Acceptability of insect ingredients by innovative student chefs: An exploratory study

Abstract

Background: In Western societies, the acceptability of entomophagy is low despite the sustainable and nutritional benefits of insects. It is recognized that insect meals incorporated in into familiar foods increases willingness to eat insects. Chefs can offer positive culinary insect-based experiences to their customers which can then contribute to increasing the acceptability of entomophagy by consumers. However, little is known about chefs' perceptions of the use of insect-based ingredients.

Objective: The aim of this study was to explore the reasons why innovative student chefs are willing (or not) to incorporate mealworms meals into their dishes.

Methodology: Semi-structured interviews were conducted with 7 innovative student chefs at the *Institut de tourisme et d'hôtellerie du Québec* (ITHQ). Thematic analysis based on *a priori* Rogers' Diffusion of Innovation Theory was conducted using transcript verbatim.

Results: Most participants had a past consumption experience with entomophagy and all of them had a positive attitude toward this practice. The main perceived disadvantages of mealworm meal was the texture (granular and uneven), the odor as well as the low acceptability by consumers. Despite that, student chefs were generally willing to use insect-based ingredients, but they thought that transparency and more opportunities for consumers to try good insect-based dishes are keys to enhancing the acceptability of insect consumption.

Conclusion: Understanding perceptions of innovative chefs about the use of insect-based ingredients can help to promote their use in gastronomy and ultimately improve their acceptability by consumers.

239 words

Keywords

Entomophagy, Edible insect meal, Qualitative study, Diffusion of Innovation Theory

Introduction/background

Entomophagy is an ancestral practice traditionally adopted by more than 2 millions people around the world (Van Huis et al., 2013). Interest in entomophagy is growing, especially in western cultures due to its many sustainable and nutritional benefits (Van Huis et al., 2013). Lower production of greenhouse gas and ammonia, a better feed conversion efficiency and lower land and water requirements are the main environmental benefits of insect production compared to livestock (Oonincx et al., 2010; Oonincx and De Boer, 2012; Van Huis et al., 2013). The nutritional properties of edible insects, particularly their richness in protein (Rumpold and Schlüter, 2013), make them an alternative source of protein in order to solve the global food crisis due mainly to the increasing world population (Van Huis et al., 2013).

Despite the advantages of entomophagy, Canada, along with other western societies, has a low consumer acceptability and negative attitude towards this practice (Baker et al., 2018; Barton et al., 2020). Current studies focused on consumer acceptability of edible insects have been mostly conducted in Europe (Halloran and Flore, 2018; Lombardi et al., 2019; Schösler et al., 2012; Sogari et al., 2018, 2019b; Van Thielen et al., 2019; Verbeke, 2015) with only few conducted in North America (Ardoin and Prinyawiwatkul, 2020; Baker et al., 2018; Barton et al., 2020; Farina, 2017; Hénault-Ethier et al., 2020). This was also noted by Sogari et al. (2019a). The Ardoin & Prinyawiwatkul (2020) study conducted in the USA has shown that 72.5% of the participants were willing to consume at least one product containing insects. Another study conducted in Quebec (Canada) have shown that 67% of the participants had tried entomophagy (Hénault-Ethier et al., 2020).

The main reasons for rejecting edible insects are fear and neophobia (Hartmann et al., 2015; Verbeke, 2015). Insects are considered to be a dirty, primitive food and their sensory properties are generally negatively anticipated (Caparros Megido et al., 2016; Tan et al., 2015; Verbeke, 2015). Some studies have shown that educating consumers about the benefits of edible insects can increase the acceptability of entomophagy (Lombardi et al., 2019; Verbeke, 2015). In other studies, it has been shown that sustainable and nutritional information did not affect the willingness to eat insects (Myers and Pettigrew, 2018; Tan

et al., 2016). Several studies have shown that the initial step to reduce neophobia is to integrate them into familiar dishes, using insect meals instead of whole insects, which seems to increase consumer willingness to eat insect-based food (Barton et al., 2020; Caparros Megido et al., 2014; Hartmann et al., 2015; Schösler et al., 2012; Tan et al., 2015). Also, the method of preparation greatly influences consumers' expectations of unfamiliar foods such as insects (Caparros Megido et al., 2014; Hartmann et al., 2015; Tan et al., 2015). Consequently, consumers are more likely to try entomophagy in restaurants where it can be explained how the insects were prepared and how to eat them (Balzan et al., 2016). In that context, their experience is likely to be more positive and it also helps to reduce neophobia towards edible insects (Barton et al., 2020). However, little is known about the perceptions of insect ingredients by the chefs who prepared the dishes, since most studies have focused on consumer perceptions. To our knowledge, only a few studies have explored chefs' perceptions, such as the Halloran & Flore (2018) study conducted at the Basque Culinary Centre (Spain), where the researchers investigated the opinions and perceptions of student chefs on the use of edible insects in the restaurant industry. Other study exploring chefs' perceptions were not about insect consumption (del Castillo et al., 2014). Sogari et al. (2017) conducted a qualitative study with culinary gastronomy students in Italy regarding to their expectations of entomophagy.

Numerous studies on edible insect acceptability are quantitative, as they were conducted using only questionnaires (Ardoin and Prinyawiwatkul, 2020; Hamerman, 2016; Hénault-Ethier et al., 2020; Hwang and Choe, 2020; Sogari et al., 2019b; Van Thielen et al., 2019), whereas very few have used qualitative methods such as focus groups (Barton et al., 2020; Tan et al., 2015). This was also highlighted by Sogari et al. (2019a). The aim of qualitative methods is to better understand social phenomena in a particular context with limited scientific evidence, which differs from quantitative methods that rely on the data collected to validate (or not) a research hypothesis based on vast previous literature (Creswell, 1998) and generalizes the results over a large population.

Objective

The objective of this study is to explore the reasons why some innovative student chefs are willing (or not) to incorporate mealworm meals as a new ingredient into their dishes. The long-term aim of this study is to better understand the factors enhancing the acceptability of this new, and uncommon in Western society, insect-based ingredient by chefs, in order to increase its use in the restaurant industry and ultimately contribute to its acceptability by consumers.

Methodology

Insect ingredient

A commercial mealworm (*Tenebrio molitor*) meal was purchased from Entomo Farms (Norwood, Ontario, Canada). To ensure food safety, the mealworm meal was treated with high hydrostatic pressures (600 MPa, 3 min) to reduce the microbial load and stored at 4°C. A microbiological count of mesophilic bacteria and some pathogens was performed by an external firm to verify safety and the respect of the norms (Couture et al., 2019) (see appendix S1). An image of the insect ingredient is shown in the appendix (S2).

Study design and data collection

Data were collected in 40-minute semi-structured interviews conducted in November and December 2019 at the *Institut de tourisme et d'hôtellerie du Québec* (ITHQ). All interviews were audio-recorded to be transcribed. All interviews were led by a moderator (ADP) using a semi-structured interview guide that had been pilot-tested with three participants prior to the study. The pilot-interview data were not included in the results of the present study. The semi-structured interview guide was developed by the research coordinator (MT), according to the principles of Patton (2002) and based on the Diffusion of Innovation Theory (Rogers, 2003) as well as intuitive criteria based on the research team's previous experience (e.g., spontaneous creative ideas). The interview included 12 sections: A- Past experience of consumption and cooking, B-Opinion, C-Emotions and memories, D-Needs, E-Innovations, F- Chefs, G-Values, H-Tasting, I-Advantages and disadvantages, J-Complexity, K-Observability and L-Creative idea (see Table 1). In section G, the participants were invited to taste and describe a sample of mealworm meal. The sample was presented in a small transparent plastic container with the same amount for each

participant (10 g) and briefly described in the same way by the moderator (ADP). Thereafter, the participants had to orally describe their perceptions (appearance, smell, texture, flavor) and their spontaneous creative ideas. After the interview, participants completed a socio-demographic questionnaire.

