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Insects as mini-livestock: New Zealand's public attitudes toward consuming insects

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ABSTRACT

Insects are a relatively sustainable food source with a high protein content, and an alternative food option for the growing global population. However, while entomophagy (eating insects) is a growing food trend on the global stage, very few studies focus on New Zealanders' perceptions of it. This research aims to better understand the New Zealand publics' attitudes to the consumption of insects, by exploring willingness to eat insects, the preferred processing methods for consumption, and barriers to adopting insects into participants' diets. An online survey was conducted via SurveyMonkey in 2019 recruiting via social media platforms. Within the sample ($n = 1322$), male participants were more likely to express a willingness to consume insects, as were younger participants (<56 years) and those who consume meat. Over sixty percent of participants responded that they would eat insects, and possibly regularly, if in an acceptable form such as a capsule for improved health. Participants were aware of the environmental benefits of eating insects over other protein sources but less aware or certain of the potential health benefits. New Zealand may be a candidate for well-marketed products containing insects, most likely in the form of a powder to add to existing foods or health products.

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Introduction

Since 2013 there has been a swathe of research published regarding the practice, and consumer acceptance, of eating insects, particularly within Western societies (Dagevos 2021; Deroy et al. 2015; Hartmann et al. 2015; Ruby and Rozin 2019; Wilkinson et al. 2018). This is in part due to research claiming environmental and nutritional benefits associated with insect rearing and consumption, in comparison with traditional livestock (Belluco et al. 2013; Van Huis et al. 2013). Also relevant is the recognition that a future global food shortage is likely given the expected population of 9 billion people by 2050, resulting in The Food and Agricultural Organisation of the United Nations advocating for the human

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consumption of insects (entomophagy) as part of a strategy to help alleviate food and nutrition shortages (Van Huis et al. 2013).

This study contributes to the growing discussion regarding entomophagy with a survey of New Zealanders' attitudes toward insects as food and the likelihood and preferences for consumption. Given the dearth of existing research regarding New Zealanders' and entomophagy, as well as New Zealand's strong focus on food production and consumption, in particular protein, the findings of this study are a valuable addition to this discussion. In 2020–21 the average New Zealander consumed 73 kg of meat, including 40 kg of chicken (IBISWorld 2021). New Zealand also plays an important role in the global meat market, exporting over 850,000 tonnes of beef, lamb and mutton, valued at $7.6 billion in 2020–21 (Beef + Lamb 2021). The country as a whole and New Zealanders' individually, therefore, have considerable power to contribute to and determine both domestic and international food consumption trends. Will we continue to produce and consume traditional animal protein following the existing agricultural model, or will we shift toward a more sustainable, longer-term food strategy? As insects provide an excellent source of protein, they represent an alternative strategy as a supplementary source of nutrition. Furthermore, New Zealanders' appear to be concerned about the state of the environment, with one survey finding that forty percent rate themselves as highly committed to living a sustainable lifestyle (Colmar Brunton 2018). Therefore, New Zealand may be a prime candidate for producing and consuming well-targeted and researched insect products. This study starts by gauging opinions regarding insects among the New Zealand public, whether they are perceived as environmentally friendly and beneficial for health, and whether there is an appetite for adding insects to our current diet.

Insect-based foods are still relatively new to the New Zealand market, with only a few products available such as flours, protein bars and snacks (Clarkson et al. 2018). Most of the insect rearing occurs overseas. Several companies in New Zealand sell products containing insects; however, they tend to use imported insect ingredients.[1] Otago Locusts is an exception, being the first insect farm in New Zealand to be registered for human consumption in 2018.[2] Insects for human consumption are also relatively new territory from a food safety legislation perspective. New Zealand does not have specific government regulation or legislation for insect farming (Lähteenmäki-Uutela et al. 2021). According to the Food Standards Australia and New Zealand (FSANZ), three edible insect types have been reviewed and classified, super mealworm (*Zophobas morio*), mealworm beetle (*Tenebrio molitar*) and the house cricket (*Achaeta domestica*) (FSANZ 2020). These insects were classified as non-traditional (not widely consumed) and non-novel, meaning they do not need to be formally assessed by FSANZ to establish their food safety before being added to the food supply (FSANZ 2020). While no safety concerns have been identified to date, it is noted that some edible insects may present an allergen risk (De Marchi et al. 2021; FSANZ 2020). Additional insects can legally be consumed by individuals in New Zealand and Australia but are not permitted to be sold; these include beetles, grasshoppers, butterflies, moths, bees, bugs and dragonflies. All foods containing insects must be labelled, and if an insect is determined 'novel', it must go through a risk-assessment process to consider toxicology, nutrition and consumption patterns (FSANZ 2020; Lähteenmäki-Uutela et al. 2021). New Zealand's Ministry for Primary Industries (MPI) also states that import permits for insect-based products require the insects are

raised in farms and processed in facilities specified for human consumption. This is advantageous from a food safety perspective and for biosecurity, as insects raised in a farm setting are considered to present a lower biosecurity risk (Ministry for Primary Industries 2015).

Despite these limitations regarding formal food safety standards, there is a well-documented history of insect consumption throughout the Pacific, particularly among indigenous groups. For example, in Australia, the traditional diet of the Aboriginal Australians included witchetty grubs (*Endoxyla leucomochla*), honey ants (*Myrmecocystus mexicanus*) and Bogong moths (*Agrotis infusa*) (Wilkinson et al. 2018). Whereas, in Aotearoa New Zealand, Māori regularly consumed the larva of a longhorn beetle known locally as 'huhu' (*Prinoplus reticularis*) (Meyer-Rochow and Changkija 1997). Other reports suggest Māori also consumed the caterpillar of the kūmara moth (*Agrius convolvuli*) (Miller 1952; Van Huis 2018), with further speculation around Māori consuming 'kihikihi', the New Zealand chorus cicada (*Amphipsalta zelandica*), the mānuka beetle (*Pyronota festiva*) and the puriri moths (*Aenetus virescens*) (Meyer-Rochow and Changkija 1997).

