Consumer acceptance of cricket-based snacks

by

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Abstract

Insects have been proposed as a more sustainable protein alternative to conventional meat sources. However, consumer acceptance of edible insects is still low in the western hemisphere. The purpose of this study was to examine how characteristics of a cricket-based product along with consumer beliefs influence the overall liking and willingness to try the cricket-based food product. An online survey was conducted in the province of Alberta, Canada. Participants (n=548) were asked to indicate their overall liking (OL) and willingness to try (WTT) a cricket-based snack in a conjoint analysis experiment. A 2x2x5 design was used for the product characteristics (type of product, presence of an image of the product, product benefit claims). Five product profiles were assigned to each participant using a balanced incomplete block design. The type of product (cricket chips and whole roasted crickets) was ~~found to be~~ the most important attribute for participants. Product benefit claims were not effective at increasing the OL or WTT of the cricket-based snacks presented to participants. Higher scores in the Entomophagy Attitude Scale, and previous experiences consuming insect-based food products positively influenced WTT and OL. The findings of this study underscore the significance of the type of product and personal attitudes towards entomophagy in shaping consumer preferences for sustainable protein sources and offer valuable insights for the development and marketing of insect-based food products in western markets.

Preface

This thesis is an original work by Susana De Leon Siller under the supervision of Dr. Wendy Wismer. No part of this thesis has been previously published.

For the research study (Chapter 3), I was responsible for study design, data collection and analysis.

Dr. Wendy Wismer, Dr. John Wolodko contributed with conceptualization, study design, supervision, and critical review of the manuscript. Dr. Ha Nguyen assisted with the study design.

The research study, of which this thesis is a part, received research ethics approval from the University of Albertan Research Ethics Board, Project name “Acceptance of cricket-based food products” (Pro00107828).

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Lastly, I express my appreciation to the participants who contributed to the data collection process.

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Table of Contents

List of tables

List of figures

1. Chapter 1 – Introduction

Projections from the United Nations estimate that the global population will reach 9 billion inhabitants by the year 2050. This increase will result in a larger demand for food. In the case of meat production, one of the main sources of protein, this would mean a need to increase production by approximately 75% in developed countries, and 113% for developing countries (*UN*, 2019).

Livestock production is a resource intensive activity. As of 2019, livestock occupied 77% of global farming land, and produced 57% of the global greenhouse gas (GHG) emissions for human food (Ritchie, 2019; Xu et al., 2021). Even though production of meat has increased in the last decade, the pressing interest in meeting sustainability goals, along with the challenge of having a limited surface available for production, have driven policymakers and researchers to present insects as an alternative protein source (Payne et al., 2019; Pippinato et al., 2020; Sogari et al., 2022; Van Der Weele et al., 2019; Van Huis, 2020b).

Entomophagy, the practice of consuming insects, is not a new concept; it has been a part of the culture of many countries for centuries and is currently practiced by over 2 billion people from 130 countries. There are approximately 2,000 insect species that have been identified as suitable for human consumption. An example of an entomophagic culture is Mexico, where approximately 549 different insect species have been documented in the country's gastronomy, from mealworms (*Tenebrio molitor*) to crickets (*Acheta domestica*), to honeypot ants (*Myrmecocystus melliger*) (Ramos-Elorduy, 2000; Ramos-Elorduy et al., 2008; Youssef & Spence, 2021). Other countries where entomophagy is practiced include China, Thailand, Nigeria and Uganda, where it is possible to find insects sold in markets and festivals (Garofalo et al., 2019).

Insects as a food source are becoming increasingly popular as they are a sustainable, affordable, and nutritious food source. Compared to conventional livestock production, insect husbandry can use land in a much more efficient way because the space is able to be utilized vertically, which allows production to multiply as growing containers can be stacked. Furthermore, farmed insects use up to 50-90% less land per kg protein, 40-80% less feed per kg edible weight, and produce 1000-2700 g less GHG emissions per kg mass gain compared to conventional livestock (Van Huis et al., 2015). Regarding their nutritional content, insects contain a high percentage of high-quality protein relative to their weight, varying from 40-70% protein dry weight; their fat content is highly variable, from 5-40%, and a good source of omega-3 and omega-6 fatty acids. In addition, because insects are consumed whole, they are generally good sources of iron and zinc (Finke, 2015; Michaelsen et al., 2011; Rumpold & Schlüter, 2013).

As defined by Sogari, Liu & Lil (2019), insect-based food products are "All kinds of products which use insect ingredients in the preparation". This includes a wide variety of products ranging from the incorporation of insect-protein powders into bakery products to roasted whole insects. Companies such as Aspire Food Group in the United States produce cricket-based products such as protein powder, cookies, and bars (EXO, 2023). In the Netherlands, AdalbaPro produces buffalo mealworm oil, insect protein concentrate, and fiber textured insect protein (AdalbaPro, 2023). In Thailand, Bugsolutely produces cricket pasta. In France, Ynsect produces cricket-based products such as protein powder and flour (Bugsolutely, 2023). In Mexico, Sal de Aquí produces chocolates, and fleur de sel with maguey worms and crickets (Sal de Aquí, 2023). Entomo Farms, based in Ontario, Canada, harvest crickets and mealworms to produce cricket flour and protein powder, as well as snacks like cricket chips (Entomo Farms, 2023). These companies are just a few of the many that are now producing insect-based food products around the world (Flore et al., 2018).

Despite the wide distribution and increasing availability of insect-based foods, entomophagy is not a familiar concept in the majority of the western world, where insects are often disregarded as a food source (Flore et al., 2018; Van Huis, 2013). As a consequence, studies measuring the acceptance of insect-based food products are often met with rejection by consumers. Some of the main barriers to acceptance include feelings of disgust, fear of contamination, associations with sickness or unhygienic circumstances and the fear of unpleasant sensory characteristics (Barton et al., 2020; Gómez-Luciano et al., 2022; Lorini et al., 2021; Modlinska et al., 2021; Ruby & Rozin, 2019; Tuccillo et al., 2020).

Previous research has explored the effect of product information presentation as a viable option to improve consumer acceptance of insect-based food products. Studies featuring information about the health (Berger et al., 2018; Lensvelt & Steenbekkers, 2014; Placentino et al., 2021) and nutritional benefits (de-Magistris et al., 2015; Jones, 2020; Laureati et al., 2016; Lombardi et al., 2019) of products made with insects has had a positive impact on consumer acceptance. Similarly, the effect of environmental awareness and product sustainability on consumer perception has been researched. The results of the studies propose that presenting insect-based food as a sustainable alternative to conventional protein has the potential to increase consumer acceptance of these products (Hartmann & Siegrist, 2018; Kostecka et al., 2017; Menozzi et al., 2017; Tan et al., 2015).

Demand for organic food products has been on the rise for the past couple of decades, reaching 132.74 billion U.S. dollars in global sales in 2021 (Shahbandeh, 2023). This interest has led to multiple studies researching the effect of organic certifications on consumers' preference or willingness to pay for food products with such certification. Most studies agree that the presence of an organic certification drives consumers' interest in the product, particularly if consumers have an interest in the environment (McFadden & Huffman, 2017; Pham et al., 2019; Sharma et al.,

2020; Xie et al., 2015). Given that insects are often perceived as a sustainable protein source due to their low environmental footprint and efficient resource utilization (Lombardi et al., 2019; Van Huis, 2020b), understanding consumers' attitudes towards organic food may shed light on their willingness to adopt alternative protein sources like insects.

As previously mentioned, the apprehension of an unpleasant sensory experience is one of the main barriers consumers face when approaching entomophagy. To help alleviate these concerns, several studies have provided information about the positive sensory characteristics of insect-based food products with relative success in generating interest in insect consumption (Berger et al., 2018; Lensvelt & Steenbekkers, 2014; Pambo et al., 2018; Rumpold & Langen, 2019).

Other studies have focused on the effect of the visibility of the insect ingredients in the food product on consumer acceptance, concluding that products with invisible insect ingredients fare better on consumer evaluations, and suggest that introducing such ingredients into familiar food products can help consumers to associate the novel ingredient with attractive flavours (Arena et al., 2020; Caparros Megido et al., 2016; de-Magistris et al., 2015; Gmuer et al., 2016).

To analyse the effect of multiple product attributes on consumer acceptance at once, conjoint analysis was chosen as part of the methodology of the research described here. Conjoint analysis is an experimental approach where consumers are presented with product profiles that are formed by the combination of specific attributes with varying levels using a statistical design of experiments (Rao, 2014). This approach allows us to measure the importance of each attribute and its levels on consumer preferences. The principle of this method is that parting from the evaluations of product profiles, the individual attributes of the product are then analyzed to calculate the individual part worth utilities of each attribute level. Conjoint analysis is often used in marketing

and the food industry as a way to understand and predict consumer behaviour so that the products or services being designed are suited to the market's expectations (Almli & Næs, 2018).

Several studies have applied this methodology to evaluate consumers' preferences for protein alternatives, such as the study from Weinrich & Elshiewy, (2019), where they performed a conjoint analysis with meat substitutes made with microalgae. Studies targeting products made with edible insects include the study from Ryu et al., (2017) which presented participants with profiles of cookies containing insects to assess the impact of the cookie flavour, size, thickness, disclosure of the nutritional facts and the presence of additives on consumer preference. Another similar study is that from de-Magistris et al., (2015), in which participants evaluated food products similar to sushi, where characteristics varied in the visibility of the insect, price, the presence or absence of a logo, and the presence or absence of a product claim about the nutritional benefits of the product. In the latter case, the nutritional benefits claim proved to be beneficial as participants were willing to pay a premium for the product when the claim was present.

Currently, research using conjoint analysis for insect-based food products is scarce, and, to my knowledge, has not been used to evaluate the effect of the information in the label along with varying product benefit claims. This study aims to provide a wider perspective of consumer preference regarding insect-based food products by exploring simultaneously the product type and visibility of insect ingredients along with product claims that act as information pieces about the benefits of insect-based food products. The information provided by the conjoint analysis in conjunction with the profiling of the consumers' personal beliefs has the potential to elucidate key driving factors for the acceptance of insect-based food products. As such, the purpose of this study was to investigate how personal values and the characteristics of a cricket-based snack influence participants' overall opinion and willingness to try such products.

The specific objectives are as follows:

a) Examine the relationship between personal views (pro-environmental world view, attitude towards entomophagy and health consciousness) and willingness to try cricket-based food products.
b) Examine the relationship between personal views (pro-environmental world view, attitude towards entomophagy and health consciousness) and overall opinion of cricket-based food products.
c) Investigate how the type of product, visibility of the product on the packaging, and product claims affect willingness to try.
d) Investigate how the type of product, visibility of the product on the packaging, and product claims affect overall opinion.

It was hypothesized that the type of product, the presence or absence of a product image, and product claims about several topics (health, sustainability, food waste, taste, organic certification) positively influences participants' overall liking and willingness to try cricket-based snacks. A secondary hypothesis was that these product attributes have varying degrees of influence on overall liking and willingness to try. The third hypothesis was that personal beliefs influence overall liking and willingness to try. The fourth hypothesis was that personal beliefs, overall liking and willingness to try the insect-based food products differ among clusters of participants with similar preference for product attributes.

2. Chapter 2 – Literature review

A review of the effect of information on the acceptance of insect-based food products

2.1. Introduction

Projections from the United Nations (2019) estimate that by the year 2050, the world's population is expected to exceed nine billion people, increasing demand for food, particularly meat. Production must increase by 113% in underdeveloped nations and by 75% in developed nations to keep up with demand. Given that 33% of agricultural land and 26% of the world's arable land are devoted to producing animal feed, livestock take up a substantial amount of land and resources (Caparros Megido et al., 2014, 2016; Deroy et al., 2015; Flore et al., 2018; Lensvelt & Steenbekkers, 2014; Van Huis, 2013). Policymakers and researchers have proposed using insects as a potential protein source to achieve sustainability goals and overcome the issue of limited land availability.

However, in the western world, entomophagy is not commonly practiced, and elicits feelings of disgust, apprehension about illness, and concerns about negative sensory characteristics, among other reasons. These unfavourable reactions present a significant obstacle to widespread acceptance and use of insects as a food source (Chan, 2019; Hartmann & Siegrist, 2016; Jensen & Lieberoth, 2019; La Barbera et al., 2020; Ruby et al., 2015; Russell & Knott, 2021; Tuccillo et al., 2020).

Providing positive information about entomophagy to consumers could help dispel some of the misconceptions and fears about edible insects, helping to overcome some of the common obstacles to their acceptance. Previous studies looking at the effect of providing information about the use,

taste, and exposure to the novel food item have been successful in increasing consumers' acceptance of these products (Caparros Megido et al., 2016; Hoek et al., 2013; Pelchat & Pliner, 1995). This approach has been used to investigate the effect of information on pulse-based spreads (Henn et al., 2023), biofortified wheat (Rizwan et al., 2022), irradiated food (D'Souza et al., 2021), reduced sodium bread (Dunteman & Lee, 2023) and vegetables with visual imperfections (Lagerkvist et al., 2023), among others.

This review will provide an overview of how the provision of information can affect consumer acceptance of insect-based food products (IBFP) and will compare the different approaches that have been taken to provide such information. Additionally, the review will provide a synthesis of the existing research that can be used to inform strategies to increase the acceptance of entomophagy and identify future areas of research.

2.2. Methodology

A literature search was performed in November 2022 using Web of Science Core Collection and Scopus data bases. The studies were limited to papers written in the English language published in scientific journals from the start of 2012 to the end of October 2022. Materials such as book chapters, editorial material and review articles were excluded from the search.

The development of the search string was an iterative process, drawing from existing knowledge, iterative refinement, and prospective searches. Initially, the construction of the search string relied on existing understanding of relevant terms and concepts within the field. Subsequent iterations involved refining the search criteria based on feedback from preliminary searches, adjusting parameters to focus on the specific aspects of the research question. Additionally, prospective searches were conducted to identify any new or emerging terms that could enhance the comprehensiveness of the search strategy. The following search string was used:

ALL=(((labe or information or framing or marketing) AND (insect* or cricket* or entomophagy or insects as food or edible insects or acheta or gryllus or tenebrio) AND (acceptance or consumer or perception* or attitude* or willingness to try or willingness to adopt or willingness to consumer or willingness to purchase) NOT (bacteri* or microbial or agricul* or morpho* or malaria or insecticide or disease)))*

Terms such as "labeling," "framing," and "marketing" were included to encompass various methods through which information about insect-based foods may be communicated to consumers. Additionally, terms related to insects and insect-based food products, including "entomophagy," "edible insects," and specific insect species names such as "acheta," "gryllus," and "tenebrio," were chosen to ensure thorough coverage of this field, as they are the most frequently commercialized insects. By incorporating terms related to consumer acceptance, perception, and willingness to try or purchase insect-based foods, the search string aimed to identify literature exploring consumer attitudes towards this emerging food category. Furthermore, the exclusion of terms related to irrelevant topics such as bacteria, diseases, and insecticides, as well as an insect genus that had particular prominence in the aforementioned topics, was implemented to maintain the focus on consumer behavior and attitudes specifically related to insect consumption.

The main inclusion criterion was that the studies contained an intervention that provided participants with information with the goal of evaluating its effect on the acceptance of insect-based food products. Excluded papers focused on insects as vectors of disease, characterization of insect species, testing of pesticides, pest management or biological pest control, the relationship of humans and insects without an emphasis on entomophagy, and of studies that provided information to participants but did not measure its effect on participants' perception.

The search string and the automated restrictions mentioned in the first paragraph resulted in 715 papers. After removing 38 duplicate papers, 677 papers were screened using their titles; titles that were explicitly related to the exclusion criteria were discarded from further review. The remaining 83 papers were screened based on their abstracts, resulting in 52 papers that were then screened using their methods to determine whether an information intervention was used. The remaining 16 papers were included in the review. Figure 2.1 depicts a flow chart summarising the selection process.

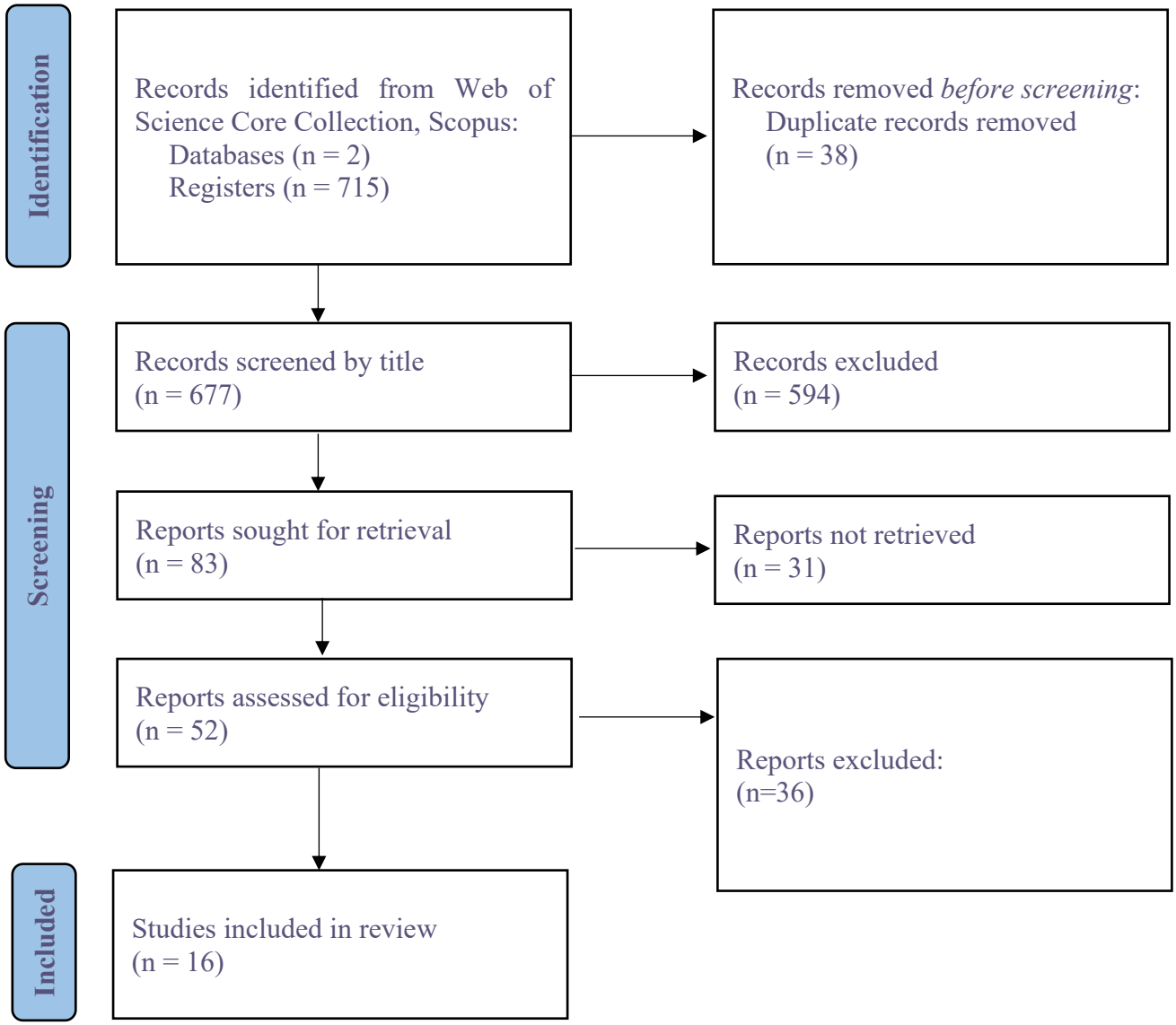

Figure 2.1. Process of the selection of papers for review.

2.3. Review of the literature

The publication years of the reviewed papers show an increasing interest in the topic at hand, with about two thirds of the papers (n=11) having been published between the years of 2018 and 2022. Research about the effect of information on the acceptance of insect-based food products is concentrated in a few countries that share a close geographical position. Figure *2.2* illustrates that research is primarily conducted in western European countries (i.e. Italy, Germany, Belgium, and the Netherlands), with few studies taking place in the rest of the world. While their generalisation to other populations is limited, it may reflect greater interest in insects as food in cultures that have traditionally focused on meat consumption. As a result, the general findings from this review cannot be extrapolated to global populations; however, may be relevant in Canada and the United States, which are considered part of the western world, and have tradition as non-entomophagic countries.

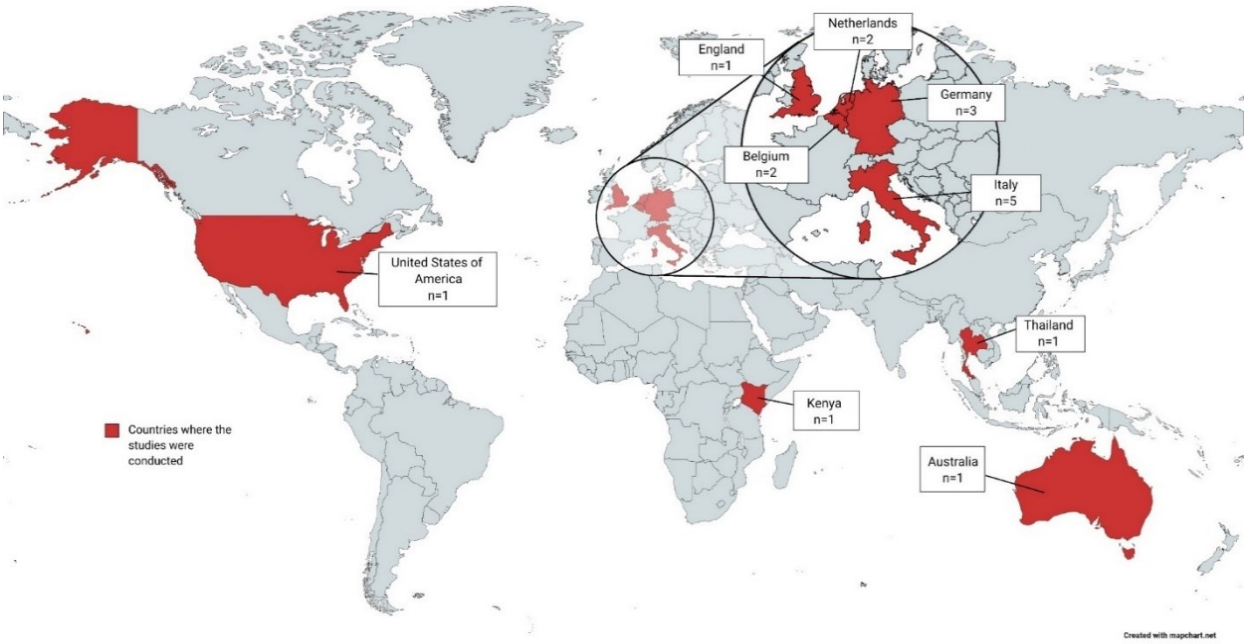

Figure 2.2. The map illustrates the number and geographic distribution of the research studies included in the review. The countries marked in red indicate the location where the studies were conducted.

The intense focus of research in Europe leaves a gap in the knowledge of the effects of information on the majority of the world. Given that cultural differences can greatly affect the outcome of research, more studies about this line of knowledge should be performed in other areas of the world to generate more accurate results that reflect the differences among regions or populations.

The methodologies used across the reviewed studies are varied and distinct. A summary of the methods and variables utilized in the study can be found in Table *2-1*. Each group of authors used unique procedures to investigate the topic at hand. Most studies used written questionnaires to gather data, primarily in person (n=8) or through online surveys (n=4). Of the 16 studies included in the review, nine provided participants with an opportunity to taste IBFPs. However, only four of the studies included sensory evaluation as a main component of their methodology. The remaining five studies offered IBFPs as an opportunity to get acquainted with entomophagy, or as an optional secondary part of their study.

Table 2-1. Summary of the methods and output variables of the reviewed studies.