Sampling and recruitment of participants

The participants were recruited at the ITHQ in Montréal (Québec, Canada) from the Advanced Culinary Arts program or in the last session of Cuisine and Gastronomy, because these students are considered to be innovative student chefs. Their culinary training allows them, among other things, to apply rigorously and disciplinedly culinary techniques, to recognize the qualities required in the choice of raw materials and their proper use in culinary applications. Also, culinary creativity is encouraged and expected of these students, especially for those in Advanced Culinary Arts program. A convenient sample of participants composed of men and women (aged over 18) was recruited using an email invitation sent to an ITHQ mailing list as well as classroom information/promotion sessions (VP), in order to present the study (nature and objectives) and the criteria for participation. The participants were informed that the tasting session of the insect meal was optional. Participants who expressed interest in participating were contacted by phone to verify their eligibility (inclusion criteria were to be enrolled in the selected programs at the ITHQ, have no allergies or dietary restrictions and be over 18 years old). Individuals with any food allergies or dietary restrictions were excluded from the study. Once included, a number was assigned to each participant to ensure their anonymity. The consent form (in French) was sent to the participant by email at the same time as their interview appointment confirmation. Immediately before the interviews, all participants signed a consent form (approved by *Université Laval* research ethics committee # 2017-232/21-10-2019 and by the HEC research ethics committee # 2020-3787). Participants did not receive any financial compensation.

Data analysis

After each interview, a summary note was written by the moderator (ADP) according to the Huberman & Miles (1991) principles. All audio tapes of the interviews were transcribed

(SLB) according to the method described by Bazeley (2007). All transcripts were verified and corrected by the moderator (ADP) to confirm language accuracy and ensure data quality. The verbatim transcripts were coded line by line, (ADP, SLB) assisted by Nvivo11 software (QRS International Pty. LTD, Doncaster, Victoria, Australia), in their original language (French). The first three interviews were double coded with an inter-coder agreement greater than 92%; the last ones (n=4) were single coded. The coders met after the coding of each interview to ensure a mutual understanding of the nodes, and if necessary, to refine their definition. A copy of the original recording and summary notes was available during the analysis for traceability or confirmation (Patton, 2002). The initial codebook was built by the researcher team (ADP, MT) based on the interview guide (deductive coding), which was based on Rogers' Diffusion of Innovation Theory (Rogers, 2003). During the analysis, the new ideas were coded inductively by creating new nodes and sub-nodes. Similar responses (textual units) were grouped in the same category or sub-category, according to the thematic analysis method (Fereday and Muir-Cochrane, 2006). The textual unit was defined as any mention of one participant during the interview. Data saturation was not reached after 7 interviews, but the number of new ideas (new nodes) greatly decreased, passing from 52 to 2 from the first to the last interview coded. After data coding, the results were discussed by the research team and a final verification was done in all nodes (ADP).

Data presentation

The main beliefs categories are presented in the Results section along with the underlying sub-categories cited by at least half of the participants. The order in which the main beliefs categories are presented follows the interview guide (Table 1). However, because human experience is a whole and complex phenomenon, inter-related ideas have been regrouped with the main belief categories. The sub-categories were described according to salience beliefs. To illustrate the credibility and trustworthiness of this study, a few examples of translated quotes are provided and revealed the nuances of the participants' perspectives. Additional tables with examples of translated quotes for each sub-category are available in the appendix (S3-16).

Results and discussion

1. Characteristics of participants and their experience with edible insects

Table 2 shows the characteristics of the participants. A total of seven participants completed the interviews, with six of them being men. The population studied had a predominance of males with 36 men out of a total of 56 students attending the two programs selected. The effect of gender on the acceptability of entomophagy is diverse in the literature. Several studies have shown that men are more willing to eat insects than women (Ardoin and Prinyawiwatkul, 2020; Caparros Megido et al., 2016; Hartmann et al., 2015; Menozzi et al., 2017; Piha et al., 2018; Schösler et al., 2012; Sogari et al., 2017, 2019b; Van Thielen et al., 2019; Verbeke, 2015). Some recent studies have even demonstrated that gender did not affect the acceptability of entomophagy (Barton et al., 2020; Lombardi et al., 2019). As an example, studies (Lammers et al., 2019; Orsi et al., 2019) have shown that gender has an influence only on the willingness to eat whole edible insects whole there was no difference caused by the gender on the willingness to consume food product with processed (invisible) insects. The effect of age is also mixed in the literature. The average age of participants was 22.6 $\pm$3.3 years. Some authors have shown that the acceptability of entomophagy is higher for young adults compared to older consumers (Sogari et al., 2019b; Van Thielen et al., 2019; Verbeke, 2015) while other studies demonstrated that ages did not influence the willingness to eat insects (Caparros Megido et al., 2014; Hartmann et al., 2015). However, it is difficult to compare the effect of age in different studies because the age ranges used are different (Pliner et al., 2006). The participants were of different origins from Africa (2), Europe (1) and Canada (4). The origin of the participants is a factor influencing the acceptability of entomophagy (Hartmann and Siegrist, 2017; Sogari et al., 2019b) as the culture determines which foods are acceptable or not (Martins and Pliner, 2005; Tan et al., 2015).

General past experiences of consumption of edible insects

All themes relating to the use of insect meals by innovative chefs identified by the seven interview participants are summarized in Table 3 according to the Diffusion of Innovation Theory (Rogers, 2003) and intuitive criteria. For the first question, almost all participants (6) had an experience with insect consumption in the past. This is most probably caused by

217 the more adventurous and curious nature of the participants of the study as well as their
218 culinary training as a result that they were more familiar and interested to trying new
219 ingredients and have a lower degree of food neophobia than general consumers. Several
220 studies demonstrated that having a past experience with entomophagy tends to present a
221 more positive attitude towards insect consumption due to increased familiarity and
222 willingness to repeat it (Barton et al., 2020; Caparros Megido et al., 2016; Hartmann et al.,
223 2015; Osimani et al., 2018; Piha et al., 2018; Sogari et al., 2018, 2019b; Tan et al., 2015;
224 Verbeke, 2015). Although a consumption experience increases the familiarity, the quality
225 of that experience is essential, as the positive effect of increased familiarity can be
226 counterbalanced by a negative consumption experience causing, for example, disgust (La
227 Barbera et al., 2018). Moreover, having a past experience with entomophagy helps to
228 reduce neophobia (Sogari et al., 2019b). Among the participants who had experience with
229 entomophagy (n=6), for most (5) of them, consumption was done with their friends or
230 colleagues. Only one participant comes from a culture where entomophagy is a common
231 practice, and he eats various dry insects on a regular basis. The insect mostly consumed by
232 participants was crickets and most often it was whole and dry. This result is similar to those
233 obtained by Van Thielen et al. (2019) where the insects most often consumed by
234 participants were grasshoppers, mealworms and crickets. Only two participants had
235 consumed insects in the form of insect meals incorporated into a dish. A recent study
236 conducted in Kenya (Africa) showed that more than 90% of the participants had a past
237 experience of whole insect consumption, but only 5% had consumed processed insect-
238 based foods (Pambo et al., 2018). In another study conducted in Belgium, only 21.6% of
239 the participants had a past consumption experience of edible insects, i.e., 10.4% in whole
240 form, 6.6% in flour form and 4.6 % in both forms (Van Thielen et al., 2019). Among those
241 who had previously practiced entomophagy (n=6), four of them considered their
242 experience as positive. A participant said: “Positive because… I would eat more of it, I
243 would eat more today, I am curious” - 100. The other two participants who had already
244 eaten edible insects considered their experience more neutral, because they thought the
245 taste of edible insects did not add any value to a dish, as illustrated by the following excerpt:
246 “I would say neutral, because gustatively speaking, I do not see any added value. ”-106.
247 Disgust was the main reason given by the participant who had never eaten edible insects

or insect-based food in the past. Disgust is a negative emotion and generally, the main reason for refusing to eat insects (Ardoin and Prinyawiwatkul, 2020; Barton et al., 2020; Gmuer et al., 2016; Tan et al., 2015; Van Thielen et al., 2019). Disgust leads to avoidance of the food, even if it is found in undetectable quantities (Martins and Pliner, 2005).