The fact that hundreds of millions of people (if not more) are estimated to currently consume insects worldwide provides robust evidence that there is no innate human aversion to eating insects (Bodenheimer 1951; Hamerman 2016; Tan et al. 2015; Van Huis 2013; Van Huis et al. 2022). However, in Western societies, insects are often seen as inappropriate or unappealing as food (Deroy et al. 2015; Hartmann et al. 2015; Sogari et al. 2017; Tan et al. 2016). The reasons behind such attitudes are culturally and socially complex but tend to centre around psychological barriers such as disgust toward insects as food, poor presentation of insects as an appealing food choice, lack of familiarity and neophobia (Clarkson et al. 2018; Deroy et al. 2015; Hartmann et al. 2015; Sogari et al. 2019; Tan et al. 2016; Wilkinson et al. 2018). In particular, people from Western cultures can be found to associate insects with the negative connotations surrounding 'pests' and disease transmission (Baker et al. 2018; Castro and Chambers IV 2019; Sogari et al. 2019; Tan et al. 2015). Furthermore, there are entrenched stigmas around entomophagy associated with poverty or eating out of necessity (Bogueva and Schmidinger 2019; Van der Spiegel et al. 2013; Van Huis et al. 2013). A study by Chan (2019) found that consumer mindfulness about entomophagy can act to *increase* the disgust factor and subsequently lower people's willingness to consume insects. This suggests that the less consumers reflect on their consumption of insects, the better. Nevertheless, there are potential avenues for progress to overcome psychological barriers, including strategic marketing and discreet inclusion, such that the presence of insects in our food is not disgusting or overwhelming but can become more normalised (Bogueva and Schmidinger 2019; Clarkson et al. 2018).

Few studies have looked at entomophagy in New Zealand, and the studies that have been conducted were qualitative. Tucker (2014) held a series of focus groups across New Zealand to explore the sensory appeal of meat substitutes, including insects. Rigter et al. (2016) held focus groups in Dunedin and looked at the dominant consumer discourses about entomophagy. The most recent study by Clarkson et al. (2018) explored consumer acceptance of insect consumption through design workshops. Given the limited New Zealand-specific literature regarding entomophagy, the aim of this study was to explore the perceptions of the New Zealand public regarding the feasibility and likelihood of them consuming insects. The research sought to better understand

preferred insect species and how the public anticipate they would prefer such insects to be processed for consumption. We looked at attitudes to health and environmental benefits, as well as issues of neophobia, to determine how such factors might influence the consumption of insects. We also explored the barriers to insect consumption to determine the main constraints impeding a willingness to consume insects within a New Zealand context.

Methodology

Participants

An online survey was conducted via the platform Survey Monkey©. The survey was promoted via paid advertisements on AgResearch's social media accounts, including Facebook, Instagram and Twitter. Advertising occurred during late January and early February 2019, with the survey open for 28 days. The survey was advertised to social media users throughout New Zealand, who could choose whether to click the link and participate. Participants who completed the survey were offered the chance to enter a prize draw to win one of ten $150 Visa Prezzy cards. All participants were required to provide informed consent before beginning the survey, and ethical approval for this research was obtained through the AgResearch Human Ethics Committee.

Survey design

The survey was comprised of seven categories of questions, covering: (1) attitudes toward food (food neophobia and concern about the healthiness of food); (2) perceptions of insects as an environmentally sustainable and healthy alternative to traditional protein sources; (3) speculative preferences around the preparation of insects for consumption (for example, eating them whole or processed); (4) perceived sensory appeal of insects (taste, texture) and potential disgust; (5) likelihood of consuming insects in various forms, for example whole or as a capsule; (6) preference for various New Zealand insect species for consumption (black field cricket nymph, huhu beetle grub, mānuka beetle adult, porina caterpillar, locust nymph and wax moth larvae) and (7) demographic information (age, gender, education, ethnicity and diet).

Table 1 provides further detail regarding the insects selected for inclusion in the survey. All species are relatively abundant (and therefore may be suitable candidates to include in insect products), and all except the wax moth are native to New Zealand.

These categories were broken down into 43 specific question items. All questions related to insect consumption were scored on a five-point Likert scale, measuring the

Table 1. Insect species chosen for the survey.

Common name	Species	Stage	Origin
Black field cricket	*Teleogryllus commodus*	Late instar nymph	Native[a]
Huhu beetle	*Prionoplus reticularis*	Larva (or grub)	Native
Mānuka beetle	*Pyronota festiva*	Adult	Native
Porina	*Wiseana cervinata*	Larva (or caterpillar)	Native
Migratory locust	*Locusta migratoria*	Nymph	Native[a]
Greater wax moth	*Galleria mellonella*	Larva (or caterpillar)	Exotic

[a]Self-introduced.

perceived likelihood of consuming insects, the extent to which participants find the factors off-putting when thinking about consuming insects or willingness to try new foods, and perceptions about the sustainability of insects for human consumption.[3] The survey was constructed based on insights from the international entomophagy literature, while also including questions relevant to the local context, such as potential candidate species for consumption in New Zealand.

