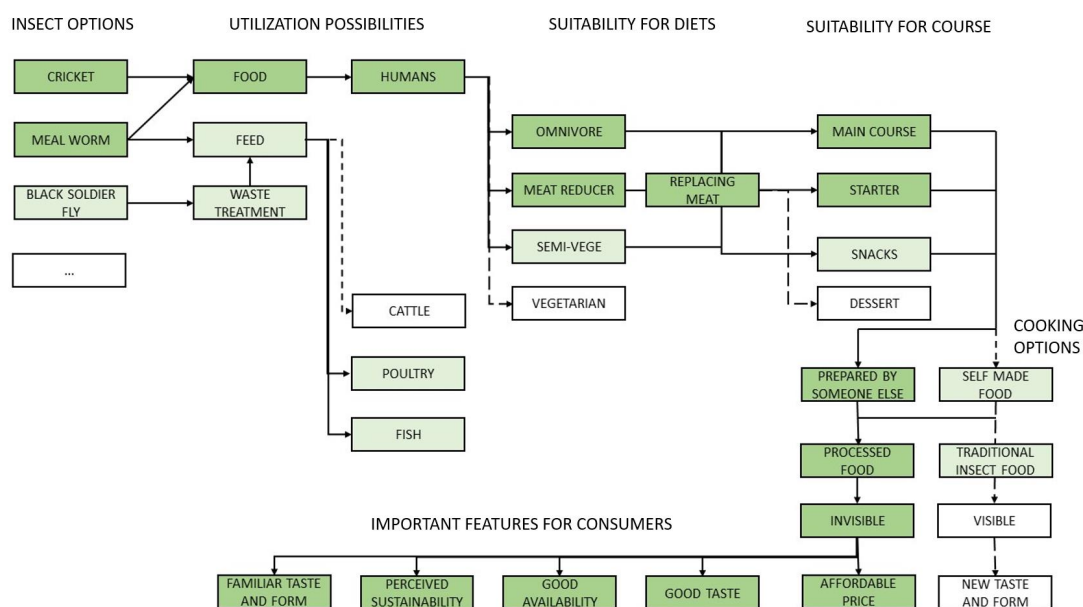


Figure 4. Potential pathways for increasing the use of insects as food, based on the consumer survey and expert interviews. Pathways with the highest potential are marked in dark green, pathways with less potential in light green, and pathways with the least potential are marked in white. Dashed lines represent possible pathways which are not recommended in this study, although they should not be ignored entirely in the future development of insect foods.

Figure 4 shows various possible pathways for increasing insect use as food. In this analysis, crickets, mealworms, and black soldier flies are considered to be potentially edible insects even though there are many more insect species which could be used as food. In addition to consumption by humans, edible insects could be utilized as animal feed such as, for example, feedstock for poultry and fish [5]. In fact, most consumers could accept insects as feed if enough information was provided on the safety aspects [54]. Black soldier flies, especially, have potential as animal feed because they can convert waste into food and generate value, thus closing nutrient loops and reducing pollution and costs [55]. Despite the potential importance of insects as animal feed, human consumption of edible insects is, however, the focus in this analysis.

Insect-based food should be recommended to people who are interested in reducing meat consumption. As most vegans and vegetarians, according to the survey results, consider insect farming unethical, they are not considered to be potential consumers of edible insects. The survey indicates that people who eat meat but have reduced, or have thought about reducing, their meat consumption are more likely to consider eating insects compared to people who do not feel the need to reduce meat consumption or do not eat meat at all. Moreover, the experts pointed out that edible insects could be a convincing alternative to meat from the sustainability perspective if they replaced food which contains high-emission animal proteins.

Based on the expert interviews, it would appear that different kinds of insect foods could be developed for different kinds of consumers, such as, for example, processed insect-based food for people who want to eat insects in an unidentifiable form and traditional and unprocessed insect food for people who want to experience new tastes. However, the results of the survey suggest that, in general, people are not very willing to eat food where the insects are visible or whole. We concluded that potential insect-based food products should be a starter or a main course and should not include insects that can be seen and identified as such. According to the survey and the interviews, insect food prepared by someone else is more acceptable to consumers. The interviewed experts suggested that the cooking and preparation of edible insects could be taught to professionals as a way to guarantee high-quality insect food.

It is important to recognize the sensory and visual characteristics of insect food because they can affect consumer acceptance and willingness to eat insects [43]. Based on the survey and the expert interviews, we concluded that the characteristics of insect food having the greatest effect on the consumer acceptance of insect use in food are familiar form, good taste and availability, perceived sustainability, and an affordable price. Consequently, the greatest attention should be paid to these characteristics if insect use is to be maintained and increased.