Emotions about edible insects

The main emotions experienced by the participants when they were thinking of using insect-based ingredients in their dishes was curiosity. Several studies have also mentioned that the positive emotions experienced is generally curiosity (Pambo et al., 2018; Sogari et al., 2017; Van Thielen et al., 2019). This is caused by the fact that entomophagy is not anchored in Western consumer mores, but rather considered a unique and novel experience (Baker et al., 2018).

Memories of edible insects' uses or consumption

Most participants (n=5) do not have memories related to the uses or consumption of insect-based ingredients or whole insects. A participant said: "I did not eat insects when I was young, it does not remind me anything nostalgic, which by the way, which plays a main role in food, in gastronomy, [...] I do not think a lot of people here who have nostalgia"-100. For those who had memories (n=3), all had pleasant memories mostly related to their childhood as seen in the following excerpt: "We had fun, we were buying packets of fried crickets and [...] when we lose at a game, we ate them at the end"-106. Among these, one of the participants had rather neutral and unpleasant memories about his insect consumption, which was related to subsistence.

Past experiences of cooking with edible insects

Four of the participants had never cooked with edible insects (whole or insect meals). For two of the three participants who had already cooked with insects, this experience took place within the framework of a course at ITHQ where they had to cook an entree of their choice and incorporate cricket meal into it. They replaced a part of the flour with cricket meal, but the proportion varied between the participants (10-30%). One of these participants regularly cooked various whole dried insects such as caterpillars, crickets,

grasshoppers and termites by frying them in a pan then seasoning them with salt and pepper, later eating them like chips. The strength of their meals most frequently named was related to the nutritional value of the insects while the main limit named was related to their strong taste. However, the participants were quite satisfied with the dish that they cooked. A participant said: “It was the first time I have been using it, so it is normal that it was not a masterpiece from the beginning”-107»). The sources of inspiration, besides being a condition imposed by their teacher (n=2), was the culture. However, for those who cooked with edible insects, curiosity was the main reason for their experience. As mentioned previously, curiosity is generally the driving force behind a positive attitude towards entomophagy (Pambo et al., 2018; Sogari et al., 2017; Van Thielen et al., 2019).

Observability, i.e., sharing their insect meals with people

The normalization of entomophagy in Western societies involves seeing more food containing insects in the media (Looy et al., 2014; Shelomi, 2015). However, among the participants who cooked with insects (n=3), none of them used any social media to share a picture or video of their culinary creations. Currently, the image of entomophagy widely conveyed through television (in programs such as in “Fear Factor” or “Survivor”) portrays a negative attitude towards insects (fear and disgust) to challenge participants (Hamerman, 2016; Looy et al., 2014). There are only a few programs or reports where it is considered a normal practice, such as in one episode of *Les Chefs!*, a cooking show broadcasted in the province of Quebec, where the participants had to cook with crickets. Nevertheless, the three study participants showed their culinary creation to their friends or colleagues. Despite the importance of the media, the opinions of friends and family, as well as what they eat, has greater influence than what is seen through the media (Frattini et al., 2014; Pitt and Shockley, 2014; Sogari et al., 2017).

2. Opinions and perceptions of the use of insect-based ingredients

Opinions about insect-based ingredients

All the participants had a positive opinion regarding the use of insect-based ingredients such as insect meals, in cooking. This positive opinion is related in part to their positive

past experience of consumption (Caparros Megido et al., 2014; Hartmann et al., 2015; Hartmann and Siegrist, 2016).

Renowned chefs who use insects

The main chefs named by the participants who use insects were Alex Atala (due to a report about him) and their teachers at ITHQ. A participant said: "Alex Atala is a Brazilian chef who is inspired by the Amazon rainforest to create his dishes"-101. Only one participant saw a chef in the course of his work in a restaurant in Montreal cooking with insects as illustrated by the following excerpt: "I had a guest chef who came to our restaurant, I really do not remember his name. Then he brought some crickets, which he had dehydrated and then fried, after we ate them like chips"-103. The participants perceived the use of insect-based ingredients by chefs as highly dependent on the customer base. They considered transparency as a key factor of social acceptability of the use of insect-based ingredients by chefs, as seen in the following excerpt: "It is socially acceptable with transparency"-100. Transparency is also an important element noted in the Van Thielen et al. (2019) study, as consumers wants insect-based food to be clearly indicated on the packaging. Moreover, another argument named by participants that may support the social acceptability of entomophagy in Western societies, like Canada, is that insect consumption is a common practice in other cultures. A participant said: "There is a lot of cultures that uses it and eat-it, so ((laughs)) It should not be a problem, I do not think it is a problem for other people"-102. As previously mentioned, entomophagy is a common practice mainly in Africa, Asia and South America and it is practiced by more than 2 billion people (Van Huis et al., 2013). The majority of the participants considered it to be socially unacceptable to serve dishes with insect-based ingredients because it might be shocking for customers. Nevertheless, the participants thought that increasing the knowledge of consumers on edible insects and insect-based ingredients might change consumers' negative perceptions and eventually enhance the acceptability of entomophagy. Several studies have also suggested using education as a way to promote entomophagy (Ardoin and Prinyawiwatkul, 2020; Deroy et al., 2015; Hamerman, 2016; Hwang and Choe, 2020; Lensvelt and Steenbekkers, 2014; Lombardi et al., 2019; Piha et al., 2018; Sogari et al., 2018). However, several authors argue that informing consumers only about the environmental and nutritional benefits of

this dietary practice was insufficient to ensure repeat consumption (Berger et al., 2018; Hartmann et al., 2015; Hartmann and Siegrist, 2016; House, 2016; Tan et al., 2015). In this vein, Berger et al. (2018) showed that hedonic information campaigns were more effective than utilitarian campaigns in promoting entomophagy. Therefore, consumer education should focus more on taste of edible insects (or insect-based ingredients) thought increasing taste experiences (Hartmann et al., 2015; Hartmann and Siegrist, 2016; Piha et al., 2018).

Complexity of preparing insect-based meals

The majority (n=6) consider the use of insect-based ingredients to be moderately complex, mainly due to the lack of current knowledge. A participant said: "Moderately, I mean it is a flour like any other until, each flour has its own characteristics and each flour will have to be worked by chefs" -104. This finding is consistent with Shelomi (2015) who suggested that the use of edible insects in culinary applications by consumers is perceived as difficult due to the lack of recipes. Compared to consumers, most chefs are more familiar with this issue because they must invent new recipes as a part of their job. Thus, it is more the lack of knowledge about insect-based ingredient properties that will make their work more difficult. Nevertheless, the complexity will be alleviated as chefs increases their experience and knowledge with these ingredients, as illustrated in the following excerpt: "It is just gonna get easier and easier to use" -107.

3. Needs and values

Perceived needs of chefs and customers

For innovative student chefs like the participants, the use of insect-based ingredients would primarily meet their need to innovate (n=7). The use of insect-based ingredients would also address their environmental concerns, add interesting nutritional value to their dishes and attract new customers (n=3). These ingredients are also seen as an interesting alternative, as mentioned by a participant: "To replace flour that contains gluten"-101. For chefs in general, e.g., at a family restaurant or bistro, using insect-based ingredients is mostly seen as a cost issue (n=2). A participant said: "If a chef can make his BBQ sauce with cricket meal replacing another ingredient and at a lower cost, then he is going to do it, that is for sure" -100. To the best of our knowledge, no literature is available assessing the needs of chef that can be met by the use of insect-based ingredients or of other unusual ingredients.