Three specific scales were identified as areas of interest to investigate. These included: (1) Attitudes toward the health-related characteristics of food, particularly concerns about the healthiness of the food one eats. Studies show that people who are concerned about the healthiness of their food may be more willing to consume insects given their known health benefits, such as high protein (Hartmann et al. 2015; Sogari et al. 2017; Tan et al. 2015). Three items were used to assess concern about the healthiness of food, which were derived from the health interest scale developed by Roininen et al. (1999). These items were utilised by Verbeke (2015) to measure health interest in a study related to consumer willingness to try insects. (2) Food neophobia and the willingness to try new foods. Fear of trying new foods has been found to be strongly and negatively correlated with willingness to eat insects (Hartmann et al. 2015; Verbeke 2015). The likelihood of trying new foods which have not been consumed before is more strongly related to interest and disgust than to expected sensory experience (e.g. taste, texture, etc.) (Martins and Pliner 2005). A total of six items from the food neophobia scale were used in this study, as developed by Pliner and Hobden (1992) consistent with Verbeke (2015). (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 adopt insects as part of their diet (Tan et al. 2015; Verbeke 2015). Consistent with Verbeke (2015) one item, based on a modified version of Roberts's (1996) scale measuring environmental concern, was included in the survey and was scored on a five-point scale. The questions utilised from these three scales are shown in the Appendix.

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 professional 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 seen in Figure 1. These pictures provided participants with a clear and consistent image of the processing method or insect in question. This approach was adopted because research suggests that where participants have limited

Figure 1. Pictorial aids depicting candidate NZ insect species for consumption (from left to right, black field cricket nymph, huhu beetle grub, manuka beetle adult, porina caterpillar, locust nymphs and wax moth larvae).

individual experience with insect consumption, detailed visual representation can play an important role in decision-making (Tan et al. 2015; Trope et al. 2007).

Participants were also provided with an 'intervention' part way through the survey; an educational description which informed them that: '*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 healthiness relative to alternative meat options. The purpose of providing this description was to increase participants' knowledge of the benefits of insects before asking them whether they would consume insects in various forms and from various species. This method of informing participants about the benefits of insects prior to answering such questions has been used by Van Huis et al. (2013) and Verbeke (2015). It also serves to mimic the information or advertising regarding insects' environmental and health benefits that participants would be likely to encounter when considering whether they will consume products containing insects.

Data analysis

The survey data was analysed using the statistical package IBM© SPSS© (Version 18). A range of descriptive statistics were calculated, including mean scores, frequency distributions and 95% confidence intervals for relevant questions. Scales were then tested for reliability using Cronbach's alpha. After attaining coefficient scores indicating acceptable reliability (Cronbach alpha values of 0.7 or higher indicate acceptable internal consistency and can be assumed as homogenous. The Cronbach alpha score for the survey showed acceptable reliability, $\alpha = 0.835$), factor analyses were used to confirm question items were loading on the correct sub-scales (food healthiness, environmental impact of food and food neophobia). Two of the three key scales were then merged using Principle Component Analysis (PCA),[4] to provide a composite score for that scale. That is, the three items measuring 'attitude toward health characteristics of food' were merged into one food healthiness score, and the six items measuring food neophobia were merged into one score. This allowed correlation between these scale constructs and other variables studied. Two types of tests were used to explore within and between group differences, independent sample t-tests and Chi-square tests. Finally, Friedman's Analysis of Variance test was used to assess whether there was a significant difference between participants' preference for a particular type of insect and preference for processing method. Wilcoxon pairwise analyses (with Bonferroni alpha adjustment to 0.008) were then used to test the significance of these differences.

Results and discussion

Sample characteristics

A total of 1322 participants completed two or more questions within the survey (responses varied per question). Overall the survey had an 80% completion rate (based

on the number of survey questions completed. Given the incomplete data, a pairwise deletion of the sample set was run through SPSS's components analysis), with an average time taken to complete the survey of seven minutes. Participants' demographic information related to gender, age, ethnicity, education and diet is shown in Table 2. The sample was skewed towards female participants, which appears to be an artefact of the sampling method used (StatsNZ 2017a). Furthermore, Māori participants were underrepresented in this sample (7.6%) compared to the national average of 15.3% (StatsNZ 2017b). Finally, the sample has a higher average level of formal education than the national population, with 59.9% of the sample having completed a university degree, compared with 26% of the national population (Ministry of Education 2019). Although this sample is not completely representative, it does provide valuable insights into New Zealanders' perceptions about insects as food.

In terms of diet, most participants indicated that they ate meat relatively regularly as part of their diet (72.9% stating they were small to moderate, or moderate to large meat eaters see Table 2), while approximately one quarter indicated that they ate an alternative diet (26.5% total, including 7.8% vegan, 5.7% vegetarian, 9.5% flexitarian and 3.5% pescatarian[5]). Unfortunately, detailed statistics regarding dietary preferences are not

Table 2. Socio-demographic characteristics and levels.

	Total sample n = 1322	*Percent*
Gender	1248	
Male	409	32.8
Female	810	64.9
Other[a]	29	2.3
Age (years)	1251	
16–25	281	22.5
26–35	307	24.5
36–45	239	19.1
46–55	206	16.5
56–65	147	11.8
≥66	71	5.7
Ethnicity[b]	1251	
European[c]	–	82.9
Māori	–	7.6
Pacific	–	1.5
Asian	–	5.0
Other[d]	–	3.0
Education	1250	
High School	251	20.1
Diploma (technical/trade certificate)	216	17.3
Undergraduate University	487	39.0
Postgraduate University	261	20.9
No Comment	35	2.8
Diet	1251	
Moderate to Large Meat Eater	403	32.2
Small to Moderate Meat Eater	509	40.7
Flexitarian/mainly vegetarian	119	9.5
Pescatarian (vegetarian but eat fish)	44	3.5
Vegetarian	71	5.7
Vegan	98	7.8
No Comment	7	0.6

[a]Other includes 'no comment' responses; [b] Participants could select more than one option; [c] European also includes New Zealand/European, New Zealander and Pākeha; [d] Other includes Middle Eastern, Latin American, African and 'no comment' responses.

available at a national level for New Zealand; however, research suggests one in ten New Zealanders is mostly meat-free (Colmar Brunton 2018). This may indicate a higher than average proportion of participants with alternative diets in this sample.