Authors	Acceptance measurements	Format of the study
Arena et al. (2020) Italy	Hedonic liking (9-point hedonic scale)	Online survey (n=210)
Barsics et al. (2017) Belgium	Overall liking, flavour, appearance, odour (9-point hedonic scale)	Written questionnaire (n=135) , sensory evaluation
Berger et al. (2018) Germany	Quality expectations (7-point Likert scale); Willingness to consume mealworm truffle (Yes/ No); Taste ratings (11-point hedonic scale); Willingness to pay	Written questionnaire (n=180) , optional tasting of the product
de-Magistris et al. (2015) Netherlands	Willingness to pay (4 levels: 1.50, 2.50, 3.50 and 4.50 euro)	Written questionnaire (n=153)
Gurdian et al. (2022) United States	Purchase intent (Yes/No); Overall liking, Aroma, Crunchiness, Overall flavour (9-point hedonic scale)	Sensory evaluation (n=84)

Table 2-1. (Continued)

Authors	Acceptance measurements	Format of the study
Jones & Beynon (2021) England	Changes in attitude (qualitative); Choosing IBFP for their school lunch (expected behaviour and actual behaviour)	Optional tasting of the product, Focus groups, Semi-structured interviews, follow-up after 6 weeks (n=187)
Lensvelt & Steenbekkers (2014) Netherlands & Australia	Willingness to try (Yes, roasted cricket/ Yes, savoury biscuit with insect flour/ Yes, both/ No, none); Taste (7-point hedonic scale)	Online survey (Netherlands n=134; Australia n=75), optional tasting of the product
Lombardi et al. (2019) Italy	Willingness to pay	Multiple price list (n=200)
Mancini et al. (2019) Italy	Willingness to try (Y/N); Appearance, Odor, Flavour, Texture, Overall liking (9-point hedonic scale); Probability of consuming the product in the future (9-point Likert scale)	Written questionnaire (n=165), optional sensory evaluation
Maw et al. (2022) Thailand	Expected sensory liking (9-point hedonic scale)	Online survey (n=727)
Pambo et al. (2018) Kenya	Expected and actual sensory evaluation for Sweetness, Smell, Colour, Softness, Taste, and Crumbliness (JAR, 5-point scale)	Written questionnaires at home, sensory evaluation (n=432)
Placentino et al. (2021) Italy	Willingness to endorse product (7-point Likert scale)	Written questionnaires (n=61)
Rumpold & Langen (2019) Germany	Willingness to eat insects in different forms (Yes/No); Willingness to buy insects in different forms (Yes/No)	Written questionnaires (n=149), optional tasting of the product
Schouteten et al. (2016) Belgium	Overall liking (9-point hedonic scale); Perceived quality (7-point Likert scale); Perceived nutritiousness (7-point Likert scale)	Sensory evaluation (n=97)
Szczepanski et al. (2022) Germany	Willingness to consume index (calculated from willingness to try, buy, and substitute meat for insect-based food (5-point Likert scale))	Written questionnaire, follow up after 4 weeks (n=114)

Regarding the assessment of the effect of information on acceptance, two main methods were identified: 1) measuring acceptance of IBFP before and after providing the same information to the complete cohort of participants, and 2) providing different information to each of the treatment groups to assess the effect of each type of information on the acceptance of IBFP. Table *2-2* shows the methods for delivering information to participants in each study. Research studies that provided information through seminars or workshops relied on the first method, while studies that used written or verbal passages to communicate the information used both methods in almost equal proportions.

Table 2-2. Formats of the information interventions in the reviewed studies.

Format of the information	**Use of controls and treatments**	**Authors**
Oral presentation (45 minutes)	Same information for all participants	Barsics et al. (2017)
Seminar (3 hours)		Mancini et al. (2019)
Two double lessons (90 minutes each)		Jones & Beynon (2021)
Workshop and cooking demonstration (45 minutes)		Szczepanski et al. (2022)
Written passage	Same information for all participants	de-Magistris et al. (2015)
		Laureati et al. (2016)
		Berger et al. (2018)
		Placentino et al. (2021)
		Gurdian et al. (2022)
	2 information treatments	Lombardi et al. (2019)
		Arena et al. (2020)
	3 information treatments	Schouteten et al. (2016)
		Maw et al. (2022)
	4 information treatments	Lensvelt & Steenbekkers (2014)
	6 information treatments	Rumpold & Langen (2019)
Passage read aloud	3 information treatments	Pambo et al. (2018)

Another aspect in which the papers are differentiated from each other is the variation in the target populations. Some of the populations include convenience samples from universities, general public in urban areas, women from rural communities, grade school children, adolescents, and professional athletes.

2.3.1. Overall effect of information on consumer perception

2.3.1.1. Direct effect on acceptance

Overall, providing information about the different aspects of entomophagy such as its cultural relevance, environmental and nutritional benefits, production processes, common species of edible insects, among others, has a positive effect on the acceptance of insects as food (Barsics et al., 2017; Berger et al., 2018; de-Magistris et al., 2015; Jones & Beynon, 2021; Laureati et al., 2016; Lensvelt & Steenbekkers, 2014; Lombardi et al., 2019; Mancini, Moruzzo, et al., 2019; Maw et al., 2022; Pambo et al., 2018; Placentino et al., 2021; Rumpold & Langen, 2019; Schouteten et al., 2016; Szczepanski et al., 2022). In addition, this positive effect is present regardless of the topics covered in the information intervention (Berger et al., 2018; Lensvelt & Steenbekkers, 2014; Lombardi et al., 2019).

2.3.1.2. Indirect influence on acceptance

In the few cases where information did not directly affect the participants willingness to adopt insect-based foods, it significantly influenced some of their beliefs and attitudes surrounding entomophagy. In a study assessing the effect of two double lessons on adolescents' willingness to consume insect-based food, Szczepanski et al. (2022) did not find any significant differences in their willingness to consume; however, food neophobia and food technology neophobia decreased while attitudes and knowledge about entomophagy increased.

A similar finding was reported by Gurdian et al. (2022), who suggested that even though information about the environmental and health benefits of insect-based food products was insufficient to directly affect product liking, they could still influence the participants liking by emotional elicitation. These findings point towards the use of information as a way to address misinformation and common fears toward entomophagy, which could serve as a stepping stone to positively influence consumers' beliefs and attitude towards insects as food.

A study that contradicts the beneficial effect on consumers' beliefs was performed by Arena et al. (2020); providing participants with information surrounding gastronomy, sustainability, and the state of the food sector did not affect expected liking of several insect-based food products but instead increased participant food neophobia. In this case where both the non-informed and informed group gave unfavourable assessments to the products studied, the information seemed to exacerbate their pre-existing prejudices against insect-based food products. This raises the question of whether certain sectors of the population are ready to consider insect-based food given that the same type of information in this study was shown to have a positive effect in other studies, including those performed in the same geographical location. Persuasion strategies should take into consideration the consumers' underlying beliefs in order to cater to different groups of people with shared beliefs.

2.3.2. Topics of Information

The information provided to participants covers a wide range of themes, from basic information about the species of edible insects to the regulations of edible insects in the food sector. A summary of the topics included in the information provided to participants in each of the reviewed papers can be found in Table 2-3.

Table 2-3. Summary of the topics covered in the information interventions in each of the studies from the review.

	Lensvelt & Steenbekkers (2014)	de-Magistris et al. (2015)	Laureati et al. (2016)	Schouteten et al. (2016)	Barsics et al. (2017)	Berger et al. (2018)	Pambo et al. (2018)	Lombardi et al. (2019)	Mancini et al. (2019)	Rumpold & Langen (2019)	Arena et al. (2020)	Jones & Beynon (2021)	Placentino et al. (2021)	Gurdian et al. (2022)	Maw et al. (2022)	Szczepanski et al. (2022)
Sustainability / Need for new food sources	✓	-	✓	✓	✓	-	✓	✓	-	✓	✓	-	✓	✓	✓	✓
Nutrition	✓	✓	✓	✓	-	-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓
History/Culture	✓	-	✓	-	✓	-	-	-	-	✓	-	-	-	✓	-	✓
Food safety	✓	-	-	-	-	-	✓	✓	✓	-	-	-	✓	-	-	-
Types of edible insects	-	-	-	-	-	-	-	-	✓	-	✓	-	-	-	-	✓
Legislation	✓	-	-	✓	-	-	-	-	✓	-	✓	-	-	-	-	-
Production processes	-	-	-	✓	-	-	✓	-	✓	-	-	✓	✓	-	✓	✓
General information about entomophagy	-	-	-	-	-	✓	✓	-	-	-	-	-	-	-	-	-
Gastronomy/ Use in current food products	✓	-	-	-	✓	-	-	-	-	-	✓	✓	-	-	-	-
Health benefits	✓	-	-	-	-	✓	-	-	-	-	-	-	✓	-	-	-
Hedonic benefits	✓	-	-	-	-	✓	✓	-	-	✓	-	-	-	-	-	-
Utilitarian claims/ Environmental	✓	-	✓	-	-	✓	✓	✓	-	✓	-	-	✓	✓	✓	-
Disadvantages	-	-	-	-	✓	-	-	-	✓	-	-	-	-	-	-	-
Benefits/Advantages	-	-	-	-	✓	-	-	-	✓	-	-	-	-	-	-	-
Social influence	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-

Complementing this, Figure *2.3* highlights the common recurring terms in the information passages provided to participants across the reviewed studies. The size of each term is directly proportional to its frequence in the information passages.

Figure 2.3. A visual representation of the most frequently used terms in the information passages presented to the study participants across the studies in this review. The size of each term and font density is proportional to its frequency in the information passages used to increase acceptance of insect-based foods.

2.3.2.1. Health and Nutritional benefits

The nutritional benefits of insect-based food products are the most frequently presented information topic. The high-quality nutritional profile is mentioned as a general fact, but specific nutrients are often emphasized. The protein content and quality of insect-based food are the most frequently mentioned facts not only when addressing nutritional aspects of IBFP, but also within all of the information interventions included in this review (Arena et al., 2020; Berger et al., 2018; de-Magistris et al., 2015; Gurdian et al., 2022; Laureati et al., 2016; Lombardi et al., 2019; Maw

et al., 2022; Pambo et al., 2018; Placentino et al., 2021; Rumpold & Langen, 2019; Szczepanski et al., 2022). Other commonly mentioned nutrients include healthy fatty acids, iron, minerals, vitamins (particularly B12), and omega -3 and -6 fatty acids.

Health is mentioned alongside the nutritional aspects of IBFP. On the one hand, a portion of the research report that participants are not greatly influenced by health, as they see it as a long-term benefit (Berger et al., 2018). On the other hand, a positive effect in acceptance was reported when participants perceived that these products directly benefited their health. In a study by de-Magistris et al. (2015), participants were willing to pay a premium for an IBFP when a nutritional and health claim was present; Lombardi et al. (2019) also reported that including health as an individual benefit increased participants' willingness to pay for IBFP.

2.3.2.2. Sustainability and environmental benefits

The topics of sustainability and environmental benefits are often mentioned in the information interventions from the studies. The information passages touch on diverse aspects such as the increasing demands of a growing global population, the need for more sustainable food alternatives, and the proposal of insects as an alternative protein source (Arena et al., 2020; Barsics et al., 2017; Laureati et al., 2016; Mancini, Moruzzo, et al., 2019; Maw et al., 2022; Rumpold & Langen, 2019).

Other aspects related to the environment are claims about insects as a sustainable protein source (Berger et al., 2018; Gurdian et al., 2022; Maw et al., 2022; Pambo et al., 2018; Szczepanski et al., 2022), comparisons of the resources needed for the production of insects and conventional livestock (Laureati et al., 2016; Lombardi et al., 2019; Placentino et al., 2021), as well as the emissions and environmental impact of the production of insects and different species of livestock

(Gurdian et al., 2022; Laureati et al., 2016; Lombardi et al., 2019; Placentino et al., 2021; Szczepanski et al., 2022)..

2.3.2.3. Entomophagy as part of history and culture

Other common pieces of information include the mention that entomophagy has been a historically documented practice in many cultures (Barsics et al., 2017; Laureati et al., 2016; Rumpold & Langen, 2019; Szczepanski et al., 2022), and the great number of people that currently include insects in their diets (Gurdian et al., 2022; Rumpold & Langen, 2019).

2.3.2.4. Information about insects in the current food sector

The reviewed research papers provide participants with information about a wide range of aspects related to the insect-based food sector. Participants were provided with information about species of edible insects (Arena et al., 2020; Mancini, Moruzzo, et al., 2019; Szczepanski et al., 2022). It was also highlighted that insect-based food products are currently being produced and commercialized in different countries (Arena et al., 2020; Maw et al., 2022; Placentino et al., 2021), and the potential of insects to be integrated into appealing gastronomic preparations (Lombardi et al., 2019).

Other topics include descriptions of the production processes (Jones & Beynon, 2021; Mancini, Moruzzo, et al., 2019; Pambo et al., 2018; Szczepanski et al., 2022), food safety of insect-based food products (Gurdian et al., 2022; Lombardi et al., 2019; Mancini, Moruzzo, et al., 2019; Pambo et al., 2018; Rumpold & Langen, 2019), as well as information about the legislation that regulates the insect-based food sector (Arena et al., 2020; Mancini, Moruzzo, et al., 2019; Maw et al., 2022; Placentino et al., 2021).

The isolated effect of information about the food sector is unclear; however, it may be worthwhile to include this information in more studies as it would potentially assure participants that the food products they are evaluating are safe and of a high quality. Legislation provides food safety standards and regulations to protect consumers from eating contaminated or improperly prepared insect-based food. Thus, the mention of safeguards established in the legislation of IBFP production, harvesting, and processing could reassure consumers that these activities are done in a manner that reduces the risk of food-borne illnesses and other types of harm to their health.

2.3.2.5. Societal and Individual benefits

The topic of the information influences consumer perception differently depending on the product's potential to affect them directly or indirectly. The studies reviewed suggest that information addressing benefits at the individual level and in the short term positively influences participants' perception of insects as food, while societal, long-term benefits are less effective at this task.

In a study by Berger et al., (2018) looking at the effect of information on the acceptance of mealworm truffles, participants randomly received one of three pieces of information: health benefits, utilitarian claims or hedonic benefits. The results showed that health and sustainability benefits had a negative correlation with the product expectations, which was identified as the main driving force of the willingness to eat (WTE) the mealworm truffles. On the other hand, presenting participants with information about hedonic benefits positively affected their WTE. Furthermore, the difference in expectations caused by the type of information resulted in higher ratings of the sensory characteristics of the mealworm truffles by the participants that were presented with the hedonic benefits of the product.

This is in line with Lombardi et al.'s (2019) study, in which participants were provided with information regarding either individual benefits (food safety, and nutrient and diet quality) or societal benefits (food security, reduction in greenhouse emissions and water use). There was an increase in the willingness to pay for three different insect-based food products (pasta, cookies, chocolate bar) regardless of the topics included in the information treatments. However, participants were willing to pay more when presented with information about the individual benefits, compared to the societal benefits.

Although this line of research aims to present participants with arguments in favour of including insects in their diets, the majority of the benefits mentioned in these studies are long-term and societal in nature. Consumers are increasingly aware and concerned about the environment and the issues surrounding it (Paul et al., 2016; Shi et al., 2017; S. Wang et al., 2018); however, when it comes to food, some of the strongest drivers are emotions and pleasant sensory experiences (Cabral et al., 2017; Carrillo et al., 2011; Januszewska et al., 2011; Marsola et al., 2020; Prescott et al., 2002; O. Wang & Scrimgeour, 2021). This phenomenon was observed in Pambo et al.'s (2018) study, in which participants were asked to rate their expectations about various nutritional and quality characteristics of cricket flour-enriched buns after being given information. The control group, which did not receive any information, expressed their apprehension of having a negative sensory experience. This aligns with the fact that immediate, pleasurable experiences are at the forefront of food choice (Bauer et al., 2022; Marty et al., 2018). Following this reasoning, future research should aim to reassure participants about the sensory characteristics of IBFP by including claims and descriptions about the appealing taste and texture of the products at hand.

2.3.3. Orientation scales

Orientation scales have been used in some of the studies to profile the participants in the studies. Food neophobia, the aversion towards new food, is a measurement often used in this line of research due to its association with the rejection of insect-based food products. The Food Neophobia Scale created by Pliner & Hobden, (1992) is a common tool in the studies included in this review.

A frequent finding in these studies is that higher levels of neophobia yield lower acceptance of IBFP in the form of low expectations of liking the product (Laureati et al., 2016), and a negative effect on willingness to pay (Lombardi et al., 2019) or willingness to try (Mancini, Moruzzo, et al., 2019; Placentino et al., 2021). A study with adolescent students followed the same trend where higher food neophobia, measured with the Food Neophobia Test Tool by Damsbo-Svendsen et al., (2017), negatively affected the willingness to consume IBFP (Szczepanski et al., 2022).

While the primary use of food neophobia scales is to profile participants, it has also been used as a baseline to understand the effects of information about entomophagy on the participants' beliefs. In a study conducted by Arena et al., (2020) participants' food neophobia scores were calculated before and after the information was presented. The results revealed an increase in food neophobia among the participants after receiving the information, along with lower liking and curiosity towards images displaying IBFP. The general approach is to measure the effectiveness of information in terms of willingness to partake in entomophagy in several ways, or by the perception of IBFP; however, it is not often taken into consideration the effects of information on the beliefs of participants in order to better understand the results of the intervention.

Other scales that have been used to characterize participants are the Short Version of the Food Technology Neophobia scale by Cox & Evans (2008); the Food Disgust Sensitivity scale by

Hartmann & Siegrist (2018) (Szczepanski et al., 2022); Beliefs and Attitudes towards insects by Ruby et al. (2015) (Lombardi et al., 2019; Szczepanski et al., 2022); the Disgust Sensitivity scale by Haidt et al. (1994) (Berger et al., 2018); the General Health Interest scale by Roininen et al. (1999), the New Environmental Paradigm scale by Dunlap et al., (2000) (Lombardi et al., 2019), a study specific scale to measure Insect Food Rejection (Mancini, Moruzzo, et al., 2019), and the abridged version of the General and Sports Nutrition Knowledge Questionnaire by Trakman et al. (2018) (Placentino et al., 2021).

2.3.4. Sensory evaluation and opportunities to taste products.

The combination of information with the opportunity to taste the product appears to be the methodology that yields the highest increase in acceptance. As illustrated with Pambo et al.'s (2018) experiment with cricket-enriched buns, information about the benefits of the enriched buns generated the most positive expectations about the product's attributes; however, after tasting the product the ratings for acceptance were positive and equal across all information treatment groups. This included the group that received information about potential risks and had originally expected most attributes to have a low level of acceptance. In this case, the actual sensory experience overrides the concerns and negative preconceptions of participants, highlighting the importance of the hedonic experience in consumers' food choice.

Other studies have also demonstrated the positive effects of combining information with tasting the product. Lensvelt & Steenbekkers (2014) concluded that information and the opportunity to taste IBFP were equally important when trying to positively influence the attitude of participants toward entomophagy. This is also supported by the study conducted by Gurdian et al. (2022), where it was suggested that the effect of the tasting opportunity was larger than the effect of the

statement provided about the benefits of Edible Cricket Protein, and that the statement on its own did not have any significant effects on overall liking or purchase intent.

This combination of methods has also been documented by Barsics et al. (2017); they observed that when participants attended a 45-minute oral presentation prior to evaluating the IBFP samples they tended to assign higher ratings compared to the group that performed a sensory evaluation of the samples before attending the presentation.

In another study examining the effect of conducting a workshop that included a presentation and a demonstration of the IBFP being prepared, children's willingness to include IBFPs in their school lunch doubled. The children mentioned that watching the preparation of the food reduced their fears about the product, and that the taste exceeded the expectations of some of them. The positive results from the intervention translated in 60% of the students choosing IBFP for their lunch for the school's Sustainable Week (Jones & Beynon, 2021). This change in behaviour and perceptions shows promise in approaching consumers by combining information with tasting opportunities. Most of the studies mentioned in this section evaluated the immediate effects of this intervention. It would be worthwhile performing follow-up in future studies to evaluate the lasting effects and/or changes in diet resulting from this methodology. Including information about the sensory characteristics of the IBFP being evaluated is highly encouraged, as well as continuing the inclusion of products containing real insects contrary to simulating their presence.

2.4. Discussion

Persuading consumers to accept insect-based food products will probably not be achieved with information alone; a combination of exposure (i.e. increasing visibility and availability of IBFP, tasting opportunities, etc.), targeting populations with affinity towards entomophagy (pre-existing

beliefs, previous experiences with IBFP), along with information will be necessary to shift the perception towards acceptance of IBFP in the wider population.

As of the present review, there is little information about the long-term effectiveness of information in increasing the acceptance of IBFP. Few studies, like the ones performed by Jones & Beynon (2021) with school grade children, and Szczepanski et al., (2022) with adolescents give follow up after providing information to their participants. While both studies show a positive change in attitude a month after the initial study took place, the adolescents' acceptance of IBFP during the 6-week follow up decreased from the reported acceptance just after completing the informational workshops but remained higher than their initial acceptance before receiving any information.

It is not possible to know whether the positive effects of information vanish over time or if they result in the incorporation of IBFP into participants' diets without subsequent follow-up. The previously mentioned studies were performed in a school environment which facilitates follow up with the study population. Other academic environments could also be explored as an option to investigate how intervention effects evolve over time in a cohort of students.

Another crucial factor to understanding consumer acceptance of IBFP is evaluating how much participants trust or believe the information being presented to them; as previous research has revealed different sources of information carry different weight on consumers' opinions. A 2018 survey from the Centre for Food Integrity shows that around 70% of consumers have become distrustful of the food system, due to missteps and exaggerated product claims. In addition, the Canadian Centre for Food Integrity (2022) revealed that scientists remain one of the most trusted stakeholders in the food system; however, trust has significantly lowered towards independent producers, university researchers, and agriculture in general. Messaging provided to participants

should be particularly conscious and deliberate to avoid losses in trust that could result in the rejection of entomophagy.

Related to the previous point, concerns about sensory experience are one of the biggest hurdles when approaching entomophagy (Castro & Chambers, 2019; Mishyna et al., 2020; Pambo et al., 2018; Wendin & Nyberg, 2021). Messages surrounding the sensory characteristics of IBFP represent an area of opportunity for researchers to address this concern by highlighting pleasant flavours and textures, and providing opportunities to try different IBFP. An important consideration is that tasting opportunities should aim to only include real insect-based food products to avoid disconfirmation effects down the line by creating false expectations about the product.

Finally, the unique focus of research in western Europe leaves a gap in knowledge about the preferences in other countries. Given that entomophagy is often promoted as an inexpensive source of protein and a potential aid to alleviate nutritional gaps in food insecure countries (Abril et al., 2022; Dürr & Ratompoarison, 2021; Kim et al., 2019; Pervez & Manzoor, 2023; Verneau, Amato, et al., 2021), a possible course of action is for researchers to turn towards the populations that this new wave of entomophagy is aiming to help. This approach could open new potential markets while actively working towards reducing food insecurity.

2.5. Conclusions

2.5.1. Summary of findings

In conclusion, providing accurate information regarding insect-based food products (IBFP) is beneficial to consumer perception. It is difficult to identify which type of information is the most effective in opening doors to the wider acceptance of IBFP, but it is clear that it is beneficial to consumer perception of insect-based food products. Information about immediate and benefits to

the individual of IBFPs are of great interest to consumers; in particular, sensory characteristics of IBFPs appears to be a common concern among consumers, which makes this type of information more effective in making a positive impact on the acceptance of IBFPs than appeals to societal or long-term benefits (e.g. sustainability benefits). Furthermore, a combination of information and the opportunity for consumers to sample the products in person has been found to yield the highest increase in acceptance rate. This strategy could be integrated in future informational or promotional campaigns regarding IBFPs.

2.5.2. Recommendations for future research

The methodologies employed in these studies vary greatly, making it difficult to compare results across papers. This issue could be addressed if future studies were to consistently include certain predefined points of comparison, allowing researchers to more accurately compare results and draw more reliable and consistent conclusions. This could include using common outcome variables, consistent use of control and treatment groups, and the use of recurrent orientation scales.

Additionally, the sensory appeal of IBFP is an area that should be explored and researched more thoroughly as the concern about the sensory experience of consuming insects has repeatedly been shown to be one of the main barriers to approach entomophagy.

Another recommendation is for researchers to be very specific in reporting the type of information that participants were exposed to during the study. To ensure that this data is comprehensive and readily accessible, a suggestion is that researchers could include it as an annex in their paper.

Finally, research should be conducted to cover other areas of the world to obtain more accurate results that reflects cultural differences.

3. Chapter 3 – Consumer perspectives on cricket-based snacks: examining personal beliefs, preferences, and product characteristics through conjoint analysis.

3.1. Introduction

The global population is projected to reach 9 billion by 2050, resulting in a significant increase in meat demand (United Nations, 2019). Given that livestock production already occupies a large portion of agricultural land, alternative protein sources are being explored (FAO, 2023; Flore et al., 2018; Xu et al., 2021). Insects are considered a viable option due to their lower resource requirements and similarity in protein content to conventional meat sources (Abril et al., 2022; Bourdrez & Chriki, 2022). Insect farming is also more land and resource-efficient compared to traditional livestock farming, with significantly lower greenhouse gas emissions (Doi & Mulia, 2021; Lange & Nakamura, 2021; Van Huis et al., 2015).