The participants perceived the needs of customers as more related to the need to discover insect-based foods (n=6) and that insect-based ingredients are an alternative product with positive aspects related to both health and environmental concerns (n=3). Hwang & Choe (2020) demonstrated that consumers would consider eating insect-based food at a restaurant to try a new experience and therefore, they did not consider it to be losing money to pay extra fees to try them. However, Lombardi et al. (2019) have shown that customers would be more willing to try entomophagy if the insect-based food was cheaper than the insect-free version.

Values associated with insect-based ingredients consumption

The main values related to the use of insect-based ingredients shared by the participants are concern for the environment (n=4), transparency, curiosity and sharing their knowledge (n=3). To our knowledge, no literature is available on the values of chefs or student chefs associated with the use of food ingredients, which contribute to the originality of the present findings.

4. Innovations

Innovativeness of insects

A participant said: “I associate the word innovation with something I do not know, so it is that”-100. Insects are considered innovative in Western countries such as Canada as there are not many products on the market with insect-based ingredients. Thus, the participants perceived that there are few opportunities to taste and become familiar with them. This is reflected in the restaurant industry, as currently there are very few restaurants that offer customers the possibility to taste insect-based foods, as reflected in the following excerpt: “There are not many of them that do it” -104. Currently, few restaurants around the world offer dishes containing insects, such as in Denmark, Brazil, New Zealand, London (England), Australia, Malaysia, Japan, Mexico, Taiwan, Tokyo and Thailand (Chen et al., 1998; Farina, 2017; Halloran and Flore, 2018; Hwang and Choe, 2020; Yen et al., 2013). Although it is possible to find a restaurant serving edible insects in other countries, such as Canada, it is not mentioned in the literature. Participants reported that insects are perceived as innovative mainly by customers, but also by chefs, as seen in the following excerpt:

403 “Everyone, especially the customers”-103. Among the products our participants considered
404 less innovative than insects were algae, akras and hunting meat. The participants
405 considered these products to be less innovative than insects because customers would be
406 more open to consume them and would be less neophobic. Foods considered more
407 innovative than insects included hemp, due to its versatility in different applications, and
408 plant roots because there is a lack of knowledge about them. One participant rated
409 molecular cuisine as equally innovative as insects-based ingredients, because in his opinion,
410 there is continuously new knowledge for culinary fields.
411
412 **5. Perceptions about mealworm meal**
413 **Tastings**
414 All participants tasted the mealworm meal in the tasting session. In the study conducted by
415 Sogari et al. (2019), 94% of the participants tasted products containing processed insects
416 and 6% did not want to taste them. In describing the texture, “granular” was the word most
417 often used by participants to describe mealworm meal. Participants compared the texture
418 of mealworm meal to wheat bran, breadcrumbs, damp soil and sand. In the Sogari et
419 al.(2018) study, the cricket meal in jelly was also described to be granular. In another study,
420 “gritty” and “grainy” were words also used to describe a protein powder containing insect
421 (Barton et al., 2020). Several participants pointed out that the particles of the mealworm
422 meals were not uniform, as illustrated by the following excerpt: “There are some pieces
423 still in there, I just saw a piece of mealworm, a piece of carapace”-107. Perceiving insects
424 parts like legs or eyes contributes to disgust and fear, hence the importance of the
425 appearance of insect-based ingredients (Sogari et al., 2018; Yen, 2009). Most participants
426 (n=5) found mealworm meals to have a neutral or mild taste. However, the mealworm meal
427 reminded them mainly of mushroom or nutty aromas. The flavors of a cricket meals were
428 described as nutty, pet food or woody in the Sogari et al. (2018) study. The color of the
429 sample in this study was brownish, but it was not homogeneous because there were lighter
430 or darker particles. Again, some participants compared the color to breadcrumbs or sand.
431 The participants considered the odors related to mealworm meals to be like fungus or algae,
432 or earthy. However, for some participants, the smell was considered strong and unpleasant,

as seen in the following excerpt: “It has a smell that might cause reluctance, because it is quite strong. You smell it that it is comes from bugs”-102.

Creative ideas

Following the tasting of the mealworm meal, the participants proposed several spontaneous creative ideas to use it, such as pastries (cake, cookies, etc.), tiles, infusion, sauce and pasta. According to the Lombardi et al. (2019) study, pasta containing insects was considered more appropriate by consumers than cookies or chocolate bars. Similarly, Ardoin & Prinyawiwatkul (2020) found that the most acceptable foods for incorporating insects were protein bars, chips or snack crackers and protein shakes. This is probably because these products are already available on the American market. In general, individuals are not willing to give up the moment of pleasure they get from certain foods in order to try a new food (van Trijp and Fischer, 2010). Moreover, consumers generally consider the insect-based food to be inferior to their conventional counterpart (without insects) (Lombardi et al., 2019). For most of the creative ideas suggested, participants would replace a proportion of the flour with insect meal by testing until the desired result was achieved. The sources of inspiration are related to their culinary school program, their personal experience, their preferences and the tasting session. The majority (n=5) used at least one piece of information mentioned (i.e., low solubility, poor emulsifiers) when the mealworm meal sample was described (Section H).

6. Advantage and disadvantages of insect meals

The sensory properties of insect-based ingredients were considered both an advantage and a disadvantage. Color and better taste than expected were the main characteristics named as an advantage of insect meal, whereas the odor, coarse grind and uneven texture of the insect meal particles were the main disadvantages. The gritty and grainy texture of insect meals was also perceived negatively by the participants of others studies (Barton et al., 2020; Sogari et al., 2018). The nutty flavor of protein powders containing insect was positively perceived in the Barton et al. (2020) study while the flavor of cricket meal was negatively perceived in the Sogari et al. (2018) study. Similarly to our results, several studies have shown that the smell of insects was considered a barrier to the willingness to

eat them (Pambo et al., 2018; Sogari et al., 2018). According to Sogari et al. (2018), the perceived texture and appearance of insect-based foods were more important barriers than their taste (Sogari et al., 2018). Other benefits mentioned were related to the nutritional properties, environmental benefits, the price of the ingredient (related to the fact that only a small amount is needed) as well as its convenience (can replace other ingredients). Nutritional and environmental benefits of edible insects were also described by the participants as advantages in another studies (Barton et al., 2020; Halloran and Flore, 2018; Sogari et al., 2017). In our study, having some knowledge could be either an advantage or a disadvantage. For instance, the knowledge that entomophagy is a common practice in other cultures was considered an advantage, while the lack of knowledge about how to prepare insects, cooking techniques and flavor combinations was considered a disadvantage. A participant said: "We are almost at zero here, in the field of entomophagy in the gastronomy, in Quebec"-100. As mentioned above, several studies have shown that providing information about the positive effects of entomophagy can reduce negative attitudes towards this practice (Lombardi et al., 2019; Verbeke, 2015) whereas others studies highlighted that providing information only on sustainable and nutritional benefits may still be insufficient (Myers and Pettigrew, 2018; Tan et al., 2016). Additionally, Berger et al.(2018) demonstrated that hedonic information was more effective than a utilitarian campaign to foster entomophagy. In other studies, the lack of recipes and experience were also considered to be the major barriers for consumers willing to try edible insects at home (Balzan et al., 2016; Halloran and Flore, 2018). Similar to the findings of Halloran & Flore (2018), disgust was another major disadvantage of insects (and insect-based ingredient) identified by our participants, as illustrated by the following excerpt: "I think people see bugs as dirty"-103. As previously mentioned, disgust is a strong barrier to the acceptability of entomophagy (Ardoin and Prinyawiwatkul, 2020; Barton et al., 2020; Gmuer et al., 2016; Shelomi, 2015; Van Thielen et al., 2019). Furthermore, the social unacceptability of entomophagy was seen as a disadvantage of using insect-based ingredients in our study, as reflected in the following excerpt: "Because the people are not ready yet" -100. In Western cultures, entomophagy is considered taboo and therefore a sociocultural and psychological barrier (Hartmann et al., 2015; Tan et al., 2015). Nonetheless, the ability to achieve renown as innovative chefs through the use of insects was seen as an advantage. Finally, other

disadvantages frequently noted by participants were the inconvenience (i.e., that it is harder to decline insect meal than whole insect), its high price and low availability (perceived as difficult to obtain). The price of insect-based food was also perceived as a barrier in the Lombardi et al. (2019) study. Another study has shown that consumers would not be ready to purchase or use insect ingredients in their everyday life (Barton et al., 2020). The low availability of edible insects was also noted as a disadvantage to their use in gastronomy in the Halloran & Flore (2018) study.

