Insects as mini-livestock? A study of New Zealand attitudes toward insect consumption

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June 2019

REPORT FOR AgResearch

CLIENT REPORT NUMBER: RE450/2019/034

agresearch
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Contents

1. Executive Summary

There is evidence that insects may represent a more sustainable and healthy alternative food source to traditional meat consumption for Western nations (Deroyet al., 2015; Verkerk et al., 2007). However, consumer perceptions regarding insect consumption remain a key barrier to their popular uptake.

This study examines New Zealanders' perceptions about insects as food, whether they are perceived as a more environmentally friendly and healthy alternative to traditional meat, and whether people would be willing to eat them. This includes consumption of insects in different forms: whole, minimally processed (e.g. fried, covered in chocolate), processed into a prebiotic 'health capsule', or ground into a powder and added to traditional New Zealand foods. Key barriers to consumption (taste, texture, disgust) are also assessed, as well as preferences of native insects for consumption (e.g. black field cricket nymphs and huhu beetle grubs). Participants were asked about food neophobia (fear of new foods), and the extent to which they considered the health and environmental impacts of their diets, to assess how these variables relate to their attitudes about insect consumption.

A total of 1322 New Zealanders participated in the research via a Facebook-advertised link that redirected them to a survey hosted on the platform SurveyMonkey©. The sample consisted of 65% females, with the largest group of participants aged 26-35, and the median age being 35. The majority of participants identified as European (82.9%).

Results indicate that participants perceive insects for human consumption to have benefits, with over 60% agreeing that insects represent a more environmentally sustainable food source compared to beef, lamb, pork, or chicken. Approximately 10% reported that they were unsure. Participants were less certain about health benefits, with 37% agreeing that insects had benefits for human health and 30% being unsure. A majority - 67% - of participants reported that they would be most likely to eat insects if they were processed into a powder to add to existing foods. A secondary preference was for fried insects, with 56% reporting that they would consume insects processed in this way. When asked about an insect product specifically designed to include health benefits (e.g. for the gut), participants reported that they would be most likely to use a health capsule, such as a prebiotic (as opposed to protein powder, or other product).

With regard to preferences for different New Zealand insect species, participants reported a clear preference for 'crunchier' options, including black field cricket nymph and locust nymphs, followed by mānuka beetle adult. Participants were less likely to report that they

would eat huhu beetle grub, porina caterpillar, or wax moth larvae. All participants reported texture as the most significant barrier to consumption, regardless of age, gender, or diet (meat eaters or alternative diets including flexitarian, vegetarian, vegan, or pescatarian).

A series of demographic analyses were also undertaken to assess patterns within groups (age, gender and diet). It was found that females are more neophobic (less willing to try new food) and less willing to eat insects, which is consistent with the literature (Hartman, Shi, Giusto & Siegrist, 2015). Females also tended to rate barriers to insect consumption as stronger than males (including taste, the 'disgust' factor, food safety concerns, lack of familiarity and lack of perceived benefits). Men are more likely to consume insects, regardless of processing method. Those under the age of 35 are also more willing to eat insects, as are those who consume a diet containing meat. This is contradictory to the existing literature, which tends to find that those who eat meat are less likely to try meat alternatives, including insects (Verbeke, 2015).

These findings suggest that an insect product with clearly explained environmental and health benefits may be successful in the New Zealand market. It is recommended that this product incorporates insects in a form in which they are not easily recognisable, to reduce the aversion to the texture of insects and the 'disgust' factor. It is also recommended that insect products are not marketed as a 'meat alternative', but rather in their own distinct category. This will minimise expectations of comparison with meat products (taste, appearance, smell). Finally, rational arguments alone are unlikely to result in product consumption; the product needs to be appealing in its own right.

2. Background

The benefits of insect consumption are well documented in the literature. Relative to livestock, insects are a more sustainable and efficient food source, requiring minimum water and space (Deroy et al., 2015; Hartman et al., 2015; van Huis et al., 2013). Insects are also an excellent source of protein and healthy fats, with high levels of vitamins, minerals and essential amino acids (Verkerk et al., 2007). There is no evidence of an innate human aversion to insects (Bodenheimer, 1951 cited in Tan et al., 2015). Despite this, insects are not generally seen as appropriate or appealing food in Western societies (Deroy et al., 2015; Hartman et al., 2015; Sogari, Menozzi & Mora, 2017; Tan et al., 2016a). The underlying reasons are culturally and socially complex but tend to orient around psychological barriers such as disgust toward insects as food, poor presentation of insects as an appealing food choice, and lack of familiarity (Deroy et al., 2015; Hartman et al., 2015, Tan et al., 2016a). Many people in Western countries may associate insects with connotations of pests and disease transmission, due to this being a common way in which they are portrayed (Tan et al., 2015).

Research regarding entomophagy (human consumption of insects) among Western countries has increased dramatically in recent years (Tan et al., 2015; Verbeke, 2015). Researchers have argued that this is due to rapid population growth and environmental sustainability concerns, which have spurred a search for more sustainable food options (Tan, van den Berg & Stieger, 2016b; van Huis et al., 2013). Despite this increase in growing international body of research, there is little to no research regarding insect consumption in New Zealand. This report presents the results of a survey of New Zealanders' perceptions regarding human consumption of insects. This includes acceptability, palatability, barriers and enablers (factors increasing or reducing chance of consumption), and knowledge regarding insects for consumption.

This survey provides critical background information about the feasibility and likelihood of uptake of such products within the New Zealand context, which will be contingent on public attitudes toward entomophagy. This research is part of a broader project that investigates the potential of rearing endemic insects for human consumption, with the aim to develop products that contain insects and improve human gut health. Other components of the project examine the feasibility of mass rearing a variety of New Zealand insect species for consumption, and to establish a proof of concept that demonstrates how consuming insects can improve gut health in humans. This proof of concept will assist in identifying a potential market for insect-based products.

The results and recommendations from this report will therefore be framed in the context of the wider study's aim to improve the chances of a successful introduction of insect-based products to the New Zealand or international market.

3. Methods

3.1 Data collection

Data was collected via an online survey on the platform Survey Monkey©. The survey was promoted through paid advertising on AgResearch's accounts on social media platforms, include Facebook, Instagram and Twitter. Advertising occurred during late January and early February 2019, with the survey open for a total of 28 days. Participants were randomly selected and notified of the survey based on geographic distribution and other demographic traits such as gender. Participants then self-selected to complete the survey by clicking on the survey link.

Participants who completed the survey were offered the chance to enter into a prize draw to win one of ten $150 Visa Prezzy cards. All participants were required to provide their informed consent in order to complete the survey. Participants were informed of the purpose and scope of the survey, the expected duration for survey completion, that their participation was voluntary and that their responses would be anonymised. Ethical approval for this research was obtained through the AgResearch Human Ethics Committee.

3.2 Survey tool

The survey tool comprised of a total of seven broad categories of questions, including:

- Attitudes toward food (new foods, healthiness of foods);
- Perceptions of insects as an environmentally sustainable and healthy alternative to traditional protein sources;
- Preference of form of insects for consumption (e.g. whole, processed);
- Factors which are barriers to eating insects (e.g. taste, texture, disgust);
- Likelihood of consuming insects in various forms (e.g. whole insects, health capsule, protein powder);
- Preference of various New Zealand insects for consumption (see Table 1); and
- Demographics (age, gender, education, ethnicity, religious affiliation and diet).

These areas were broken down into 43 specific question items. All questions related to insect consumption were scored on a five-point Likert scale[1], measuring likelihood of performing a behaviour (e.g. consuming insects), extent (e.g. to which various factors were barriers to insect consumption) and agreement (e.g. about willingness to try new foods, and perceptions about the sustainability of insects for human consumption). The survey was constructed based on relevant literature and particular questions of interest relevant to the local context (e.g. candidate species for consumption in New Zealand).

Three specific scales/items were identified from the literature as areas of interest to investigate. Items for these three scales are included verbatim in Appendix 11.1.
Scales included:

1) Assessing attitudes toward the health characteristics of food (i.e. are participants concerned about the healthiness of the food they eat). Findings from the literature suggest that people who are concerned about the healthiness of the food they eat may be more willing to consume insects with known health benefits (e.g. high protein content, nutrients) (Hartmann et al., 2015; Sogari et al., 2017; Tan et al., 2015). Three items were used to assess concern about the healthiness of food, derived from the health interest scale developed by RoininenLahteenmaki and Tuorila (1999). These items were utilised by Verbeke (2015) to measure health interest in a study related to consumer willingness to try insects. Items were scored on a five-point scale and merged into one 'food health interest' score.
2) Food neophobia (i.e. willingness to try new foods). Fear of trying new foods was found to be strongly and negatively related to willingness to eat insects (Hartman et al., 2015; Verbeke, 2015). Likelihood of trying new foods that have not been consumed before was more strongly related to interest and disgust, as opposed to expected sensory experience (taste, texture, etc.) (Martins & Pliner, 2005). A total of six items from the food neophobia scale were used in this study, as developed by Pliner and Hobden (1992) and consistent with Verbeke (2015). These six items were selected by Ritchey et al. (2003) to be scored on a five-point scale and then merged into one 'food neophobia' score.
3) Attention to the environmental impact of food. Consumer attention to the environmental impact of food was found to be strongly and positively related to consumer willingness to include insects into their diet (Tan et al., 2015; Verbeke, 2015). Consistent with Verbeke (2015), one item based on a modified version of Roberts' (1996) scale measuring environmental concern was used and scored on a five-point scale.