The potential of insect-based food as a sustainable source of nutrition is increasingly recognized. As a result, the acceptability of insect-based food is gaining attention from academics and the general public alike (Abril et al., 2022; Ballingall, 2014; Dion-Poulin et al., 2021; Ha, 2021). The feeling of disgust has been identified as one of the biggest barriers to the acceptance of insect-based food products, and has also been linked with food neophobia, the fear or reluctance to try new foods. The consensus among studies indicates that people who are more easily disgusted and more neophobic are more likely to reject the idea of insects as a food source (Gumussoy et al., 2021; Jensen & Lieberoth, 2019; La Barbera et al., 2018; Ros-Baró et al., 2022; Russell & Knott, 2021; Sogari et al., 2023).

To overcome these barriers, ongoing research is trying to develop strategies to increase the acceptance of insects as food. Some of the strategies include incorporating insects into familiar food (Caparros Megido et al., 2016; Orsi et al., 2019), the use of invisible insect ingredients such

as flours, extracts, powders, *etc*. (Gmuer et al., 2016; Schäufele et al., 2019), the use of sensory panels and tasting experiences to improve familiarity with entomophagy (Sogari et al., 2019; Woolf et al., 2021), and the use of information interventions and product labelling (Barsics et al., 2017; Mancini, Sogari, et al., 2019; Rovai et al., 2021), the latter having increased the acceptance of the insect-based foods presented in each study by providing information focusing on the environmental and nutritional benefits of entomophagy.

This study incorporated written and visual information on the packaging of a cricket-based snack as stimulus for participants' perception of the product. Crickets were chosen for this study because they are one of the most consumed insects worldwide and have been approved for human consumption in many countries, including Canada, where this study takes place (Canadian Food Inspection Agency, 2021; Van Huis, 2020a). To evaluate characteristics prioritized by participants on the package, conjoint analysis was chosen as part of the methodology.

Conjoint analysis is a statistical technique commonly used in consumer science research to measure consumer preferences for different products or service attributes. It is used to determine what combination of product or service attributes are most important to customers. It is also helpful in determining how much value a consumer places on each attribute, how much each attribute contributes to overall product acceptance, and how changes to the product or service will affect consumer preferences. This allows researchers to gain insights into consumer preferences and tailor their products accordingly (Rao, 2014).

The study aimed to examine the acceptance of an insect-based snack using conjoint analysis, concurrently examining the impact of brief informational interventions, such as product claims highlighting various benefits of insect consumption, the presence of a visual depiction of the product, and different food product types. Consumer profiling included assessing personal beliefs

related to health, environmental consciousness, and attitudes toward entomophagy. Our hypotheses suggested that both personal views and product characteristics displayed on the packaging influence overall liking and willingness to try cricket-based snacks. Furthermore, we anticipated that personal views also shape the importance that each product characteristic holds in determining willingness to try and overall liking, as revealed in the conjoint analysis. Consequently, the study aimed to explore how the characteristics of a cricket-based snack and the information presented on its packaging impact participants' overall liking and willingness to try the product. Simultaneously, the secondary objective was to profile participants' personal beliefs to determine whether a correlation exists between these beliefs and preferences for specific product attributes.

3.2. Methods

The study consisted of a survey covering demographic data, personal attitudes or orientations and a conjoint analysis of cricket-based food products (Figure 3.1). Participants were given the option to submit additional comments at the end of the survey. The complete survey is presented in Appendix A. The survey was conducted online and targeted participants residing in the province of Alberta in Canada.

A total of 600 participants residing in Alberta, Canada were recruited through the internet using social networks (Facebook, Reddit, and Twitter), as well as through email snowballing. For email snowballing, individuals within the researchers' personal and professional networks were contacted directly with the survey information, encouraging them to participate and share the survey with others who might be interested. Posts to social media were strategically shared in communities or groups likely to have individuals interested in the topic of the survey, such as gardening clubs, outdoors enthusiasts, fitness groups, hunting clubs, as well as general interest

groups that gathered people from specific geographic locations or cities within Alberta. The questionnaire was accessible through a link and a QR code that was distributed within the online recruitment material.

The study protocol was approved by a Research Ethics Board at the University of Alberta (Pro00107828). Each participant provided informed consent prior to the study.

The survey was conducted between June and September 2021 using the online platforms Compusense® Cloud sensory software (Compusense Inc., Guelph, Ontario, Canada) and Qualtrics software (Qualtrics, Provo, Utah, USA) to collect participant responses. Participants who completed the survey could enter their email address into a prize draw for one of three $25 giftcards.

We initially received 742 responses; 409 of them were excluded from the analysis because they were either incomplete or deemed as not genuine. This large influx of questionable responses led to a change of response collection platform. Qualtrics was chosen because their security protocols were deemed as more appropriate to counter the type of fraud we encountered. The remaining responses were collected through this platform. Various criteria were employed to refine the dataset. Firstly, duplicate responses were removed, identified either by Qualtrics using their duplicate scores parameter, set at 75 or higher, or manually by cross-referencing identical comments with matching responses throughout the survey. Additionally, responses were eliminated if at least one section of the survey was left unanswered. Furthermore, responses were filtered out if they had a Qualtrics fraud score exceeding 30 or a Qualtrics reCAPTCHA score below 0.5, indicating potential issues with respondent authenticity. Short response times of less than 3 minutes were also flagged as potential indicators of careless or insincere responses and thus excluded. Responses that skipped reCAPTCHA verification or consent sections were likewise

excluded to ensure compliance with ethical standards and study protocols. Lastly, responses with unintelligible comments, particularly if they were identical or similar to other unintelligible comments, were disregarded to ensure data quality and coherence in analysis.

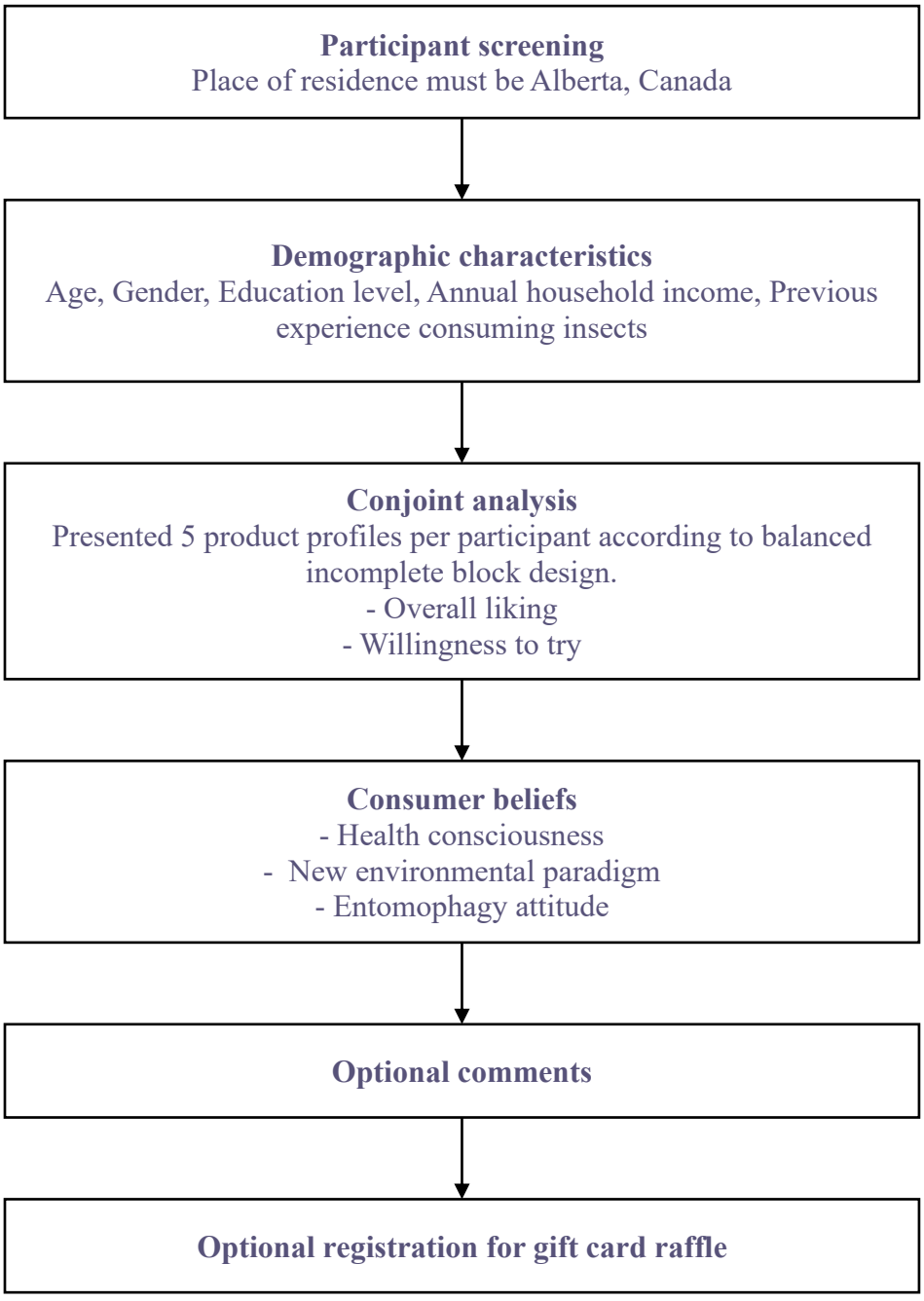

Figure 3.1. Flowchart outlining the survey structure.

3.2.1. Demographic information

Participants were asked about their area of residence, gender, age, length of time they have resided in Canada, education level, income, and any previous experience consuming insect-based products at least once in the past. The areas of residence within the province were based on the geographic zones used by the local health authority, Alberta Health Services, as these were likely known to participants as they were frequently cited during the COVID-19 pandemic. The Calgary Zone, positioned in the southern part of Alberta, is defined by the boundaries of the city of Calgary and its surrounding areas. The Edmonton Zone, located in central Alberta, encompasses the city of Edmonton and the adjacent regions. The Central Zone extends across central Alberta, including cities such as Red Deer and its neighboring communities. The North Zone serves the northern areas of the province, covering towns like Grande Prairie, Fort McMurray, and Peace River. The South Zone is responsible for the southern regions, which include cities like Lethbridge and Medicine Hat. A supplementary map was included to help participants determine their area of residence.

3.2.2. Conjoint analysis

A conjoint analysis approach was chosen to identify the most appealing attributes of an insect-based food product for consumers. The attributes and levels for the conjoint study were based on a previous review of the published literature on consumer acceptance of edible insects (Wendin & Nyberg, 2021) and conversations with industry stakeholders.

For the conjoint analysis, three attributes were selected: the type of product, which was cricket-based chips or whole roasted crickets; an image of the insect-based food product on the packaging, which could be present or absent; and claims about benefits of eating crickets, such as sustainability benefits, desirable hedonic properties, health benefits, food waste reduction, and the

possibility of organic certification. Table 3-1 contains a summary of the attributes used in the conjoint experiment.

Table 3-1. Attributes and their corresponding levels used for conjoint analysis.

Attribute	Levels	Text in the label
Type of product	Cricket-based chips Whole roasted crickets	
Image of product	Present Absent	
Claims	Sustainability benefits	Sustainable food source: Low carbon & water footprint
	Hedonic properties	Tasty snack: Delightfully crunchy and deliciously nutty
	Health benefits	Healthy and Nutritious snack: Rich in proteins, vitamins, and minerals
	Food waste reduction	Crickets raised with 100% diverted food waste
	Organic certification	Certified organic

The absence or presence of the product image in the packaging was included to find out whether being able to preview the product appearance would positively or negatively affect consumers' ratings of the product. Several studies have found that consumers prefer products in which insects are not visible (Gurdian et al., 2021; Jones, 2020; Modlinska et al., 2020). However, because chips are already a form of invisible inclusion of crickets into a food product, this attribute was used to explore whether the presence of an image on the packaging would produce different results, or if the acceptance of food containing whole crickets would increase if the product was hidden by the packaging.

The five claims were designed to represent trends and potential drivers of insect-based food product acceptance. The benefits of sustainability and food waste reduction were chosen to

represent consumers' preoccupation with choosing to consume environmentally friendly products. The inclusion of hedonic properties addressed one of the most significant barriers to entomophagy: concern about the sensory properties of insect-derived products. The health benefit claim reflects the main nutritional properties of crickets. Finally, the organic certification is associated with healthier and less environmentally damaging food products, which consumers are more familiar with and often associate with higher quality products (Botonaki et al., 2006; Brito et al., 2022; Janssen & Hamm, 2012; Thøgersen et al., 2019).

The combination of these attributes produced a full design with 20 profiles. A Balanced Incomplete Block Design was used to form twenty blocks consisting of 5 profiles each, which were then randomly assigned to the participants and presented in a monadic manner. A ratings-based conjoint analysis was chosen for this study for its ease of use and simple analysis; in addition, the rating system is easy to understand and less cognitively demanding for responders (Rao, 2014). The product pictures used for the product profiles were obtained from the royalty free website Pixabay. The labels were then designed using Microsoft PowerPoint (Microsoft® PowerPoint® for Microsoft 365 MSO, Washington, USA, Version 2308 Build 16.0.16731.20052) and exported as portable network graphics. The base model for the package was obtained from the website Free PSD templates. Adobe Photoshop (Adobe Photoshop Creative Suite 6, Adobe, California, USA, Build 13.0.1.1) was used to overlay the label on the base model to create the different product profiles. The images were then exported as Joint Photographic Experts Group files to incorporate them in the survey.

For each of the profiles to be evaluated, participants were presented with a mockup image of the hypothetical snack packaging where the different levels of the attributes were illustrated (Appendix B). They were then asked to rate their overall liking of the product on a 9-point hedonic

scale (1 = dislike extremely; 9 = like extremely) and their willingness to try the product on a binomial scale with the options “Yes” and “No”.

3.2.3. Personal beliefs

In the second part of the survey, participants completed three scales to assess their personal beliefs towards health, entomophagy, and pro-environmental orientation.

3.2.4. Health consciousness

The Health orientation section from the Food Choice Questionnaire by Steptoe et al. (1995), was answered on a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). This sub-scale of six questions was chosen to evaluate health consciousness as a driver for food choice. Scores could range from 1 to 5. Higher scores indicate that the individual has a greater concern for the health benefits of food.

This tool has been adapted and used by Escobar-López et al. (2019) to identify the motivations to consume ecological foods in southern Spain. Verain et al. (2022) also used items inspired by the Food Choice Questionnaire to understand why meat consumers are moving towards flexitarian diets. The scale has also been used to examine the link between food choice and consumption profile on the perception of labels for kefir products (Penna et al., 2021).

3.2.5. Environmental consciousness (Pro-environmental orientation)

Pro-environmental orientation was measured using the New Ecological Paradigm (NEP) from Dunlap et al., (2000). The NEP scale is one of the most commonly used tools to measure a “pro-ecological” worldview (Lou & Li, 2023; Rosa et al., 2021; Wang & Sun, 2021). It consists of 15 statements encompassing the concepts of reality of limits to growth, anti-anthropocentrism, the fragility of nature's balance, rejection of exemptionalism, and the possibility

of an ecocrisis. Previous work by Moons et al. (2018) used the NEP scale as a tool to investigate the drivers and barriers for the adoption of food products enriched with Spirulina.

For this part of the study, participants were asked to indicate their agreement with each statement on a 5 point-Likert scale (1 = strongly disagree; 5 = strongly agree). Responses to even-numbered statements were reverse-coded so that higher scores represent lower levels of agreement with the corresponding statement. The scores for each statement were then averaged to obtain the total score for the questionnaire. The possible range of the score spans from 1 to 5, in which higher scores correspond to a higher support for pro-environmental behaviour.

3.2.6. Attitude towards entomophagy

To evaluate participants' attitude towards the consumption of insects, the Entomophagy Attitude Questionnaire (EAQ) from La Barbera et al (2020) was included. This scale explores consumers' attitudes towards entomophagy in three areas: their disgust towards direct entomophagy, interest to try novel food and experiences, and their attitude towards indirect entomophagy. The scores for the EAQ range from 1 to 7, with higher scores indicating a higher acceptance of direct and indirect entomophagy. Participants were asked to indicate their agreement to the statements in the questionnaire on a 7-point Likert scale (1 = disagree strongly; 7 = agree strongly). Items 1 to 5 were reverse coded. While relatively new, this valid and reliable tool has the advantage of being a tool specifically designed to evaluate attitudes to entomophagy. The EAQ measures individuals' opinions, beliefs, and perceptions about eating insects, including factors such as disgust, interest, knowledge, and willingness to try. By measuring multiple aspects of attitudes, the questionnaire allows researchers to gain a more nuanced understanding of the acceptance of insects as food (Verneau, Zhou, et al., 2021). The Entomophagy Attitude Questionnaire has been used in different cultural contexts and populations, making it applicable for cross-cultural studies. Recent studies,

such as the one performed by Sogari et al., (2023) have made use of the EAQ to evaluate consumers' willingness to engage in entomophagy when presented with processed and whole insects; and the study from Verneau et al., (2021), which compared which subscales of the EAQ influenced the intention to engage in entomophagy for insect eaters and non-eaters.

3.2.7. Data Analysis

All analyses were performed using XLSTAT software (version 2021.4.1, Addinsoft, New York, USA). Demographic data and personal beliefs scores were analysed using descriptive statistics. For the willingness to try responses, a Chi-square test was used with a 0.05 level of significance. The relative importances and part-worth utilities of the Conjoint Analysis were calculated using Ordinary Least Squares regression with the Conjoint analysis tool from XLSTAT. The part-worth utilities were used to form clusters using Agglomerative Hierarchical Clustering analysis with Euclidean Distances and Ward's Method for aggregation. The clusters were then described using the Personal Belief Scales' scores and demographic data. The demographic information from the clusters was compared using the Chi-square test at a significance level of 0.05. ANOVA was used to compare the Personal Belief scale scores and utilities from each cluster at a 0.05 level of significance. Subsequently, pairwise comparisons of the means were conducted using the Tukey-Kramer test to identify differences between clusters at a significance level of 0.05.

3.3. Results

3.3.1. Participants' Sociodemographic characteristics

Table *3-2* shows the sociodemographic characteristics of the participants. The Edmonton Zone had the highest proportion of study participants (42 %). Participants were evenly split between male and female, with a minority not identifying as either.

The majority of participants (82.7 %) were between the ages of 18 and 39, and had a high level of education, with 63.7 % having completed post-secondary education and 13.5 % having completed graduate studies. Participants who indicated some prior experience made up 45.3 % of the sample, while the remaining 54.7 % had no prior experience consuming edible insects.

Table 3-2. Sociodemographic characteristics of the participants (n=548).

Characteristics		%	n
Alberta region	South	14.0%	84
	Calgary	20.0%	120
	Central	16.0%	96
	Edmonton	42.0%	252
	North	8.0%	48
Gender	Male	48.3%	290
	Female	48.3%	290
	Other	2.3%	14
	Prefer not to answer	1.0%	6
Age	18-29 years	42.0%	252
	30-39 years	40.7%	244
	40-49 years	12.2%	73
	Over 50 years	4.8%	29
	Prefer not to answer	0.3%	2
Education level	Some or all high school	21.2%	127
	Post-secondary studies (e.g. technical training, college, university)	63.7%	382
	Graduate studies	13.5%	81
	Prefer not to answer	1.7%	10
Household annual income*	Less than $36,600	10.8%	65
	$36,601 - $71,000	23.2%	139
	$71,000 - $115,000	28.5%	171
	More than $115,000	27.0%	162
	Prefer not to answer	10.5%	63
Previous experience consuming insects	Yes	45.3%	272
	No	54.7%	328

*Income categories based on 2020 Canadian tax brackets

3.3.2. Personal beliefs

3.3.2.1. Health consciousness

The health consciousness score had a mean of 3.9±0.64 and a median of 4 out of the maximum score of 5. This indicates a high level of involvement from the participants towards the impact of food on their health. Table 3-3 presents participants' mean scores for the personal belief scales and subscales.

3.3.2.2. Entomophagy Attitude Questionnaire (EAQ)

Participants had a mean score of 5.1±1.31 and a median of 5.4 on a 7-point Likert scale for the EAQ (Table *3-3*). In general, the results indicated a positive attitude toward entomophagy. Participants with previous experiences consuming insects had significantly higher scores on the EAQ (5.4±1.15) than their counterparts without previous experience consuming insects (4.8±1.41).

The subscales of the EAQ revealed a secondary trend concerning participants' attitude towards different facets of entomophagy; the subscale EAQ-Feed received the highest score (5.6±1.23), suggesting the most support towards using insects as feed for livestock. EAQ-Interest followed with a mean of 5.3±1.51, and EAQ-Disgust with a mean of 4.8±1.65. While both the scores for EAQ-Interest and EAQ-Disgust point to a high interest in trying food made with edible insects, and a relatively low level of disgust towards personally consuming insects, the results indicate participants were more inclined to support indirect entomophagy through the use of insects as feed rather than for human consumption.

3.3.2.3. New Environmental Paradigm (NEP)

Scores for the NEP scale had a mean of 3.9±0.64 and a median of 4 out of the maximum possible score of 5. This indicates a high tendency towards an ecocentric worldview, which indicates participants value the intrinsic value of nature, the need for sustainability and conservation, and the importance of living in equilibrium with the natural environment. The subscale NEP-Ecocrisis had higher scores than the other subscales. With a mean of 4.3±0.80 and a median of 4.67, it is apparent that participants are well aware of the likelihood of environmental catastrophes as a result of human actions.

Table 3-3. Mean scores for the personal belief scales and their subscales.

Scale	Mean
EAQ	5.1 ± 1.31
EAQ-Disgust	4.8 ± 1.65
EAQ-Interest	5.3 ± 1.50
EAQ-Feed	5.6 ± 1.22
Health	3.9 ± 0.64
NEP	3.8 ± 0.57
NEP-Limits	3.4 ± 0.79
NEP-Antianthro	3.7 ± 0.86
NEP-Balance	3.9 ± 0.73
NEP-Exemptionalism	3.6 ± 0.72
NEP-Ecocrisis	4.3 ± 0.78

3.3.3. Conjoint analysis

3.3.3.1. Overall liking

The results show that both “Product” (37.8% ± 27.3) and “Claim” (38.3% ± 25.8) were the most important attributes that dictated participant liking, with the levels “Chips” and “Tasty” being the preferred levels for each, respectively. The attribute “Image” was the least important for product liking in this scenario. A summary of the mean importances is shown in Table 3-4.

Table 3-4. Mean importances for the attributes of the cricket-based snacks.

Attribute	Mean	Std. deviation
Product	37.8	27.33
Image	23.8	22.39
Claim	38.3	25.85

The average utility values for the attributes and their levels are depicted in Figure *3.2*. The values represent how much each level of the attributes contributes to the participants' acceptance of the insect-based snack.

For the "Product" attribute "Chips" was the preferred level. That is, given that everything else remained the same, the product "Chips" is preferred to "Whole crickets". This outcome could be interpreted as participants preferring a more processed, familiar food in which the insect ingredient is not visible. This is a recurrent finding in research concerning insects as food; a cross-country study by Bartkowicz & Babicz-Zielinska (2020) found that across the five countries included in their study (Belgium, China, Italy, Mexico, and United Stated), participants preferred including processed mealworms into their diets to including whole mealworms. In another cross-country study looking at the same five countries, Sogari et al. (2023) noted that participants were more willing to eat insects when they were incorporated in the form of flour into other food products than eating whole insects. Higa et al. (2021) reported that participants were more willing to eat, and more willing to feed their dogs foods in which black soldier fly larvae was not visible.