Strengths and limitations

This study has strengths and limitations. This exploratory qualitative study provides a better understanding of the student chefs' perspectives on the subject, since only one study has been done (Spain) on the perception of student chefs in using edible insects in gastronomy (Halloran and Flore, 2018). The credibility and trustworthiness of this study were enhanced by using recognized and rigorous qualitative methods, such as having the same team members carry out the data collection, transcription and data analysis; building the interview guide on a theorical framework and pre-testing it before data collection; double-coding the first three interviews, assisted by an analysis software, and reaching a mutual understanding of the codes. The participants in this study were student chefs and thus, the results cannot be transferred to all innovative chefs. Moreover, only one woman participated in the study, consequently it was not possible to compare the effect of gender on participants' opinions and perspectives. Despite the pre-testing of the interview guide, some questions, such as those on needs (section D) and values (section G), were generally less understood by the participants. The tasting session conditions were not ideal, as participants' perceptions might have been influenced by drinking coffee and no glass of water was offered before the tasting sessions. The sample of insect meal was raw and was no other comparison such as cooked or with other ingredients or other insect meals was offered. The results of this study cannot be transferred to all insect ingredients because only mealworm meal was used in tasting session. However, this study provides relevant findings that are transferable to other similar populations (innovative student chefs from other culinary schools in other Western countries) in a similar context (this insect-based ingredient, with tasting session and individual interview). Moreover, the fact that the most

of the participants had a previous experience of consumption before the study may have affected their perceptions and opinions as this decreased the barriers of entomophagy (neophobia and disgust) (Barton et al., 2020; Caparros Megido et al., 2016; Hartmann et al., 2015; Osimani et al., 2018; Sogari et al., 2018, 2019b; Tan et al., 2015; Verbeke, 2015).

Conclusion

This qualitative study explores the opinions and perceptions of innovative student chefs on the use of insect-based ingredients in Quebec (Canada). In general, they have already experimented with entomophagy, and all have a positive attitude towards insect consumption (whole or insect-based ingredient). They considered the texture (granular and uneven) and odor to be the main disadvantages of using insect meals, whereas the color and a better than expected taste were positive sensory properties of insect meals. Despite their positive attitude and creative ideas for using insect meal in their dishes, they considered low social acceptability as a major barrier, which could be enhanced by transparency and more opportunities for consumers to try these ingredients. Despite the current low acceptability, the results of this study showed the culinary potential of using insect meals in Quebec's gastronomy and the willingness of chefs to explore new uses. As a next step, it could be interesting to evaluate how the student chefs introduce insect-based foods into dishes in natural settings (i.e. workshop), in order to understand the barriers and the facilitating factors when they cook their creative ideas. Other studies could also explore the impact of ingredients characteristics on chefs' proposition and customer acceptance. Future research on chef's acceptability of entomophagy should also include chefs who already use this resource in their restaurants to better understand their perceptions.

Author Contributions:

Conceptualization, A.D-P., A.D., M.T. and S.T.; Methodology, A.D-P., M.T., A.D. and S.T.; Software, A.D-P., S.L-.B; Validation, A.D-P., M.T. A.D. and S.T.; Formal Analysis, A.D-P.; Investigation, A.D-P., A.D. and S.T.; Resources, A.D-P., M.T.,V.P.; V.P; A.D. and S.T.; Data Curation, A.D-P.; Writing – Original Draft Preparation, A.D-P.; Writing – Review & Editing, A.D-P., M.T, V.P.;V.P; A.D. and S.T.; Visualization, A.D-P., A.D. and

S.T.; Supervision, A.D., S.T.; Project Administration, A.D., S.T.; Funding Acquisition, A.D and S.T.

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Tables

Table 1. Standardized semi-structured interview guide based on the Diffusion of Innovation Theory (Rogers, 2003) and intuitive criteria

	Introduction	
A	Consuming experience	Have you ever had an experience of eating insects?
	Cooking experience	Have you ever used an insect-based ingredient in your dishes?
B	Opinion	What do you think of using insect-based ingredient in the kitchen?
C	Emotions	How do you feel about using insect-based ingredients in the kitchen?
	Memories	Does the use of insect-based ingredients refer to a particular experience or memory?
D	Needs	Do the uses of insect-based ingredients in the kitchen, meet a current need among innovative chefs? General chefs? and customers?
E	Innovation	How innovative the use of insect-based ingredients in cooking is?
F	Chefs	To your knowledge, which chefs have agreed to use insect-based ingredient in the kitchen?
G	Values	To what extent does the uses of insect-based ingredient in the kitchen meet your values as an innovative cook?
H	Tasting	Can you comment all your sensory perceptions and creative idea related to the sample presented?

I	Advantages	What do you think are the benefits of using this mealworm meal in the kitchen?
	Disadvantages	What do you think are the disadvantages of using this mealworm meal in the kitchen?
J	Complexity	How complex in your opinion is using this mealworm meal in the kitchen?
K	Observability	Have other people ever had a chance to see one of your insect-based dishes?
L	Creative idea	What are the dishes you would like to cook in order to introduce this mealworm meal into your dishes?

Table 2. Socio-demographic characteristics of the participants (n=7)

		n (%)
Gender	Men	6 (86%)
	Women	1 (14%)
Age	18-25 years old	5 (71%)
	≥26 years old	2 (29%)
Origin	Africa	2 (29%)
	Canada	4 (57%)
	Europe	1 (14%)
Programs	Cuisine and Gastronomy (last session)	3 (43%)
	Advanced culinary Arts	4 (57%)
Other formation	Yes, and completed	1 (14%)
	Yes, but not completed	4 (57%)
	No	2 (29%)
Past experience of consumption	Yes	6 (86%)
	No	1 (14%)
Appreciation of past consumption experience	Positive	4 (67%)
	Negative	0
	Neutral	2 (33%)

All percentages were calculated for the total participants (n=7), except for appreciation of past consumption experience (n=6) and rounded to the nearest unit

.

