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Perception of cat owners on the use of insects as feed ingredients for cats

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Abstract

Currently, insects represent a sustainable alternative to animal-based ingredients for pet food, but there is little information on the willingness of cat owners to incorporate insects into their pet diets. The objective of this study was to assess the perception of cat owners to feed insect-based feed. Between June and August 2021, an on-line survey was provided to cat owners in Chile; of the total number of participants (1684), the majority were female (89.2%), with university education (73%) and omnivorous eating habits (63.7%). Participants had an average of 2 cats per household with indoor lifestyle (70.2%). Most participants (63.6%) were willing to feed insects to their cats. Participants were more willing to feed their cats treats containing 20% insect meal (Overall willingness (OW) = 7.1 ± 3.1, on a scale of 1 to 10), than pure insect meal (OW = 4.9 ± 3.3) or whole insects (OW = 4.4 ± 3.3). Cricket meal treats were the most acceptable. Acceptance toward insects increased when mentioning the environmental benefits of insect production (OW = 7.6 ± 2.9). Participants more willing to offer insect-based treats to their cats were also more willing to use pure insect meal and even whole insects. The reasons for not wanting to include insects in cat feed were disgust, unfamiliarity and preference for traditional pet foods.

Keywords

insect – pet feed – cat owners – survey

1 Introduction

Pet ownership in the world has grown significantly primarily due to the strengthening of the human-pet bond, pet humanisation, and urbanisation (Alexander *et al.*, 2020). In response to this phenomenon, the pet food industry has experienced rapid growth (Deng and Swanson, 2015), resulting in increased demand for animal protein sources to feed dogs and cats (Hu *et al.*, 2020). Animal protein constitutes an essential part of cat diets, because they are strict carnivores and have a high protein requirement (26-30%) (AAFCO, 2014). However, in pet food production, animal protein is the most expensive and least sustainable nutrient, with a high negative environmental impact (Acuff *et al.*, 2021; Alexander *et al.*, 2020; Okin, 2017). Therefore, there is a constant search for alternative protein sources that are sustainable and nutritionally adequate.

Insects have been proposed as an alternative source of protein (Bessa *et al.*, 2020; Mishyna *et al.*, 2020). In terms of sustainability, insects can be raised in mini-farms and require fewer resources than other animals such as chicken, pigs or cattle. Insects produce many offspring in a short period of time, with rapid growth

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and high feed conversion efficiency (Bessa *et al.*, 2020; Premalatha *et al.*, 2011). For example, the black soldier fly (*Hermetia illucens*) consumes 2 kg of feed to produce 1 kg of edible mass, while cattle require 10 kg to produce the same amount (Oonincx *et al.*, 2015). Some insects can feed on waste (household, agro-forestry, marine, etc.), contributing to the circular economy (Ramos-Elorduy *et al.*, 2002). In addition, conventional livestock is responsible for 14% of global greenhouse emissions (Baiano, 2020); broiler chickens produce 32-167% more CO_2 equivalent emissions compared to mealworms (*Tenebrio molitor*) (Oonincx and de Boer, 2012), and most commercially raised edible insect species produce negligible amounts of greenhouse gases and ammonia (Oonincx *et al.*, 2010).

Insects can provide the protein requirements of dogs (Bosch *et al.*, 2016; Koutsos *et al.*, 2019) because they have a high protein content (35-60% on a dry basis) and high proportions of essential amino acids (Cappelli *et al.*, 2020; Melgar-Lalanne *et al.*, 2019) with good digestibility (77-93%) (Bosch and Swanson, 2021), similar to other foods of animal origin, such as chicken meal and meat-bone meal (Bednar *et al.*, 2000). The use of insects in dog feed has been shown to maintain optimal health (Hong *et al.*, 2020; Lei *et al.*, 2019), with no negative effects on the microbiota (Jarett *et al.*, 2019), and are well tolerated and accepted by dogs (Freel *et al.*, 2021; Kröger *et al.*, 2020). Furthermore, they can be used as olfactory attractants (Feng *et al.*, 2020; Kierończyk *et al.*, 2018). However, studies in cats are scarce and have investigated only a few topics, including effects on health, acceptability, tolerance, palatability and digestibility of insects (Do *et al.*, 2022; Hu *et al.*, 2020; Paßlack and Zentek, 2018; Pezzali and Shoveller, 2021; Reilly *et al.*, 2022). Insects can be part of the diet of feral and domestic cats and are consumed through hunting (Escobar-Aguirre *et al.*, 2019; Medina and García, 2007).