[1] Likert scales are used to present people's attitudes or opinions regarding a topic, for example ranging from 'Strongly disagree', through 'Neutral', to 'Strongly agree'.

Further details regarding the insects selected for the survey are displayed in Table 1, including life cycle stage and whether species are native to New Zealand or introduced.

Table 1. Insect species used in consumer attitudes survey.

Common name	**Species**	**Order: Family**	**Stage**	**Origin**
Black field cricket	*Teleogryllus commodus*	Orthoptera: Gryllidae	Late instar nymph	Native*
Huhu beetle	*Prionoplus reticularis*	Coleoptera: Cerambycidae	Larva (or grub)	Native
Mānuka beetle	*Pyronota festiva*	Coleoptera: Scarabeidae	Adult	Native
Porina	*Wiseana cervinata*	Lepidoptera: Hepialidae	Larva (or caterpillar)	Native
Migratory locust	*Locusta migratoria*	Orthoptera: Acrididae	Nymph	Native*
Greater wax moth	*Galleria mellonella*	Lepidoptera: Pyralidae	Larva (or caterpillar)	Exotic

*Self-introduced.

At two points within the survey, participants were provided with visual aids to assist them with decision-making. When asked to rate the likelihood that they would consume insects in a range of different forms, participants were provided with example images of these forms, including whole insects cooked in a meal, chocolate-coated grasshoppers in packaging, powdered insects, and capsules containing a powdered substance. Participants were also provided with close-up images of the candidate insect species they were asked to consider eating, as displayed in Figure 1. These pictures served to provide participants with a clear and consistent construct of the processing method or insect in question. This approach was adopted because research suggests that detailed visual representation could play an important role in decision making when participants have limited individual experience with insect consumption (Tan et al., 2015; Trope,Liberman & Wakslak, 2007).

Figure 1. Pictorial aids used to depict candidate New Zealand insect species for consumption (from left to right: black field cricket nymph, huhu beetle grub, mānuka beetle adult, porina caterpillar, locust nymphs and wax moth larvae).

Participants were also provided with an 'intervention' part way through the survey; an educational description that informed them: "Studies have shown insects are more environmentally sustainable to farm than livestock, using less energy and resources. They are also considered to be a healthy option for human consumption, with high protein content, good fats and nutrients. Please keep this in mind while answering the following questions". This description was provided to participants after gathering their perceptions about the environmental sustainability of raising insects for human consumption and their perceived healthiness relative to alternative meat options. The purpose of providing this description was to increase participants' knowledge of the environmental and health benefits of insects before asking them whether they would consume insects in various forms and from various species. This method was utilised to mimic information consumers are likely to read on insect products, as this may influence the likelihood that they would be willing to consume them. This method of providing information about the benefits of insects prior to answering such questions has been used by van Huis et al. (2013) and Verbeke (2015).

3.3 Data analysis

Survey data was exported from Survey Monkey© and analysed using the statistical package SPSS. First, the reliability of the data was assessed by examining the internal reliability of each group of survey questions using Cronbach's alpha. These survey question groups included:

- Concerns for health, environment and food neophobia
- Perceptions of insects
- Preferred processing methods
- Preferred NEW ZEALAND species
- Barriers to consuming insects
- Preferred health products

The results of these analyses are provided in Appendix 11.2, where all indicated acceptable reliability. A factor analysis was also undertaken, to examine whether items on the three chosen sub-scales aligned correctly with the construct they were aiming to assess (food healthiness, environmental impact of food, and food neophobia). A principal components analysis was used with the Oblimin rotation method with Kaiser Normalisation.

A range of descriptive statistics were then gathered, including frequency distributions and mean scores for each question. Finally, further testing was undertaken to assess whether within and between group differences were statistically significant. Two types of tests were used to assess this: independent samples t-tests and Chi-Square tests. Appendix 11.3 describes which tests were used for individual variables and their results. The results of these tests (such as t-scores and p-values) are not described in the results section, only whether this difference was statistically significant and what this means.

4. Results and Discussion

A total of 1,415 participants entered the survey, with 1,412 providing their informed consent. Of these, 1,322 completed two or more questions within the survey (responses varied per question). As number of responses per question varied, the number of participants who answered each question will be displayed in brackets beside the associated results (e.g. n=1322). The survey had an 80% completion rate (based on the number of survey questions completed), with an average completion time of seven minutes.

4.1 Demographics

The sample consisted of 64.9% female and 32.8% male respondents, with 1.7% indicating other and 0.6% preferring not to disclose (n=1249). The skew toward female participants appeared to be an artefact of the sampling method used (social media). The participants ranged in age from the 16-25 bracket to 76+, with the largest group aged 26-35. This is slightly younger than the national average age of New Zealanders, which is 36.9 years (Statistics New Zealand, 2017a). The age distribution is shown in Figure 2.

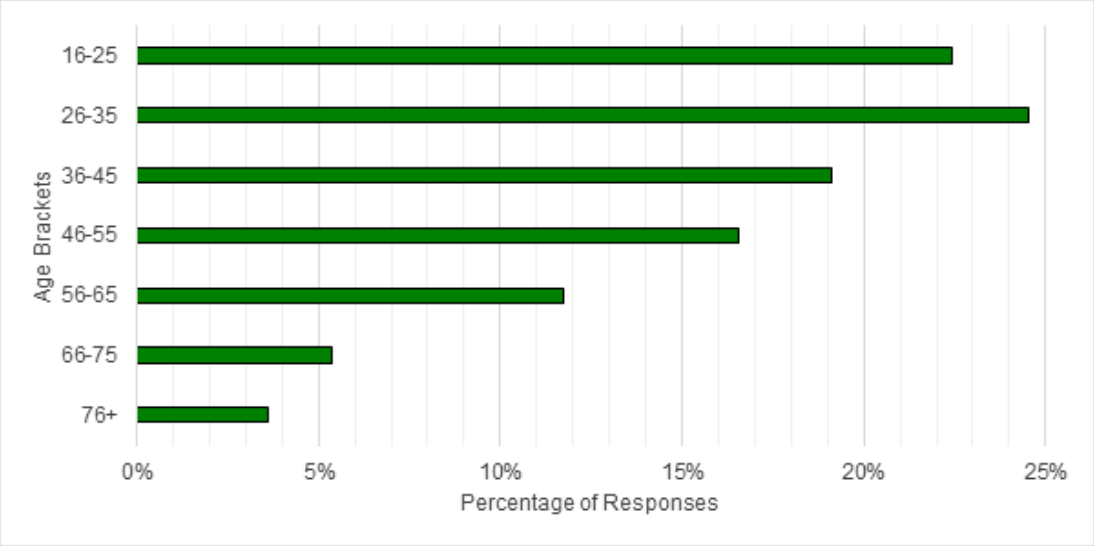

Figure 2. Age distribution of survey participants (n=1252).

The majority of participants identified as European (including Pākeha/New Zealand European), with 82.9% of participants selecting this ethnic category. The sample included other ethnicities, particularly Māori and Asian, as shown in Figure 3. This suggests that Māori are less represented in this sample than in the national population where 15.3% of New Zealanders identify as Maori (Statistics New Zealand, 2017b). Further research will be required to determine if and how this may have affected the results.