Table 3. Salient beliefs categories regarding the use of insect meal by innovative student chefs, according to the Diffusion of Innovation Theory (Rogers, 2003) and intuitive criteria

Past consumption experience	**Past cooking experiences**	**Opinion**	**Emotions (Regarding to)**	**Memories**	**Perceived needs**	**Innovativeness**	**Renowned chefs**	**Values**	**Tasting session**	**Advantages/ Disadvantages**	**Complexity**	**Observabi-lity**	**Creative ideas**
Consumed	**Did not cook**	Positive	use	**No memories**	Being the first [a]	In what	Socially acceptable /unacceptable	Environmental value	Texture	Lack of knowledge[e]	Moderately	**Not observed**	Tools and techniques
Circumstances	**Had an experience**		entomophagy	**Had memories**	Attracting consumers[a]	By whom	Which ones	Transparency	Taste-flavors	Sensory properties[d,e,]	Over the time	**Observed**	Sources of inspiration
Insects consumed	Context		memories	Pleasant	Nutritional value[a]	Other innovative products (less, more or equally)	Saw him or not	Curiosity	Spontaneous creative ideas	Health benefits[d]	Very complex	By whom	Uses
Positive experience	Types of ingredients		the tasting session	Unpleasant	Environmental concerns [a]		Example of use	Sharing values	Appearance	Disgust[e]		Type of dishes	Forms
Neutral experience	Type of meals			Neutral	Education [a]			Cultural	Olfactory perception	Ecological benefits[d]		Means of dissemination	Technical information used or not
No consumed	Satisfaction				Price [a,b, c]			Concern quality	No taste	Social impact[d,e] Practical[d]/ Inconvient[e]			Other contributing elements
	Type of insects				discover[b]					Economic[d,e]			Comments
	Techniques				New option[b,c]					Visibility[d]			
	Sources of inspiration				No worries [b]					Availability[e]			
	General knowledge				Special flavors [b]								
	Reasons for this choice												

In descending order according to the frequency reported (n interviews)

[a] Belief categories that emerged only for innovative chefs

[b] Belief categories that emerged only for customers

[c] Belief categories that emerged only for general chefs

[d] Belief categories that emerged only as an advantage

[e] Belief categories that emerged only as a disadvantage

Appendix

Appendix S1. Microbiological count of mealworm meal after the high hydrostatic treatment (600 MPa, 3 min).

Microorganism's analyzed	***Count (UFC/g)***	***Norm (UFC/g)[1]***
Mesophilic aerobic bacteria	120	$< 1 \times 10^4$
Mesophilic anaerobic bacteria	15	NA
Escherichia coli	<10	$< 1 \times 10^2$
Staphylococcus aureus	<10	NA
Bacillus cereus	<25	NA
C. perfringens	<5	NA
Enterobacteriaceae	<10	NA
Listeria spp. and monocytogenes	U	U
E. coli O157:H7	U	U
Salmonella spp.	U	U

Abbreviation: U, Undetected, NA, Not applicable

[1]According to the standard for dry ready-to-eat products of the Quebev Ministry of Agriculture, Fisheries and Food (MAPAQ).

Appendix S2. Sample of mealworm meal presented to the participants.

Appendix S3: Past edible insects consumption experience: Emerging themes and sample quotes

		Definitions	Source[a]	TU	Sample quotes
Consumed		The participant has already consumed insects (including spiders)	0	0	NA
	Circumstance of consumption	The context of the participant's insect consumption, e.g. at home, with friends, etc.	6	13	The last session at the ITHQ, a friend made me eat a cricket (104)
	Forms of insects consumed	The insect eaten was in what form (whole or flour)	6	13	Dried insects (whole). (102)
	Insect consumed	Species or order of insects eaten (including scorpions and spiders) during his past consumption experience	6	13	Caterpillars, grasshoppers, crickets, termites, well there are more (101) /
	Positive experience	Insect consumption experience was perceived as positive by the participant	6	10	Positive because I would eat more, I would eat more today, I am curious. (100)
	Neutral experience	Insect consumption experience was perceived as neutral by the participant	2	2	I would say neutral, because gustatively speaking, I do not see any added value. (106)

	Negative experience	Insect consumption experience was perceived as negative by the participant	0	0	NA
Never consumed		The participant has never eaten insects (including reasons)	1	3	I did not want to at this time, I was a bit reluctant [...], yes, it was [$disgust$], I thought it was dirty, I thought it was an insect. (103)

Abbreviation: TU, Textual Unit; NA, Non-Applicable

[a]Number of interviews in which a least one meaning unit appears.

Note: The quotes were originally in French and have been translated

Appendix S4: Emotions: Emerging themes and sample quotes

	Definitions	Source[a]	TU	Sample quotes
Regarding use	The emotions felt by the participant about using (or the idea of using) an insect-based ingredient.	7	14	Curiosity. (100)
Regarding entomophagy	Emotions felt by the participant that are not directly related to their past experience of consumption or use or memories.	4	6	Insane curiosity towards insect I would not go that far, but I find it interesting. (102)
Related to memories	Emotions felt by the participants related to memories.	2	4	I thought it was wow! (101)
Linked to the tasting session	The emotions felt by the participant related to the tasting session.	1	1	Well, I am positively surprised. I did not expect that. (106)

Abbreviation: TU, Textual Unit

[a]Number of interviews in which a least one meaning unit appears.

Note: The quotes were originally in French and have been translated

Appendix S5: Memories of edible insects' use or consumption: Emerging themes and sample quotes

		Definitions	Source[a]	TU	Sample quotes
Had memories		The participant had memories related to entomophagy.	0	0	NA
	Pleasant memories	The memories were considered pleasant by the participant.	3	6	We had fun, we were buying packets of fried crickets and [...] when we lose at a game, we ate them at the end. (106)
	Unpleasant memories	The memories were considered unpleasant by the participant	1	2	I was forced one day on my life to eat them because I did not have enough money to get other types of food, other types of proteins than insects. (101)
	Neutral memories	The participant was indifferent to their memories, i.e., it is neither pleasant or unpleasant.	1	2	We used to eat insects et it all. (101)
No memories		The participant had no memories related to entomophagy.	5	5	I did not eat bugs when I was a kid. (100)

Abbreviation: TU, Textual Unit; NA, Non-Applicable

[a]Number of interviews in which a least one meaning unit appears.

Note: The quotes were originally in French and have been translated

Appendix S6: Past experience of cooking with edible insects: Emerging themes and sample quotes

		Definitions	Source[a]	TU	Sample quotes
Cooked		The participant replied that they had already cooked with insects (whole or insect meal)	0	0	NA
	Context	The context of the use of the insect-based ingredient (With whom? where?)	4	7	It was here at the ITHQ as part of a course. (100)
	Type of ingredients	The insect-based ingredient used (whole or flour)	3	9	Cricket meal. (100)
	Type of dishes	Type of dish prepared by the participant with insect-based ingredients	3	7	It was to support an appetizer (100)

Satisfaction			Satisfaction, strengths and limitations of the dish cooked by the participant	0	0	NA
	Limits		The limits of cooked dishes	0	0	NA
		Has limits	The participant considers that the prepared dish has limitations	3	6	It tasted strong. (107)
		No limit	The participant considers that there is no limit to the prepared dish	1	1	We used it like the other flours. (100)
	Key points		The strengths of the cooked dish by the participant	3	5	It has great nutritional values that can be added. (107)
	Satisfied		The participant was satisfied with the	2	4	As satisfied with cricket meal as I would have been with any other flour. (100)

		dish they cooked with insect-based ingredients.			
	Dissatisfied	The participant was not satisfied with the dish they cooked with insect-based ingredients.	1	1	I did not think it was ideal in the bread, because it gave a very strong taste. (107)
Type of insects		Insects used in their dish (including scorpions and spiders)	3	6	Crickets. (100)
Techniques		The techniques used by the participant to incorporate the insect-based ingredients into their dish.	3	5	I had taken I think a 10% of the amount of flour I had used in cricket meal. (107)
Source of inspiration		What inspired the choice of cooking	3	3	It is really the Congolese culture that I am trying to adapt a little with the techniques

		with insect-based ingredients.			and knowledge I have, which I learn at school. (101)
	General knowledge	The participant had knowledge about how to use insect-based ingredients.	3	3	I already knew how to use it. (100)
	Reason for this choice	The reasons why the participant chose to use an insect-based ingredient in their dish.	2	2	Because I had heard about it a lot and I had never seen it myself. (100)
Did not cook		The participant has never cooked with insect-based ingredients.	4	5	I have never cooked insects before. (103)

Abbreviation: TU, Textual Unit; NA, Non-Applicable

[a]Number of interviews in which a least one meaning unit appears.