The respondents to the survey considered taste to be the most important factor, and the experts also underlined the importance of this aspect. Therefore, insect-based food should be tasty enough to promote increased use. The perceived sustainability of edible insects and the fact that insect-based food has a lower environmental impact compared to conventional meat affected consumers positively. For instance, the environmental perspective was one of the most important factors influencing the survey respondents' willingness to eat insect-based foods. In the survey, an affordable price had a significant effect on consumers' willingness to buy insects. In addition, the experts felt that a current problem in the Finnish insect market is that there is a lack of affordable and tasty insect-based food in everyday use that could replace conventional meat consumption. Thus, both price and availability should be considered in the future. In this case, availability means the variety of insect-based food products and the number of products available in grocery stores.

4. Discussion

The aim of this study was to assess how the consumption of edible insects could be increased in Western countries and what pathways would be the most promising. To put it briefly, the food system needs a sustainable system change, and edible insects can be a small part of it. The experts interviewed in this study believe that insect farming will remain a part of the food-production chain, but there will not be a move to large-scale production. Stull and Patz [16] point out that even though insects are a potentially novel form of animal protein with fewer environmental impacts, they are not the solution to the current global food crisis. Furthermore, they say it would be shortsighted to optimize all insect production systems to be similar to current, intensive livestock production because such an approach could be environmentally and ethically problematic. Sogari et al. [56] mention that it is difficult to say whether entomophagy will become the "food of the future" because it will depend on consumer behavior and acceptance, market availability, food product choice, culinary trends, marketing strategies, and education. The experts in this study see similar factors affecting insect eating in Finland.

Based on our findings, to obtain edible insects as an acceptable food for consumers, insect-based food products should be less emission-intensive than other, conventional animal proteins and should thus replace meat-based products. Generally, edible insects are considered to be a sustainable animal protein replacement for meat [8,57], and thereby, the environmental impacts of edible insects should be underlined when attempting to increase the consumption of insect-based food. According to Guiné et al. [58], the level of knowledge on the sustainability of edible insects is good in a traditionally non-insect-eating country, and those sustainability aspects may motivate people to consume insects. As the

perceived sustainability of edible insects is a very important factor in consumer preferences, GHG emissions from insect production should be further studied so that edible insects can be reliably marketed as a climate-friendly food option.

Even though experts and some earlier studies [17,59] have declared that entirely new insect meals should be developed, our survey and earlier studies [23,40] find that familiarity is an important factor affecting the popularity of insect eating. Insects in an invisible form inside processed food have been recommended as a way to introduce edible insects to a larger audience in European countries [31,40]. Consumers' low food neophobia [19,20] and earlier experience of insect eating [26] positively affect the interest in consuming insects. Hartmann and Siegrist [34] found that even a single positive experience with a processed insect food product can increase the willingness to eat unprocessed edible insects, i.e., insects that are recognizable as such. Therefore, a strategy to increase insect eating in Finland or in other Western countries could start with processed insect-based food and later continue to unprocessed foods. The experts interviewed in this study mentioned that to enable an increase in the production of processed insect food and a decrease in the price of insect-based food, insect food production should become more automated. According to Cortes Ortiz et al. [60], 80% mechanization in the production process could allow volumes of edible insects high enough to ensure costs per kilo sufficiently low enough to be competitive with other, conventional animal-based proteins. However, De Marchi et al. [61] and Jeong and Park [62] have found risks related to insect allergens when insects are used as food and more research will be required to ensure the safety of insect eating.

In this study, we also analyzed who would be the most likely consumers of edible insects. The present findings seem to be consistent with other studies, which have identified the potential consumers of insect foods as being people who are concerned about the environmental impact of their diet or have a flexitarian or semi-vegetarian diet [20,25,29]. The effect of diet choices on insect eating may depend on vegetarians' and omnivores' different attitudes towards meat consumption. Omnivores have positive attitudes towards meat, associating it with good taste, luxury, and social status, whereas vegetarians link meat with cruelty, the killing of animals, and poor health [63]. These associations may be valid with insect eating too.

In addition to diet and the perceived sustainability, the consumers' socio-demographic characteristics need to be considered when assessing people's willingness to eat insects. The results of our survey show that gender, age, earlier experience of insect eating, and the level of food neophobia have an effect on consumers' attitudes towards edible insects. Based on the results of this survey and other studies, a higher share of men than women are interested in eating insects [20,23,36,41]. Some studies have not found a correlation between age and educational level as regards the acceptance of eating insects [33,41]; our results, however, and the studies of Tan et al. [64] and Verbeke [20], have noted that young people are more curious about adopting insects into their diet. In our survey, we obtained more answers from females than males, and this may have an impact on the results when considering the total amount of answers for each question.