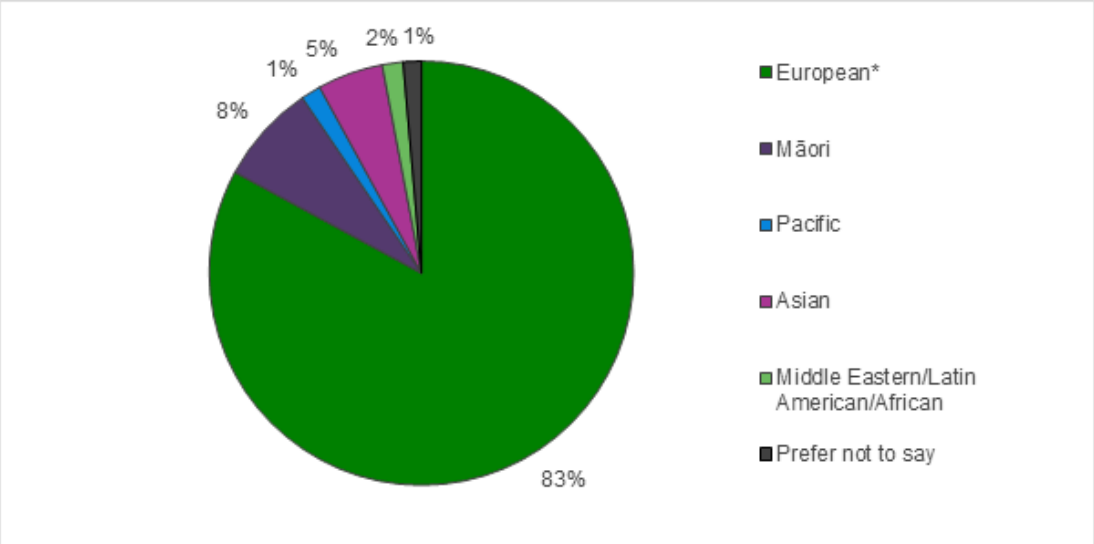

Figure 3. Ethnicity distribution of survey participants (n=1251). *European included Pākeha/New Zealand European.

The findings showed varying levels of education where over half of participants had completed some form of tertiary qualification (n=1250). From the sample, 20.1% of the participants had either started or completed High School, 17.3% had completed a Diploma, while 39.0% had completed a Bachelors degree, and 20.9% had competed a post-graduate qualification. A further 2% of the sample preferred not to disclose their level of education. This suggests that the sample had a higher level of formal education than the national population as a whole, where 26% have completed a Bachelor's degree or higher (Ministry of Education, 2019).

Participants also noted that they had a range of different diets. Regular meat consumption represented the highest proportion of diets, with 72.9% of participants indicating they were meat eaters. Comparatively, 26.5% of the participants indicated they have an alternative diet (vegan, vegetarian, flexitarian or pescatarian), and 0.6% of the sample preferred not to disclose their diets. A breakdown of diets is shown in Figure 4.

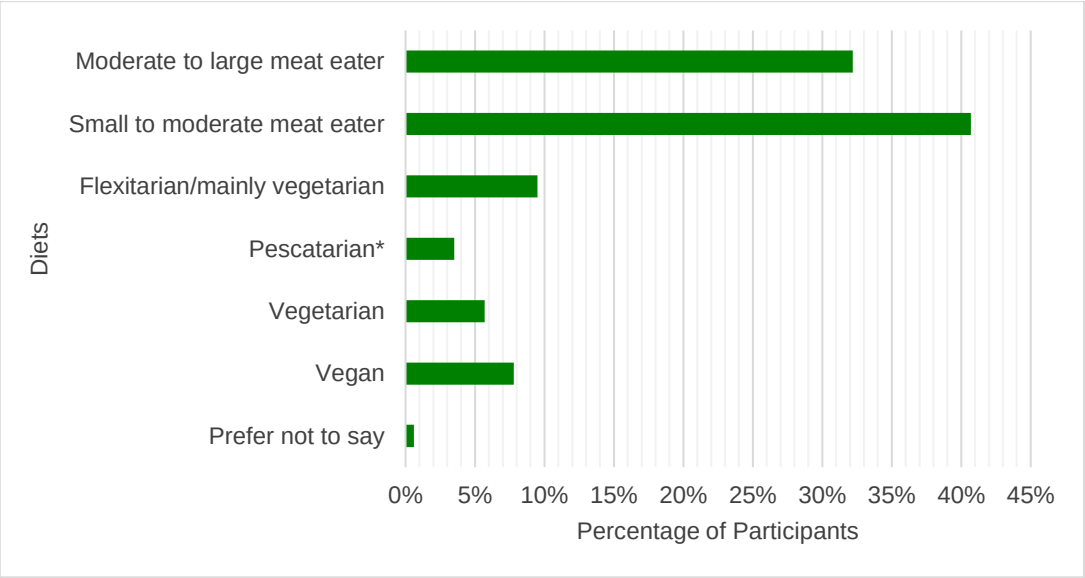

Figure 4. Dietary distribution of the survey sample, self-identified by participants (n=1252). *Pescatarian was described as a vegetarian apart from consuming fish.

4.2 General Findings

4.2.1 Concern about health, environment and food neophobia

For the 'food healthiness', 'environmental impact of food' and 'food neophobia' sub-scales which were included in the research, a factor analysis was undertaken, to assess whether the items were correctly aligning into the sub-scales. The results show there were three distinct factors that correctly align with the three types of groupings that will be assessed, as shown in Table 2.

Table 2. Structure matrix for principal component analysis.

	Component		
	1: Food healthiness	2: Environmental impact of food	3: Food neophobia
I am very particular about the healthiness of the food I eat	0.77		
The healthiness of food has little impact on my food choices	-0.78		
I eat what I like and I do not worry much about the healthiness of food	-0.80		
When I buy foods, I try to consider how my use of them will affect the environment		0.80	
I intend to reduce my meat consumption over the next year		0.80	

I am afraid to eat things I have never had before			-0.78
At dinner parties, I will try a new food			0.77
I don't trust new foods			-0.76
I will eat almost anything			0.73
I am constantly sampling new and different foods			0.64
If I don't know what is in a food, I won't try it			-0.63

Overall, participants indicated that they were concerned about the healthiness of food they ate, and this concern influenced their food choices. Participants agreed that they were particular about the healthiness of the food they ate, disagreeing with the two statements *"The healthiness of food has little impact on my food choices"* and *"I eat what I like and I do not worry much about the healthiness of food",* as shown in Figure 5. Across the three scale items, health interests had a mean factor score of 4.3 (out of 5), suggesting that participants are concerned about the healthiness of their food.

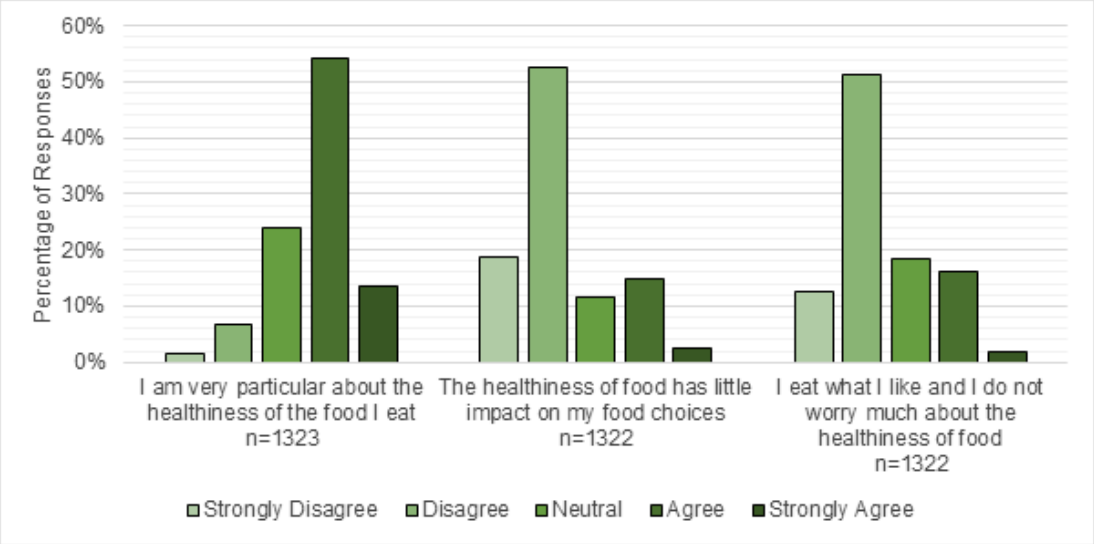

Figure 5. Participant level of agreement with statements related to concern about the healthiness of food, designed to measure 'health interest'.

Participants also indicated that they are interested in the environmental aspects of the food they purchase (Figure 6). Nearly half of participants (46.9%) agreed with the statement *"When buying food, I try to consider how my use of them will affect the environment"* with a further 17.4% strongly agreeing. Participants were then asked whether they intended to reduce their meat consumption within the next year. Over half the participants agreed that they did intend to reduce their consumption, with 30.1%

agreeing and 22.2% strongly agreeing (Figure 6). Overall, environmental interest had a mean factor score of 4.0 (out of 5), suggesting a high level of concern among participants about the environmental impact of their food choices.