Note: The quotes were originally in French and have been translated

Appendix S7: Observability: Emerging themes and sample quotes

		Definitions	Source[a]	TU	Sample quotes
Not observed		No food containing at least one insect-based ingredient prepared by the participant could be observed by others	4	6	No. (101)
Observed		A dish that containing at least one insect-based ingredient prepared by the participant was observed by others.	0	0	NA
	By whom	Who had the opportunity to observe one of the dishes with insect-based ingredients prepared by the participant.	3	4	My friends. (101)
	Type of dish containing insects	The participant's dishes with an insect-based ingredient that have been observed by others.	3	4	Appetizers. (100)
	Means of dissemination	Means used to disseminate the prepared dish, e.g., social media, in person, etc.	2	4	No photos have been published. (107)

Abbreviation: TU, Textual Unit; NA, Non-Applicable

[a]Number of interviews in which a least one meaning unit appears.

Note: The quotes were originally in French and have been translated

Appendix S8: Opinions: Emerging themes and sample quotes

	Definitions	Source[a]	TU	Sample quotes
Positive	The participant has a positive opinion about the use of insect-based ingredients in dishes.	7	13	It is a good idea, to make a change. (102)
Negative	The participant has a negative opinion about the use of insect-based ingredients in dishes.	0	0	NA
Neutral	The participant has a neutral opinion about the use of insect-based ingredients in dishes.	0	0	NA

Abbreviation: TU, Textual Unit; NA, Non-Applicable

[a]Number of interviews in which a least one meaning unit appears.

Note: The quotes were originally in French and have been translated

Appendix S9: Renowned chefs who use edible insects: Emerging themes and sample quotes

		Definitions	Source[a]	TU	Sample quotes
Perceptions		The participant's perceptions that a renowned chef uses insect-based ingredienst	0	0	NA
	Socially acceptable	The participant's reasons for finding the use of insect-based ingredients by a renowned chef to be socially acceptable.	6	8	It is socially acceptable with transparency. (100)
	Socially unacceptable	The participant's reasons for finding the use of insect-based ingredients by a renowned chef to be socially unacceptable	5	9	We have not gotten there yet with the people, the clientele in Montreal, Quebec… you might shock someone if you tell them they ate bugs. (100)
Which ones		Renowned chefs using insect-based ingredients (or whole insects) named by the participant.	5	5	Alex Atala is a Brazilian chef who takes his inspiration from the Amazonian forest to make his dishes. (101)

Saw him	The participant has seen the renowned chef cook the insect-based dish.	4	6	Reportages. (103)
Does not know any	The participant does not name any chefs.	4	4	I don't know any chef who use insects. (107)
Example of use	Examples of dishes prepared with insect-based ingredients by the renowned chef named by the participant.	2	2	Crickets that had dehydrated after that he fried them and then we ate them like chips. (103)
Did not see	The participant did not see the named chef cook the insect-based dish or cooked it according to the named chef's instruction.	1	1	We are us, the student, who cooked. (100)

Abbreviation: TU, Textual Unit; NA, Non-Applicable

[a]Number of interviews in which a least one meaning unit appears.

Note: The quotes were originally in French and have been translated

Appendix S10: Complexity of preparing insect meals: Emerging themes and sample quotes

	Definitions	Source[a]	TU	Sample quotes
Moderately complex	Why the participant finds the use of insect-based ingredients to be moderately complex.	6	13	It is medium, I mean, it is a flour like any other flour until each flour has its own characteristics, and each flour will have to be worked by a cook. (104)
Over the time	The perception of the complexity over the time of using insect-based ingredients.	6	7	It is just gonna get easier and easier to use. (107)
Very complex	Why the participant finds the use of insect-based ingredients to be very complex.	1	1	It is going to take a few tries before you get to a final result that is ready to put on the menu. (103)
Not complex	Why the participant finds the use of insect-based ingredients to be a little or not complex.	1	0	NA

Abbreviation: TU, Textual Unit; NA, Non-Applicable

[a]Number of interviews in which a least one meaning unit appears.

Note: The quotes were originally in French and have been translated

Appendix S11: Perceived needs of innovative chefs, general chefs and customers: Emerging themes and sample quotes

		Definitions	Source[a]	TU	Sample quotes
Among innovative chefs		Needs met by innovative chefs using insect-based ingredients.	0	0	NA
	Being the first	The needs met by the use of insect-based ingredient by innovative chefs in relation to being innovative, being the first to use them, etc.	7	10	They want to innovate. (100)
	Attracting customers	How the use of insect-based ingredients allows innovative chefs to attract customers.	3	5	To attract customer. (107)
	Nutrition	How the use of insect-based ingredients by innovative chefs allows them to meet their needs in relation to the nutritional quality of their dishes (e.g., offering healthy, nutritive or gluten-free dishes to customers).	3	4	To replace flour that contains gluten. (101)

	Environmental concerns	All the concerns of innovative chefs are addressed by the use of environmentally friendly ingredients.	3	3	Anything environmental. (107)
	Education	Needs met by the use of insect-based ingredients by innovative chefs such that they can educate, transmit their knowledge about insects, etc.	2	2	Educate the client. (100)
	Price	Any concerns of innovative chefs met by the use of insect-based ingredients in relation to its costs.	1	2	Everyone is concerned that the price is affordable. (107)
Among customers		Customer needs met through the use of insect-based ingredients in restaurants.	0	0	NA
	Discover	Needs of customers met by the use of insect-based ingredients in relation to trying, discovering, curiosity, etc.	6	7	To try, to get out of their comfort zone. (103)

	New option	The needs of customers met by the use of insect-based ingredients by chefs such that it is a healthy or environmentally friendly alternative.	3	3	Gluten intolerant. (101)
	No worries	No customer needs are met by the use of insect-based ingredients by chefs.	2	3	I do not think the demand is there. (104)
	Amount spent	Needs of customers met through the use of insect-based ingredients that are linked to the price.	1	2	It should not be something very expensive. (107)
	Special flavor	Needs of customers related to the special taste of insects.	1	1	That would be the taste. (102)
Among general chefs		The needs met by the use of insect-based ingredients by chefs in general (family restaurant or bistros).	0	0	NA
	Cost	Concerns of general chefs linked to the cost of insect-based ingredients.	2	3	If a chef can make his BBQ sauce with cricket meal replacing another ingredient and

				at a lower cost, then he is going to do it, that is for sure. (100)
Need an alternative	The needs of general chefs in relation to nutritional characteristics (e.g., offering healthy or nutritious dishes, gluten free products, etc.)	2	2	To replace flour that has gluten in it. (101)

Abbreviation: TU, Textual Unit; NA, Non-Applicable

[a]Number of interviews in which a least one meaning unit appears.

Note: The quotes were originally in French and have been translated

Appendix S12: Values associated with the use of insect-based ingredients: Emerging themes and sample quotes

	Definitions	Source[a]	TU	Sample quotes
Environmental value	All values named by the participant that were related to the environment (e.g., less polluting, less GHGs, it is local, etc.)	4	6	A protein source that does not destroy the environment. (100)
Transparency	The importance of transparency for the participant (e.g., important to mention to the client that the dish contains insects).	3	6	Always be transparent. (100)
Curiosity	Coherence in the use of insect-based ingredients in relation to curiosity or innovation.	3	5	Trying to move thing along. (100)
Sharing value	All the values named by the participant that were related to educating their clientele, attracting curious customers, etc.	3	5	A value of attracting a community, a clientele a little more curious, a little more willing. (100)
Cultural	Promoting their culture was important to the participant.	1	5	To promote my own culture, the Congolese culture. (101)

Concern for quality	The importance of quality for the participant (e.g., wanting to offer a quality product or a product that people will like, etc.)	1	1	I want to give a product that I know they will like. (107)

Abbreviation: TU, Textual Unit

[a]Number of interviews in which a least one meaning unit appears.