There is a significant supply of insect-based pet feed and treats on the world market (Beynen, 2018), but the big question is whether pet owners are willing to feed their cats insect-based food. Studies on pet owners' perceptions of feeding insect-based ingredients to their pets are scarce. Higa *et al.* (2021) described the acceptance of US Citizens eating insects, eating insect-fed livestock animals, or feeding insect-based foods to their dogs. La Barbera *et al.* (2021) studied the willingness of Western individuals to consume insect-based foods, however, they did not include feeding insects to pets. To date, no such studies exist for cat owners. The objective of this study was to assess, through a survey, the perception of cat owners to feed insect-based foods.

This study was conducted in Chile, because it is a country of 'pet lovers', as 8 out of 10 people have at least one pet. The average number of pets per household is 2.7 in the year 2022 and pets are considered by Chileans as another member of the family (CADEM survey, 2022). In Chile, there are 12,482,679 dogs and cats with owners (Subdere and UC, 2022), being a very high number, with respect to the population of Chileans that reaches 17,574,003 people (INE, 2017).

2 Materials and methods

Survey

A survey was conducted using the 'Google Forms' platform, which was entitled 'Cat owner feed survey'. The questionnaire was developed based on the research of Higa *et al.* (2021) with modifications, focusing on the willingness of cat owners to feed their cats insect-based ingredients and food. The main difference of our study with respect to the one developed by Higa *et al.* (2021), was that we included images of whole insects in our questionnaire (Figure 1); since one of the reasons for not consuming insects is the negative impact of insect appearance (Cicatiello *et al.*, 2016; Ruby *et al.*, 2015; Stone *et al.*, 2022).

In general, the survey contained questions where participants chose alternatives, and there were some open-ended questions to better understand the opinions of the participants (see questionnaire in Supplementary Material and Methods S1). The survey consisted of 34 questions, divided into five sections. The first section contained questions to characterise cat owners and their cats (indoor/outdoor cat ownership and number of cats per household). The second section was related to the cats' diet (consumption of commercial food, treats, hunting habits of animals and/or insects). The third section was designed to learn about the human-animal bond (sleeping with or talking to cat, human-cat interaction, other). The fourth section measured the willingness of cat owners to feed cats different ingredients or insect-based foods. Following the methodology described by Higa *et al.* (2021), participants were first given a brief description of the insects:

'Black soldier fly larvae, mealworm larvae and adult crickets are efficient, nutritious, ecological and harmless insects (they do not transmit diseases). They taste good and have a high concentration of certain nutrients (high levels of protein, calcium, magnesium, unsatu-

FIGURE 1 Images used in the survey: treats with 20% insect meal (A), whole insects (B), (1) black soldier fly larvae (*Hermetia illucens*), (2) mealworm larvae (*Tenebrio molitor*), (3) adult crickets (*Acheta domesticus*) and insect meal (C). Sources: A: https://fridamascotas.cl; B-1: https://www.agropprod.com; B-2: https://www.feedandadditive.com; B-3: https://www.edibleinsects.com; C: https://entofood.com.

rated fatty acids, manganese, vitamin D and B_{12}). There are several pet foods containing insect meal. Contrary to popular belief about most insects, insect meals are very hygienic'.

Participants were also shown a series of pictures with possible insect inclusion formats, such as: treats containing 20% insect meal (Figure 1A), whole insects (Figure 1B) and pure insect meal (Figure 1C). For each of these formats, the three most used insect species in dog and cat food were included: black soldier fly larvae (BSFL) (Figure 1B-1), mealworm larvae (Figure 1B-2) and the adult house cricket (Figure 1B-3) (Bosch and Swanson, 2021).