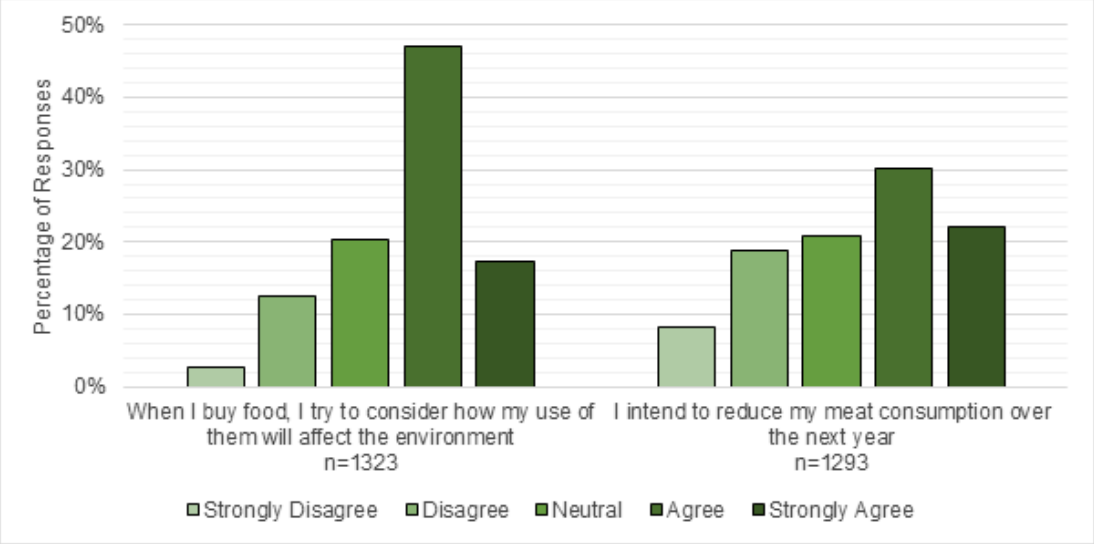

Figure 6. Participant level of agreement with statements related to concern about the environmental effects of food, designed to measure 'environmental interest'.

Food neophobia is another consideration that can impact food choices. The survey asked a series of questions to assess participants' willingness to eat new foods to establish how neophobic the sample was. Overall, the participants indicated that they are willing to try new foods, demonstrating a generally low level of food neophobia, as shown in Figure 7. The mean factor score for this sub-scale was 4.2 (out of 5). This suggests that New Zealanders may be relatively open to trying new foods, such as insects.

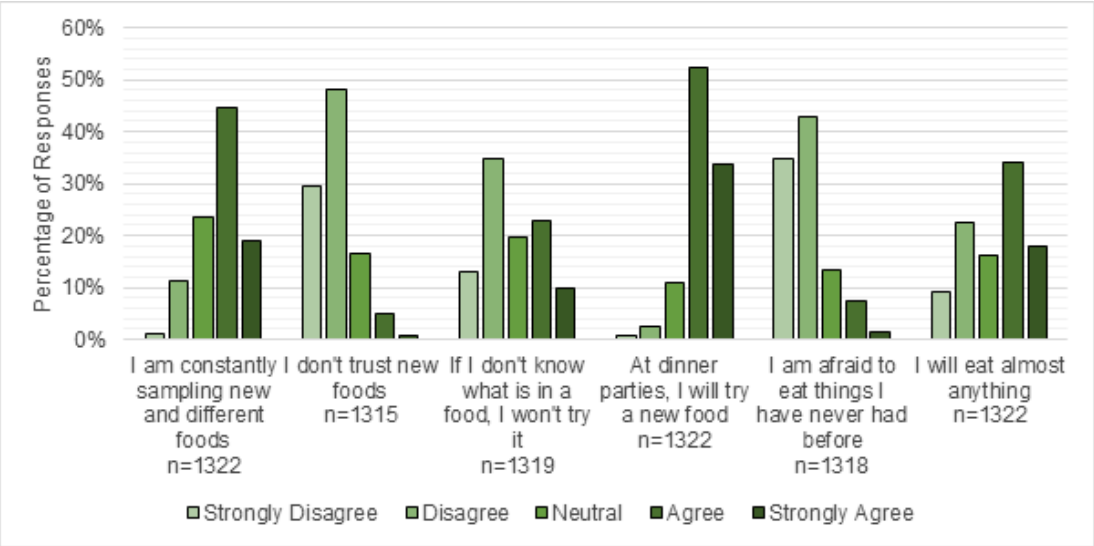

Figure 7. Participant level of agreement with statements related to concern about food neophobia, designed to measure 'willingness to try new food interest'.

Overall, participants in this research indicated that they were concerned about both the healthiness and environmental aspects of their food and reported being generally willing to sample new foods. This was particularly the case when they are out for dinner and when new food is being offered to them.

4.2.2 Perceptions regarding the benefits of insects

This study also assessed whether participants viewed insects as an environmentally sustainable source of food for human consumption, relative to traditional meat options. Over 60% of the sample perceived that there were positive environmental benefits of insects for human consumption, with 40.1% agreeing and 29.7% strongly agreeing that *"insects represent an environmentally sustainable source of food for human consumption".* Moreover, 34.0% agreed and 32.8% strongly agreed that *"Insects represent a more environmentally sustainable food for human consumption than meat that is commonly consumed, including beef, lamb, pork and chicken"* as shown in Figure 8.

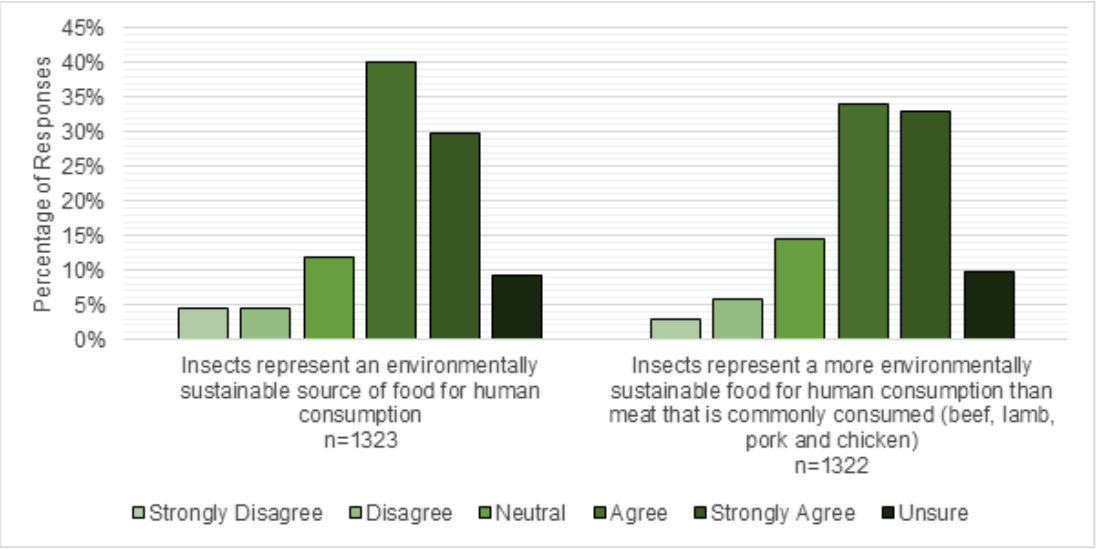

Figure 8. Participant level of agreement with statements related to the environmental sustainability benefits of insects.

Although participants were aware of the potential environmental benefits in insects, they were less certain about the potential health benefits (Figure 9). Over 30% of participants expressed that they were unsure whether insects would have a positive health benefit for humans, and if insects were a healthier alternative for humans than current meat options. However, there was still a positive trend in agreement with the statement *"When consumed, insects have positive health benefits for humans",* with 27.3% agreeing and 9.7% strongly agreeing. There was a lower level of agreement with the notion that insects are healthier than current meat options (beef, lamb, pork and chicken), with 20.6% agreeing and 8.9% strongly agreeing with the statement.