Note: The quotes were originally in French and have been translated

Appendix S13: Innovativeness of edible insects: Emerging themes and sample quotes

		Definitions	Source[a]	TU	Sample quotes
In what		In what way is the use of insect-based ingredients novel?	6	11	There are not many of them that do it (104)
By whom		Who sees the use of insect-based ingredients as innovative food ingredients.	6	11	Everybody, especially the customers. (103)
Other innovative products		Other products that the participant currently considers innovative.	0	0	NA
	Less innovative	Products that the participant considers less innovative than insects or insect-based ingredients (including the reason for their choice).	4	15	It is already accepted the fake meat, it is just normal, people see the insects et they are not ready yet. (107)
	More innovative	Products that the participant considers more innovative than insects or insect-based ingredient (including the reason for their choice).	2	8	[$Roots$] is so unknown that there would be so many unknown benefits to health and abundance. (106)

	Equally innovative	The product chosen is as innovative as the insects (at the same level).	1	2	Anything molecular. (103)

Abbreviation: TU, Textual Unit; NA, Non-Applicable

[a]Number of interviews in which a least one meaning unit appears.

Note: The quotes were originally in French and have been translated

Appendix S14: Perception of mealworm meals during the tasting session: Emerging themes and sample quotes

	Definitions	Source[a]	TU	Sample quotes
Texture	Participant's comment regarding the texture of the mealworm meal sample presented.	7	20	The texture is nice, grainy a little, but soft, and still airy. (100)
Taste-Flavor	Participant's comment regarding the taste (or flavor) of the mealworm meal sample presented.	7	19	It tastes nut like walnut. (101)
Spontaneous creative ideas	Participant's creative ideas following the tasting session of the mealworm meal sample.	7	15	I would try to work with that in baking such as pasta or for cakes or cookies. (102)
Appearance	Participant's comment regarding the appearance (visual perceptions) of the mealworm meal sample presented.	7	14	I would say brownish, but it is not homogeneous, there are darker and lighter parts. (106)
Olfactory perceptions	The participant's olfactory perceptions (smell) of the mealworm meal sample presented.	7	12	Mushroom smell. (100)

No taste	The participant does not perceive any taste (or flavor) of the mealworm meal sample presented.	1	7	It does not really have any flavor. (102)

Abbreviation: TU, Textual Unit

[a]Number of interviews in which a least one meaning unit appears.

Note: The quotes were originally in French and have been translated

Appendix S15: Creative ideas for the use of mealworm meal: Emerging themes and sample quotes

		Definitions	Source[a]	TU	Sample quotes
Tools and techniques		The tools and techniques that the participant would use to incorporate mealworm meal into their dish.	7	29	Roast it a little. (106)
Source of inspiration		How did the idea for the dish come to them?	7	14	This session we are doing a lot of Viennese. (103)
Uses		The dish the participant plans to do.	7	14	Bakery, for sure. (104)
Forms		The form (insect meal or whole insect) the participant plans to use in the dish.	6	12	Flour, even finer, more grounded than this. (102)
Information		If the participant has used (or not) the technical information mentioned (the solubility, emulsifying properties, water and oil binding capacity as well as the sensory perceptions of the participants) during the interview.	0	0	NA
	Used the information	The participant used the technical information mentioned during the interview.	5	7	Since you said doing an emulsion it would work less. (100)

	Not used the information	The participant did not use the technical information mentioned during the interview.	4	7	I did not take that into consideration. (101)
Other contributing elements		All other elements that contributed to the participant's creative process (e.g., previous experience).	4	7	When I taste dit earlier. (103) /
Comments		Any comments that the participant wants to share with the research team regarding to the use of insect-based ingredients.	2	2	I think it can be a nice alternative, a nice door to open minds. (104)

Abbreviation: TU, Textual Unit; NA, Non-Applicable

[a]Number of interviews in which a least one meaning unit appears.

Note: The quotes were originally in French and have been translated

Appendix S16: Advantages and disadvantages of insect meals: Emerging themes and sample quotes

		Definitions	Source[a]	TU	Samples quotes
Advantages		Advantages of the use of insect-based ingredients.	0	0	NA
	Positive sensory properties	Benefits related to the positive sensory properties of insect-based ingredients.	7	33	The taste is interesting, super interesting, it is much more interesting than a basic flour, a whole wheat flour, I find it more interesting anyway, the color is also no bad at all. (106)
	Health benefits	Benefits related to nutritional properties or an alternative ingredient to foods at high risk of allergy or intolerance.	7	26	There is a lot of proteins in insects. (101)
	Ecological benefits	Benefits related to the environment (e.g., less GHGs, less water and land, local, better for the environment, etc.)	7	18	It is going to cost less in resources and it is going to cost less to raise a cricket than a beef or whatever a field of wheat. (104)
	Practicality	Advantages related to the convenience or versatility	7	15	It can replace a lot of things. (102)

	of insect-based ingredients.			
Economic benefits	Benefits related to the price of insect-based ingredients.	6	10	I guess the price must also be interesting because you do not need to put a big quantity of it to get a strong taste and that has interesting values.(107)/
Related to knowledge	Advantages related to the knowledge of insect-based ingredients.	6	8	I come from a country where they eat a lot of insect species, so that is ((laughs)) something I am still familiar with. (101)
Social benefits	Advantages related to others possibly perceiving it as more courageous, it attracts customers, it is new, etc.	3	7	It is so easy to be the first, just because nobody's done it yet. (100)
Visibility	Advantages related to being are less visible.	2	3	I think that if they already see the finish product, they will not be reluctant to say no, I am not touching that, it is disgusting. (101)
Availability	Advantages related to the availability of insect-based ingredients from suppliers.	1	1	You can even find them here in ethnic and exotic shops. (101)

Disadvantages		Disadvantages of the use of insect-based ingredients.	0	0	NA
	Lack of knowledge	Disadvantages related to the lack of knowledge of people, customers, chefs about insect-based ingredients.	7	60	We are almost at zero here, it is in terms of insects in gastronomy, in Quebec. (100)
	Negative sensory properties	Disadvantages related to negative sensory properties of insect-based ingredients.	7	32	There's some pieces still there, I just saw a piece of mealworm, a piece of shell. (107)
	Disgust	Disadvantages linked to disgust (or neophobia) of insect-based ingredients.	7	24	I think people see insects as dirty. (103)
	Social disadvantages	Disadvantages related to damage to reputation, loss of customers, taboo, etc.	6	18	because the people are not ready yet. (100)

	Inconvenience	Disadvantages related to the inconvenience of insect-based ingredients.	4	9	It might be interesting to give the crude product to the chef, and the chef decides what he actually does with it. (103)
	Economic disadvantages	Disadvantages related to cost.	4	5	The economic load she has behind her. (104).
	Non-availability	Disadvantages related to the difficulty in obtaining insect-based ingredients.	3	5	I know that now they are selling cricket meal there, it is pretty specific were they have it there. (104)
	Health disadvantages	Disadvantages related to health (i.e., allergy).	2	3	People who develop allergies. (101)
	Ecological disadvantages	Disadvantages related to the environment (e.g., use of animals, loss of biodiversity, etc.)	1	1	How many insects were used to make this amount of flour, and how many wheat plants were planted for those insects? (101)

Abbreviation: TU, Textual Unit; NA, Non-Applicable

[a]Number of interviews in which a least one meaning unit appears.

Note: The quotes were originally in French and have been translated