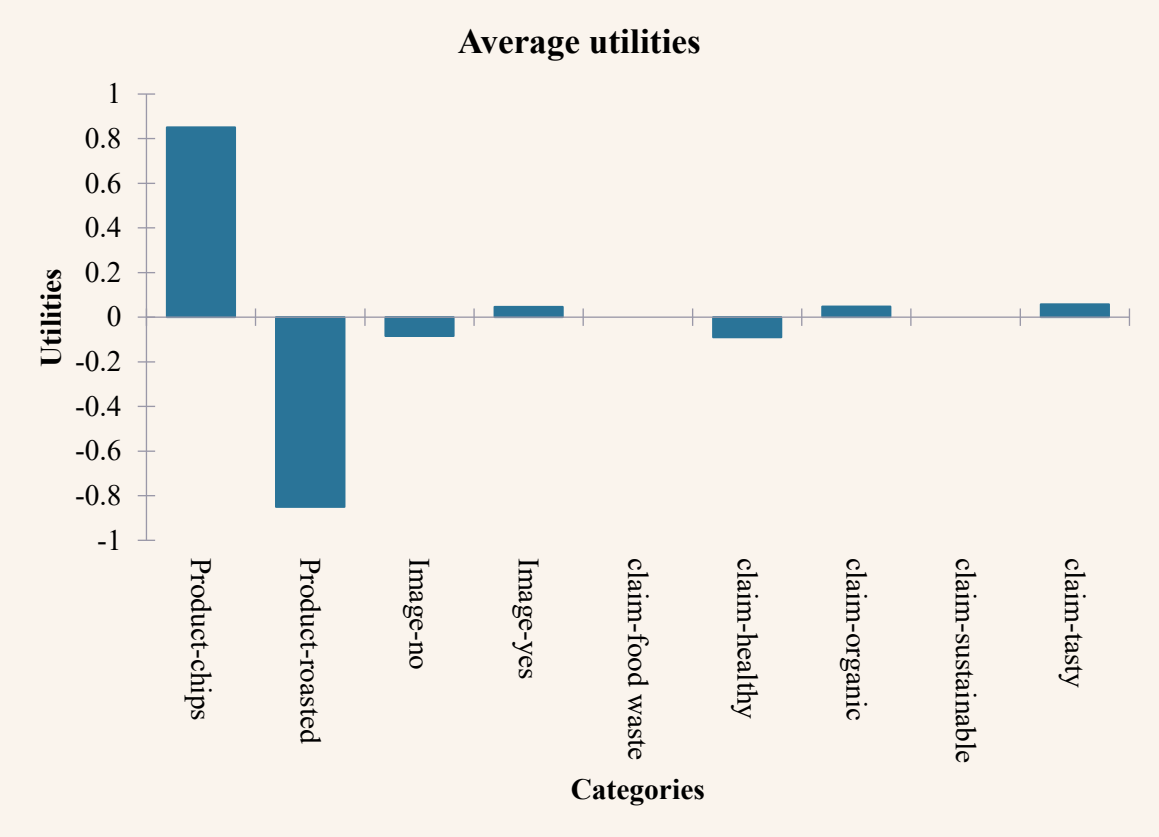

Figure 3.2. Average utilities for the attributes and their levels of the cricket-based snacks.

This explanation is supported by the comments provided by participants at the end of the survey. Some examples are:

"… I don't like the idea of eating a whole insect because their digestive tract is intact. … I would eat anything if bugs were prepared and processed though."

"More likely to eat insect flour, or insects as part of other foods than as a recognizable centerpiece of a dish, at least to start with."

"… It would need to be processed to the point where it wasn't at all recognizable as an insect. Chips that look like regular tortilla chips or potato chips. Flour. Not whole crickets."

In the case of the "Image" attribute, the product was preferred when an image of the contents was present on the package. Concerning the benefit claims, the one indicating the hedonic characteristics of the product was the most preferred, followed by the claim of an organic certification. Reduction and food waste were tied as the third most preferred claims, and the claim about health benefits was the least preferred.

3.3.3.2. Willingness to try (WTT)

A Chi-Square Goodness of Fit Test was performed on each profile to determine whether the difference in proportions between positive and negative WTT was statistically significant. The null hypothesis is that WTT is distributed equally between those who gave a positive response and those who gave a negative response. The alternative hypothesis is that WTT is not distributed equally between the two possible responses. The null hypothesis was not rejected for 8 profiles, which indicates that the proportions of positive or negative WTT did not differ for these profiles. Distribution is not different to that expected if WTT was chosen at random.

On the other hand, the test shows that for 12 profiles the WTT is not distributed evenly between "Yes" and "No". Eight of these profiles had a statistically significant larger proportion of positive WTT, and four a negative proportion of WTT. The product profiles with the highest WTT were those that presented chips, along with an image of the product (Table *3-5*). There was a substantial drop in the proportion of positive WTT when the image was absent from the profiles that contained chips as their product. On the other hand, the product profiles with the lowest WTT were those whose product were whole roasted crickets presented with an image of the product. In contrast to when the product is chips, the presence of an image of a whole roasted cricket led to an increase

in negative responses to the WTT. The WTT results don't show any distinct pattern of preference among the claims, which supports the findings of the Overall liking.

Table 3-5. Product profile characteristics and their impact on Willingness to Try (WTT) responses. The p-value, derived from a chi-square goodness of fit test indicates whether observed patterns are statistically meaningful or due to chance.

Overall WTT	Type of product	Image	Claim	p-value
Yes	Cricket chips	Yes	Healthy	0.0000
Yes	Cricket chips	No	Healthy	0.0004
Yes	Cricket chips	Yes	Sustainable	0.0000
Yes	Cricket chips	No	Sustainable	0.0000
Yes	Cricket chips	Yes	Hedonic	0.0000
Yes	Cricket chips	No	Hedonic	0.0001
Yes	Cricket chips	Yes	Organic	0.0000
Yes	Cricket chips	Yes	Food waste	0.0000
No	Whole crickets	Yes	Sustainable	0.0250
No	Whole crickets	Yes	Hedonic	0.0015
No	Whole crickets	Yes	Organic	0.0004
No	Whole crickets	Yes	Food waste	0.0021

3.3.4. Agglomerative Hierarchical Clustering Analysis

Three clusters were identified using the utility values as the clustering variable to perform an Agglomerative Hierarchical Clustering analysis. The clustering centroids can be found in Table *3-6*. A dendrogram that illustrates the clustering of participants is included in Appendix D. A differentiating factor among the clusters was the proportion of participants that had previously consumed edible insects; clusters 1 and 2 had an approximately even distribution of participants with and without experience with entomophagy; however, the proportion of participants without previous experiences was slightly higher. On the other hand, the majority of participants from cluster 3 had previously consumed insects. Participants in the three clusters were not significantly different in age, income, education level, and region of residence (Table *3-7*).

Table 3-6. Cluster centroids of the attribute levels' utilities for each of the participant clusters.

	Cluster 1	Cluster 2	Cluster 3
Intercept	4.154	4.129	6.847
Product-chips	1.979	0.158	0.242
Product-roasted	-1.979	-0.158	-0.242
Image-no	-0.079	-0.076	-0.120
Image-yes	0.005	0.088	0.026
Claim-food waste	0.000	0.000	0.000
Claim-healthy	0.224	-0.373	-0.024
Claim-organic	-0.027	0.119	0.021
Claim-sustainable	0.000	0.000	0.000
Claim-tasty	0.031	0.093	0.023
Sum of weights	204.000	248.000	96.000
Within-cluster variance	5.651	7.828	2.193

Table 3-7. Demographic information and conjoint analysis results for each cluster.

	Cluster 1 n=204		Cluster 2 n=248		Cluster 3 n=96	
	n	%	n	%	n	%
Alberta region of residence						
South Zone	23	11.3	36	14.5	18	18.8
Calgary Zone	34	16.7	57	23.0	18	18.8
Central Zone	33	16.2	37	14.9	21	21.9
Edmonton Zone	95	46.6	100	40.3	33	34.4
North Zone	19	9.3	18	7.3	6	6.3
Gender						
Male	83	40.7	131	52.8	54	56.3
Female	114	55.9	111	44.8	39	40.6
Other	6	2.9	3	1.2	3	3.1
Prefer not to answer	1	0.5	3	1.2	0	0.0
Age						
18-29 years old	82	40.2	116	46.8	35	36.5
30-39 years old	88	43.1	92	37.1	38	39.6
40-49 years old	26	12.7	30	12.1	16	16.7
Over 50 years old	8	3.9	9	3.6	7	7.3
Prefer not to answer	0	0.0	1	0.4	0	0.0
Highest education level						
Some or all high school	47	23.0	53	21.4	17	17.7
Post-secondary studies	123	60.3	156	62.9	67	69.8
Graduate studies	29	14.2	35	14.1	12	12.5
Prefer not to answer	5	2.5	4	1.6	0	0.0
Annual household income (CAD)						
Less than $36,600	21	10.3	28	11.3	10	10.4
$36,601 - $71,000	46	22.5	52	21.0	34	35.4
$71,000 - $115,000	59	28.9	72	29.0	23	24.0
More than $115,000	56	27.5	66	26.6	23	24.0
Prefer not to answer	22	10.8	30	12.1	6	6.3
Previous experience consuming insects	82	40.2[a]	111	44.8[a]	67	69.8[b]
Overall liking*	4.24 ± 2.14[a]		4.10 ± 1.89[a]		6.76 ± 1.24[b]	
Willingness to try*	55.3%[a]		52.7%[a]		92.3%[b]	

*averaged over all conjoint profiles.
Superscript letters denote statistically significant differences among clusters ($p < 0.05$).

3.3.4.1. Conjoint Analysis

3.3.4.1.1. Utilities by cluster

All clusters preferred the profiles when the product was presented was Cricket chips. Another common preference among clusters is that having an image of the product is preferable to not having one. Appendix E presents a profile plot of the average utilities of each attribute level by each cluster.

Regarding the claims, Cluster 1 preferred the claim about the health and nutritional benefits of eating insects, Cluster 2 preferred the organic certification, and Cluster 3, the claim that the product provides a pleasant taste and texture, followed very closely by the health claim. For Clusters 2 and 3, the health claim had the lowest preference, while Cluster 1 preferred the organic certification the least.

Interestingly, Cluster 3 has a high baseline for liking and despite having preferences for each of the attribute levels, the various levels have little influence over their liking of the profiles. In contrast, the overall liking ratings from Cluster 1 were greatly influenced by the type of product, with preference for Cricket chips.

In summary, the ideal product profiles for each cluster are as follows: 1) For cluster 1, Cricket chips with a health claim and the product visible on the packaging; 2) for Cluster 2, Cricket chips with an organic certification and an image of the product on the packaging, and 3) for Cluster 3, Cricket chips with an appeal to the sensory characteristics of the product and an image of the product on the packaging.

3.3.4.1.2. Overall liking by cluster

Cluster 1 and 2 had statistically similar overall liking ratings when calculating the average rating across all samples. However, when looking at the average overall liking of each product profile a pattern emerges; cluster 1 only gave high ratings to product profiles that included an image in the packaging and the product inside was cricket chips, and cluster 2 gave average ratings around the middle point of the scale (5 points out of 9) to profiles that contained cricket chips as the product. Both clusters assigned low ratings to the rest of the profiles not described previously. Cluster 3 assigned the highest ratings to all profiles. All product profiles were rated above 5 points in the hedonic scale, which indicates that all profiles were liked by this cluster.

3.3.4.1.1. Willingness to try

The same pattern as with Overall liking was observed with the Willingness to try the different product profiles; Clusters 1 and 2 tended to prefer profiles that included chips and images while rejecting other profiles, and Cluster 3 was significantly more willing to try all profiles regardless of their characteristics. A summary of the responses from each cluster are shown in Table *3-8*.

Cluster 3 stands out from the other clusters because all profiles had a positive WTT equal to or higher than 83%. Meanwhile, Cluster 2's responses were more evenly distributed between positive and negative WTT than the other clusters. Despite this, there was some agreement among the clusters. Three product profiles received statistically significant and positive WTT from all clusters. The common characteristics among these profiles were the type of product "Chips", and the presence of an image of the product in the packaging. The claims "Health", "Sustainable", and Organic" differentiated each profile. The profiles with the lowest proportion of positive WTT presented the image of the product ' Roasted whole crickets' along with the claims "Sustainable", "Organic" and "Food Waste".

Table 3-8. Overall liking (OL) ratings and percentage of willingness to try (WTT) for the product profiles by each cluster.

Product profile	Cluster 1		Cluster 2		Cluster 3	
	OL	WTT	OL	WTT	OL	WTT
Overall	4.24 ± 2.14	55.3*	4.10 ± 1.89	52.7	6.76 ± 1.24	92.3*
Product = Cricket chips						
Image present						
Food waste	6.06 ± 1.72	87.5*	4.51 ± 2.16	48.9	7.47 ± 1.24	93.8*
Health	5.81 ± 1.73	90.7*	5.28 ± 1.83	87.3	7.75 ± 1.18	100*
Organic	6.60 ± 1.59	84*	5.16 ± 1.81	67.2	7.41 ± 1.07	100*
Sustainable	6.08 ± 1.64	90.8*	4.84 ± 1.92	75	7.52 ± 0.95	100*
Tasty	6.10 ± 1.51	86.3*	5.24 ± 1.85	65.8	7.52 ± 1.08	95.2*
Image absent						
Food waste	4.43 ± 2.17	57.1	4.22 ± 1.73	50	6.42 ± 1.14	83.3*
Health	4.48 ± 1.55	63.6	4.27 ± 1.70	54.7	6.77 ± 0.77	100*
Organic	4.11 ± 1.36	50.9	3.89 ± 1.61	46.9	6.94 ± 1.25	94.1*
Sustainable	4.39 ± 1.45	67.9	4.52 ± 1.68	64.8	6.09 ± 1.00	95.7*
Tasty	4.67 ± 1.63	62.8	4.58 ± 1.74	60.9	6.50 ± 1.18	91.7*
Product = Whole roasted crickets						
Image present						
Food waste	3.18 ± 1.78	25*	3.05 ± 1.91	30.8	6.13 ± 1.01	86.7*
Health	2.43 ± 1.12	27.7*	3.00 ± 1.54	43.4	5.87 ± 1.10	95.7*
Organic	2.55 ± 1.47	26.7*	3.17 ± 1.91	35.6	6.20 ± 1.32	93.3*
Sustainable	2.54 ± 1.25	31.5*	3.36 ± 1.89	36.2	6.68 ± 1.28	84*
Tasty	2.05 ± 1.36	20.6*	3.23 ± 1.64	41.7	6.63 ± 1.38	94.7*
Image absent						
Food waste	3.45 ± 1.69	34.2	4.01 ± 1.71	46.4	6.68 ± 1.52	86.4*
Health	3.51 ± 1.53	41.9	3.95 ± 1.67	44.4	6.91 ± 1.15	90.9*
Organic	4.13 ±1.89	46.4	4.07 ± 1.79	44.4	6.26 ± 1.10	85.2*
Sustainable	3.75 ± 1.86	46.2	4.23 ± 1.78	58.3	6.96 ± 1.15	92.3*
Tasty	3.35 ± 1.84	45	4.00 ± 1.71	53.2	6.29 ± 0.95	83.3*

WTT is expressed as the percentage of participants who indicated they would be willing to try each product profile. Product profiles marked with an asterisk (*) have statistically significant differences in WTT compared to chance ($p<0.05$).

OL was evaluated on a 9-point hedonic scale (1 = dislike extremely; 9 = like extremely).

3.3.4.2. Consumer beliefs by cluster

3.3.4.2.1. Health consciousness

The average scores for this scale reveal that health is an important consideration in food choice for all clusters (Table 3-9). Statistical analysis (ANOVA) indicates that there were significant differences in the scores among clusters, with Cluster 3 having the highest scores. However, these differences are marginal and do not represent differences in practical use.

3.3.4.2.2. New Environmental Paradigm

There were no significant differences among clusters in their scores for the New Environmental Paradigm scale as well as in its subscales, which indicates a similar perception towards the environment. The clusters' average scores, ranging from 3.74 to 3.81 on a 5-point Likert scale, show a pro-ecological worldview.

3.3.4.2.3. Entomophagy Attitude Questionnaire

In this scale, rated on a 7-point Likert scale, the average scores of all clusters showed statistical differences among them. Cluster 3 showed the highest average (5.69±1.150), while Cluster 2 (4.84±1.361) had the lowest. Thus participants in Cluster 3 had a greatly positive attitude towards entomophagy. A table with the mean scores of the EAQ scales and subscales for each cluster is presented below (Table 3-9).

Table 3-9. Scores for the Entomophagy Attitude Questionnaire (EAQ) and subscales, Food Choice Health subscale, and New Environmental Paradigm (NEP) questionnaire and subscales for each cluster.

Scale	Cluster 1	Cluster 2	Cluster 3
EAQ	5.17 ± 1.22^{b}	4.84 ± 1.36^{a}	5.70 ± 1.15^{c}
EAQ-Disgust	4.81 ± 1.53^{a}	4.50 ± 1.71^{a}	5.58 ± 1.48^{b}
EAQ-Interest	5.39 ± 1.40^{b}	5.02 ± 1.60^{a}	5.81 ± 1.26^{b}
EAQ-Feed	5.75 ± 1.12^{b}	5.42 ± 1.23^{a}	5.83 ± 1.30^{b}
Health	3.85 ± 0.64^{a}	3.86 ± 0.68^{ab}	4.04 ± 0.57^{b}
NEP	3.81 ± 0.53	3.80 ± 0.58	3.74 ± 0.59
NEP-Limits	3.33 ± 0.73	3.40 ± 0.82	3.45 ± 0.85
NEP-Antianthro	3.76 ± 0.81	3.67 ± 0.89	3.72 ± 0.88
NEP-Balance	3.91 ± 0.75	3.96 ± 0.71	3.88 ± 0.78
NEP-Exemptionalism	3.67 ± 0.70	3.64 ± 0.70	3.47 ± 0.77
NEP-Ecocrisis	4.39 ± 0.73	4.32 ± 0.80	4.20 ± 0.82

Superscript letters denote statistically significant differences among clusters ($p < 0.05$).
EAQ (1=Strongly disagree;7=Strongly Agree)
NEP (1=Strongly disagree;5=Strongly Agree)
Health (1=Strongly disagree;5=Strongly Agree)

3.4. Discussion

The results from this conjoint experiment yielded three participant clusters which grouped people with similar preferences for the product characteristics included in this experiment. In overall terms, there are two clusters that group participants who are hesitant to try the cricket snacks, and one cluster that is overwhelmingly accepting of the cricket snacks.

Cluster 1 and Cluster 2 demonstrated a general reluctance to liking and trying the product profiles presented in the conjoint analysis, with the exception of select profiles which included cricket-based chips. However, the preferences of Cluster 1 were more accentuated, leading to larger differences in overall liking and WTT among liked and disliked profiles.

Cluster 1 consistently assigned high overall liking ratings to five profiles which featured cricket chips and an accompanying product image. The same profiles received a high willingness to try, with over 84% of participants in this cluster indicating that they would be willing to try these products. This strong preference for chips, a familiar food, aligns with the average utilities observed in this cluster. The notably high utilities for the product type suggests that, for Cluster 1, the overall liking of the product profiles was heavily influenced by the type of product being presented. The combination of presenting a familiar product (chips) along with a visual representation appears to have positively influenced the acceptance of the product profiles with these characteristics. However, when the product was chips without an accompanying image, both the OL ratings and WTT decreased significantly.

It's worth noting that a significant portion of the participants in Cluster 1 lacked prior experience consuming insects. They also had a higher degree of aversion towards consuming edible insects than the other clusters, as indicated by their scores on the "Disgust" subsection of the Entomophagy Attitude Questionnaire (EAQ-D). The absence of an image even when the product presentation is chips increases the focus on the descriptions in the labelling, and the word 'cricket', thus highlighting the presence of insects in the product. Other studies have documented that participants tend to have a more negative attitude to food products simply by the presence of the word 'insect' in the label or description of the product (Baker et al., 2016; Ho et al., 2022; Iannuzzi et al., 2019). Modlinska et al., (2020) reported that participants ate products labelled as containing insects with more hesitance and in lower quantities even when said products did not contain insects in their ingredients. Tan et al., (2015) performed a similar experiment where they simulated the presence of novel ingredients in burger patties, including insects. All the novel burgers received lower expected liking ratings and product appropriateness than the conventional beef burger.

Since a substantial portion of the avoidance of eating insects is caused the lack of familiarity with the sensory characteristics of insect-based food products (IBFP) (Castro & Chambers, 2019; Mishyna et al., 2020; Tan et al., 2016), the presence of a familiar and well liked product, such as chips, can reassure the consumer that the eating experience will be similar to what they already know, and might encourage them to try the product. In contrast, packaging that only describes its contents leaves the consumer wondering about the characteristics of the product inside. Coupled with the pre-existing concerns about the texture and taste of insect-based food products (IBFP), the consumer is left to speculate about the entire experience of consuming the product.

In contrast, participants in clusters 1 and 2 were not willing to try the product profiles they evaluated. Both clusters had similar proportions of participants with insect-eating experience, 40.2% for Cluster 1 and 44.8% for Cluster 2. While the average EAQ score for Cluster 1 (5.17±1.48) was higher than Cluster 2 (4.84±1.36), participants in Cluster 1 assigned low overall liking ratings to most profiles, with the exception of those featuring chips as the product accompanied by an image. Meanwhile, Cluster 2 assigned slightly higher scores than Cluster 1 on a more consistent basis.

A possible explanation can be found by examining the average scores for the EAQ subscales; the mean score for the 'disgust' dimension was the lowest for cluster 2 among all the clusters, which indicates a higher tendency to feel disgust towards eating insects than the other clusters. On the other hand, their average score for the 'feed' dimension showed a much higher level of acceptance of the use of insects as feed for livestock. While the idea of directly consuming food products made with insects is not very appealing to this cluster, they are willing to indirectly support entomophagy through the use of insects as feed. This could explain the general dislike of the products presented in the conjoint analysis given that they were aimed for human consumption.

Cluster 2 presents a more complex scenario; their overall responses to the conjoint experiment and the orientation scales suggest an ambivalent attitude towards IBFP. Their average overall liking ratings are clustered around the middle point of the 9-point hedonic scale, and their WTT responses are also more evenly distributed rather than having a clear acceptance or rejection of the profiles.

Cluster 3's profile includes participants with a predisposition to accept edible insects, which could be explained by the high percentage of participants with previous experience consuming insects, and their positive attitude towards entomophagy (measured by the average scores for the EAQ) in its three dimensions (disgust, interest, and use as feed). This phenomenon has been observed by Hartmann and Siegrist (2015) who found that participants with no previous experience with insect consumption had a lower willingness to eat unprocessed insects. Similarly, in the study of Sergi et al (2017), 74% of the participants were willing to taste other edible insects in the future after participating in an insect-product tasting (bug banquet). Palmieri et al (2019) reported that participants who had previous experiences with entomophagy were 10% more likely to be willing to eat insect-based food.

The fact that Cluster 3's baseline was much higher than the other clusters, in conjunction with the almost negligible magnitude of the utilities across the product attributes and their levels suggest that this cluster was minimally influenced by the product and its packaging; instead their liking for the product profiles appear to have been influenced by a pre-existing positive attitude towards entomophagy, and concern for health and the environment. The beliefs of the participants in this cluster carry more weight than the product itself.

While the average score in the EAQ was higher for Cluster 1, they assigned low ratings to most profiles, with the exception of high ratings to the profiles that included chips as the product with an image of the product. This could be explained by examining the scores of the individual

subscales of the EAQ; the mean score for the 'disgust' dimension was the lowest among all the clusters, which indicates a higher tendency to feel disgust towards eating insects than the other clusters. On the other hand, their average score for the 'feed' dimension showed a much higher level of acceptance towards the use of insects as feed for livestock.

While partaking in the consumption of IBFP is not appealing to this cluster, they are willing to indirectly support entomophagy through the use of insects as feed. Multiple recent studies have also reported that consumers find using insects as animal feed is more acceptable than insects as human food (Giotis & Drichoutis, 2021; Onwezen et al., 2019; Ribeiro et al., 2022), and that they are aware of the sustainability and environmental benefits of using insects as feed for animals (Ferrer Llagostera et al., 2019; Rumbos et al., 2021). These findings align with this study's results, pointing to a favourable landscape for the use of insects as feed.

Alberta's economy is largely dependent on the production of livestock; nearly half of Canadian beef is produced within the province (Dimmell, 2021; Statistics Canada, 2017), which is then commercialized both locally and internationally (Statistics Canada, 2021). The high level of acceptance of the use of insects as feed for livestock could be driven by the importance of beef production for the province's economy, and as such, naturally aligns with the already established economic activities. Including edible insects in the livestock's diet could be a viable alternative to encourage the commercial production of edible insects. Given that the greater demand to feed a vast quantity of livestock would require insect production in greater quantities, the benefits of insect consumption would be significantly observed.

In recent years, the costs for livestock production have been on the rise throughout Canada, including Alberta. Unfavorable dry weather conditions and shortages in the global grain supply are currently affecting farmers in Alberta (Campbell, 2021; CNS Canada, 2017; CTV News, 2022;

SPCA, 2018). Hay production is often insufficient to cover the needs of livestock, which has led beef producers to look for alternative feed suppliers and absorb the additional expenses from product transportation (Labby, 2023). During the second quarter of 2022, the prices for commercial feed were reported to have had increased almost one third (29.8%) compared to the same quarter in the previous year (Agri-News, 2022; Statistics Canada, 2022).