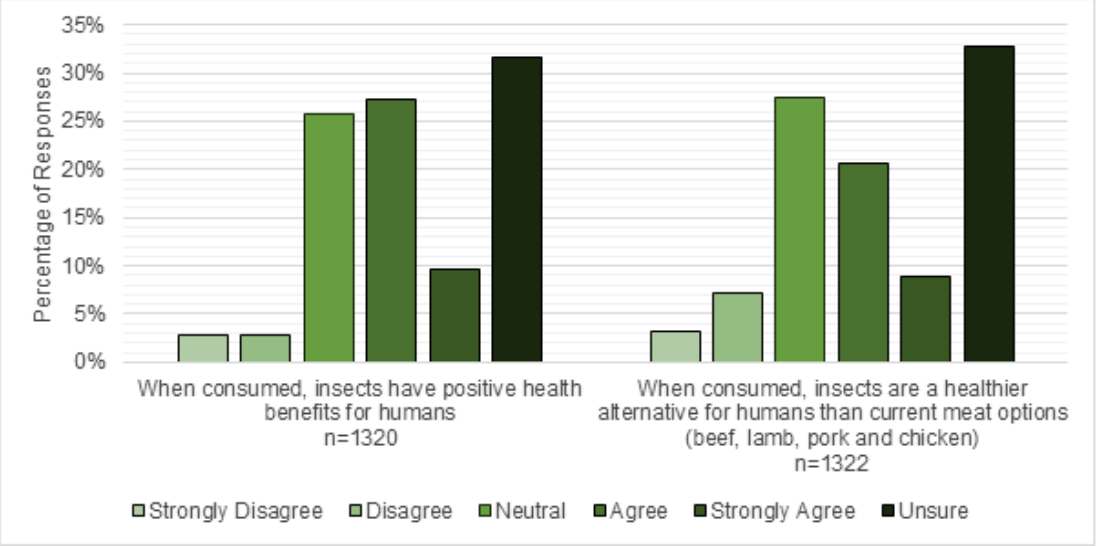

Figure 9. Participant level of agreement with statements related to health benefits of insect consumption.

Together, these results suggest that participants perceive there to be more environmental than health benefits to eating insects; however, a significant portion agree that there are both. This makes sense given there is more research assessing the sustainability of insects relative to their health benefits, and consumers appear to be aware of this.

4.2.3 Likelihood of insect consumption

To assess the likelihood of participants' consuming insects, participants were asked a series of questions about preferred processing methods and the types of insects they would most likely eat. It was found that participants reported being most likely to consume insects if they were processed into a powder and added into a food that is currently being consumed (such as cricket flour in bread) (Figure 10). A total of 67.4% of participants responded that they would likely (32.1%) or highly likely (35.3%) to consume insects in this way. The second most preferred option was processing by frying the insects to make them more palatable. Over half of the participants (55.6%) responded that they would likely consume insects this way, with 17.3% from the sample responding with highly likely (Figure 10). Interestingly, chocolate or other sugar coatings did not increase perceived palatability compared with eating plain cooked insects.

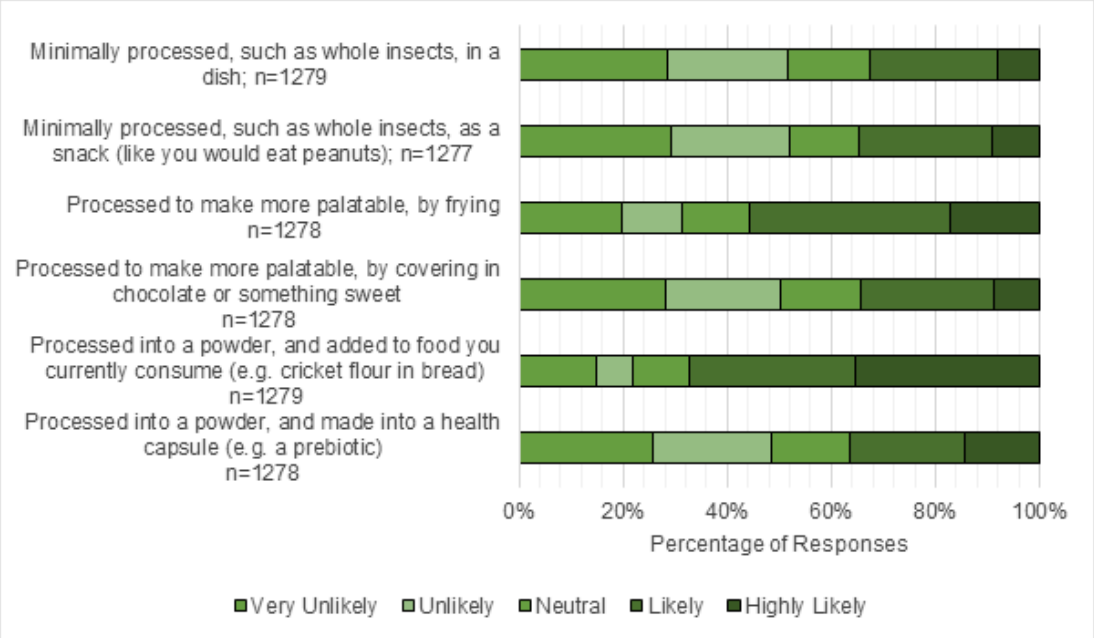

Figure 10. Participants reported likelihood of insect consumption, based on processing methods.

One aim of this research was to assess which New Zealand insects participants would be most likely to consume, in order to test the market potential of each insect as a product. The findings show that participants are more likely to eat black field cricket nymphs and locust nymphs. These were followed by mānuka beetle adults and huhu beetle grub.

Participants reported being least likely to consume porina caterpillar and wax moth larvae, as seen in Figure 11. This suggests that participants may be more open to eating 'crunchier' insects as opposed to softer/'squishier' insects, suggesting that texture is an important factor influencing decisions to consume insects.

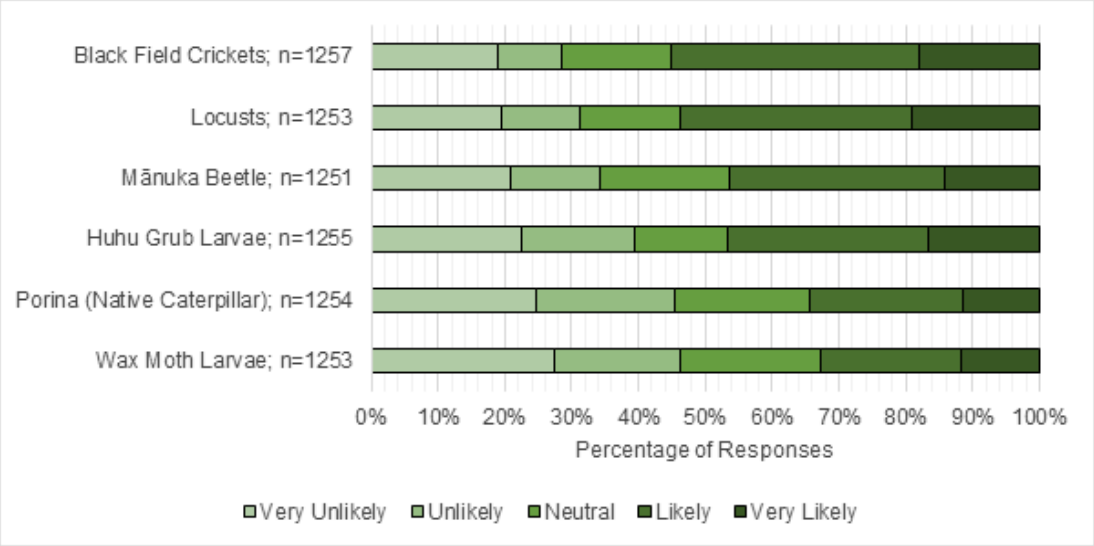

Figure 11. Participant likelihood of insect consumption based on New Zealand insect types.

Over half the sample responded that they were likely to eat black field cricket nymphs and locust nymphs, with just under half reporting they would be likely to eat huhu beetle grub and mānuka beetle adult. Interestingly, black field cricket nymphs were evaluated most positive overall, however a slightly larger number of participants responded they were 'very likely' to try locust nymphs. More than half the sample responded that they were unlikely to consume porina caterpillar and wax moth larvae.

Given that consuming insects can be beneficial for human health, this study investigated the means by which participants would be interested in receiving health-specific products. The findings show that a health capsule designed to be beneficial for gut health was evaluated as the most appropriate product by this group, with 32.1% of participants indicating that they would likely consume capsules and a further 11.5% indicating that they would very likely do so (Figure 12). It is worth noting that a proportion of this sample does not consume these types of products, regardless of whether they were to contain insects or not.