In this section, some positive nutritional and environmental sustainability characteristics of insects and their rearing process were highlighted to see if this could influence participants' willingness to use insect-based ingredients or food for their cats. For example, 'insect meal may contain more omega-3 and vitamin B_{12} than traditional pet treats made from animal-based ingredients' and 'the production of 12 bags of 227-grams of insect meal could save 1000 gallons of water and 50 m^2 of land compared to production of beef protein'. Finally, participants were asked an open-ended question as to why they would not be willing to feed their cat insect-based food.

The last section collected demographic data of survey participants (gender, age, educational level and eating habits). The classification of dietary habits of participants was done as follows: omnivores, who consume all types of food including meat and animal products (meat, eggs, dairy, others); ovo-dairy vegetarians, who exclude meat from their diet, but consume animal products such as eggs and dairy; partial vegetarians, who do not consume red meat, but consume fish, poultry or others; reducetarians, who have substantially reduced their intake of animal foods (red meat, fish, poultry, seafood, others) and vegans, who do not consume any animal foods.

In this study, no personal information was requested from the participants, and all gave their informed consent before starting the questionnaire. The information was used for academic purposes. The survey was active between June and August 2021 and was disseminated through social networks such as Instagram, Facebook, and LinkedIn. It was also sent by email to different veterinary clinics located in Santiago, Chile. After the form was closed, the responses were downloaded to an Excel spreadsheet (Microsoft Corporation, USA, 2021).

Survey analysis

Participants and their cats were characterised by means of observed frequencies, summarising the data as a percentage of the total sample of participants. To ascertain participants' willingness to feed their cats the insect-based ingredients shown in Figure 1, a simple 10-point sliding scale was used (Higa *et al.*, 2021; Rozin and Ruby, 2020). Briefly, this scale is used to represent participants' level of willingness; ratings are valued in whole numbers, from 1 meaning 'not at all willing' to 10 'completely willing'. To analyse this information, mean ± standard deviation was calculated. Overall willingness (OW) was also calculated, which was the average of the responses for each insect inclusion format (such as treats, pure insect meal or whole insects). Comparisons between the willingness to use different insect products were performed by repeated measures ANOVA analysis, adjusted by the Greenhouse-Geisser test. The model used is described as follows:

$$Yij = \mu + \alpha i + \pi\sigma + \epsilon$$

where:

Yij = willingness observed in the respondent;

μ = population average;

αi = effect of the i^{th} insect format;

$\pi\sigma$ = random effect of the individuals;

ϵ = experimental error.

Statistical differences between groups were analysed using Fisher's least significant difference (LSD) test ($P < 0.05$).

The Cat Owner Relationship Scale (CORS) (Howell *et al.*, 2017) was applied to assess the influence of the human-animal bond on pet owners' willingness to feed insect-based ingredients to their cats. Briefly, Overall Cat-owner Interaction (OCI) was measured based on questions 6, 12 and 14 and Overall Perceived Emotional Closeness (OPEC) was measured using questions 13 and 16 (see questionnaire in Supplementary Material S1).

To determine the association between the OW of the different insect formats, the characteristics of the participants (such as age, eating habits and the human-animal bond according to the CORS scale), a Pearson's correlation coefficient was calculated and strength of association was measured according to Akoglu's (2018) criteria, where the levels of association were: strong (≥|0.7|), moderate (≥|0.4|) and weak (≥|0.10|).

To determine the association between the responses to the question 'Are you in favour of producing insects to incorporate them into cat's food?' with the characteristics of the participants (gender, educational level and eating habits), a χ^2 test of independence was applied. The strength of association was measured through Cramer's V contingency coefficient, according to the criteria of Akoglu (2018). The levels of association were: very strong (>0.25), strong (>0.15), moderate (>0.10), weak (>0.05) and very weak or no association (0-0.04) (Ratner, 2009). All analyses were performed using RStudio Team software (RStudio, USA, 2020).

Finally, to analyse the response obtained from the open-ended question, 'If you are not willing to feed your cat any insects in any form, please explain the reason', seven categories were established to classify the responses and a word cloud was created to visualise the data (Figure 3).

Ethical statement

Participants gave their informed consent at the beginning of the survey, where they were informed that, upon indicating that they agreed to participate in this study, it would be anonymous and that their responses would be used for academic purposes. It was also specified that they could withdraw their participation at any time.