Insects as a protein source have the potential to replace high quality feed ingredients in livestock's diet. Recent studies have found that it is possible to completely replace soybean meal in cattle with the added benefits of enhanced nutrient digestibility and mitigating the rumen methane production in ruminant livestock (Ahmed et al., 2021; Herliatika et al., 2021; Phesatcha et al., 2023); while others suggest replacing up to 20% of protein concentrate in a 60:40 grass:concentrate diet to avoid affecting the digestibility of the feed (Ahmed & Nishida, 2023).

Including insects as part of livestock's diet would aid to mitigate the rising costs of feed, while also providing the landscape to develop insect production at a larger scale. In Alberta's case, edible insects for human consumption might make more sense as a side stream of the rearing of edible insects for feed. This could make IBFP available for human consumption without exerting as much pressure on the business if there is insufficient demand as it would if the business depended solely on the commercialization of edible insects as food. As evidenced by cluster 3, there are people within the province that are highly interested in entomophagy that could act as the early adopters of IBFP. As a participants commented:

"Using insects for farmed fish is absolutely brilliant"

Despite being the smallest cluster, Cluster 3 reveals a consumer niche that is enthusiastic about IBFP. Furthermore, all of the clusters were willing to try products that included chips with an

image of the product on the package, even when they rejected other product profiles. This presents the possibility to successfully introduce chips as a gateway interaction with IBFP to the general population.

The results from the conjoint analysis had some limitations, which were that it did not provide a clear understanding of why participants made the choices they did, and why the product claims had such a small influence on participants' responses. Consequently, the comments compiled at the end of the survey were used as an additional source of information. A closer examination of the comments revealed valuable metadata that helped to clarify and contextualize participants' decision-making.

Participants from all clusters expressed their interest in promoting entomophagy due to their awareness of the benefits of consuming insects; however, they expressed hesitation in consuming insects personally. While they endorsed the benefits of IBFPs, they were not the main reason to consume such products.

"I've read insect based proteins are a good, sustainable, efficient way to feed people. Eating bugs kind of grosses me out, but I like to keep an open mind and try it. It would need to be processed to the point where it wasn't at all recognizable as an insect. …"

This phenomenon has been reported in several studies; while consumers may openly express their support for healthy and environmentally friendly food options, these expressed concerns and preferences may not positively impact their willingness to actually consume IBFP (Ankamah-Yeboah et al., 2018; Naranjo-Guevara et al., 2021; Spartano & Grasso, 2021; Szendro et al., 2020; Weinrich & Busch, 2021). In other words, while people may advocate for healthier and more sustainable food choices in principle, their practical openness to incorporating insects

into their diets may not always align with these ideals. This suggests that there may be other factors or barriers at play when it comes to the acceptance of insect-based foods, beyond just the desire for healthy and eco-friendly options.

A consensus among participants from all clusters is that in order to consume IBFP, the insect ingredients would need to be hidden. The visibility of the insects was the most mentioned attribute. Participants expressed that using processed insects (*e.g.* in the form of flour) could mark the difference between acceptance and rejection. Other characteristics that were mentioned include the texture, taste, and smell.

"I have no issue with insects as an ingredient in my food, as long as the food itself does not look like insects."

"Eating a plain roasted cricket is unappetizing, but if it's in the form of a chip or other shape, I'm all for it."

A previous study by Broeckhoven et al. (2021) examined consumers' willingness to substitute beef for different protein alternatives, including plant-based proteins. One of the clusters, labelled as "meat lovers", were the least willing to substitute red meat and poultry for alternative plant-based proteins regardless of the product's carbon-friendliness. The authors suggested that the high levels of meat attachment played a vital role in this cluster's responses. Circus & Robison (2019) found that there was a significant relationship between meat attachment and participants' willingness to consume insects; participants with high meat attachment were less willing to consume insects than participants with low meat attachment. Van Thielen et al. (2019) noted that among the potential insect consumers, there are fewer individuals who partake in daily meat consumption. Conversely, the group least willing to try insects consists of more "real meat eaters". Albertans are likely to

share a similar attitude towards conventional meat sources given the importance of meat production in the province. A participant expressed in one comment:

"leave the bugs for[other] countries, we have real meat here"

Another factor that was stressed by many participants is that the product's presentation was very important to their perception of the product. The wording on the label was one of the most frequently mentioned elements. Participants stated that the use of the word "waste" was off-putting regardless of the intended positive connotation (*i.e.,* reduction of food waste). These comments provide some insight into the lower-than-expected effect of the "food waste" claim.

"I like the idea of diverted food waste being used as cricket feed but seeing the words "food waste" on a bag of snack is somewhat disconcerting."

The denomination of the product was also mentioned as being unappealing. Participants suggested describing in which manner the edible insects are integrated into the product. One suggestion by a participant was to change the name of the product from "Cricket chips" to "Chips made with insect flour", which also serves to make clear that insects were not the only ingredient in the chips and takes some of the focus off the insect ingredients.

Comparable findings have been reported for other novel food products; Hallman & Hallman, (2021) conducted an experiment in the United States in which two common names for frozen salmon made from fish cells were presented to participants. The aim of their study was to observe the effect of product denomination on consumer perception. When the product was labelled as "Cell-based" participants rated it more positively, were more interested in tasting and purchasing the frozen salmon than when the product was labelled as "Cell cultured".

A similar study explored the effect of the denomination of a novel product in consumer acceptance. Bryant & Barnett (2019) tested the names “clean meat”, “cultured meat”, ”animal free meat” and “lab grown meat” to refer to *in vitro* meat. The terms “clean meat” and “animal free meat” yielded more positive attitudes towards *in vitro* meat than “lab grown meat”. Furthermore, the term “clean meat” had a higher behavioural intention towards *in vitro* meat. Given the negative associations that insects often elicit, the marketing of insect-based food products should take into consideration how the name of a product can alter consumer perception.

The third major factor concerning the product presentation is the graphic design of the packaging. Per the objective of the study, the packaging design was kept as minimal as possible to make the attributes selected for the conjoint analysis the focus for participants. However, some participants stated that the design was too plain and unappealing, to the extent that, for some of them, the low ratings or unwillingness to try the product were guided solely by their dislike of the graphic design.

“… it was really the lack of product design that made me less likely to buy the product, not the nutritional information or name. …”

Although the graphic design was not part of the scope of this experiment, it affected participants’ responses. This highlights the powerful influence that the visual properties of a product have over consumer perception and could be used as a tool to increase consumer interest in IBFP.

A final noteworthy element found in participants’ comments is the concern for food safety. Given that westerners often associate insects with the three “D”s, dirty, danger, and disgusting, (Castro & Chambers, 2019; Chan, 2019; Orsi et al., 2019), some participants mentioned that they need assurance regarding the safety of consuming insects, expecting to see regulation for insect production similar to the regulation currently in place for conventional meat sources as well as

having seals or certifications that could be shown in the packaging of the IBFPs. Allergies were a concern for some participants. People with shellfish allergies are advised to refrain from consuming insects like crickets due to the presence of proteins in their exoskeleton that are also present in shellfish (Duan et al., 2020). Concerns about ailments affecting the digestive track, like irritable bowel syndrome and problems when consuming fiber, were also mentioned.

Multiple studies have reported that consumers expect mandatory labeling and certificates of quality in order to deem products made with animals fed with insects as acceptable (Altmann et al., 2022; Giotis & Drichoutis, 2021; Khaemba et al., 2022; Lippi et al., 2021). The findings point towards the lack of assurance of quality and safety as a major barrier towards the acceptance of insects in the food industry.

Informational campaigns could help to educate people on the safety of edible insects as well as the potential risks. Information campaigns should aim to educate consumers about the use of insects as feed as studies have found that consumers in the Western hemisphere are relatively uninformed about livestock feed produced with insects (Ferrer Llagostera et al., 2019; Popoff et al., 2017; Rumbos et al., 2021; Spartano & Grasso, 2021; Weinrich & Busch, 2021). Presenting a wider variety of edible insect species along with the differentiation between insect species that are associated with disease and contamination, and edible insect species could prove to be helpful to improve consumers' trust in IBFP. Nevertheless, if the edible insect industry is to keep growing and developing, it is to the interest of consumers and producers that regulations be put in place. However, current insect production is not standardized and is often not practiced on a large scale, which makes it difficult to create guidelines for the current state of this industry.

3.5. Study limitations

The survey from this study was conducted completely online, making it reliant on participants self-reporting their demographic information and opinions regarding the product. The nature of online anonymity made the survey vulnerable to including fraudulent data, which could have altered some of the results despite our best efforts to filter out disingenuous responses.

This study did not ask participants about the frequency and type of interactions with IBFP. It is not possible to distinguish between participants who have had a single experience consuming insects and participants who are recurrent consumers of IBFP. Future studies should also take into consideration whether these experience(s) were viewed as positive or negative by participants.

Another limitation is the absence of a question asking about participants' diets. This aspect was brought up by the participants' comments, suggesting that different diets could yield different perceptions of edible insects. A common viewpoint in the participants' comments concerned the vegan or vegetarian population, which could have motivations to make changes to their diet to include insects. Future studies could stratify participants by their diet to investigate differences in perception and motivations between the groups and identify potential niches for insect consumption.

3.6. Future research recommendations

The way information is presented about insect-based food products can significantly impact how consumers perceive them. Future research should explore how different wording strategies can influence consumer attitudes and preferences.

For many consumers, transitioning from traditional meat to insect-based alternatives can be challenging due to taste, texture, and cultural factors. Studying meat attachment and consumption habits could help researchers understand the emotional barriers that may exist when trying to

replace meat with insects. It can reveal the extent to which individuals are attached to meat and the psychological factors that influence their food choices.

Knowing the level of meat attachment and eating frequency among consumers allows the development of targeted messaging strategies; individuals with a strong attachment to meat may require different messaging than those who eat meat infrequently. Future studies can explore how to effectively communicate the benefits of insect-based foods to different segments of the population based on their meat-related attitudes and behaviors.

Livestock producers are increasingly exploring sustainable and cost-effective protein sources for animal feed, with edible insects emerging as a promising alternative to traditional options like soy or fishmeal. Future studies should look into the feasibility of incorporating insects into livestock diets, and assess their impact on animal health and growth. Additionally, research can focus on the economic viability of insect-based feed, considering production costs, feed conversion rates, and market demand. Quantifying the environmental benefits of insect-based feed compared to conventional options is crucial for encouraging the adoption of sustainable practices among producers. Considering regulatory standards and safety concerns for livestock feed, future research should assess the safety of insect-based feeds and identify potential legal or regulatory barriers. This approach can aid efforts to promote the adoption of insects as a viable and sustainable source of livestock feed.

3.7. Conclusions

A conjoint analysis aimed at evaluating how various product attributes (type of product, presence or absence of a product image, and product claims) influenced participants' acceptance of cricket-based snacks revealed that the type of product was the main driver of overall liking and willingness to try among all participants, particularly in participant clusters with fewer individuals with

experience consuming insects. Across all clusters, cricket chips emerged as the preferred option. Conversely, product claims were marginally effective in persuading participants to like or try the cricket-based snacks, and could not be used to override aversion towards visible insect ingredients.

The participant cluster comprising the greatest number of individuals with prior exposure to insect consumption had the greatest overall liking and willingness to try the cricket-based snacks. despite marginal effects from all product attributes on their liking. In this instance, it became evident that previous experiences had the most significant influence on the perception of the cricket snacks, highlighting the role of familiarity and exposure in shaping consumer preferences.

4. Chapter 4 – General discussion and conclusions

In light of the expectation for global population to reach 9 billion by 2050 and the resulting increase in meat consumption, the search for innovative solutions to alleviate the strain on resources has become urgent. With conventional livestock farming already exerting considerable pressure on agricultural land, there is a critical need to explore alternative protein sources. Among these, insects stand out as a promising candidate, characterized by their minimal resource demands and protein content comparable to traditional meats.

The potential of insect-based foods as sustainable nutrition sources has garnered the attention of researchers and the general public alike. However, a significant barrier to wider acceptance of insects as a food source is the aversion associated with entomophagy, which is exacerbated by food neophobia—the unwillingness to embrace new foods. Existing literature suggests a correlation between disgust sensitivity, neophobia, and rejection of insect-based foods. To overcome these hurdles, ongoing research endeavors are focused on devising strategies to enhance the acceptability of insect-derived products. Such strategies encompass familiarizing consumers with insect incorporation into foods, leveraging invisible insect ingredients, employing sensory experiences, and utilizing informative interventions and product labeling. To further explore the potential of the latter two strategies and inform the choice of information for the current research study, a literature review was conducted.

The review of literature on the effect of information on the acceptance of insect-based food products revealed a growing interest in the topic, particularly between 2018 and 2022. However, the concentration of research in western European countries, such as Italy, Germany, Belgium, and the Netherlands, limits the generalizability of findings to a global scale. While insects have

emerged as a promising alternative protein source due to their minimal resource demands and comparable protein content to conventional meats, cultural differences may significantly influence acceptance levels. Thus, there is a notable gap in knowledge concerning the effects of information on acceptance in regions beyond Europe.

Information interventions covered a broad range of topics, from nutritional benefits to cultural significance and environmental sustainability. Nutritional benefits, particularly protein content, were frequently emphasized, with health and environmental sustainability also being common themes. The literature suggests that information focusing on individual benefits tends to have a greater impact on acceptance compared to societal benefits, likely due to consumers' immediate concerns and sensory experiences driving food choices.

The methodologies employed across reviewed studies varied widely, making comparisons challenging. However, a common trend emerged regarding the positive impact of information provision, particularly on individuals' perceptions of the nutritional benefits and sustainability of insect-based food products. The combination of information with sensory evaluation through tasting opportunities appears to yield the highest increase in acceptance rates. Future research should focus on standardizing methodologies, exploring sensory appeal in greater depth, reporting information types comprehensively, and conducting studies in diverse cultural contexts to obtain more globally representative results.

The present study sought to analyse how personal beliefs and the characteristics of a cricket-based snack product would affect participants' acceptance of the product. The study employed an online survey including a conjoint analysis to investigate the factors influencing participants' perceptions of cricket-based food products. The survey encompassed demographic data, personal attitudes, and orientations, followed by a conjoint analysis of cricket-based food products. Participants were

recruited online from the province of Alberta, Canada, via social networks and email snowballing. The survey, conducted using Compusense® Cloud sensory software and Qualtrics software, ran from June to September 2021. A total of 600 responses were compiled for analysis.

Demographic information collected included area of residence, gender, age, length of residency in Canada, education level, income, and previous experience with insect-based products. Personal beliefs were assessed through scales evaluating health consciousness, pro-environmental orientation, and attitudes towards entomophagy. Health consciousness was measured using a subscale from the Food Choice Questionnaire, while pro-environmental orientation was evaluated using the New Ecological Paradigm (NEP) scale. Attitudes towards entomophagy were gauged using the Entomophagy Attitude Questionnaire (EAQ).

Conjoint analysis was employed to identify appealing attributes of cricket-based food products, considering type of product, presence of a product image, and product claims related to health, sustainability, food waste reduction, taste, and organic certification. A full design with 20 profiles was developed, with participants rating their overall liking and willingness to try each product profile on a 9-point hedonic scale and binomial scale, respectively.

The study's findings indicated that information had minimal impact on participants' preferences for a cricket-based snack. The first hypothesis, stating that the type of product, the presence or absence of a product image, and product claims would affect participants' overall liking and willingness to try cricket-based snacks, was partially disproven. While product claims related to health and sustainability had some impact on participants' perceptions, the effect was not as pronounced as initially hypothesized. This suggests that factors beyond mere product attributes play a significant role in shaping consumer attitudes toward insect-based foods, a likely one being the influence of pre-existing beliefs on consumer preference. To support this, the "entomophagic"

participant cluster consistently rated the product profiles favorably, suggesting that their liking was predetermined by personal convictions before the study commenced.

On the other hand, the second hypothesis, postulating that product attributes will have varying degrees of influence on overall liking and willingness to try, was confirmed. Contrary to the minimal effect of claims on participants' acceptance, product type and the presence of a visual representation of the product had substantial effect on participants' overall liking and willingness to try the product profiles. Product type held the most influence on the conjoint utilities, followed by the presence of a product image on the package.

The third hypothesis proposed that personal beliefs would influence participants' overall liking and willingness to try the product profiles. This hypothesis can be partially confirmed as a more positive attitude towards entomophagy, quantified using the Entomophagy Attitude Questionnaire, resulted in higher ratings and willingness to try cricket-based snacks. For future research, exploring different personal beliefs beyond those considered in this study is recommended. A suggestion is using The Eating Motivation Survey by Renner et al. (2012), which evaluates 15 factors that influence food choice; namely, liking, habits, need and hunger, health, convenience, pleasure, traditional eating, natural concerns, sociability, price, visual appeal, weight control, affect regulations, social norms, and social image. The latter two factors concerning social influence have been under-researched in the context of insects as food and could provide valuable clues to understand consumers' aversion to trying insects as food. Given the participants' homogeneous responses on health and environmental matters, diversifying the range of beliefs under scrutiny could provide a more nuanced understanding of factors influencing consumer attitudes toward insect-based products.

The fourth hypothesis stated that personal beliefs, overall liking and willingness to try the insect-based food products would differ among clusters of participants with similar preference for product attributes. By employing Agglomerative Hierarchical Clustering methods, participants were assigned to one of three clusters according to their calculated utilities for each attribute level. The hypothesis was partially confirmed as the clusters' attitude towards entomophagy, overall liking and willingness to try were different from each other. However, as mentioned above, personal beliefs related to health and environmental consciousness did not vary among clusters, leaving only one dimension of personal beliefs to guide the understanding of participants' responses.

The use of conjoint analysis in a study's methodology is a notable strength. Conjoint analysis provided a systematic method for examining consumers' preferences regarding different components of a cricket-based snack. The results of the conjoint experiment helped to demonstrate the importance of investigating traits other than those chosen for this investigation. Additionally, the use of personal belief measures allowed for a more systematic assessment of subjective aspects including health and environmental consciousness, and attitudes toward entomophagy. Furthermore, consistent use of well-established scales increases the credibility and replicability of study findings, supporting future research in the field.

A suggestion for future research is shifting the focus from persuasion strategies to investigating the motivations behind pro- and anti-entomophagy behaviours and views. Conducting focus groups or individual interviews may provide a deeper understanding of the underlying factors shaping attitudes toward entomophagy, paving the way for more targeted and effective approaches in promoting insect consumption.

The current study reveals a distinct divide among participants from Alberta, showcasing two contrasting groups: entomophagy enthusiasts (Cluster 3) and those reluctant to embrace insect

consumption (Clusters 1 and 2). Notably, some participants perceive insects as a solution to a non-existent problem, which could be explained by the province's significant role as a major meat producer in Canada and the ready availability for consumers. This perspective positions insects as a last resort for individuals facing food insecurity, adding a layer of complexity to introducing them into the Albertan diet. The cultural dispositions observed in this study pose a notable challenge, suggesting that insects may not align with the preferences and needs of this specific population. The notion of insects as an unconventional or emergency food source may contribute to reluctance among participants.

In spite of this, survey results underscore the potential of insects as a promising alternative for animal nutrition. Participants expressed enthusiasm about using insects as feed, especially considering the escalating costs associated with traditional animal rearing. This duality in perception emphasizes the need for targeted and nuanced approaches in promoting insect consumption within Alberta, recognizing both the cultural nuances and the potential for insects to serve as a sustainable solution in specific contexts, such as animal nutrition.

In conclusion, as the concept of consuming edible insects remains relatively unfamiliar in Alberta, investigating the level of belief and trust that individuals place in the information provided by researchers is important for evaluating the effectiveness of promoting insect consumption. The reception and rational assimilation of information, while significant, do not always translate into changes in behaviour. Therefore, a comprehensive understanding of public perceptions, beliefs, and the relationship between knowledge acquisition and behaviour is essential for creating strategies that can successfully encourage the acceptance and incorporation of edible insects into dietary practices in this region.

This behavioural phenomenon is evident in the disconnect between individuals expressing pro-environmental and pro-sustainability attitudes and their subsequent actions aligned with these beliefs. While someone may outwardly endorse environmentally friendly principles, their actual sustainable behaviour often falls short of these professed ideals. Understanding and addressing this disconnect is crucial for developing interventions that bridge the gap between positive environmental attitudes and tangible sustainability-oriented actions. Factors influencing this disparity warrant exploration, ranging from psychological barriers to societal norms, in order to enhance the efficacy of initiatives aiming to align attitudes with behaviour for a more sustainable future.

While information has the potential to improve people's perceptions of edible insects, it is only a small part of the overall equation. Recognizing that information alone falls short in convincing individuals to incorporate insects into their diets is crucial. Cultural beliefs, emotional reactions, and sensory considerations all play important roles in shaping consumer behaviour. Therefore, a holistic approach that integrates targeted information with strategies addressing cultural dispositions and emotional responses is essential to effectively promote the acceptance and consumption of edible insects.

The emotional response plays a critical role in the widespread acceptance of insects as a food source. Human food choices are deeply intertwined with emotions, cultural perceptions, and personal experiences. Understanding and addressing the emotional aspect is crucial because individuals often make food decisions based on feelings of disgust, fear, or novelty. By identifying and strategically targeting these emotions, marketing efforts can work to shift perceptions, making edible insects more appealing and acceptable. Moreover, positive emotional associations can create a connection between consumers and insect-based products, creating a sense of familiarity

and comfort that is essential for overcoming the initial resistance to adopting insects as a mainstream food item. To summarize, recognizing and managing emotional responses is key to navigating the complex landscape of consumer acceptance and facilitating the integration of insects into everyday diets.

Taking into account consumers' emotional reactions to edible insects is a fundamental component of successful marketing and informational campaigns. These campaigns should go beyond presenting factual information and engage with consumers on an emotional level. By recognizing and strategically addressing emotional barriers, such as disgust or apprehension, marketers can tailor their messages to evoke positive emotions, curiosity, or a sense of adventure. This emotional connection enhances the likelihood of consumers embracing the idea of insect consumption. In essence, an in-depth understanding of emotional responses is the foundation for developing effective campaigns that not only inform but also resonate with consumers, therefore contributing significantly to the widespread acceptance of insects as a viable and sustainable food choice.

Using social influence emerges as a potential method to appeal to the emotional side of consumers. By creating a sense of familiarity and closeness with the concept of insect consumption, marketing strategies can effectively counter the perception of insects as a foreign concept in the realm of food. Highlighting social norms, communal practices, or positive experiences within a group setting can create a shared connection, making the idea of consuming insects more relatable. By emphasizing social influence in this manner helps bridge the emotional gap, paving the way for greater acceptance and incorporation of insects into dietary choices within a community or societal context.

Moreover, incorporating influencers or opinion leaders within a community who openly endorse and participate in insect-based diets can create a ripple effect. People often look to others for cues

on acceptable behaviour, and when influential figures within a community embrace insect consumption, it can positively influence the attitudes and emotions of others.

By strategically weaving social elements into marketing campaigns, the goal is to establish a sense of familiarity and acceptance, mitigating the emotional resistance associated with the novelty of insect consumption. This approach aims to align the emotional responses of consumers with positive communal experiences, ultimately contributing to a shift in perception and fostering greater openness to incorporating insects into everyday diets.

To enhance the promotion of entomophagy, delving into the motivations of individuals who already embrace this diet within the non-entomophagic context of the western world becomes a powerful tool. Understanding how these motivations align with or differ from prevailing cultural norms, environmental conditions, and dietary backgrounds can provide valuable insights. By uncovering the factors that drive individuals to adopt entomophagy in a non-traditional setting, researchers can discern whether these motives can be effectively translated to a broader demographic.

These insights not only contribute to a more complete understanding of the cultural and environmental factors influencing entomophagy but also shed light on the feasibility of integrating insect consumption into the mainstream diet. Recognizing shared motivations across diverse populations can inform targeted strategies that resonate with a wider audience, potentially paving the way for a more widespread acceptance of entomophagy within the broader context of Western dietary practices.

The actual sustainability of insects as a protein source is dependant upon their minimal processing and consumption in their entirety. The current practice of incorporating insects into existing food

products, while useful to familiarize consumers with entomophagy, may fall short in inducing a substantial shift in resource usage for food production or altering the demand for conventional meat products.

In order to accurately assess the impact caused by insect-based food products, in-depth research is required to identify the "tipping point." This key threshold would signify when the production and consumption of insect-based foods yield tangible benefits, such as reduced environmental impact and increased resource efficiency. Analyzing this tipping point is critical for understanding how insect consumption could shift from a niche practice to a mainstream dietary choice, thus fulfilling its potential to make a significant contribution to sustainable and resource-efficient food systems.