Factor analyses and scale reliability

Factor analyses indicated question items were loading on the intended sub-scales, with all items achieving a factor loading score between 0.63 and 0.80. Cronbach's alpha was used to assess the internal reliability of the survey scales used. All scales showed acceptable reliability, with coefficient scores between 0.67 (concerns for health, environment and food neophobia) and 0.96 (preference for NZ insect species).

Concern about health, environment and food neophobia

Overall, participants indicated that they were concerned about the healthiness of their food ($m = 4.3$ out of 5) and were interested in the environmental sustainability aspect of their food choices ($m = 4.0$ out of 5). On the whole, participants indicated a willingness to try new foods ($m = 4.2$ out of 5), suggesting low levels of neophobia as shown in Table 3. In contrast to the findings of similar studies (Hartmann et al. 2015; Schlup and Brunner 2018; Verbeke 2015), no significant difference between female and male participants regarding neophobia was found.

Perceptions regarding environmental sustainability and health benefits of eating insects

Participants were well aware of the environmental benefits of insects as food, with over 60% agreeing that insects represent an environmentally sustainable source of food for human consumption ($m = 4.0$ out of 5). Furthermore, over 66% agreed that insects represent a *more* environmentally sustainable food for human consumption than commonly consumed meats, including beef, lamb, pork and chicken ($m = 4.0$ out of 5).

Interestingly, participants demonstrated a higher level of uncertainty regarding the health benefits of insects relative to the environmental benefits, with 31.7% of

Table 3. Mean factor scores of concerns for health, environment and food neophobia.

	Health concern			Environmental concern			Willingness to try new food		
	Mean	SD	n	Mean	SD	n	Mean	SD	n
Total sample	2.34	0.74	1323	2.36	1.00	1322	3.73	0.71	1323
Gender									
Females	2.28	0.73	810	2.28	0.96	809	3.63	3.63	810
Males	2.45	0.76	410	2.55	1.04	410	3.91	0.69	410
Age									
16–35 years	2.43	0.73	588	2.34	1.04	587	3.79	0.73	588
36–55 years	2.28	0.73	448	3.73	0.70	448	2.36	0.96	448
≥ 56 years	2.19	0.77	218	2.46	0.98	218	3.54	0.69	218
Diet									
M – L Meat Eater[a]	2.56	0.76	404	2.78	0.98	404	3.87	0.70	404
S – M Meat Eater[b]	2.30	0.70	509	2.43	0.96	509	3.76	0.72	509
Alternative Diet[c]	2.13	0.72	331	1.77	0.79	330	3.52	0.66	331

Means scores out of five: 1 = Strongly Disagree and 5 = Strongly Agree; [a] Moderate to large meat eater; [b] Small to moderate meat eater; [c]Alternative diet includes: Vegan, Vegetarian, Flexitarian and Pescatarian.

participants responding that they were unsure of the positive health benefits for humans. Additionally, on average participants only slightly agreed that insects have positive health benefits if consumed ($m = 3.6$ out of 5). Participants were similarly less certain that insects represent a healthier alternative for humans than current meat options (including beef, lamb, pork and chicken, $m = 3.4$ out of 5), with 32.7% reporting they were unsure.

Willingness to consume insects

Preferred insect species and likelihood of consumption

Participants were asked how likely they would be to consume different insects found in New Zealand and their preferred method of processing for edibility. Of the insect species included in the survey, participants reported that they were most likely to eat black field cricket nymphs ($m = 3.23$) and locust nymphs ($m = 3.22$), and least likely to eat porina (native caterpillar, $m = 2.76$) and wax moth larvae ($m = 2.71$), as seen in Table 4.

Friedman's Analysis of Variance test indicated that a significant difference existed in terms of preference for different insects, χ^2 (5, $N = 1241$) = 815.21, $p < 0.005$. Wilcoxon pairwise analysis revealed significant differences between each insect species included in the survey, $p < 0.0005$, except for: (1) black field cricket nymph and locust nymph; (2) huhu beetle grub and mānuka beetle adult and (3) wax moth larvae and porina caterpillar. This suggests that the following insects are considered similarly appealing; locusts and crickets, beetle grubs and adults, and larvae and caterpillars. This may be due to textural similarities between the pairs (excepting beetle grubs and adults).

Using the mean factor scores of all insect species included in the survey as an indicator for willingness to consume ($m = 3.00$), a significant relationship was revealed between willingness to consume these insects and willingness to try new foods, $r(1257) = 0.44$, $p < 0.05$. As females were found to be more neophobic in this sample, we wanted to determine if males state a greater reported willingness to consume insects. Comparing gender and reported willingness to consume these insects (mean factor score), a significant difference was found between male ($m = 3.32$) and female ($m = 2.82$) participants $t(1216) = 6.65$, $p < 0.05$. This indicates that the male participants reported themselves to be more likely to consume the insects included in the survey than the female participants.