When it comes to the development of insect consumption in Finland, previously published studies on Finnish consumer acceptance of insect eating should be compared to the current study. Even though insect selling has been allowed in Finland for a few years and public discussion about the consumption of edible insects has increased [65], the production and marketing of insect-based food products has not increased; rather, it has diminished [51,65]. In 2017, 70% of Finnish consumers were interested in eating insects [66], whereas the current figure is 56%. However, the knowledge of entomophagy may have increased as over 80% of the respondents to the current survey knew what insect eating was. Yet, the willingness to eat insects has not increased, even though it is often held that improved knowledge would increase the desire to eat insects [23,67].

This study focused on analyzing the potential pathways for increasing the consumption of edible insects. The theory, practices, and results of the study are mainly similar to those of other studies conducted in Europe; thus, the findings of this study can be consid-

ered to be broadly applicable to other European countries where the sale of edible insects as food is allowed. The methodological approach of this study was that of mixed-method research, and two methods were used in the same study because the required results would not have been obtained with each method alone. The consumer survey provided information on what the current consumer acceptance of insect eating in Finland is and how it has been developed in recent years, and expert interviews provided data on the possible future consumption of edible insects in Finland. The results of the study can be utilized in the development of future insect-based food products. For example, insect farmers should consider the consumer expectations and requirements for edible insects. This study may provide clarifications on which aspects should be the focus of the development of insect-based food. Moreover, the study strengthens the results of earlier studies about the consumer acceptance of insect eating.

The study does, however, come with some limitations. The study does not represent the whole demographic situation in Finland as the respondents to the survey were self-selected, and the consumer survey was conducted online, which excludes people who do not use the internet regularly or do not have access to the internet. The age of the respondents was mainly between 25–49, and most of the respondents were highly educated. In the future, a broader consumer survey could be conducted so that the results reflect the views of the Finnish population as a whole. Alternatively, a smaller and more accurate sampling of the population could be carried out to gain detailed information for specific groups. For example, the experiences of eating insects could be researched among people who have eaten insects more than once. In addition, the design of the study could also be improved further. A larger number of experts could have been interviewed to give a broader picture of the possible future of entomophagy. The current study has only examined potential solutions for increasing insect use in the food sector from the consumer perspective. The study is thus limited by the lack of consideration of legislative and technological pathways for increasing edible insect consumption. However, the study provides an insight into how the consumer acceptance of entomophagy has developed in Finland in recent years and how to take into consideration consumer preferences when developing future insect foods.

5. Conclusions

This research extends our knowledge of the state of insect eating in Finland and how it could be developed in the future. Currently, interest in insect eating has not increased in the past few years even though it has become legal to use insects as food. The study draws attention to the pathways that could increase the consumption of edible insects. The present study confirms previous findings and contributes additional evidence that suggests that the initial steps should be towards the development of insect-based products for people whose diet is flexitarian and towards the production of processed food where the insects are in a familiar and unidentifiable form.

When considering the issue of acceptability directly, it was found that insect-based food is more acceptable when it is prepared by someone else, in a restaurant kitchen for example, and when the food replaces a high-emission, intensively farmed animal protein. In addition to these two characteristics, good taste, familiar form, affordable price, the perceived sustainability of the insect food, and good availability in grocery stores are important factors for consumers. Our findings conclude that to meet the aim of increasing the consumption in Finland and other Western countries, insect-based food products should be developed and produced bearing in mind these considerations. However, other ways of convincing people to consume insect-based food should not be overlooked, such as developing unprocessed insect food or creating new types of food.

Further research, however, needs to be conducted to establish the extent of the effect of the price and the perceived environmental impact on consumer purchasing decisions when comparing the actual prices and the carbon footprints of different food products. If the perceived environmental impact of edible insects is affecting consumer preferences,

GHG emissions from insect production should be further studied so that edible insects can be reliably marketed as a sustainable food option. In addition, the consumer acceptance of the use of insects as animal feed should be investigated as the use of edible insects in animal feed is considered a potential way to increase the use of insects in the future.

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Appendix A. Questions from the Survey Used to Gather the Data for This Paper

Gender.

- ☐ Male
- ☐ Female
- ☐ Other
- ☐ I do not want to say

Date of birth

For example, 1980

Education

- ☐ No basic education
- ☐ Primary school
- ☐ Secondary school
- ☐ Bachelor of science
- ☐ Master of science
- ☐ Licentiate or doctoral degree
- ☐ None of these

Diet

- ☐ Omnivore
- ☐ Vegetarian
- ☐ Semi-vegetarian
- ☐ Vegan
- ☐ Something else, what? _____

If you answered that you are a vegetarian, a semi-vegetarian, or a vegan, do insects fit into your diet from an ethical point of view?