In conclusion, the study suggests that the broader Albertans may not be fully accepting of a cricket-based snack for human consumption. However, the observed curiosity among participants indicates a potential avenue for ongoing education and familiarization efforts. Rather than focusing solely on human consumption, the study hints at the possibility of redirecting attention towards utilizing insects as feed. This dual approach acknowledges current preferences while capitalizing on existing curiosity, presenting an opportunity to gradually introduce and normalize the concept of insect consumption within the broader context of Alberta's cultural and dietary landscape.

Notably, the study suggests that Albertans might be more accepting of a cricket-based snack if the insect component is entirely invisible. The findings indicate that for non-entomophagic participants, the type of product played a crucial role in shaping preferences. This insight emphasizes the potential for innovative approaches, such as incorporating insects in a manner where their presence is imperceptible, to bridge the gap between consumer preferences and the integration of insect-based snacks into the dietary landscape of Alberta.

References

Abril, S., Pinzón, M., Hernández-Carrión, M., & Sánchez-Camargo, A. del P. (2022). Edible Insects in Latin America: A Sustainable Alternative for Our Food Security. *Frontiers in Nutrition*, *9*. https://www.frontiersin.org/articles/10.3389/fnut.2022.904812

AdalbaPro. (2023). *About—AdalbaPro—Effective nutrition for a healthy lifestyle and planet*. AdalbaPro. https://adalbapro.com/about-us/

Agri-News. (2022, December 5). *Alberta hay prices*. https://www.alberta.ca/agri-news-alberta-hay-prices

Ahmed, E., Fukuma, N., Hanada, M., & Nishida, T. (2021). Insects as Novel Ruminant Feed and a Potential Mitigation Strategy for Methane Emissions. *Animals*, *11*(9), 2648. https://doi.org/10.3390/ani11092648

Ahmed, E., & Nishida, T. (2023). Optimal Inclusion Levels of Cricket and Silkworm as Alternative Ruminant Feed: A Study on Their Impacts on Rumen Fermentation and Gas Production. *Sustainability*, *15*(2), 1415. https://doi.org/10.3390/su15021415

Almli, V. L., & Næs, T. (2018). Conjoint Analysis in Sensory and Consumer Science. In *Methods in Consumer Research, Volume 1* (pp. 485–529). Elsevier. https://doi.org/10.1016/B978-0-08-102089-0.00019-4

Altmann, B., Anders, S., Risius, A., & Morlein, D. (2022). Information effects on consumer preferences for alternative animal feedstuffs. *Food Policy*, *106*. https://doi.org/10.1016/j.foodpol.2021.102192

Ankamah-Yeboah, I., Jacobsen, J. B., & Olsen, S. B. (2018). Innovating out of the fishmeal trap: The role of insect-based fish feed in consumers' preferences for fish attributes. *British Food Journal*, *120*(10), 2395–2410. https://doi.org/10.1108/BFJ-11-2017-0604

Arena, E., Mazzaglia, A., Selvaggi, R., Pecorino, B., Fallico, B., Serranò, M., & Pappalardo, G. (2020). Exploring Consumer's Propensity to Consume Insect-Based Foods. Empirical Evidence from a Study in Southern Italy. *Applied System Innovation*, *3*(3), 38. https://doi.org/10.3390/asi3030038

Baker, M. A., Shin, J. T., & Kim, Y. W. (2016). An Exploration and Investigation of Edible Insect Consumption: The Impacts of Image and Description on Risk Perceptions and Purchase Intent. *Psychology and Marketing*, *33*(2), 94–112. edselc. https://doi.org/10.1002/mar.20847

Ballingall, A. (2014, June 6). Toronto organization bets on growing appetite for insects: Startup is creating bug farm kits for less wealthy food producers. *Toronto Star*, GT.1.

Barsics, F., Caparros Megido, R., Brostaux, Y., Barsics, C., Blecker, C., Haubruge, E., & Francis, F. (2017). Could new information influence attitudes to foods supplemented with edible insects? *British Food Journal*, *119*(9), 2027–2039. https://doi.org/10.1108/BFJ-11-2016-0541

Bartkowicz, J., & Babicz-Zielinska, E. (2020). Acceptance of bars with edible insects by a selected group of students from Tri-City, Poland. *Czech Journal Of Food Sciences*, *38*(3), 192–197. https://doi.org/10.17221/236/2019-CJFS

Barton, A., Richardson, C., & McSweeney, M. (2020). Consumer attitudes toward entomophagy before and after evaluating cricket (Acheta domesticus)-based protein powders. *Journal Of Food Science*, *85*(3), 781–788. https://doi.org/10.1111/1750-3841.15043

Bauer, J. M., van der Laan, L. N., Bruijn, G.-J. de, & Reisch, L. A. (2022). Battle of the primes – The effect and interplay of health and hedonic primes on food choice. *Appetite*, *172*, 105956. https://doi.org/10.1016/j.appet.2022.105956

Berger, S., Bärtsch, C., Schmidt, C., Christandl, F., & Wyss, A. M. (2018). When Utilitarian Claims Backfire: Advertising Content and the Uptake of Insects as Food. *Frontiers in Nutrition*, *5*, 88. https://doi.org/10.3389/fnut.2018.00088

Botonaki, A., Polymeros, K., Tsakiridou, E., & Mattas, K. (2006). The role of food quality certification on consumers' food choices. *British Food Journal*, *108*(2), 77–90. https://doi.org/10.1108/00070700610644906

Bourdrez, V., & Chriki, S. (2022). Nutritional and sensory qualities, and willingness to pay for meat alternatives: The case of plant-based alter- natives, "in vitro meat" and insects. *INRAE Productions Animales*, *35*(3), 217–235. https://doi.org/10.20870/productions-animales.2022.35.3.7265

Brito, T. P., de Souza-Esquerdo, V. F., & Borsatto, R. S. (2022). State of the art on research about organic certification: A systematic literature review. *Organic Agriculture*, *12*(2), 177–190. https://doi.org/10.1007/s13165-022-00390-6

Broeckhoven, I., Verbeke, W., Tur-Cardona, J., Speelman, S., & Hung, Y. (2021). Consumer valuation of carbon labeled protein-enriched burgers in European older adults. *Food Quality and Preference*, *89*, 104114. https://doi.org/10.1016/j.foodqual.2020.104114

Bryant, C. J., & Barnett, J. C. (2019). What's in a name? Consumer perceptions of in vitro meat under different names. *Appetite*, *137*, 104–113. https://doi.org/10.1016/j.appet.2019.02.021

Bugsolutely. (2023). *Bugsolutely*. Bugsolutely. https://www.bugsolutely.com/

Cabral, D., de Almeida, M. D. V., & Cunha, L. M. (2017). Food Choice Questionnaire in an African country – Application and validation in Cape Verde. *Food Quality and Preference*, *62*, 90–95. https://doi.org/10.1016/j.foodqual.2017.06.020

Campbell, Q. (2021, November 26). *Low grain yields in Alberta mean high grain prices will continue*. Global News. https://globalnews.ca/news/8327739/alberta-grain-prices/

Canadian Food Inspection Agency. (2021, September 27). *Edible insects: What to know before biting into bugs*. https://inspection.canada.ca/inspect-and-protect/food-safety/edible-insects/eng/1632237657892/1632245370544

Caparros Megido, R., Gierts, C., Blecker, C., Brostaux, Y., Haubruge, É., Alabi, T., & Francis, F. (2016). Consumer acceptance of insect-based alternative meat products in Western countries. *Food Quality and Preference*, *52*, 237–243. https://doi.org/10.1016/j.foodqual.2016.05.004

Caparros Megido, R., Sablon, L., Geuens, M., Brostaux, Y., Alabi, T., Blecker, C., Drugmand, D., Haubruge, É., & Francis, F. (2014). Edible Insects Acceptance by Belgian Consumers: Promising Attitude for Entomophagy Development: Could Belgian Consumers Accept Edible Insects? *Journal of Sensory Studies*, *29*(1), 14–20. https://doi.org/10.1111/joss.12077

Carrillo, E., Varela, P., Salvador, A., & Fiszman, S. (2011). Main factors underlying consumers' food choice: A first step for the understanding of attitudes toward "healthy eating". *Journal of Sensory Studies*, *26*(2), 85–95. https://doi.org/10.1111/j.1745-459X.2010.00325.x

Castro, M., & Chambers, E. (2019). Consumer Avoidance of Insect Containing Foods: Primary Emotions, Perceptions and Sensory Characteristics Driving Consumers Considerations. *Foods*, *8*(8), 351. https://doi.org/10.3390/foods8080351

Chan, E. Y. (2019). Mindfulness and willingness to try insects as food: The role of disgust. *Food Quality and Preference*, *71*, 375–383. https://doi.org/10.1016/j.foodqual.2018.08.014

Circus, V. E., & Robison, R. (2019). Exploring perceptions of sustainable proteins and meat attachment. *British Food Journal*, *121*(2), 533–545. edselc. https://doi.org/10.1108/BFJ-01-2018-0025

CNS Canada. (2017, August 15). Feed Grains: Feed grain shortage starting to force early cattle sales. *The Western Producer*. https://www.producer.com/market_update/feed-grains-feed-grain-shortage-starting-to-force-early-cattle-sales/

Cox, D., & Evans, G. (2008). Construction and validation of a psychometric scale to measure consumers' fears of novel food technologies: The food technology neophobia scale. *Food Quality and Preference*, *19*, 704–710. https://doi.org/10.1016/j.foodqual.2008.04.005

CTV News. (2022, January 24). *Alberta cattle producers "stretching supplies" amid feed shortage*. CTV Edmonton Edmonton. https://edmonton.ctvnews.ca/alberta-cattle-producers-stretching-supplies-amid-feed-shortage-1.5752002

Damsbo-Svendsen, M., Frøst, M. B., & Olsen, A. (2017). Development of novel tools to measure food neophobia in children. *Appetite*, *113*, 255–263. https://doi.org/10.1016/j.appet.2017.02.035

de-Magistris, T., Pascucci, S., & Mitsopoulos, D. (2015). Paying to see a bug on my food How regulations and information can hamper radical innovations in the European Union. *British Food Journal*, *117*(6), 1777–1792. https://doi.org/10.1108/BFJ-06-2014-0222

Deroy, O., Reade, B., & Spence, C. (2015). The insectivore's dilemma, and how to take the West out of it. *Food Quality and Preference*, *44*, 44–55. https://doi.org/10.1016/j.foodqual.2015.02.007

Dimmell, M. (2021, August 17). *I 'Heart' Western Canadian Beef: Beef Industry in Western Canada | Canada West Foundation*. Canada West Foundation.

https://cwf.ca/research/publications/our-west-i-heart-western-canadian-beef-beef-industry-in-western-canada/

Dion-Poulin, A., Turcotte, M., Lee-Blouin, S., Perreault, V., Provencher, V., Doyen, A., & Turgeon, S. L. (2021). Acceptability of insect ingredients by innovative student chefs: An exploratory study. *International Journal of Gastronomy and Food Science*, *24*, 100362. https://doi.org/10.1016/j.ijgfs.2021.100362

Doi, H., & Mulia, R. N. (2021). Future Land Use for Insect Meat Production Among Countries: A Global Classification. *Frontiers in Nutrition*, *8*. https://www.frontiersin.org/articles/10.3389/fnut.2021.661056

D'Souza, C., Apaolaza, V., Hartmann, P., Brouwer, A. R., & Nguyen, N. (2021). Consumer acceptance of irradiated food and information disclosure – A retail imperative. *Journal of Retailing and Consumer Services*, *63*, 102699. https://doi.org/10.1016/j.jretconser.2021.102699

Duan, L., Hoang, J. A., Kothari, A., Eiwegger, T., & Vadas, P. (2020). Shellfish allergy is a risk factor for cricket anaphylaxis. *The Journal of Allergy and Clinical Immunology: In Practice*, *8*(7), 2396-2398.e1. https://doi.org/10.1016/j.jaip.2020.02.039

Dunlap, R. E., Van Liere, K. D., Mertig, A. G., & Jones, R. E. (2000). New Trends in Measuring Environmental Attitudes: Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale. *Journal of Social Issues*, *56*(3), 425–442. https://doi.org/10.1111/0022-4537.00176

Dunteman, A. N., & Lee, S. (2023). Consumer acceptance of reduced sodium white and multigrain bread: Impact of flavor enhancement and ingredient information on sample liking. *Journal of Food Science*, *88*(1), 417–429. https://doi.org/10.1111/1750-3841.16395

Dürr, J., & Ratompoarison, C. (2021). Nature's "Free Lunch": The Contribution of Edible Insects to Food and Nutrition Security in the Central Highlands of Madagascar. *Foods*, *10*(12), 2978. https://doi.org/10.3390/foods10122978

Entomo Farms. (2023). *Home*. Entomo Farms. https://entomofarms.com/

Escobar-López, S. Y., Espinoza-Ortega, A., Lozano-Cabedo, C., Aguilar-Criado, E., & Amaya-Corchuelo, S. (2019). Motivations to consume ecological foods in alternative food networks (AFNs) in Southern Spain. *British Food Journal*, *121*(11), 2565–2577. https://doi.org/10.1108/BFJ-01-2019-0051

EXO. (2023). *EXO Protein*. https://exoprotein.com/

FAO. (2023). *Land Use*. https://www.fao.org/faostat/en/#data/RL

Ferrer Llagostera, P., Kallas, Z., Reig, L., & Amores De Gea, D. (2019). The use of insect meal as a sustainable feeding alternative in aquaculture: Current situation, Spanish consumers' perceptions and willingness to pay. *Journal of Cleaner Production*, *229*, 10–21. https://doi.org/10.1016/j.jclepro.2019.05.012

Finke, M. D. (2015). Complete nutrient content of four species of commercially available feeder insects fed enhanced diets during growth. *Zoo Biology*, *34*(6), 554–564. https://doi.org/10.1002/zoo.21246

Flore, R., Halloran, A., Roos, N., & Vantomme, P. (Eds.). (2018). *Edible Insects in Sustainable Food Systems* (1st ed. 2018). Springer International Publishing : Imprint: Springer. https://doi.org/10.1007/978-3-319-74011-9

Garofalo, C., Milanović, V., Cardinali, F., Aquilanti, L., Clementi, F., & Osimani, A. (2019). Current knowledge on the microbiota of edible insects intended for human consumption:

A state-of-the-art review. *Food Research International*, *125*, 108527. https://doi.org/10.1016/j.foodres.2019.108527

Giotis, T., & Drichoutis, A. C. (2021). Consumer acceptance and willingness to pay for direct and indirect entomophagy. *Q Open*, *1*(2), qoab015. https://doi.org/10.1093/qopen/qoab015

Gmuer, A., Nuessli Guth, J., Hartmann, C., & Siegrist, M. (2016). Effects of the degree of processing of insect ingredients in snacks on expected emotional experiences and willingness to eat. *Food Quality and Preference*, *54*, 117–127. https://doi.org/10.1016/j.foodqual.2016.07.003

Gómez-Luciano, C. A., Rondón Domínguez, F. R., Vriesekoop, F., & Urbano, B. (2022). Consumer Acceptance of Insects as Food: Revision of Food Neophobia Scales. *Journal of International Food & Agribusiness Marketing*, *34*(3), 305–319. https://doi.org/10.1080/08974438.2021.1889733

GregReese. (2018). *Salted drink chips*. Pixabay. https://pixabay.com/id/photos/asin-minuman-keping-tortila-3258237/

Gumussoy, M., Macmillan, C., Bryant, S., Hunt, D. F., & Rogers, P. J. (2021). Desire to eat and intake of 'insect' containing food is increased by a written passage: The potential role of familiarity in the amelioration of novel food disgust. *Appetite*, *161*, 105088. https://doi.org/10.1016/j.appet.2020.105088

Gurdian, C. E., Torrico, D. D., Li, B., & Prinyawiwatkul, W. (2022). Effects of Tasting and Ingredient Information Statement on Acceptability, Elicited Emotions, and Willingness to Purchase: A Case of Pita Chips Containing Edible Cricket Protein. *Foods*, *11*(3), 337. https://doi.org/10.3390/foods11030337

Gurdian, C. E., Torrico, D. D., Li, B., Tuuri, G., & Prinyawiwatkul, W. (2021). Effect of Disclosed Information on Product Liking, Emotional Profile, and Purchase Intent: A Case of Chocolate Brownies Containing Edible-Cricket Protein. *Foods*, *10*(8), Article 8. https://doi.org/10.3390/foods10081769

Ha, K. O. (2021). Coming Soon: Faux-Meat Burgers Made From Maggots and Mealworms. *Bloomberg.Com*, N.PAG-N.PAG.

Haidt, J., McCauley, C., & Rozin, P. (1994). Individual differences in sensitivity to disgust: A scale sampling seven domains of disgust elicitors. *Personality and Individual Differences*, *16*(5), 701–713. https://doi.org/10.1016/0191-8869(94)90212-7

Hallman, W. K., & Hallman, W. K. (2021). A comparison of cell-based and cell-cultured as appropriate common or usual names to label products made from the cells of fish. *Journal of Food Science*, *86*(9), 3798–3809. https://doi.org/10.1111/1750-3841.15860

Hartmann, C., & Siegrist, M. (2016). Becoming an insectivore: Results of an experiment. *Food Quality and Preference*, *51*, 118–122. https://doi.org/10.1016/j.foodqual.2016.03.003

Hartmann, C., & Siegrist, M. (2018). Development and validation of the Food Disgust Scale. *Food Quality and Preference*, *63*, 38–50. https://doi.org/10.1016/j.foodqual.2017.07.013

Henn, K., Reinbach, H. C., Olsen, S. B., Aaslyng, M. D., Laugesen, S. M. B., & Bredie, W. L. P. (2023). Health versus environmental benefits: Does additional information influence consumer acceptance of pulse-based spreads? *Journal of Food Science*, *88*(3), 1144–1158. https://doi.org/10.1111/1750-3841.16471

Herliatika, A., Permatahati, D., Pujiawati, Y., Tresia, G. E., & Wina, E. (2021). Utilization of Cricket (Gryllus bimaculatus), Black Soldier Fly (Hermetia illucens), Mealworm (Tenebrio molitor), and Silkworm (Samia ricini dan Bombyx mori) as Alternative Feed

Protein Sources. *Indonesian Bulletin of Animal and Veterinary Sciences*, *31*(4), 185. https://doi.org/10.14334/wartazoa.v31i4.2889

Higa, J. E., Ruby, M. B., & Rozin, P. (2021). Americans' acceptance of black soldier fly larvae as food for themselves, their dogs, and farmed animals. *Food Quality and Preference*, *90*, 104119. https://doi.org/10.1016/j.foodqual.2020.104119

Ho, I., Gere, A., Chy, C., & Lammert, A. (2022). Use of Preference Analysis to Identify Early Adopter Mind-Sets of Insect-Based Food Products. *Sustainability*, *14*(3), 1435. https://doi.org/10.3390/su14031435

Hoek, A. C., Elzerman, J. E., Hageman, R., Kok, F. J., Luning, P. A., & Graaf, C. de. (2013). Are meat substitutes liked better over time? A repeated in-home use test with meat substitutes or meat in meals. *Food Quality and Preference*, *28*(1), 253–263. https://doi.org/10.1016/j.foodqual.2012.07.002

Iannuzzi, E., Sisto, R., & Nigro, C. (2019). The willingness to consume insect-based food: An empirical research on Italian consumers. *Agricultural Economics*, *65*(10), 454–462. https://doi.org/10.17221/87/2019-AGRICECON

Janssen, M., & Hamm, U. (2012). Product labelling in the market for organic food: Consumer preferences and willingness-to-pay for different organic certification logos. *Food Quality and Preference*, *25*(1), 9–22. https://doi.org/10.1016/j.foodqual.2011.12.004

Januszewska, R., Pieniak, Z., & Verbeke, W. (2011). Food choice questionnaire revisited in four countries. Does it still measure the same? *Appetite*, *57*(1), 94–98. https://doi.org/10.1016/j.appet.2011.03.014

Jensen, N. H., & Lieberoth, A. (2019). We will eat disgusting foods together – Evidence of the normative basis of Western entomophagy-disgust from an insect tasting. *Food Quality and Preference*, *72*, 109–115. https://doi.org/10.1016/j.foodqual.2018.08.012

Jones, V. (2020). 'Just don't tell them what's in it': Ethics, edible insects and sustainable food choice in schools. *British Educational Research Journal*, *46*(4), 894–908. https://doi.org/10.1002/berj.3655

Jones, V., & Beynon, S. (2021). Edible insects: Applying Bakhtin's carnivalesque to understand how education practices can help transform young people's eating habits. *Children's Geographies*, *19*(1), 13–23. https://doi.org/10.1080/14733285.2020.1718608

Khaemba, C. N., Kidoido, M. M., Owuor, G., & Tanga, C. M. (2022). Consumers' perception towards eggs from laying hens fed commercial black soldier fly (Hermetia illucens) larvae meal-based feeds. *Poultry Science*, *101*(3), 101645. https://doi.org/10.1016/j.psj.2021.101645

Kim, T.-K., Yong, H. I., Kim, Y.-B., Kim, H.-W., & Choi, Y.-S. (2019). Edible Insects as a Protein Source: A Review of Public Perception, Processing Technology, and Research Trends. *Food Science of Animal Resources*, *39*(4), 521–540. https://doi.org/10.5851/kosfa.2019.e53

Kostecka, J., Konieczna, K., & Cunha, L. (2017). Evaluation Of Insect-Based Food Acceptance By Representatives Of Polish Consumers In The Context Of Natural Resources Processing Retardation. *Journal of Ecological Engineering*, *18*(2), 166–174. https://doi.org/10.12911/22998993/68301

La Barbera, F., Verneau, F., Amato, M., & Grunert, K. (2018). Understanding Westerners' disgust for the eating of insects: The role of food neophobia and implicit associations. *Food Quality and Preference*, *64*, 120–125. https://doi.org/10.1016/j.foodqual.2017.10.002

La Barbera, F., Verneau, F., Videbæk, P. N., Amato, M., & Grunert, K. G. (2020). A self-report measure of attitudes toward the eating of insects: Construction and validation of the Entomophagy Attitude Questionnaire. *Food Quality and Preference*, *79*, 103757. https://doi.org/10.1016/j.foodqual.2019.103757

Labby, B. (2023, August 8). *Hot, dry summer leaves ranchers, farmers in southern Alberta with tough decisions*. CBC News. https://www.cbc.ca/news/canada/calgary/alberta-drought-hay-producers-1.6927341

Lagerkvist, C. J., Edenbrandt, A. K., Bolos, L. A., & Nayga, R. M. (2023). Consumer acceptance of aesthetically imperfect vegetables – The role of information framing and personal values: Evidence from the United States. *Food Quality and Preference*, *104*, 104737. https://doi.org/10.1016/j.foodqual.2022.104737

Lange, K. W., & Nakamura, Y. (2021). Edible insects as future food: Chances and challenges. *Journal of Future Foods*, *1*(1), 38–46. https://doi.org/10.1016/j.jfutfo.2021.10.001

Laureati, M., Proserpio, C., Jucker, C., & Savoldelli, S. (2016). New Sustainable Protein Sources: Consumers' Willingness To Adopt Insects As Feed And Food. *Italian Journal Of Food Science*, *28*(4), 652–668.