Additionally, we compared participants' diets with their reported willingness to consume insects. We found that there was a significant difference between participants with alternative diets[6] ($m = 2.51$) and participants who identified as small to moderate meat-eaters ($m = 3.11$) and those who identified as moderate to large meat-eaters ($m = 3.28$), $F(2,1240) = 38.73$, $p < 0.05$. This suggests that participants who identify as meat-

Table 4. Mean scores regarding preferred New Zealand insect species for consumption.

Insect species	Mean	SD	n	95% CI
Black field cricket nymph	3.26	1.37	1256	± 0.08
Huhu beetle grub	3.02	1.43	1254	± 0.08
Mānuka beetle adult	3.06	1.36	1250	± 0.08
Porina (native caterpillar)	2.76	1.35	1253	± 0.08
Locust nymph	3.22	1.40	1252	± 0.08
Wax moth larvae	2.71	1.37	1252	± 0.08

Mean scores out of five: 1 = Very Unlikely and 5 = Highly Likely to consume.

eaters are more likely to eat insects than those who practice an alternative diet (vegan, vegetarian, pescatarian and flexitarian diets).

Lastly, we compared the different age brackets with participants' willingness to consume insects. Participants aged ≥ 56 years ($m = 2.69$) were statistically less willing to consume insects than those aged 16–35 years ($m = 3.14$) and 36–55 years ($m = 2.96$), ($F(2,1247) = 10.25$, $p < 0.05$).

Preferred processing methods for edibility

There were two clear preferences for the processing method of insects as food; grinding insects into a powder for addition into foods already consumed, such as insect flour in bread ($m = 3.66$) and frying for palatability ($m = 3.22$), as seen in Table 5. It must however be noted that the inclusion of the phrase 'for palatability' in regard to this and one other processing method (covering the insects in chocolate or something sweet) may have introduced response bias, as this phrase was not used for all processing methods. Nevertheless, both preferred forms of processing would allow participants to add insects into foods they already consume and dishes that have recognisable flavours, which may account for these results. Using Friedman's Analysis of Variance, a significant difference was found between the participants' preferences for various processing methods, χ^2 (5, $N = 1273$) = 1279.32, $p < 0.0005$. Wilcoxon pairwise analysis (with Bonferroni alpha adjustment to 0.008) revealed significant differences between all the processing methods, $p < 0.0005$, except for: (1) Minimally processed, such as whole insect in a dish, and as a snack; (2) Processed to make more palatable, by covering in chocolate or something sweet, and minimally processed such as whole insect in a dish; (3) Processed to make more palatable, by covering in chocolate or something sweet, and minimally processed such as a snack and (4) Processed into a powder, and made into a health capsule, and minimally processed such as whole insect in a dish. Overall, there was a moderate positive relationship between willingness to consume insects and all the types of processing methods ($p < 0.05$), indicating that the respondents who perceived that they would consume insects, believed they would do so regardless of how they were prepared.

Barriers to human consumption of insects

The findings from this study suggest that texture was the biggest barrier for consumer acceptance ($m = 3.57$), followed by 'disgust' ($m = 3.20$), as seen in Table 6. In addition,

Table 5. Mean scores of preferred processing methods for edibility.

Processing methods	Mean	SD	n	95% CI
Minimally processed – whole insect in a dish	2.61	1.34	1278	± 0.07
Minimally processed – whole insect as a snack	2.63	1.37	1276	± 0.08
Processed to make more palatable by frying	3.22	1.39	1277	± 0.08
Processed to make more palatable, by covering in chocolate or something sweet	2.65	1.35	1277	± 0.07
Processed into a powder, and added to a food you currently consume (e.g. cricket flour in bread)	3.66	1.41	1278	± 0.08
Processed into a powder, and made into a health capsule (e.g. prebiotic)	2.77	1.42	1277	± 0.08

Mean scores out of five: 1 = Very Unlikely and 5 = Highly Likely.

Table 6. Mean scores of perceived barriers to insect consumption.

Barriers to insect consumption	Mean	SD	n	95% CI
Taste	3.02	1.16	1270	± 0.06
Texture (e.g. crunch or squish)	3.57	1.18	1275	± 0.07
The 'disgust' factor	3.20	1.31	1276	± 0.07
Concerns about food safety	2.53	1.22	1277	± 0.07
Lack of familiarity	2.87	1.18	1277	± 0.07
Lack of perceived benefit or incentive (no reason to)	2.77	1.24	1278	± 0.07

Mean scores out of five: 1 = Very Unlikely and 5 = Highly Likely.

participants were not particularly concerned about food safety, nor did they see a lack of perceived benefit to eating insects as a strong deterrent to consuming them.

There was a significant difference between the perceived barriers to insect consumption χ^2 (5, $N = 1244$) = 775.07, $p < .0005$, with the Wilcoxon pairwise analysis detecting significant differences between all forms of barriers ($p < 0.008$). This suggests that each barrier was treated separately by participants and would be worth exploring further given their potential explanatory power regarding entomophagy decisions.

To establish an indicator for the extent to which participants' perceived the barriers as off-putting when thinking about consuming insects, we used the mean factor scores for all barriers ($m = 2.99$). Comparing willingness to try new foods and participants' level of perceived barriers towards eating insects, we found a moderately strong negative relationship, $r(1282) = -0.44$, $p < 0.05$. That is, a greater score on perceived barriers is associated with a reduced willingness to try new food, as would be expected. As females were shown to be more neophobic than males in this sample, we compared gender and the mean scores of perceived barriers. There was a significant difference between male ($m = 2.77$) and female ($m = 3.13$) participants and their perception of barriers to consuming insects, $t(815.51) = 7.06$, $p < 0.05$. Female participants perceived the barriers to consuming insects to be of greater magnitude than male participants (e.g. they felt greater disgust etc.), which may provide an insight into why men reported a greater willingness to consume insects overall. No significant differences were found between the different diet types, suggesting that the barriers applied to all dietary groups. However, a significant difference was observed between the age brackets, with participants aged ≥ 56 years ($m = 3.25$) reporting a higher average score regarding barriers to consumption when compared to the participants in the age brackets of 16–35 years ($m = 2.89$) and 36–55 years ($m = 3.01$), $F(2,1248) = 14.08$, $p < 0.05$. This is consistent with the finding that participants aged ≥ 56 years were the least willing to consume insects.