3 Results

Participant characteristics

A total of 1770 responses were received, which were subjected to different exclusion criteria, eliminating participants who had no cats, who had a very high number of cats (>10 cats), who could not provide an estimated weight of their cat, who were minors (under 18 years of age) and who provided erroneous data on their gender and age. After applying the exclusion criteria, 86 responses were eliminated, resulting in a final count of 1684 participants. The main characteristics of the participants and their cats are presented in Table 1 and Figure 2, most of the participants were young women, with university education. Most of the participants were omnivores, followed by reducetarians.

TABLE 1 Characteristics of study participants (n = 1684)

Characteristics	Sample (%)
Gender	
Male	10.0
Female	89.2
Others	0.8
Age	
18-25	16.5
26-35	44.8
36-50	32.0
51-65	6.0
66-79	0.7
Education	
Elementary school	0.3
High school	14.7
Incomplete secondary school	0.1
Undergrade	73.0
Master-level	10.3
PhD	1.6
Feeding habits	
Reducetarian	14.1
Lacto-ovo vegetarian	9.3
Partially vegetarian	8.9
Vegan	4.0
Omnivorous	63.7

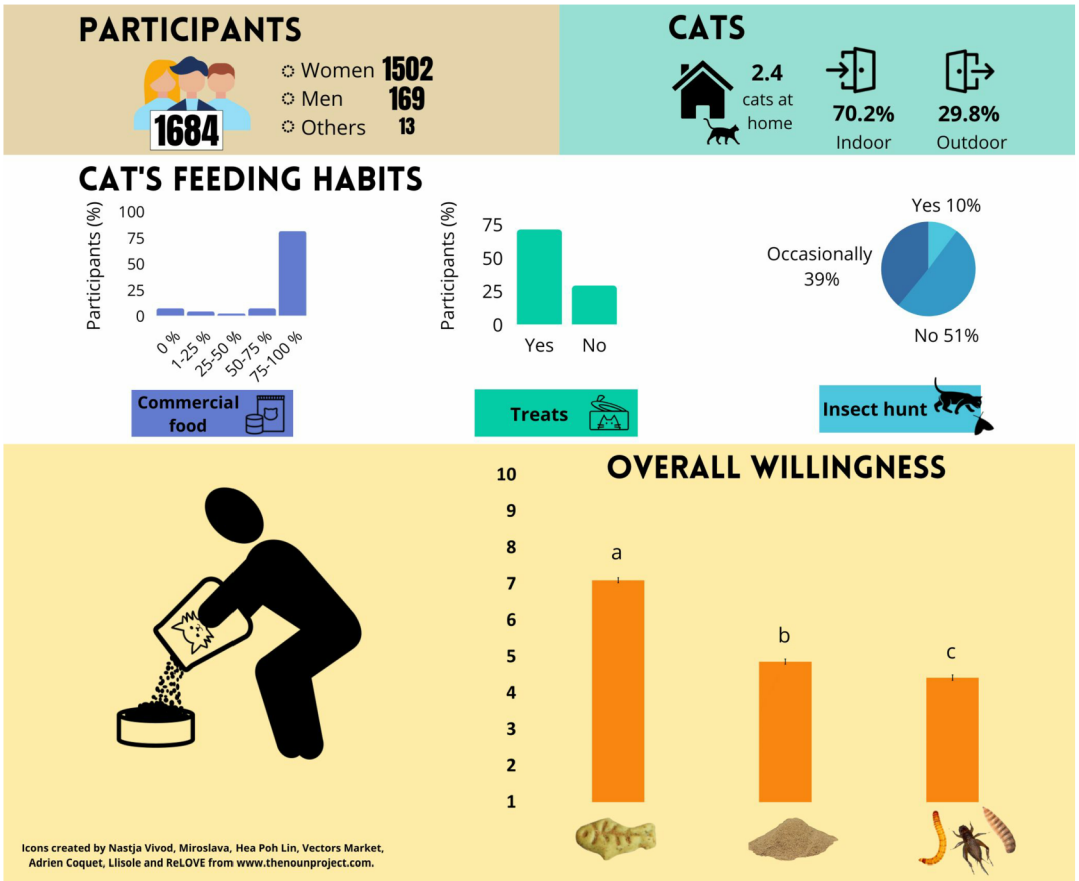

FIGURE 2 Characterisation of the participants and their cats and overall willingness of the participants to feed insect foods to their cats (mean ± SD), using a scale ranging from 1 (not at all willing) to 10 (completely willing).