Lensvelt, E. J. S., & Steenbekkers, L. P. A. (2014). Exploring Consumer Acceptance of Entomophagy: A Survey and Experiment in Australia and the Netherlands. *Ecology of Food and Nutrition*, *53*(5), 543–561. https://doi.org/10.1080/03670244.2013.879865

Lippi, N., Predieri, S., Chieco, C., Daniele, G., Cianciabella, M., Magli, M., Maistrello, L., & Gatti, E. (2021). Italian Consumers' Readiness to Adopt Eggs from Insect-Fed Hens. *Animals*, *11*(11). https://doi.org/10.3390/ani11113278

Lombardi, A., Vecchio, R., Borrello, M., Caracciolo, F., & Cembalo, L. (2019). Willingness to pay for insect-based food: The role of information and carrier. *Food Quality and Preference*, *72*, 177–187. https://doi.org/10.1016/j.foodqual.2018.10.001

Lorini, C., Ricotta, L., Vettori, V., Del Riccio, M., Biamonte, M., & Bonaccorsi, G. (2021). Insights into the Predictors of Attitude toward Entomophagy: The Potential Role of Health Literacy: A Cross-Sectional Study Conducted in a Sample of Students of the University of Florence. *International Journal Of Environmental Research And Public Health*, *18*(10). https://doi.org/10.3390/ijerph18105306

Lou, X., & Li, L. M. W. (2023). The relationship of environmental concern with public and private pro-environmental behaviours: A pre-registered meta-analysis. *European Journal of Social Psychology*, *53*(1), 1–14. https://doi.org/10.1002/ejsp.2879

Mancini, S., Moruzzo, R., Riccioli, F., & Paci, G. (2019). European consumers' readiness to adopt insects as food. A review. *Food Research International*, *122*, 661–678. https://doi.org/10.1016/j.foodres.2019.01.041

Mancini, S., Sogari, G., Menozzi, D., Nuvoloni, R., Torracca, B., Moruzzo, R., & Paci, G. (2019). Factors Predicting the Intention of Eating an Insect-Based Product. *Foods*, *8*(7), 270. https://doi.org/10.3390/foods8070270

Marsola, C. D., Cunha, L. M., Carvalho-Ferreira, J. P., & da Cunha, D. T. (2020). Factors Underlying Food Choice Motives in a Brazilian Sample: The Association with

Socioeconomic Factors and Risk Perceptions about Chronic Diseases. *Foods*, *9*(8). https://doi.org/10.3390/foods9081114

Marty, L., Chambaron, S., Nicklaus, S., & Monnery-Patris, S. (2018). Learned pleasure from eating: An opportunity to promote healthy eating in children? *Appetite*, *120*, 265–274. https://doi.org/10.1016/j.appet.2017.09.006

Maw, W., Sae-Eaw, A., Wongthahan, P., & Prinyawiwatkul, W. (2022). Consumers' emotional responses evoked by fermented rice noodles containing crickets and/or mango peel: Impact of product information and prior insect consumption. *International Journal Of Food Science And Technology*, *57*(9), 6226–6236. https://doi.org/10.1111/ijfs.15943

McFadden, J. R., & Huffman, W. E. (2017). Willingness-to-pay for natural, organic, and conventional foods: The effects of information and meaningful labels. *Food Policy*, *68*, 214–232. https://doi.org/10.1016/j.foodpol.2017.02.007

Menozzi, D., Sogari, G., Veneziani, M., Simoni, E., & Mora, C. (2017). Eating novel foods: An application of the Theory of Planned Behaviour to predict the consumption of an insect-based product. *Food Quality and Preference*, *59*, 27–34. https://doi.org/10.1016/j.foodqual.2017.02.001

Michaelsen, K. F., Dewey, K. G., Perez-Exposito, A. B., Nurhasan, M., Lauritzen, L., & Roos, N. (2011). Food sources and intake of n-6 and n-3 fatty acids in low-income countries with emphasis on infants, young children (6-24 months), and pregnant and lactating women: Sources and intake of fatty acids in low-income countries. *Maternal & Child Nutrition*, *7*, 124–140. https://doi.org/10.1111/j.1740-8709.2011.00302.x

Mishyna, M., Chen, J., & Benjamin, O. (2020). Sensory attributes of edible insects and insect-based foods – Future outlooks for enhancing consumer appeal. *Trends in Food Science & Technology*, *95*, 141–148. https://doi.org/10.1016/j.tifs.2019.11.016

Modlinska, K., Adamczyk, D., Goncikowska, K., Maison, D., & Pisula, W. (2020). The Effect of Labelling and Visual Properties on the Acceptance of Foods Containing Insects. *Nutrients*, *12*(9), 2498. https://doi.org/10.3390/nu12092498

Modlinska, K., Adamczyk, D., Maison, D., Goncikowska, K., & Pisula, W. (2021). Relationship between Acceptance of Insects as an Alternative to Meat and Willingness to Consume Insect-Based Food—A Study on a Representative Sample of the Polish Population. *Foods*, *10*(10), 2420. https://doi.org/10.3390/foods10102420

Moons, I., Barbarossa, C., & De Pelsmacker, P. (2018). The Determinants of the Adoption Intention of Eco-friendly Functional Food in Different Market Segments. *Ecological Economics*, *151*, 151–161. https://doi.org/10.1016/j.ecolecon.2018.05.012

Naranjo-Guevara, N., Fanter, M., Conconi, A., & Floto-Stammen, S. (2021). Consumer acceptance among Dutch and German students of insects in feed and food. *Food Science & Nutrition*, *9*(1), 414–428. https://doi.org/10.1002/fsn3.2006

Onwezen, M. C., Van Den Puttelaar, J., Verain, M. C. D., & Veldkamp, T. (2019). Consumer acceptance of insects as food and feed: The relevance of affective factors. *Food Quality and Preference*, *77*, 51–63. https://doi.org/10.1016/j.foodqual.2019.04.011

Orsi, L., Voege, L. L., & Stranieri, S. (2019). Eating edible insects as sustainable food? Exploring the determinants of consumer acceptance in Germany. *Food Research International*, *125*, 108573. https://doi.org/10.1016/j.foodres.2019.108573

Pambo, K. O., Okello, J. J., Mbeche, R. M., Kinyuru, J. N., & Alemu, M. H. (2018). The role of product information on consumer sensory evaluation, expectations, experiences and emotions of cricket-flour-containing buns. *Food Research International*, *106*, 532–541. https://doi.org/10.1016/j.foodres.2018.01.011

Paul, J., Modi, A., & Patel, J. (2016). Predicting green product consumption using theory of planned behavior and reasoned action. *Journal of Retailing and Consumer Services*, *29*, 123–134. https://doi.org/10.1016/j.jretconser.2015.11.006

Payne, C., Caparros Megido, R., Dobermann, D., Frédéric, F., Shockley, M., & Sogari, G. (2019). Insects as Food in the Global North – The Evolution of the Entomophagy Movement. In G. Sogari, C. Mora, & D. Menozzi (Eds.), *Edible Insects in the Food Sector* (pp. 11–26). Springer International Publishing. https://doi.org/10.1007/978-3-030-22522-3_2

Pelchat, M. L., & Pliner, P. (1995). "Try it. You'll like it". Effects of information on willingness to try novel foods. *Appetite*, *24*(2), 153–165. https://doi.org/10.1016/S0195-6663(95)99373-8

Penna, A. C. G., Portel, C. S., Pagani, M. M., Máralém, E. T., Silva, A. C. O., & Esmerino, E. A. (2021). Impact of food choice and consumption profile on the perception of food coloring on kefir labels: Insights of the projective technique of Product Personality Profiling. *Food Research International*, *150*, 110802. https://doi.org/10.1016/j.foodres.2021.110802

Pervez, M., & Manzoor, F. (2023). Role of Edible Insects as Food Source to Combat Food Security Challenges – Innovative and Traditional Approaches. In M. Haseeb Ahmad, M. Imran, & M. Kamran Khan (Eds.), *Sustainable Development* (Vol. 6). IntechOpen. https://doi.org/10.5772/intechopen.106809

Pham, T. H., Nguyen, T. N., Phan, T. T. H., & Nguyen, N. T. (2019). Evaluating the purchase behaviour of organic food by young consumers in an emerging market economy. *Journal of Strategic Marketing*, *27*(6), 540–556. https://doi.org/10.1080/0965254X.2018.1447984

Phesatcha, B., Phesatcha, K., Matra, M., & Wanapat, M. (2023). Cricket (Gryllus bimaculatus) meal pellets as a protein supplement to improve feed efficiency, ruminal fermentation and microbial protein synthesis in Thai native beef cattle. *Animal Bioscience*, *36*(9), 1384–1392. https://doi.org/10.5713/ab.23.0107

Pippinato, L., Gasco, L., Di Vita, G., & Mancuso, T. (2020). Current scenario in the European edible-insect industry: A preliminary study. *Journal of Insects as Food and Feed*, *6*(4), 371–381. https://doi.org/10.3920/JIFF2020.0008

Placentino, U., Sogari, G., Viscecchia, R., De Devitiis, B., & Monacis, L. (2021). The New Challenge of Sports Nutrition: Accepting Insect Food as Dietary Supplements in Professional Athletes. *Foods*, *10*(5), 1117. https://doi.org/10.3390/foods10051117

Pliner, P., & Hobden, K. (1992). Development of a scale to measure the trait of food neophobia in humans. *Appetite*, *19*(2), 105–120. https://doi.org/10.1016/0195-6663(92)90014-W

Popoff, M., MacLeod, M., & Leschen, W. (2017). Attitudes towards the use of insect-derived materials in Scottish salmon feeds. *Journal of Insects as Food and Feed*, *3*(2), 131–138. https://doi.org/10.3920/JIFF2016.0032

Prescott, J., Young, O., O'Neill, L., Yau, N. J. N., & Stevens, R. (2002). Motives for food choice: A comparison of consumers from Japan, Taiwan, Malaysia and New Zealand. *Food Quality and Preference*, *13*(7), 489–495. https://doi.org/10.1016/S0950-3293(02)00010-1

Ramos-Elorduy, J. (2000). La etnoentomología actual en México en la alimentación humana, en la medicina tradicional y en el reciclaje y alimentación animal. *Memorias Del XXXV Congreso Nacional de Entomología*, 11–14.

Ramos-Elorduy, J., Landero-Torres, I., Murguía-González, J., & Pino M, J. M. (2008). Biodiversidad antropoentomofágica de la región de Zongolica, Veracruz, México. *Revista de Biología Tropical*, *56*(1), 303–316.

Rao, V. R. (2014). *Applied conjoint analysis* (University of Alberta - Internet Internet Access). Springer.

Renner, B., Sproesser, G., Strohbach, S., & Schupp, H. T. (2012). Why we eat what we eat. The Eating Motivation Survey (TEMS). *Appetite*, *59*(1), 117–128. https://doi.org/10.1016/j.appet.2012.04.004

Ribeiro, J. C., Gonçalves, A. T. S., Moura, A. P., Varela, P., & Cunha, L. M. (2022). Insects as food and feed in Portugal and Norway – Cross-cultural comparison of determinants of acceptance. *Food Quality and Preference*, *102*, 104650. https://doi.org/10.1016/j.foodqual.2022.104650

Ritchie, H. (2019, November 11). *Half of the world's habitable land is used for agriculture*. Our World in Data. https://ourworldindata.org/global-land-for-agriculture

Rizwan, M., Abbas, A., Xu, H., Ahmed, U. I., Qing, P., He, P., Iqbal, M. A., & Shahzad, M. A. (2022). Role of Nutrition Information in Acceptance and Willingness to Pay for Biofortified Cereal Food: Implications for Better Health and Sustainable Diet. *Nutrients*, *14*(16), 3352. https://doi.org/10.3390/nu14163352

Roininen, K., Lähteenmäki, L., & Tuorila, H. (1999). Quantification of Consumer Attitudes to Health and Hedonic Characteristics of Foods. *Appetite*, *33*(1), 71–88. https://doi.org/10.1006/appe.1999.0232

Rosa, C. D., Collado, S., & Profice, C. C. (2021). Measuring Brazilians' environmental attitudes: A systematic review and empirical analysis of the NEP scale. *Current Psychology*, *40*(3), 1298–1309. https://doi.org/10.1007/s12144-018-0061-y

Ros-Baró, M., Sánchez-Socarrás, V., Santos-Pagès, M., Bach-Faig, A., & Aguilar-Martínez, A. (2022). Consumers' Acceptability and Perception of Edible Insects as an Emerging Protein Source. *International Journal of Environmental Research and Public Health*, *19*(23), Article 23. https://doi.org/10.3390/ijerph192315756

Rovai, D., Michniuk, E., Roseman, E., Amin, S., Lesniauskas, R., Wilke, K., Garza, J., & Lammert, A. (2021). Insects as a sustainable food ingredient: Identifying and classifying early adopters of edible insects based on eating behavior, familiarity, and hesitation. *Journal of Sensory Studies*, *36*(5), e12681. https://doi.org/10.1111/joss.12681

Ruby, M. B., & Rozin, P. (2019). Disgust, sushi consumption, and other predictors of acceptance of insects as food by Americans and Indians. *Food Quality and Preference*, *74*, 155–162. https://doi.org/10.1016/j.foodqual.2019.01.013

Ruby, M. B., Rozin, P., & Chan, C. (2015). Determinants of willingness to eat insects in the USA and India. *Journal of Insects as Food and Feed*, *1*(3), 215–225. https://doi.org/10.3920/JIFF2015.0029

Rumbos, C. I., Mente, E., Karapanagiotidis, I. T., Vlontzos, G., & Athanassiou, C. G. (2021). Insect-Based Feed Ingredients for Aquaculture: A Case Study for Their Acceptance in Greece. *Insects*, *12*(7), 586. https://doi.org/10.3390/insects12070586

Rumpold, B. A., & Langen, N. (2019). Potential of enhancing consumer acceptance of edible insects via information. *Journal of Insects as Food and Feed*, *5*(1), 45–53. https://doi.org/10.3920/JIFF2018.0041

Rumpold, B. A., & Schlüter, O. K. (2013). Nutritional composition and safety aspects of edible insects. *Molecular Nutrition & Food Research*, *57*(5), 802–823. https://doi.org/10.1002/mnfr.201200735

Russell, P. S., & Knott, G. (2021). Encouraging sustainable insect-based diets: The role of disgust, social influence, and moral concern in insect consumption. *Food Quality and Preference*, *92*, 104187. https://doi.org/10.1016/j.foodqual.2021.104187

Ryu, J. P., Shin, J. T., Kim, J., & Kim, Y. W. (2017). Consumer preference for edible insect-containing cookies determined by conjoint analysis: An exploratory study of Korean consumers: Preferences for edible insect cookies. *Entomological Research*, *47*(2), 74–83. https://doi.org/10.1111/1748-5967.12203

SadiaK123. (2020). *Fried Cricket Food*. Pixabay. https://pixabay.com/id/photos/jangkrik-jangkrik-goreng-5554644/

Sal de Aquí. (2023). *Sal de Aqui*. Sal de aqui. https://www.saldeaqui.com/collections/sal-de-aqui

Schäufele, I., Barrera Albores, E., & Hamm, U. (2019). The role of species for the acceptance of edible insects: Evidence from a consumer survey. *British Food Journal*, *121*(9), 2190–2204. https://doi.org/10.1108/BFJ-01-2019-0017

Schouteten, J., De Steur, H., De Pelsmaeker, S., Lagast, S., Juvinal, J., De Bourdeaudhuij, I., Verbeke, W., & Gellynck, X. (2016). Emotional and sensory profiling of insect-, plant- and meat-based burgers under blind, expected and informed conditions. *Food Quality and Preference*, *52*, 27–31. https://doi.org/10.1016/j.foodqual.2016.03.011

Shahbandeh, M. (2023, August 30). *Worldwide sales of organic foods 2021*. Statista. https://www.statista.com/statistics/273090/worldwide-sales-of-organic-foods-since-1999/

Sharma, N., Saha, R., Sreedharan, V. R., & Paul, J. (2020). Relating the role of green self-concepts and identity on green purchasing behaviour: An empirical analysis. *Business Strategy and the Environment*, *29*(8), 3203–3219. https://doi.org/10.1002/bse.2567

Shi, H., Wang, S., & Zhao, D. (2017). Exploring urban resident's vehicular PM2.5 reduction behavior intention: An application of the extended theory of planned behavior. *Journal of Cleaner Production*, *147*, 603–613. https://doi.org/10.1016/j.jclepro.2017.01.108

Sogari, G., Dagevos, H., Amato, M., & Taufik, D. (2022). Consumer Perceptions and Acceptance of Insects As Feed and Food: Current Findings and Future Outlook. In L. Scaffardi & G. Formici (Eds.), *Novel Foods and Edible Insects in the European Union* (pp. 147–169). Springer International Publishing. https://doi.org/10.1007/978-3-031-13494-4_8

Sogari, G., Menozzi, D., & Mora, C. (2019). The food neophobia scale and young adults' intention to eat insect products. *International Journal of Consumer Studies*, *43*(1), 68–76. https://doi.org/10.1111/ijcs.12485

Sogari, G., Riccioli, F., Moruzzo, R., Menozzi, D., Tzompa Sosa, D. A., Li, J., Liu, A., & Mancini, S. (2023). Engaging in entomophagy: The role of food neophobia and disgust between insect and non-insect eaters. *Food Quality and Preference*, *104*, 104764. https://doi.org/10.1016/j.foodqual.2022.104764

Sogari, Giovanni, Liu, Aijun, & Li, Jie. (2019). Understanding Edible Insects as Food in Western and Eastern Societies. In P. Ordóñez de Pablos (Ed.), *Environmental, Health, and Business Opportunities in the New Meat Alternatives Market:* IGI Global. https://doi.org/10.4018/978-1-5225-7350-0

Spartano, S., & Grasso, S. (2021). UK consumers' willingness to try and pay for eggs from insect-fed hens. *Future Foods*, *3*, 100026. https://doi.org/10.1016/j.fufo.2021.100026

SPCA. (2018, November 5). *Livestock Feed in Short Supply in Many Parts of Alberta*. Alberta SPCA. https://www.albertaspca.org/livestock-feed-in-short-supply-in-many-parts-of-alberta/

Statistics Canada. (2017, May 10). *Alberta has the most beef cattle in Canada and the second largest total farm area*. https://www150.statcan.gc.ca/n1/pub/95-640-x/2016001/article/14808-eng.htm

Statistics Canada. (2021, July 29). *Analysis of the beef supply chain*. https://www150.statcan.gc.ca/n1/pub/18-001-x/18-001-x2021002-eng.htm

Statistics Canada. (2022, November 22). *Growing and raising costs for farmers*. https://www.statcan.gc.ca/o1/en/plus/2413-growing-and-raising-costs-farmers

Steptoe, A., Pollard, T. M., & Wardle, J. (1995). Development of a Measure of the Motives Underlying the Selection of Food: The Food Choice Questionnaire. *Appetite*, *25*(3), 267–284. https://doi.org/10.1006/appe.1995.0061

Szczepanski, L., Dupont, J., Schade, F., Hellberg, H., Buscher, M., & Fiebelkorn, F. (2022). Effectiveness of a teaching unit on the willingness to consume insect-based food—An intervention study with adolescents from Germany. *Frontiers in Nutrition*, *9*. https://doi.org/10.3389/fnut.2022.889805

Szendro, K., Nagy, M., & Toth, K. (2020). Consumer Acceptance of Meat from Animals Reared on Insect Meal as Feed. *Animals*, *10*(8). https://doi.org/10.3390/ani10081312

Tan, H. S. G., Stieger, M., Steenbekkers, L. P. A., Fischer, A. R. H., van Trijp, H. C. M., & Tinchan, P. (2015). Insects as food: Exploring cultural exposure and individual experience

as determinants of acceptance. *Food Quality and Preference*, *42*, 78–89. edselc. https://doi.org/10.1016/j.foodqual.2015.01.013

Tan, H. S. G., Stieger, M., & van den Berg, E. (2016). The influence of product preparation, familiarity and individual traits on the consumer acceptance of insects as food. *Food Quality and Preference*, *52*, 222–231. edselc. https://doi.org/10.1016/j.foodqual.2016.05.003

The Canadian Centre for Food Integrity. (2022). *2022 Public Trust Research*. The Canadian Centre for Food Integrity. https://www.foodintegrity.ca/wp-content/uploads/2022/10/2022-ENG-Public-Trust-Research-Report.pdf

The Centre for Food Integrity. (2018). *A Dangerous Food Disconnect: When Consumers Hold You Responsible But Don't Trust You*. The Centre for Food Integrity; 08/16/2023. https://www.foodintegrity.org/wp-content/uploads/2018/01/CFI_Research_8pg_010918_final_web_REV2-1.pdf

Thøgersen, J., Pedersen, S., & Aschemann-Witzel, J. (2019). The impact of organic certification and country of origin on consumer food choice in developed and emerging economies. *Food Quality and Preference*, *72*, 10–30. https://doi.org/10.1016/j.foodqual.2018.09.003

Trakman, G. L., Forsyth, A., Hoye, R., & Belski, R. (2018). Development and validation of a brief general and sports nutrition knowledge questionnaire and assessment of athletes' nutrition knowledge. *Journal of the International Society of Sports Nutrition*, *15*(1), 17. https://doi.org/10.1186/s12970-018-0223-1

Tuccillo, F., Marino, M., & Torri, L. (2020). Italian consumers' attitudes towards entomophagy: Influence of human factors and properties of insects and insect-based food. *Food Research International*, *137*. https://doi.org/10.1016/j.foodres.2020.109619

United Nations. (2019). *World population prospects 2019: Highlights*. United Nations.

Van Der Weele, C., Feindt, P., Jan Van Der Goot, A., Van Mierlo, B., & Van Boekel, M. (2019). Meat alternatives: An integrative comparison. *Trends in Food Science & Technology*, *88*, 505–512. https://doi.org/10.1016/j.tifs.2019.04.018

Van Huis, A. (2013). *Edible insects: Future prospects for food and feed security*. Food and Agriculture Organization of the United Nations.

Van Huis, A. (2020a). Edible crickets, but which species? *Journal of Insects as Food and Feed*, *6*(2), 91–94. https://doi.org/10.3920/JIFF2020.x001

Van Huis, A. (2020b). Insects as food and feed, a new emerging agricultural sector: A review. *Journal of Insects as Food and Feed*, *6*(1), 27–44. https://doi.org/10.3920/JIFF2019.0017

Van Huis, A., Dicke, M., & van Loon, J. J. A. (2015). Insects to feed the world. *Journal of Insects as Food and Feed*, *1*(1), 3–5. https://doi.org/10.3920/JIFF2015.x002

Van Thielen, L., Vermuyten, S., Storms, B., Rumpold, B., & Van Campenhout, L. (2019). Consumer acceptance of foods containing edible insects in Belgium two years after their introduction to the market. *Journal of Insects as Food and Feed*, *5*(1), 35–44. https://doi.org/10.3920/JIFF2017.0075

Verain, M. C. D., Dagevos, H., & Jaspers, P. (2022). Flexitarianism in the Netherlands in the 2010 decade: Shifts, consumer segments and motives. *Food Quality and Preference*, *96*, 104445. https://doi.org/10.1016/j.foodqual.2021.104445

Verneau, F., Amato, M., & La Barbera, F. L. (2021). Edible Insects and Global Food Security. *Insects*, *12*(5), 472. https://doi.org/10.3390/insects12050472

Verneau, F., Zhou, Y., Amato, M., Grunert, K. G., & La Barbera, F. (2021). Cross-validation of the entomophagy attitude questionnaire (EAQ): A study in China on eaters and non-eaters. *Food Quality and Preference*, *87*, 104029. https://doi.org/10.1016/j.foodqual.2020.104029

Wang, O., & Scrimgeour, F. (2021). Willingness to adopt a more plant-based diet in China and New Zealand: Applying the theories of planned behaviour, meat attachment and food choice motives. *Food Quality and Preference*, *93*, 104294. https://doi.org/10.1016/j.foodqual.2021.104294

Wang, S., Li, J., & Zhao, D. (2018). Institutional Pressures and Environmental Management Practices: The Moderating Effects of Environmental Commitment and Resource Availability. *Business Strategy and the Environment*, *27*(1), 52–69. https://doi.org/10.1002/bse.1983

Wang, X., & Sun, Y. (2021). Theoretical Exploration of the New Environmental Paradigm Scale in China. *E3S Web of Conferences*, *251*, 02078. https://doi.org/10.1051/e3sconf/202125102078

Weinrich, R., & Busch, G. (2021). Consumer knowledge about protein sources and consumers? Openness to feeding micro-algae and insects to pigs and poultry. *Future Foods*, *4*. https://doi.org/10.1016/j.fufo.2021.100100

Weinrich, R., & Elshiewy, O. (2019). Preference and willingness to pay for meat substitutes based on micro-algae. *Appetite*, *142*. https://doi.org/10.1016/j.appet.2019.104353

Wendin, K. M., & Nyberg, M. E. (2021). Factors influencing consumer perception and acceptability of insect-based foods. *Current Opinion in Food Science*, *40*, 67–71. https://doi.org/10.1016/j.cofs.2021.01.007

Woolf, E., Maya, C., Yoon, J., Shertukde, S., Toia, T., Zhao, J., Zhu, Y., Peter, P. C., & Liu, C. (2021). Information and taste interventions for improving consumer acceptance of edible insects: A pilot study. *Journal of Insects as Food and Feed*, *7*(2), 129–139. https://doi.org/10.3920/JIFF2020.0057

Xie, B., Wang, L., Yang, H., Wang, Y., & Zhang, M. (2015). Consumer perceptions and attitudes of organic food products in Eastern China. *British Food Journal*, *117*(3), 1105–1121. https://doi.org/10.1108/BFJ-09-2013-0255

Xu, X., Sharma, P., Shu, S., Lin, T.-S., Ciais, P., Tubiello, F. N., Smith, P., Campbell, N., & Jain, A. K. (2021). Global greenhouse gas emissions from animal-based foods are twice those of plant-based foods. *Nature Food*, *2*(9), 724–732. https://doi.org/10.1038/s43016-021-00358-x

Youssef, J., & Spence, C. (2021). Introducing diners to the range of experiences in creative Mexican cuisine, including the consumption of insects. *International Journal of Gastronomy and Food Science*, *25*, 100371. https://doi.org/10.1016/j.ijgfs.2021.100371

Appendices

Appendix A. Survey questionnaire

Study title: Acceptance of cricket-based food products

Please read this information carefully. Feel free to contact the research team if you have any questions. We also encourage you to share the link to this survey with people that might be interested.