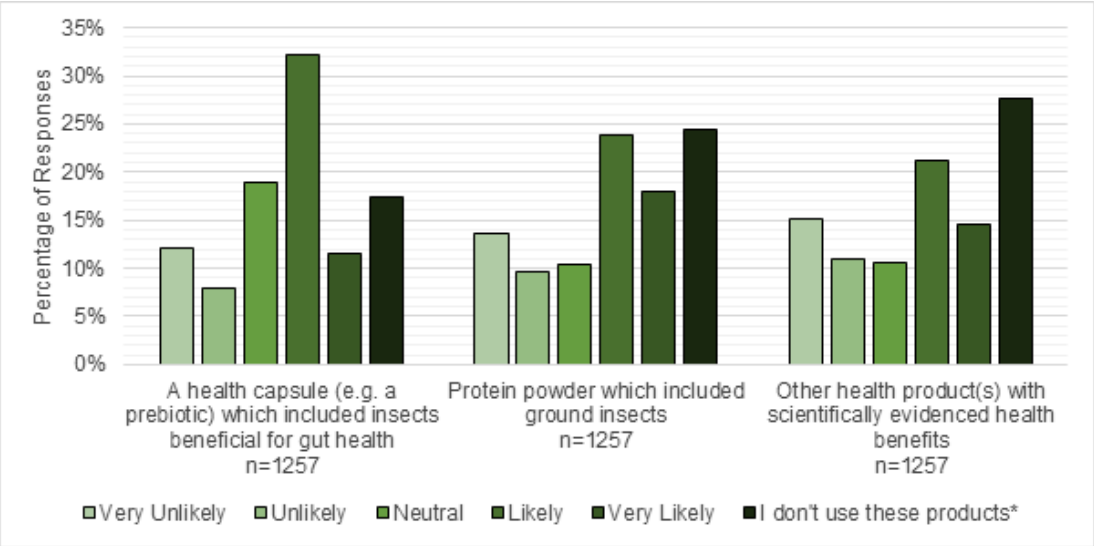

Figure 12. Participant likelihood of insect consumption based on items beneficial for human health. *The complete statement is as follows: 'I wouldn't be likely to use this product whether it contained insects or not'.

4.2.4 Barriers to insect consumption

To determine which barriers to human insect consumption may be present, participants were asked to rate the extent to which factors are considered off-putting when thinking about eating insects. The most off-putting factor identified was 'texture', suggesting that participants dislike the potential 'crunch' or 'squish' factor of particular insects. These were followed by the 'disgust' factor, 'taste' and a 'lack of familiarity'. Variables that tend not to be considered as barriers are 'concerns about food safety' and the 'lack of perceived benefits or incentives', as shown in Figure 13.

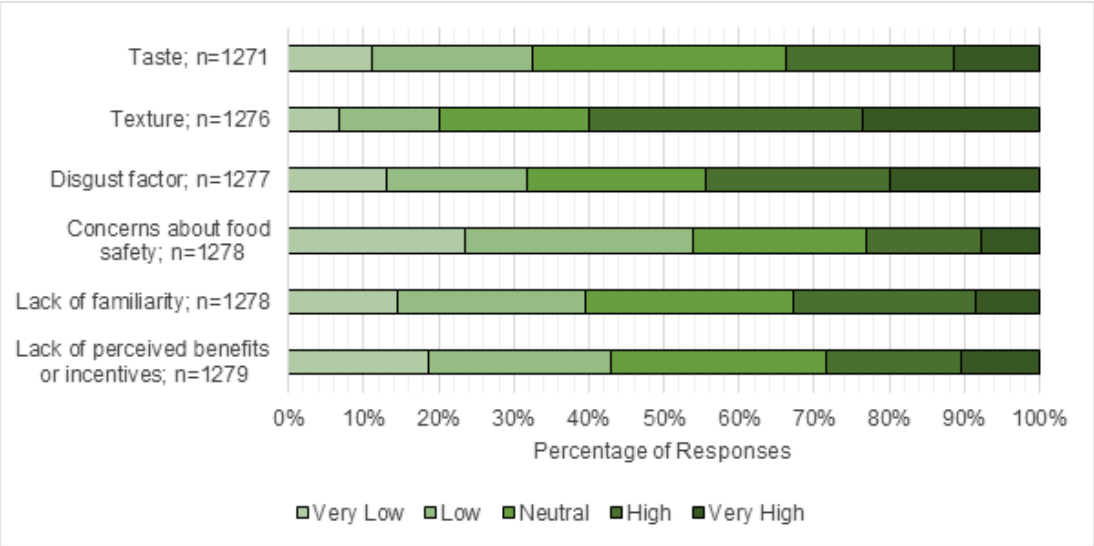

Figure 13. Extent to which factors are rated as off-putting by participants when thinking about eating insects.

Approximately 60% of participants thought that texture was an off-putting factor, of which 23.6% thought texture was a 'very high' barrier (Figure 13). In comparison, 44.4% of participants agreed that 'disgust' factor was a high or very high off-putting factor. This suggests that these two variables would appear to be the most significant barriers to developing a successful insect-based product for the New Zealand market. It is interesting to note that participants would not be put off eating insects solely because they perceived there to be no benefit or incentive to consume them.

4.3 Demographic patterns

This section provides summaries of relevant findings regarding demographic variables (specifically gender, age and diet) and the overarching themes of willingness to consume insects and barriers to insect consumption. For the full statistical analysis, please see Appendix.11.3.

4.3.1 Willingness to consume insects

Gender

One component of the study assessed whether a particular gender was more or less willing to consume insects. Findings show that males are more likely to consume all types of insects compared to female participants. However, if females were likely to eat insects, they would be most likely to eat black field cricket nymphs, locust nymphs and mānuka beetle adults, which supports the study's general findings.

To further assess gender differences in willingness to consume insects, we looked at the participants' preference for processing methods. Males were found to be willing to consume insects regardless of the different processing methods. There was no significant difference between male and female preference for the two most popular processing methods, powder (to add to existing food) or frying. It is also worth noting that there was no significant difference between males and females in their preference for insects processed into a powder and made into a health capsule.

Finally, food neophobia differences were assessed by gender. The results show that male participants reported being more willing to try new foods, while female participants are more neophobic. This supports the difference in the gender scores throughout the statistical analysis and supplies one reason why females may be less likely to eat insects than males.

Age: Under 35 years, and 36 years and above

Another variable that can influence willingness to consume insects is age. The sample was split into only two groups (35 years and under, and 36 years and above), to ensure sufficient statistical power for analyses.

This research found that younger participants report being more likely to consume insects, particularly black field cricket nymphs, locust nymphs and mānuka beetle adults. Preference for processing method was also assessed, and it was found that participants under 35 years report being more likely to consume insects if they are minimally processed, such as whole insects in a dish. There was no difference in the other processing methods, which suggests that participants share similar views regarding processing methods, although the younger participants would be more open to consuming insects whole.

The research also examined the difference in food neophobia between the groups of participants. Within this sample, participants under 35 years were found to be more willing to try new foods, as there was a significant difference in scores for *"I am constantly sampling new and different food"* and *"At dinner parties, I will try new food".* Participants who were 36 years and above were found to be more neophobic, as they had significant differences in the scores for *"If I don't know what is in a food, I won't try it"* and *"I don't trust new foods".* This suggests that the older participants want to know more about the foods they consume, compared to younger participants who are more likely to consume food regardless. Interestingly, there was no difference found in the statements *"I am afraid to eat new things I have never had before"* and *"I will eat almost anything",* which suggests

that the older participants could be more willing to consume new foods if they know what the food is.

Diet: Alternative and Meat-Based

The last key variable tested in relation to willingness to eat insects was diet, specifically whether participants with meat-based diets or alternative diets (vegan, vegetarian, pescatarian, and flexitarian) would be more willing to consume insects. The findings show that overall, participants who choose meat-based diets report being more willing to consume insects, with statistically significant findings for consuming porina caterpillar and wax moth larvae. If participants who choose to follow alternative diets were to consume insects, they would be more likely to consume black field cricket nymphs, locust nymphs and the mānuka beetle adult.

It was then assessed whether processing methods would make a difference for willingness to consume insects among participants with various diets. Participants with meat-based diets had significantly higher scores for preferring insects that were minimally processed, covered in chocolate or something sweet, and processed into a powder for a health capsule. Fried insects or insects made into a powder to add to food were not particularly preferred by either group.

Lastly, we assessed the types and diets and whether there was a difference in food neophobia. Surprisingly there was no difference in the findings between the types of diets, suggesting that both meat-based and alternative diet participants are willing to try new foods.

4.3.2 Barriers to insect consumption

Gender

The study examined whether gender impacted the perception of barriers for human consumption of insects. Findings show that female participants view the following factors as more significant barriers than males:

- Taste;
- The ‘disgust’ factor;
- Concerns about food safety;
- Lack of familiarity; and
- Lack of perceived benefits.

These results suggest that female participants have larger psychological barriers to overcome if they are to consume insects. The only barrier for which there was no statistical

difference was texture, which was reported as the single most off-putting barrier for both men and women. This suggests that marketing needs to reassure consumers about the texture of the product, for example as crunchy rather than squishy. Further research is needed to determine exactly the texture consumers prefer for which type of product.