Discussion

The findings from this study suggest a relative openness amongst New Zealanders to trying insects as food, and possibly to including them regularly as part of their diet, most likely in foods already consumed, such as insect protein powder in bread or fried insects included in a familiar dish. These findings are supported by a recent similar study in New Zealand conducted through the University of Auckland,[7] which found a similar proportion (60%) of New Zealanders' would be willing to try insects (2021). Also consistent with previous research, participants reported being more willing to

accept insects when they were prepared in a familiar manner and associated with known flavours (Caparros Megido et al. 2014). This makes sense as it helps consumers to cognitively separate edible insect products from their origins, and consequently from the attributes of disgust, particularly for those used to a more traditional New Zealand diet (Hartmann et al. 2015; Schlup and Brunner 2018). Indeed, the literature finds that disguising insects effectively to make them less identifiable will reduce barriers to consumption (Sogari et al. 2017; Tan et al. 2015).

Several of the other key findings in this study concur with the literature; males being more likely to consume insects than females (Sogari et al. 2017; Tucker 2014; Wilkinson et al. 2018) and younger participants being more likely to consume than older participants (Verbeke 2015). The finding that meat-eaters reported being more likely to consume insects than those who follow an alternative diet was supported by the findings of some researchers (Wilkinson et al. 2018), but not others, who found that consumption was expected to be lower among those with a strong focus on meat in their diet (Schlup and Brunner 2018; Verbeke 2015). This alludes to the complex nature of dietary choices; insects may be considered an 'alternative food' and therefore more likely to be appealing to those already eating alternative diets. However, insects are also living creatures and may be unappealing to vegans or those concerned about animal welfare. Nonetheless, consumers' reasons for adopting vegan, vegetarian or other diets may include environmental and health concerns abated by a diet including insects. It may be that careful marketing is needed to ensure each group feels an insect product meets their needs. For example, research suggests that insects should not be marketed as an alternative to meat; they are best marketed as their own distinct category to minimise expectations of similar sensory attributes (taste, appearance, smell) (Deroy et al. 2015). This may be particularly important when targeting meat-eaters as consumers. Another strategy may involve using particular species in different ways or products, which maximise their benefits and cater to diverse audiences. After all, insects should not be lumped together as one category – they each have a unique taste and properties, which should be utilised (Deroy et al. 2015).

A further finding in this study was that texture was seen to be the biggest barrier for participant acceptance of insects, where the disgust factor is commonly reported as the most significant for consumers (Sogari 2015; Sogari et al. 2017; Van Huis et al. 2013). Interestingly the insects participants reported that they were more likely to consume were those with hard rather than soft bodies, with crickets and locusts being clear preferences over the caterpillar and wax moth larvae. This may suggest a perceived preference for crunchy or crispy rather than squishy or soft textures (the texture of crickets was described as 'crispy' and that of wax moth larvae as 'soft' by participants in a study by Sogari (2015)), which would be consistent with literature for Western consumers (Caparros Medigo et al. 2018). Similarly, participants' preference for processing methods involved making insects dry or crunchy (i.e. turning the insects into a dry powder, or frying them), as has been found in the past (e.g. Lensvelt and Steenbekkers 2014; Wilkinson et al. 2018). However, the inclusion of the descriptors 'crunch' and 'squish' as examples of texture (see Table 6) may have introduced a response bias, given that these terms may have held negative connotations for some participants, who may have interpreted their inclusion as an indicator that edible insects are either crunchy or

squishy. As such, further research to explore texture as a barrier to the consumption of insects would be beneficial.

Participants appeared relatively well informed about the environmental benefits of insect consumption over other forms of protein; however, they were less certain about the potential health benefits. This represents an opportunity for both researchers and businesses marketing insect products to further investigate, and better publicise these benefits. Nevertheless, 'lack of perceived benefits or incentives' was not considered to be a strong barrier to insect consumption, and therefore rational arguments alone may be unlikely to result in product consumption; the product needs to be appealing in its own right (Acosta-Estrada et al. 2021; Sogari et al. 2017).

Conclusion

This study suggests that New Zealand may be an ideal location for trialling increased uptake of products containing insects, particularly if these products are strategically marketed, are appealing in their own right, and can tout evidenced health benefits. Successful target markets for such products are likely to be young male consumers, who are conscious about their health and the environment. Products most likely to achieve uptake are those involving fried insects or insect powders, possibly in the form of a capsule or discreetly mixed into existing foods (clearly labelled). Participants' uncertainty regarding the benefits of insects (health in particular) suggests more scientific research is needed here, for example, to test which insects are beneficial for gut health, specific conditions and health overall.

Limitations and future research

The sample method used in this study resulted in a group of participants who were not entirely representative of a national sample of New Zealanders in terms of gender, age, ethnicity and education. Furthermore, the inclusion of the phrase 'for palatability' in regard to only two processing methods explored in the survey (see Table 5), and the inclusion of the descriptors 'crunch' and 'squish' as examples of texture in the question exploring perceived barriers to consumption (Table 6) may have introduced response biases, that should be corrected for in future research on this topic. Nevertheless, the findings reported are largely consistent with research conducted in other Western countries, suggesting the results are valid. Further research is needed to explore nuance in the relationships between variables, such as how dietary choices and preferences relate to entomophagy, and whether there is sufficient appetite for species beyond locusts and crickets. Research regarding Māori (indigenous New Zealanders') insect consumption would also be highly interesting, including the history of insect consumption and the modern-day likelihood of reintroducing insects as mahinga kai (a food resource).