- ☐ Yes
- ☐ No
- ☐ I do not know

Are you familiar with insect eating?

- ☐ I have not heard of insect eating before
- ☐ I have heard that insects are eaten somewhere in the world
- ☐ I have heard that insects are eaten in some restaurants

- ☐ I have heard of eating insects, but I do not exactly know what it is
☐ Yes, I have heard of eating insects, and I know what it is
☐ Something else _____

Have you eaten insect food?

- ☐ I have never tasted insect food
☐ I have tasted insect food once
☐ I have eaten insects multiple times
☐ I eat insect food occasionally
☐ I eat insect food regularly

How do you feel about new foods?

I often taste new dishes and test different products	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
If offered to me, I will be happy to taste new dishes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I eat almost anything	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I am very selective about what foods I eat	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
If I do not know what the food contains, I will not eat it	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I do not like tasting new foods	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Have you considered reducing meat intake? In this case, meat eating does not include insect eating.

- ☐ I have not thought about reducing meat consumption
☐ I have thought about reducing meat consumption, but I am not going to reduce it
☐ I have thought about reducing meat consumption, and I am going to reduce it
☐ I have reduced meat consumption
☐ I do not eat meat
☐ Something else _____

What kind of thoughts does insect eating evoke in you?

	Strongly Disagree	Partly Disagree	Neither Agree Nor Disagree	Partly Agree	Strongly Agree
The idea of insect eating disgusts me	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I do not want to use insects in my diet	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
My attitude towards insect eating is positive	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Insect eating does not evoke thoughts in me	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

What factors would increase your willingness to eat insects? Put the options in order of priority from 1–9 so that 1. is the most important influencing factor and 9. is the least influencing factor.

- Taste
 Environmental reasons
 Affordable price
 Diet diversification
 Domestic production
 Good availability in stores
 Ethical reasons
 Novelty
 Other people's recommendations
 1. _____
 2. _____
 3. _____
 4. _____
 5. _____
 6. _____
 7. _____
 8. _____
 9. _____

Choose options which suit you the best.

"I could eat food with insects . . . "

- ☐ which looks like familiar food
☐ which tastes like familiar food
☐ where the insects do not have a taste
☐ where the insects are invisible
☐ where the insects are ground
☐ where the insects are chopped
☐ where the insects are whole
☐ if someone else has prepared the food
☐ if I have made the food
☐ which looks like new food
☐ which tastes like new food
☐ where the insects are visible
☐ I could not eat any food with insects

I could eat insects in the following foods:

	Strongly Disagree	Partly Disagree	Neither Agree Nor Disagree	Partly Agree	Strongly Agree
Starter	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Main course	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dessert	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Snack	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bar snack	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
As a substitute for meat	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Soup	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Pizza	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Salad	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fine dining	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Processed food	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
As a substitute for plant-based food	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Hypothetically, there is an insect food product on the market that could be used as a source of protein in the same way as minced meat or soy, and the nutritional values would be almost the same for everyone. Which product would you choose if the price per kilo of the products were the following?

Beef: 8 EUR/kg and 17 kg CO₂eq.

Insect-based food product: 4 EUR/kg and 4 kg CO₂eq.

Soybean meal: 6 EUR/kg and 1 kg CO₂eq.

- ☐ Beef
- ☐ Soybean meal
- ☐ Insect-based food product
- ☐ I do not know

Open question

Why do you eat insect-based food, or could you think of eating insect-based food?

Appendix B. Questions of Interviews

Background and earlier experience

- Who are you?
- Could you tell me in your own words if you have had any experiences of insect eating and what kind of experiences you have had?
- Have you eaten insect food?
 - What kind of insect food do you prefer?

General views on insect eating

- What do you think is the general view of insect eating? Why?
- Do you think insect eating is a marginal phenomenon or perhaps part of a bigger change in food and eating habits?
- Has insect eating decreased in Finland or is its popularity still rising?
- What kind of consumers are typical consumers of insect food?
- Do you think insect eating is ethical? / Do you see ethical problems in insect eating?

Challenges and possibilities of insect eating

- What kind of obstacles or challenges do you think insect eating has?
 - How could these challenges be solved?
- What opportunities do you think insect eating has?
 - How could these opportunities be promoted?

The role of insect eating in the future

- What factors do you think would influence the mainstreaming of insect eating?
- In what ways could the use of insects as food be increased in Finland?
- Is there an insect species or dish that could interest consumers?
- What role will insect eating play in the West in the future?

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