Age: Under 35 years, and 36 years and above

We assessed whether age contributed to perceptions of barriers to consuming insects. Results show that participants who are 36 years and older rate most barriers as stronger than the younger group, including taste, the 'disgust' factor, concerns about food safety, lack of familiarity, and lack of perceived benefits. The only barrier for which there was no significant difference was texture, suggesting again that this is a primary barrier for all participants. Overall, these results suggest that participants aged 36 years and above have a larger barrier to overcome if they were to consume insects.

Diet: Alternative and Meat-Based

Lastly, we compared the two types of diets (meat eaters versus alternative diets) and the barriers for insect consumption. Interestingly, we found that participants with a meat-based diet are more concerned about food safety than those with alternative diets. All other barriers showed no difference.

5. Summary of findings

The results show that participants in this sample are concerned about the healthiness and environmental impact of their food. Participants demonstrated a willingness to try new foods and tended to exhibit a low level of food neophobia. This suggests a general openness to trying new foods with potential health or environmental benefits. Participants' perception of insects for human consumption was swayed toward the notion of insects being an environmentally sustainable food source, which has the potential to be an alternative to commonly consumed meat products. Regarding the healthiness of insects, many participants were unsure whether insects were a healthier option or what the health value would be. If participants were to consume insects, black field cricket nymphs, locust nymphs and mānuka beetle adults are rated as more likely to be consumed, particularly if they were made more palatable by frying or processed as a powder for adding to food. This suggests that the form of the insect product is an important determinant of consumption, which links to the texture of the product.

Texture is perceived as the largest barrier to consumption for most participants, and it seems that participants are more interested in consuming insects that are 'crunchy', given

the preference for black field cricket nymphs, locust nymphs, and mānuka beetle adults. Insect larvae and caterpillars were the less preferred, 'squishier' options. Based on the statistical analysis, males are more likely to consume insects than females; beyond these differences, however, insect preferences are the same (crickets, locust nymphs and beetles). People who are under 35 years are more likely to consume insects as they are less neophobic, and they are more likely to eat insects with minimal processing. Interestingly, people with meat-based diets are more likely to eat insects than those with an alternative diet. As insects are considered an alternative protein, this finding was surprising. It does, however, fit with the notion that people with alternative diets may be less likely (or unwilling) to consume animal products, and this may include insects.

6. Key survey findings

The survey was designed to assess public perceptions of human insect consumption and to determine willingness to consume insects based on types and processing methods. Further, the survey sought to identify potential barriers limiting consumer adoption of insects as a food option. This section outlines the key findings and relates them to the literature.

- The preferred insects for consumption were the black field cricket nymph, followed by locust nymphs and mānuka beetle adults. Findings show that males are more willing to consume insects than females, which is consistent with previous studies (Sogari et et al., 2017).
- The methods for consumption that were most popular involve the insects being processed, either by frying or into a powder that can be added to food. This supports the findings from the literature, which indicate that people would more readily accept insects when they were prepared in a familiar manner and associated with known flavours (Caparros Megido et al., 2013). Processing also helps to reduce the psychological association of the food with the insect, therefore reducing attributes of disgust, particularly for people from Western nations (Hartmann et al., 2015; Schlup & Brunner, 2018). Both forms of processing mentioned above allow for participants to add insects to foods that they already consume and into dishes that have recognisable flavours. Increasing the palatability of insects by frying them may mean they can be added to existing dishes which people are familiar with. Processing into a powder similarly allows them to be added to baking or cooks, where the insect component may not be the main ingredient.
- Females are more neophobic than males, which is consistent with the international literature. These studies also confirm that neophobia is correlated with a

reduced willingness to eat insects (Hartman et al., 2015; Schlup & Brunner, 2018; Verbeke, 2015).

- Sogari et al. (2017) found that men were more likely to consider consuming insects if they were processed into a flour for increased protein. However, our results show that men were more likely to consume insects regardless of processing methods, whereas females preferred the options of insects being processed either by frying or into a powder that can be added to food.
- While the literature suggests that the disgust factor is the most common reason for refusing an insect-based product (Sogari et al., 2017; Sogari, 2015; van Huis et al., 2013), our study found that texture was the biggest barrier to acceptance, followed by the 'disgust' factor. This suggests that participants in this study were more concerned about the texture of the insect – whether it was crunchy or squishy – which may be linked to the disgust factor (Martins & Pliner, 2006).
- Our study showed that people under 35 years are more willing to eat insects. This is consistent with the literature (Verbeke, 2015).
- Our findings show that people with an alternative diet (vegan, vegetarian, pescatarian, and flexitarian) are less likely to consume insects than people with a meat-based diet. This contradicts the findings from Verbeke (2015) and Schlup & Brunner (2018) who found that the likelihood of consuming insects was expected to be lower among those with a strong focus on meat consumption and a belief that meat is nutritious and healthy.
- Finally, this research shows that New Zealanders overall perceive insects as a more environmentally sustainable option than traditional meat alternatives, with 65% agreeing or strongly agreeing with this statement. This is higher than those rates reported in the literature, for example Sogari et al. (2017) who report that 25% participants in Italy agreed with this statement. However, Schlup & Brunner (2018) found that although participants rate sustainability as a key benefit of insect consumption, this knowledge did not significantly influence their willingness to consume insects.

7. Key recommendations from the literature

As iterated earlier, the purpose of the broader project is to better understand potential barriers and opportunities regarding products containing insects. In particular, this research is interested in insect products which may be beneficial for human gut health. The existing literature on consumption of insects within Western societies provides many constructive recommendations for improving acceptance of such products. This section outlines these recommendations at a high level, in accordance with the findings from this research.

- Disguise insects if possible and make them less identifiable in products (Sogari et al., 2017; Tan et al., 2015). This will reduce perceived averse textural properties (e.g. sliminess, crunchiness) and 'animalness' (Hartmann et al., 2015). Alternatively, include insects in familiar foods or with familiar flavours, and be clear about how they have been prepared (fried, boiled, etc.) (Deroy et al., 2015; Hartmann et al., 2015).
- Do not try to market insects as an alternative to meat; they are best marketed as a distinct category rather than an extension of the 'meat' category. This minimises expectations of similar sensory attributes (taste, appearance, smell) as meat (Deroy et al., 2015).
- Increase consumer exposure to insects over time (Deroy et al., 2015).
- Consider providing free trials of insect products for consumption as this may increase the chance that consumers will try insects. Ensure that experiences of insect consumption are positive and make sure that they are in an appealing form (Deroy et al., 2015).
- When advertising products containing insects, focus on psychologically motivating factors, such as nutritional and health benefits. Tie these to existing knowledge of consumers about what is 'good,' for example that 'protein is good', 'insects are a source of good fat' and 'insects are a sustainable food source' (Deroy et al., 2015).
- Rational arguments alone are unlikely to change behaviours regarding insect consumption. Insects need to become appealing in their own right, not as a substitute and not merely as something that is novel (Deroy et al., 2015).
- Do not lump all 'insects' together. They each have a unique taste and unique properties, and these should be utilised (Deroy et al., 2015).
- Initial success in having consumers try products containing insects may be due to a novelty factor. Ongoing consumption of a product will require pleasant sensory experiences and perceived benefits of product consumption (e.g. sustainability, health benefits) (Tan et al., 2015).
- Ensure the name of the product or insect is not repulsive, which may require 'rebranding' (Deroy et al., 2015).

8. Limitations

Administration of the survey via Facebook resulted in some demographic differences in the surveyed population, relative to the general population in New Zealand. In particular, women were overrepresented in the sample, as 64.9% of respondents. European/Pakeha participants were also overrepresented, as 88.6% of the sample group, with Maori making up 8.4% of the sample (as opposed to 15.3% in the general population).

9. Acknowledgements

Thank you to AgResearch for funding this research, through the Curiosity Plus programme. Thank you to the wider project team, including Wayne Young (Project Leader), Nigel Bell, Mark McNeill, Jessica Gathercole and Sai Arojju, and the internal reviewers (Margaret Brown and Roxanne Henwood). Thank you also to all participants who responded to this survey.