Notes

1. For example Eat Crawlers (www.eatcrawlers.co.nz), and Primal Future (www.primalfuture.co.nz).

2. See https://sustainable.org.nz/sustainability-success-stories/otago-locusts/.
3. From Very Unlikely to Very Likely, Very Low Extent to Very High Extent and Strongly Disagree to Strongly Agree.
4. Oblimin rotation method with Kaiser Normalisation.
5. Pescatarian was described as a vegetarian apart from consuming fish.
6. Alternative diet includes: Vegan, Vegetarian, Flexitarian, and Pescatarian.
7. University of Auckland (2021). Kiwis quite keen on the idea of eating insects. Retrieved from https://www.auckland.ac.nz/en/news/2021/09/22/kiwis-quite-keen-on-the-idea-of-eating-insects.html.

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Data availability statement

The data is not available due to confidentiality issues, but the authors are happy to discuss the material.

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References

Acosta-Estrada B, Reyes A, Rosell CM, Rodrigo D, Ibarra-Herrera CC. 2021. Benefits and challenges in the incorporation of insects in food products. Frontiers in Nutrition. 8:Article 687712. doi:10.3389/fnut.2021.687712.

Baker MA, Shin JT, Kim YW. 2018. Customer acceptance, barriers, and preferences in the US. In: Halloran A, Flore R, Vantomme P, Roos N, editors. Edible insects in sustainable food systems. Cham, Switzerland: Springer International Publishing; p. 387–399.

Beef + Lamb. 2021. Meat export tool; [accessed 2022 Jan 7]. https://beeflambnz.com/data-tools/meat-export-tool.

Belluco S, Losasso C, Maggioletti M, Alonzi CC, Paoletti MG, Ricci A. 2013. Edible insects in a food safety and nutritional perspective: a critical review. Comprehensive Reviews in Food Science and Food Safety. 12(3):296–313.

Bodenheimer FS. 1951. Insects as human food: a chapter of the ecology of man. The Hague: Springer.

Bogueva D, Schmidinger K. 2019. Normality, naturalness, necessity, and nutritiousness of the new meat alternatives. In: Bogueva D, Marinova D, Raphaely T, Schmidinger K, editors. Environmental, health, and business opportunities in the new meat alternatives market. Hershey, PA, USA: IGI Global; p. 20–37.

Caparros Megido R, Sablon L, Geuens M, Brostaux Y, Alabi T, Drugmand D, Haubruge É, Francis F. 2014. Edible insects acceptance by Belgian consumers: promising attitude for entomophagy development. Journal of Sensory Studies. 29(1):14–20.

Caparros Medigo R, Poelaert C, Ernens M, Liotta M, Blecker C, Danthine S, Tyteca E, Haubruge É, Alabi T, Bindelle J, et al. 2018. Effect of household cooking techniques on the microbiological load and the nutritional quality of mealworms (Tenebrio molitor l. 1758). Food Research International. 106:503–508.

Castro M, Chambers IV E. 2019. Willingness to eat an insect based product and impact on brand equity: a global perspective. Journal of Sensory Studies. 34(2):e12486.

Chan EY. 2019. Mindfulness and willingness to try insects as food: the role of disgust. Food Quality and Preference. 71:375–383.

Clarkson C, Mirosa M, Birch J. 2018. Consumer acceptance of insects and ideal product attributes. British Food Journal. 120(12):2898–2911.

Colmar Brunton. 2018. Better Futures Report: celebrating a decade of tracking New Zealanders' attitudes and behaviours around sustainability; [accessed 2022 Jan 5]. https://www.kantarnewzealand.com/wp-content/uploads/2019/05/Colmar-Brunton-Better-Futures-2019-MASTER-FINAL-REPORT.pdf.

Dagevos H. 2021. A literature review of consumer research on edible insects: recent evidence and new vistas from 2019 studies. Journal of Insects as Feed and Food. 7(3):249–259.

De Marchi L, Wangorsch A, Zoccatelli G. 2021. Allergens from edible insects: cross-reactivity and effects of processing. Current Allergy and Asthma Reports. 21(5):1–12. doi:10.1007/s11882-021-01012-z

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.

FSANZ. 2020. Novel food – Record of views formed in response to inquiries; [accessed 2022 Jan 5]. https://www.foodstandards.govt.nz/industry/novel/novelrecs/Documents/Record%20of%20views%20updated%20April%202020.pdf.

Hamerman EJ. 2016. Cooking and disgust sensitivity influence preference for attending insect-based food events. Appetite. 96:319–326.

Hartmann C, Shi J, Giusto A, Siegrist M. 2015. The psychology of eating insects: a cross-cultural comparison between Germany and China. Food Quality and Preference. 44:148–156.

IBISWorld. 2021. Meat consumption: business environment profiles – New Zealand; [accessed 2022 Jan 5]. https://www.ibisworld.com/nz/bed/meat-consumption/144/#:~:text = On%20average%2C%20New%20Zealanders%20are,capita%20in%20the%20current%20year.

Lähteenmäki-Uutela A, Marimuthu SB, Meijer N. 2021. Regulations on insects as food and feed: a global comparison. Journal of Insects as Food and Feed. 7(5):849–856.