Participants had an average of two cats per household and the majority kept their cats indoors (Figure 2). The majority of participants (81%) stated that their cat's diet consists of 75-100% commercial food, and 71% of cat owners offer commercial treats to their cats. Seventy-one percent of participants indicated that their cat does not consume fruits and/or vegetables, and 53% do not offer human food to their cats, while 41% do so sometimes and 6% do so regularly. 90% of the participants stated that their cat does not hunt small mammals and/or birds for feeding, and only 7% do it sometimes and 3% do it regularly. 49% indicated that their cats do consume insects (Figure 2).

Willingness of cat owners to use insects as feed ingredients for their cats

Table 2 shows the willingness to include the different insect products previously shown in Figure 1. Participants had a higher willingness to feed their cats treats with 20% insect meal, especially when the environmental and nutritional advantages of insects were mentioned. Within the category 'treats' the most preferred insects were crickets and mealworm, while BSFL ranked

TABLE 2 Willingness of cat owners to feed their cats different insect products[1]

Insect format	Willingness[2] (mean ± SD)
Treats – 'environmental sustainability highlights'	7.9 ± 2.9[a]
Treats – 'nutritional highlights'	7.6 ± 2.9[b]
Treats – crickets	7.3 ± 3.1[c]
Treats – mealworms	7.1 ± 3.1[cd]
Treats – BSFL	7.0 ± 3.1[d]
Pure insect meal – crickets	5.0 ± 3.3[e]
Pure insect meal – mealworms	4.9 ± 3.3[e]
Pure insect meal – BSFL	4.8 ± 3.2[e]
Whole insect – crickets	4.5 ± 3.4[f]
Whole insect – mealworms	4.4 ± 3.3[f]
Whole insect – BSFL	4.3 ± 3.3[f]

1 BSFL = black soldier fly larvae.
2 Willingness scale ranging from 1 (not at all willing) to 10 (completely willing). Means with a common letter are not significantly different ($P < 0.05$).

TABLE 3 Pearson correlation coefficients between overall willingness (OW), to different insect products: insect meal treats with 20% of insect meal (IMT), whole insect (WI) and pure insect meal (PIM) versus characteristics of the participants, such as: age, eating habits (EH), overall cat-owner interaction (OCI) and overall perceived emotional closeness (OPEC)

Correlations	OW-IMT	OW-WI	OW-PIM	Age	EH	OCI	OPEC
OW-IMT	–						
OW-WI	0.55	–					
OW-PIM	0.59	0.68	–				
Age	−0.13			–			
EH				0.13	–		
OCI						–	
OPEC	−0.05					0.44	–

last. The willingness to provide insect-based treats is considered very good, since half of the scale (i.e. more than 5 points) is considered good acceptance.

The willingness to use pure insect meal scored significantly lower than treats and there were no differences between the three insects. Finally, the lowest score was for whole insects, and no differences were found between insects. Figure 2 shows the OW of the insect products, where the most accepted product was treats with 20% insect meal, followed by pure insect meal, and then whole insects.

Table 3 shows the results of the Pearson's correlation coefficient between OW and participant features. Only significant relationships ($P < 0.05$) are displayed. Table 3 shows a weak negative correlation between age and OW-IMT indicating that there is a slight tendency for older participants to be less willing to provide their cats 20% insect meal treats. There is also a positive and moderate correlation between OW-WI, OW-PIM with OW-IMT meaning that participants that tend to provide pure insect meal and whole insects to cats tend to have willingness to provide 20% insect meal treats to their cats as well. As expected, when there is a higher human-animal bond (determined by OPEC) the interaction of the participants with their cat (OCI) was higher. However, there was no significant correlation between a stronger human-animal bond and a willingness to feed cats insect-based ingredients. Although there is significant coefficient of correlation between OPEC and OW-IMT, the strength of the association is less than weak by Akoglu's criteria (2018) and therefore not taken into account.