Research team
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Research study
The purpose of this survey is to determine the perceptions about cricket-based food products among the population of Alberta, Canada.

Survey information
In this survey we will ask for your opinion about descriptions of food products made with crickets. We will also ask questions about your personal views about the environment, health and food.
The findings of this study will be included in a master's degree thesis and a research paper.

Time commitment
The survey is estimated to take about 15 minutes to complete.

Voluntary participation
Participation in this study is completely voluntary. If you wish to participate, please select "I agree" on the next page. You are able to withdraw from the study at any time by exiting the survey, and your data will not be included in the analysis. You will not be able to withdraw from the study after clicking the "submit" button at the end of the survey as your participation is anonymous.

Risks and benefits
Participating in this survey has no costs to you and poses no reasonable, foreseeable risks. There are no direct benefits from completing the survey.

Compensation for participation
At the end of the survey you will have the opportunity to enter your email in a raffle to win 1 of 3 Amazon giftcards with a value of $25 CAD.

Anonymity and use of data
The data you provide are completely anonymous. Your answers will be kept confidential. All data will be collected using Compusense Cloud and stored in a password protected electronic format for at least 5 years. Compusense software complies with Canadian privacy laws and won't share any of your responses with third partys. Only the research team and the University of Alberta's Research Ethics Board will have access to the data. Your answers will only be used for research purposes.

Ethics Approval
The plan for this study has been reviewed by a Research Ethics Board at the University of Alberta (Pro00107828). If you have any questions regarding your rights as a research participant or how the research is being conducted you may contact the Research Ethics Office at 780-492-2615.

By selecting "I agree", I indicate that:
- I am over the age of 18.
- I have read and understood the information provided above.
- I consent to participate in the survey.

Do you agree to take part in this voluntary research study?

- ○ Yes
- ○ No

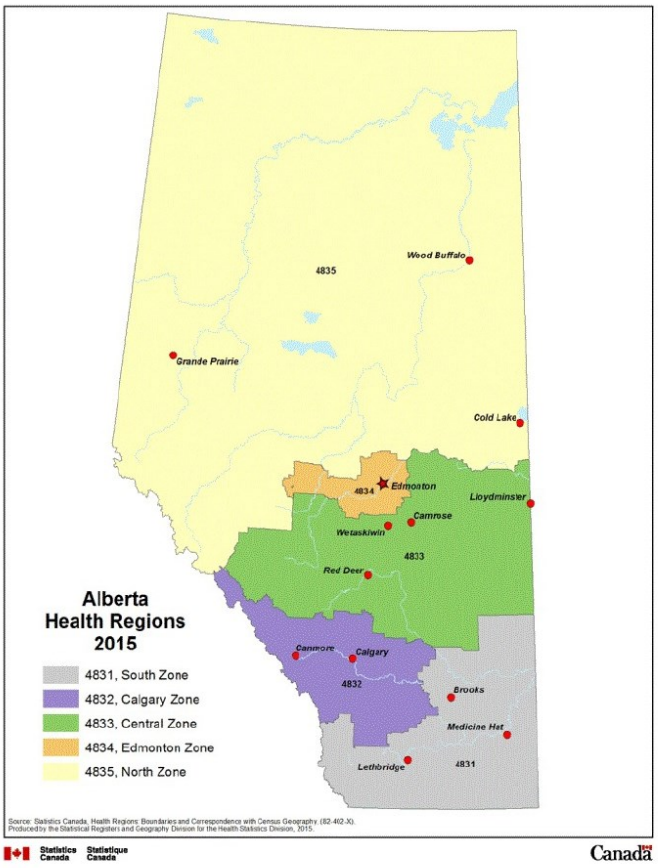
First we would like to ask you some questions about yourself.

Are you currently living in the province of Alberta, Canada?

- ○ Yes
- ○ No

Appendix A. (continued)

Which of the AHS regions do you live in?

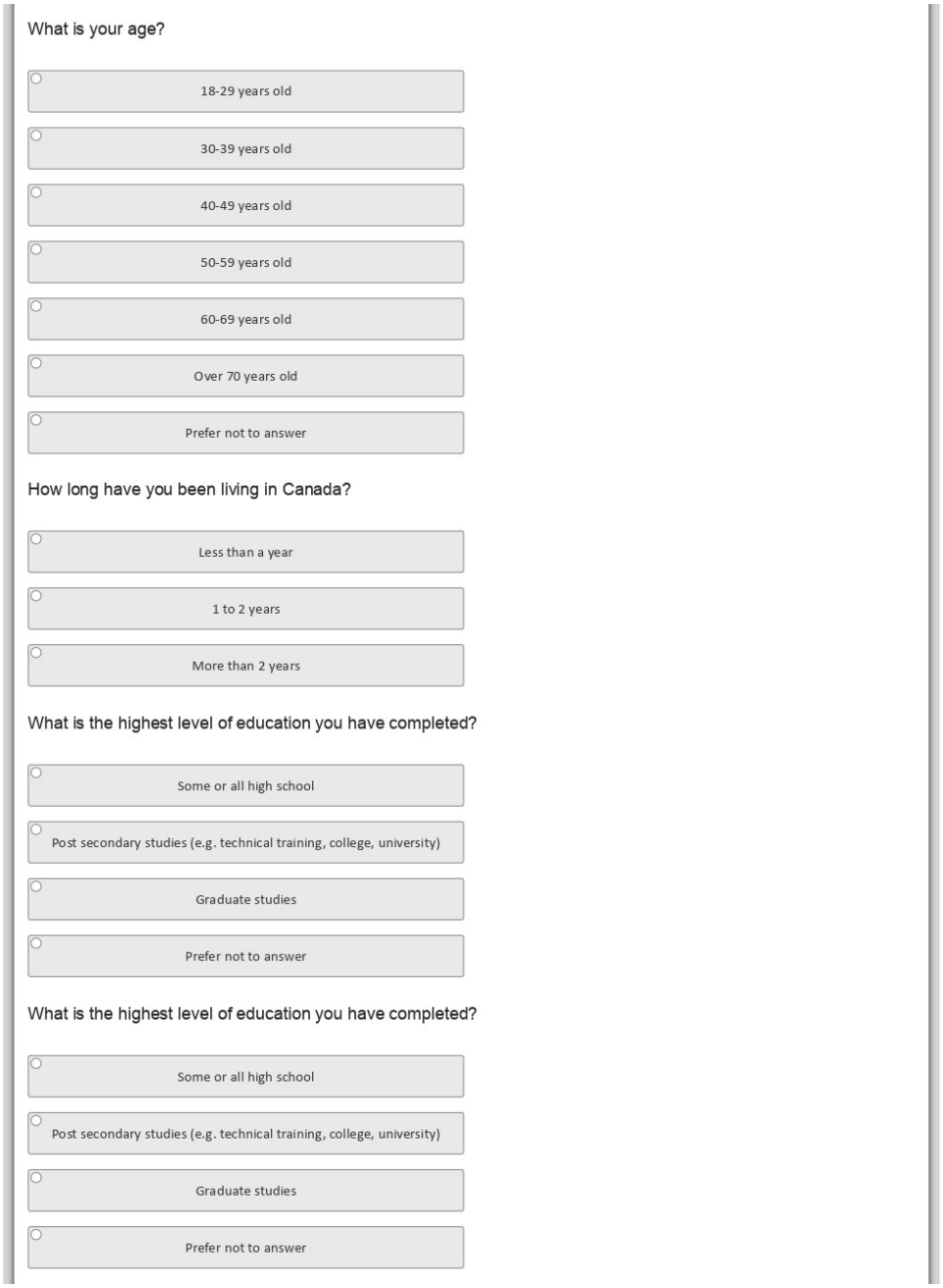


- South Zone
- Calgary Zone
- Central Zone
- Edmonton Zone
- North Zone

What gender do you identify as?

- Female
- Male
- Other
- Prefer not to answer

Appendix A. (continued)



Appendix A. (continued)

What is your annual household income (before taxes)?

- Less than $36,600
- $36,601 - $71,000
- $71,001 - $115,000
- More than $115,000
- Prefer not to answer

Have you eaten insect-based products at least once in the past? (e.g. roasted or raw insects, powders, snack bars, chips, use of insect flours)

- Yes
- No

You will be presented with descriptions of five products.

Please rate your **willingness to try** and **overall impression** for each.

Please look at the following product carefully and answer the questions.

What is your overall impression of this product?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Would you be willing to try this product?

- Yes
- No

Please indicate your agreement with the following statements by ticking one box for each statement.

It is important to me that the food that I eat on a typical day:

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Contains a lot of vitamins and minerals					
Keeps me healthy					
Is nutritious					
Is high in protein					
Is good for my skin, teeth, hair, nails, etc.					
Is high in fibre and roughage					

Appendix A. (continued)

Listed below are statements about the relationship between humans and the environment. For each one, please indicate how much you agree or disagree with each statement.

	Strongly disagree	Mildly disagree	Unsure	Mildly agree	Strongly agree
We are approaching the limit of the number of people the earth can support					
Humans have the right to modify the natural environment to suit their needs					
When humans interfere with nature it often produces disastrous consequences					
Human ingenuity will ensure that we do NOT make the earth unlivable					
Humans are severely abusing the environment					
The earth has plenty of natural resources if we just learn how to develop them					
Plants and animals have as much right as humans to exist					
The balance of nature is strong enough to cope with the impacts of modern industrial nations					
Despite our special abilities humans are still subject to the laws of nature					
The so-called "ecological crisis" facing humankind has been greatly exaggerated					
The earth is like a spaceship with very limited room and resources					
Humans were meant to rule over the rest of nature					
The balance of nature is very delicate and easily upset					
Humans will eventually learn enough about how nature works to be able to control it					
If things continue on their present course, we will soon experience a major ecological catastrophe					

Appendix A. (continued)

Please indicate your agreement with the following statements by ticking one box for each statement.

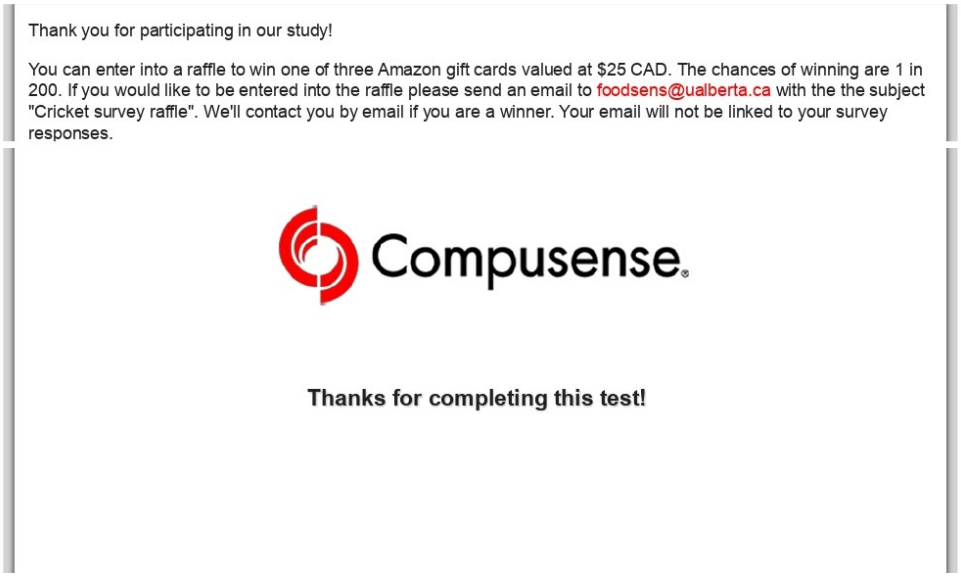
	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
I would be disgusted to eat any dish with insects.							
Thinking about the flavour that a bug might have sickens me.							
If I ate a dish and then came to know that there were insects among the ingredients, I would be disgusted.							
I would avoid eating a dish with insects among the ingredients, even if it was cooked by a famous chef.							
I would be bothered by finding dishes cooked with insects on a restaurant menu.							
I'd be curious to taste a dish with insects, if cooked well.							
In special circumstances, I might try to eat a dish of insects.							
At a dinner with friends I would try new foods prepared with insect flour.							
Using insects as feed is a good way of producing meat.							
I think it is fine to give insect-based feed to fish that are farmed for human consumption.							

You can use the space below to provide comments, if you wish.

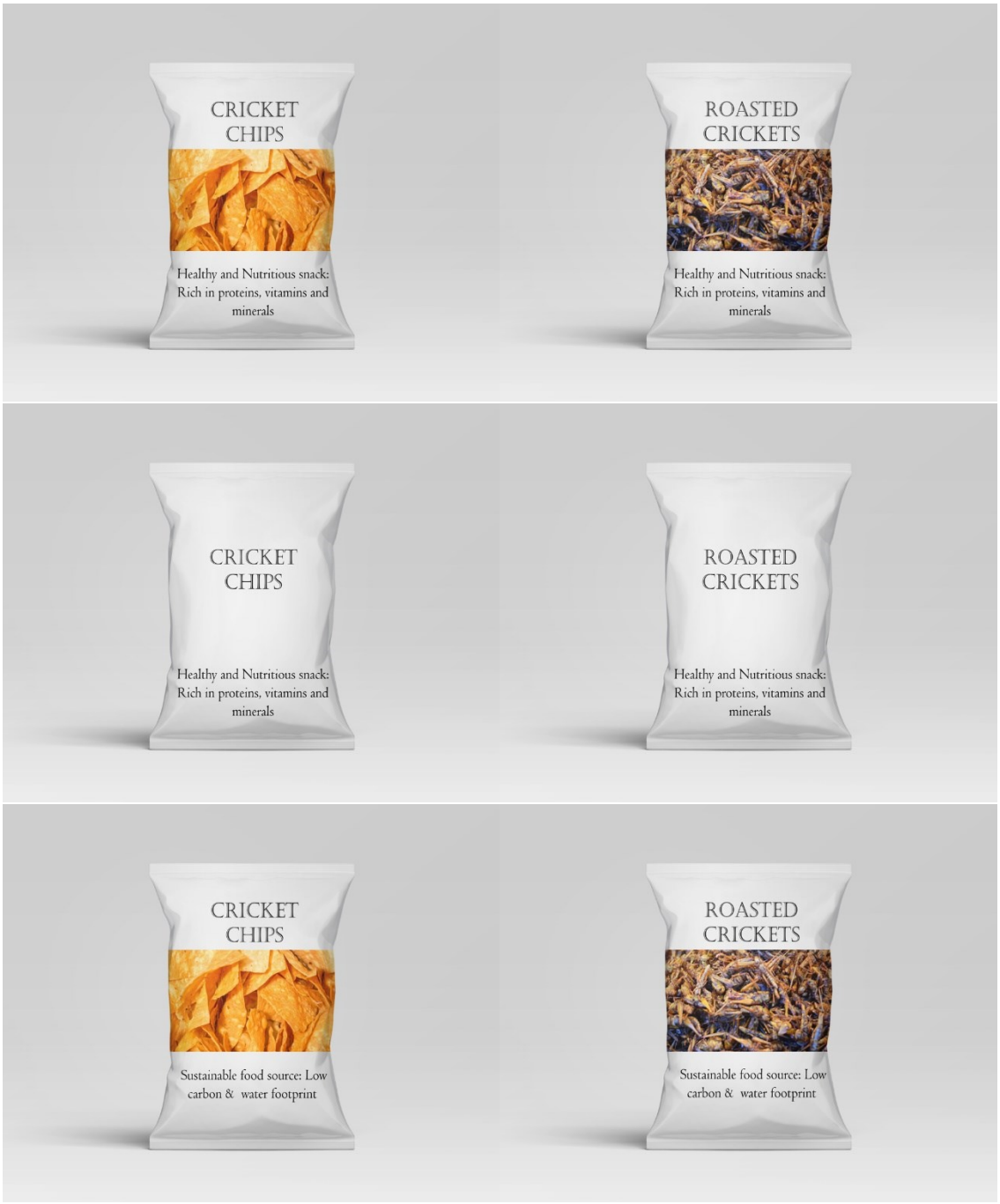
How did you hear about this study?

- ☐ Facebook
- ☐ Instagram
- ☐ Email
- ☐ Friends or family
- ☐ Posters
- ☐ Other

Appendix A. (continued)



Appendix B. Product profile images presented in the survey.



Appendix B. (continued)

Appendix B. (continued)

Appendix B. (continued)

Appendix C. Supplementary Table 1

Table S 1. Average utilities for the attributes and their levels of the cricket-based snacks.

Source	Minimum	Maximum	Mean	Std. deviation
Intercept	0.000	9.000	4.614	1.700
Product-chips	-6.500	5.500	0.851	1.229
Product-roasted	-5.500	6.500	-0.851	1.229
Image-no	-3.500	4.000	-0.085	1.015
Image-yes	-4.000	3.500	0.046	0.720
claim-food waste	0.000	0.000	0.000	0.000
claim-healthy	-6.000	4.000	-0.090	0.903
claim-organic	-3.000	5.000	0.047	0.545
claim-sustainable	0.000	0.000	0.000	0.000
claim-tasty	-1.500	2.333	0.057	0.313

Appendix D. Supplementary Figure 1

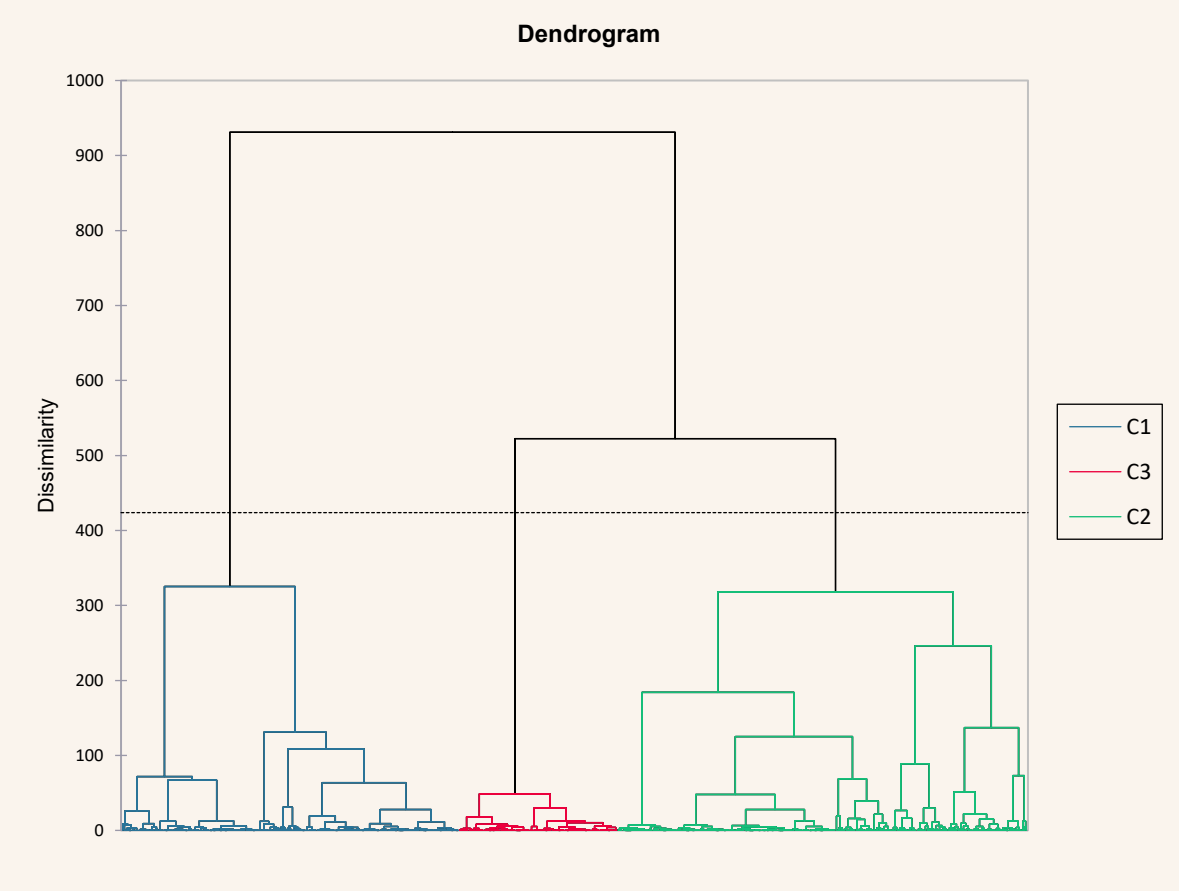


Figure S 1. Dendrogram illustrating the results of agglomerative hierarchical clustering, revealing the formation of three distinct clusters.

Appendix E. Supplementary figure 2

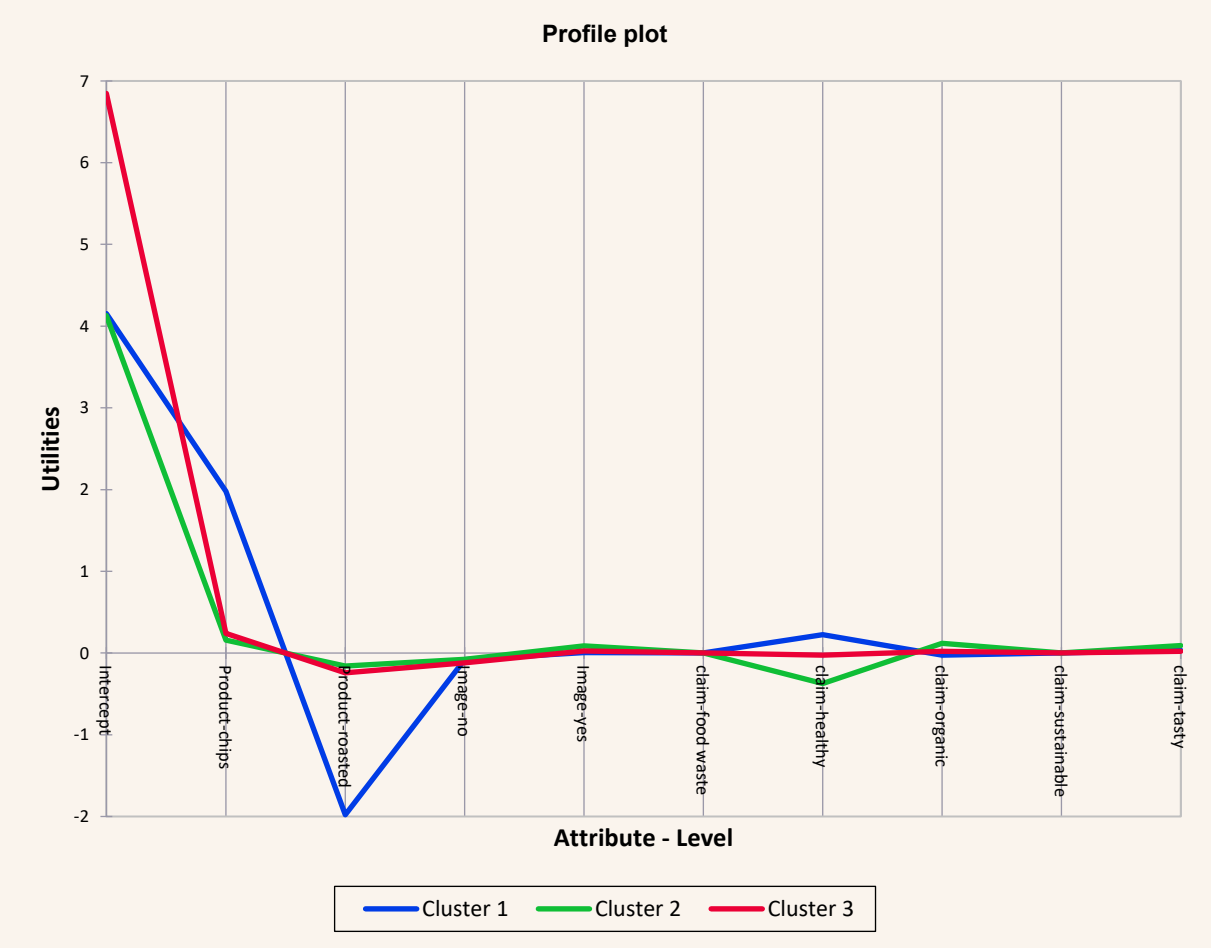


Figure S 2. Mean Utilities for each product attrbute level per participant cluster.