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11. Appendices

11.1 Scales

Three items were used to assess concern about the healthiness of food, from the health interest scale developed by Roininen, Lahteenmaki and Tuorila (1999), consistent with Verbeke (2015):

"I am very particular about the healthiness of the food I eat"	Assessed using a five-point Likert scale using anchors 1 = 'Strongly disagree', 2 = 'Disagree', 3 = 'Neither agree or disagree', 4 = 'Agree', 5 = 'Strongly agree'.
"The healthiness of food has little impact on my food choices"	
"I eat what I like and I do not worry much about the healthiness of food"	

Six items were used to assess food neophobia (willingness to try new foods), from a scale developed by by Pliner and Hobden (1992), consistent with Verbeke (2015):

"I am constantly sampling new and different foods"	Assessed using a five-point Likert scale using anchors 1 = 'Strongly disagree', 2 = 'Disagree', 3 = 'Neither agree or disagree', 4 = 'Agree', 5 = 'Strongly agree'.
I don't trust new foods"	
"If I don't know what is in a food, I won't try it"	
"At dinner parties, I will try a new food"	
"I am afraid to eat things I have never had before"	
"I will eat almost anything"	

One item was used to assess participants' attention to the environmental impact of food, based on a modified version of Roberts (1996) scale measuring environmental concern, consistent with Verbeke (2015):

"When I buy foods, I try to consider how my use of them will affect the environment"	Assessed using a five-point Likert scale using anchors 1 = 'Strongly disagree', 2 = 'Disagree', 3 = 'Neither agree or disagree', 4 = 'Agree', 5 = 'Strongly agree'.

11.2 Reliability of survey scales and data

The reliability of 'Insects for Human Consumption' survey was represented by using the Cronbach alpha coefficient. Cronbach alpha values of 0.7 or higher indicate acceptable internal consistency. The reliability coefficients for the survey were found to be between 0.672 and 0.959, as shown here, suggesting an acceptable reliability.

A reliability analysis was carried out on the 'concerns for health, environment and food neophobia interests' scale comprising ten items. Cronbach's alpha showed the questionnaire reached reasonable reliability, α = 0.672. *Some items were reverse coded to ensure consistent positive message framing.
A reliability analysis was carried out on the preferred 'perceptions of insect' scale comprising 4 items. Cronbach's alpha showed the questionnaire to reach robust reliability, α = 0.810.
A reliability was carried out on the preferred 'processing methods' scale comprising 6 items. Cronbach's alpha showed the questionnaire to reach acceptable reliability, α = 0.855.
A reliability analysis was carried out on the preferred New Zealand insect species for consumption scale comprising 6 items. Cronbach's alpha showed the questionnaire to reach excellent reliability, α = 0.959.
A reliability analysis was carried out on the barriers to consuming insects scale comprising 6 items. Cronbach's alpha showed the questionnaire to reach fairly high reliability, α = 0.779.
A reliability analysis was carried out on the preferred health product scale comprising 3 items. Cronbach's alpha showed the questionnaire to reach acceptable reliability, α = 0.868.

11.3 Statistical tests

Variables testing	Type of test chosen	Result
Type of insect and gender	Chi-Square Test	X^2 (4, N = 1218) = 19.347, p = 0.001
Locust nymphs and gender	Chi-Square Test	X^2 (4, N = 1215) = 36.612, p = 0.001;
Mānuka beetle adult and gender	Chi-Square Test	X^2 (4, N = 1213) = 27.748, p = 0.001
Huhu beetle grub and gender	Chi-Square Test	X^2 (4, N = 1217) = 58.090, p = 0.001
Porina caterpillar and gender	Chi-Square Test	X^2 (4, N = 1216) = 47.168, p = 0.00
Wax moth larvae and gender	Chi-Square Test	X^2 (4, N = 1215) = 54.333, p = 0.001

Conclusion: Males are more likely to consume all types of insects than females.		
black field cricket nymph and age	Independent t-test	< 35 years (M = 4.45, SD = 1.98) and > 36 years (M = 3.88, SD = 2.01) participants; t(1230) = 5.073, p = 0.001
Huhu beetle grub and age	Independent t-test	< 35 years (M = 3.99, SD = 2.13 and > 36 years (M = 3.61, SD = 2.08) participants; t(1230) = 3.155, p = 0.002
Mānuka beetle adult and age	Independent t-test	< 35 years (M = 4.11, SD = 2.01) and > 36 years (M = 3.62, SD = 1.95) participants; t(1230) = 4.284, p = 0.001
Porina caterpillar and age	Independent t-test	< 35 years (M = 3.56, SD = 2.05) and > 36 years (M = 3.30, SD = 1.94) participants; t(1230) = 2.318, p = 0.021
Locust nymphs and age	Independent t-test	< 35 years (M = 4.32, SD = 2.04) and > 36 years (M = 3.89, SD = 2.07) participants; t(1230) = 3.740, p = 0.001
Wax moth larvae and age	Independent t-test	< 35 years (M = 3.50, SD = 2.09) and > 36 years (M = 3.25, SD = 1.96) participants; t(1230) = 2.125, p = 0.034
Conclusion: Younger participants are more willing to consume insects than other older participants, in particular black field cricket nymphs, locust nymphs and mānuka beetle adults.		
black field cricket nymph and diet	Chi-Square test	X^2 (4, N = 1243) = 87.1686, p = 0.001
Locust nymphs and diet	Chi-Square test	X^2 (4, N = 1241) = 89.159, p = 0.001
Mānuka beetle adult and diet	Chi-Square test	X^2 (4, N = 1238) = 79.646, p = 0.001
Huhu beetle grub and diet	Chi-Square test	X^2 (4, N = 1242) = 82.975, p = 0.001
Porina caterpillar and diet	Chi-Square test	X^2 (4, N = 1216) = 66.539, p = 0.001
Wax moth larvae and diet	Chi-Square test	X^2 (4, N = 1240) = 65.844, p = 0.001
Conclusion: Meat-based diets are more likely to consume all insect types.		
Diet and processing method (whole insects)	Independent t-test	Alternative diets (M = 2.90, SD = 2.23) and meat-based diets (M = 3.61, SD

		= 2.17) participants; t(1236) = -5.091, p = 0.001
Diet and processing method (whole as a snack)	Independent t-test	Alternative diets (M = 3.00, SD = 2.27) and meat-based diets (M = 3.64, SD =2.23) participants; t(1236) = -4.470, p = 0.001
Diet and processing method (chocolate or sweet)	Independent t-test	Alternative diets (M = 2.93, SD = 2.22) and meat-based diets (M = 3.69, SD =2.20) participants; t(1236) = -5.355, p = 0.001
Diet and processing method (health capsule)	Independent t-test	Alternative diets (M = 3.13, SD = 2.32) and meat-based diets (M = 3.84, SD =2.25) participants; t(1236) = -4.868, p = 0.001
Conclusion: Meat based diets are more likely to consume insects whether they are minimally processed, or processed into a powder for a health capsule. Alternative diets could be willing to consume insects if they were processed into a powder and added to food currently consumed, or fried.		
Gender and barriers to insect consumption (taste)	Independent t-test	Female (M = 4.19, SD = 1.95) and male (M = 3.76, SD = 1.90) participants; t(1185) = -3.609 , p = 0.001
Gender and barriers to insect consumption ('disgust' factor)	Independent t-test	Female (M = 4.64, SD = 2.11) and the male (M = 3.72, SD = 2.08) participants; t(1213) = 7.30, p = 0.001
Gender and barriers to insect consumption (food safety)	Independent t-test	Female (M = 3.37, SD = 2.02) and the male (M = 3.00, SD = 1.98) participants; t(1214) = 3.11, p = <0.02
Gender and barriers to insect consumption (lack of familiarity)	Independent t-test	Female (M = 3.94, SD = 2.01) and the male (M = 3.53, SD = 1.96) participants; t(1214) = 3.57, p = 0.001
Gender and barriers to insect consumption (lack of perceived benefits)	Independent t-test	Female (M = 3.77, SD = 2.04) and the male (M = 3.36, SD = 2.00) participants; t(1214) = 3.36, p = 0.001
Conclusion: Females rate all barriers to eating insects more strongly than males, except texture, which they rate equally.		

Age and barriers to insect consumption (taste)	Independent t-test	Under 35 years (M = 3.88, SD = 1.97) and over 36 years (M = 4.12, SD = 1.93) participants; t(1211) = -2.177 , p = 0.030
Age and barriers to insect consumption ('disgust' factor)	Independent t-test	Under 35 years (M = 4.16, SD = 2.13) and over 36 years (M = 4.45, SD = 2.15) participants; t(1211) = -2.315, p = 0.021
Age and barriers to insect consumption (food safety)	Independent t-test	Under 35 years (M = 2.92, SD = 1.93) and the over 36 years (M = 3.47, SD = 2.02) participants; t(1211) = -4.869, p = 0.001
Age and barriers to insect consumption (lack of familiarity)	Independent t-test	Under 35 years (M = 3.61, SD = 1.99) and over 35 years (M = 3.93, SD = 2.00) participants; t(1211) = -2.794, p = 0.001
Age and barriers to insect consumption (lack of perceived benefits)	Independent t-test	Under 35 years (M = 3.38, SD = 2.00) and over 35 years (M = 3.87, SD = 2.04) participants; t(1211) = -4.205, p = 0.001
Conclusion: Participants aged 36 years and above rated all barriers except texture more strongly than younger participants.		