Most participants agreed (63.6%) with the question: 'Are you willing to produce insects as food ingredients for cats?' There is a moderate association between the educational level of the participants and the willingness to produce insects to feed cats ($\chi^2 = 34.274$, $P = 0.027$, Cramer's V coefficient = 0.142), where 46% of participants that are willing to produce insects to feed cats have university studies. It was observed that 41% of the respondents were omnivorous and they were willing to produce insect feed for cats ($\chi^2 = 42.201$, $P < 0.01$) showing a strong association (Cramer's V coefficient = 0.186).

When cat owners were asked why they were unwilling to feed insect-based ingredients to their cat, the responses were classified into seven categories specified below: (1) insects are unpleasant and generate disgust, (2) lack of information about insects as feed ingredients, (3) insects are not considered safe, (4) the cat has a special disease and/or dietary requirements (e.g. requires consumption of medicated feeds), (5) the cat does not consume or does not like processed feeds, (6) insects are considered animals and there is no agreement on the exploitation of more animal species to produce food and (7) they prefer traditional feeds. The majority of responses were in the category 'unpleasant and generate disgust' (n = 53), followed by 'lack of information about insects as feed ingredients' (n = 44) and 'prefer traditional feeds' (n = 22) (Figure 3).

4 Discussion

The development of survey-type studies that explore pet owners' willingness to use insects as novel ingredients is important as the number of cats is expected to increase by about 600 million worldwide. Cats are highly valued pets because they provide companionship, emotional support and are even beneficial to the health of their owners (Friedmann and Son, 2009; Friedmann and Thomas, 1985; Howell *et al.*, 2017; Levine *et al.*, 2013; Somervill *et al.*, 2008), and are one of the most popular pets in the world (Searle, 2019). People are becoming more concerned about the nutrition and well-being of their cats, which has driven the 'premiumisation' trend, increasing the purchase of premium