Lensvelt EJ, Steenbekkers L. 2014. Exploring consumer acceptance of entomophagy: a survey and experiment in Australia and The Netherlands. Ecology of Food and Nutrition. 53(5):543–561.

Martins Y, Pliner P. 2005. Human food choices: an examination of the factors underlying acceptance/rejection of novel and familiar animal and nonanimal foods. Appetite. 45(3):214–224.

Meyer-Rochow V, Changkija S. 1997. Uses of insects as human food in Papua New Guinea, Australia, and north-east India: cross-cultural considerations and cautious conclusions. Ecology of Food and Nutrition. 36(2-4):159–185.

Miller D. 1952. The insect people of the Maori. The Journal of the Polynesian Society. 61(1/2):1–61.

Ministry of Education. 2019. Educational attainment in the adult population: highest educational attainment of the New Zealand population aged 15 years and over; [accessed 2019 October 30]. https://www.educationcounts.govt.nz/statistics/indicators/data/education-and-learning-outcomes/3680.

Ministry for Primary Industries. 2015. CTO direction to biosecurity inspectors for the clearance of insect-based food; [accessed 2022 Jan 5]. https://www.mpi.govt.nz/dmsdocument/10304/direct.
Pliner P, Hobden K. 1992. Development of a scale to measure the trait of food neophobia in humans. Appetite. 19(2):105–120.
Rigter S, Mirosa M, Mangan-Walker E, Clarkson C. 2016. Understanding New Zealand consumers' attitudes towards eating insects. The Australian-Pacific Journal of Regional Food Sciences. 6:22–40.
Roberts JA. 1996. Green consumers in the 1990s: profile and implications for advertising. Journal of Business Research. 36(3):217–231.
Roininen K, Lähteenmäki L, Tuorila H. 1999. Quantification of consumer attitudes to health and hedonic characteristics of foods. Appetite. 33(1):71–88.
Ruby MB, 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.
Schlup Y, Brunner T. 2018. Prospects for insects as food in Switzerland: a tobit regression. Food Quality and Preference. 64:37–46.
Sogari G. 2015. Entomophagy and Italian consumers: an exploratory analysis. Progress in Nutrition. 17(4):311–316.
Sogari G, Bogueva D, Marinova D. 2019. Australian consumers' response to insects as food. Agriculture. 9(5):108.
Sogari G, Menozzi D, Mora C. 2017. Exploring young foodies' knowledge and attitude regarding entomophagy: a qualitative study in Italy. International Journal of Gastronomy and Food Science. 7:16–19.
StatsNZ. 2017a. Summary figures for the New Zealand resident population, year ended December 2017; [accessed 2022 Jan 7]. www.stats.govt.nz/topics/population.
StatsNZ. 2017b. Māori population estimates: at 30 June 2017 – tables; [accessed 2019 Oct 30]. http://archive.stats.govt.nz/browse_for_stats/population/estimates_and_projections/MaoriPopulationEstimates_HOTPAt30Jun17.aspx.
Tan HSG, Fischer AR, Tinchan P, Stieger M, Steenbekkers L, van Trijp HC. 2015. Insects as food: exploring cultural exposure and individual experience as determinants of acceptance. Food Quality and Preference. 42:78–89.
Tan HSG, Fischer AR, van Trijp HC, Stieger M. 2016. Tasty but nasty? Exploring the role of sensory-liking and food appropriateness in the willingness to eat unusual novel foods like insects. Food Quality and Preference. 48:293–302.
Trope Y, Liberman N, Wakslak C. 2007. Construal levels and psychological distance: effects on representation, prediction, evaluation, and behavior. Journal of Consumer Psychology. 17(2):83–95.
Tucker CA. 2014. The significance of sensory appeal for reduced meat consumption. Appetite. 18(c):168–179.
Van der Spiegel M, Noordam M, Van der Fels-Klerx H. 2013. Safety of novel protein sources (insects, microalgae, seaweed, duckweed, and rapeseed) and legislative aspects for their application in food and feed production. Comprehensive Reviews in Food Science and Food Safety. 12(6):662–678.
Van Huis A. 2013. Potential of insects as food and feed in assuring food security. Annual Review of Entomology. 58:563–583.
Van Huis A. 2018. Insects as human food. In: Alves RRN, Albuquerque UP, editor. Ethnozoology: animals in our lives. London, UK: Elsevier; p. 195–213.
Van Huis A, Van Itterbeeck J, Klunder H, Mertens E, Halloran A, Muir G, Vantomme P. 2013. Edible insects: future prospects for food and feed security. Rome, Italy: Food and Agriculture Organization of the United Nations.
Van Huis A, Halloran A, Van Itterbeeck J, Klunder H, Vantomme P. 2022. How many people on our planet eat insects: 2 billion? Journal of Insects as Food and Feed. 8:1–4. doi:10.3920/JIFF2021.x010.
Verbeke W. 2015. Profiling consumers who are ready to adopt insects as a meat substitute in a Western society. Food Quality and Preference. 39:147–155.

Wilkinson K, Muhlhausler B, Motley C, Crump A, Bray H, Ankeny R. 2018. Australian consumers' awareness and acceptance of insects as food. Insects. 9(2):44.

Appendix

Scale	Items
Concern about healthiness of food	The healthiness of food has little impact on my food choices
	I am very particular about the healthiness of the food I eat
	I eat what I like and I do not worry much about the healthiness of food
Willingness to try new foods	I am constantly sampling new and different foods
	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
Attention to the environmental impact of food	When I buy foods, I try to consider how my use of them will affect the environment

Note. Responses to all items were marked on a 5-point Likert scale from 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree or disagree, 4 = Agree and 5 = Strongly agree.