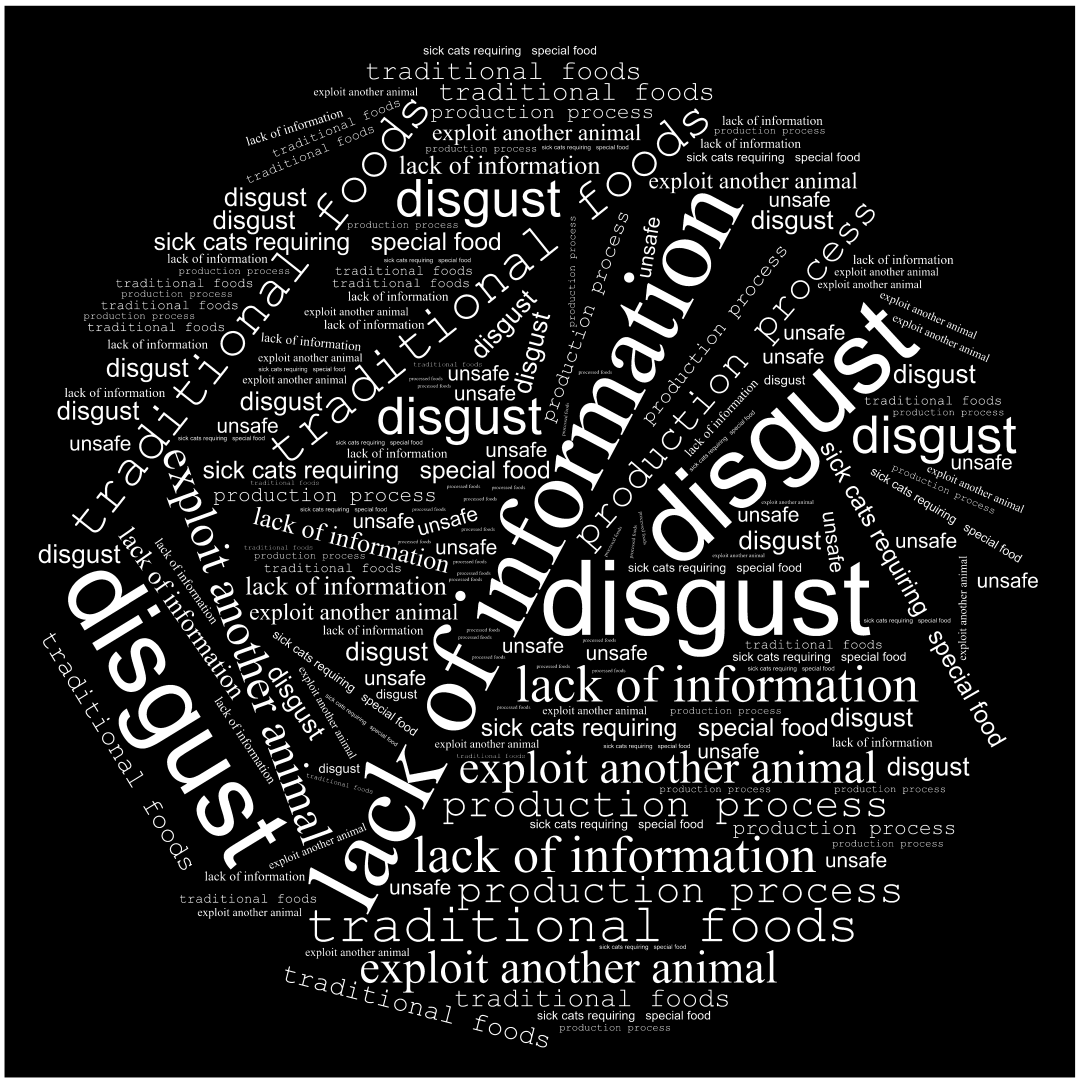

FIGURE 3 Word cloud with the main reasons participants are not willing to include insects in their cat's diet.

and super premium foods. These foods contain animal-derived ingredients, meats, and human-grade ingredients, that together with other new eating styles (natural, holistic, raw or BARF diets) that contain large amounts of animal-derived ingredients, exacerbate the issue of environmental sustainability (Su and Martens, 2018). These concerns have led some to suggest reducing the rate of dog and cat ownership (Okin, 2017; Su and Martens, 2018). Alternative protein ingredients are vegetable-based proteins, however, they do not have the same quality of amino acid digestibility, amino acid profile and essential amino acid content (Kanakubo *et al.*, 2015). Other protein sources that have been studied are proteins from fungi, algae, microalgae, yeasts, and others (Agboola *et al.*, 2022; Bleakley and Hayes, 2017; Brain-Isasi *et al.*, 2021; Milledge, 2011; Zhu *et al.*, 2020), but these are not produced in large volumes and their cost is high. It has been suggested that insects could be the protein ingredient of the future, but in some cultures their consumption is rejected (Lange and Nakamura, 2021). Thus, knowing the willingness of cat owners to include insect-based ingredients in a cat's diet is important.

Most of the cats from surveyed participants were kept indoors, which is a current trend in the world, due to urbanisation and the increased concern of pet owners for animal welfare and health, as outdoor cats are more likely to contract diseases, disappear, be mistreated and suffer accidents (Machado *et al.*, 2021; Wilson *et al.*, 2017; Yeates and Yates, 2017). Interestingly, the type of ownership (indoor/outdoor) influences cat feeding. Cats confined indoors depend on their owners for feeding (Delgado and Dantas, 2020); therefore, in this study, the majority of cats consumed commercial food (Laflamme *et al.*, 2008; Schleicher *et al.*, 2019). Also, cat owners offer a high number of treats as a reward, because these tighten the human-animal bond (Rogues *et al.*, 2022) and are used as a demonstration of affec-

tion (He *et al.*, 2020). In contrast, outdoor cats have access to diverse feed sources and express their hunting behaviours (Cline *et al.*, 2019; Levy *et al.*, 2003). In our study, participants indicated that their cats do not regularly hunt other animals, contrary to what was reported by Escobar-Aguirre *et al.* (2019) in a study conducted in Chile, where 84% of cat owners reported that cats hunted birds and mammals, followed by insects. These differences may be due to the fact that most of the cats in the present study were kept indoors, which reduces the chances of hunting larger prey. Indoor cats tend to hunt insects, such as moths, crickets, beetles, dragonflies, and spiders (Hernandez *et al.*, 2018). Half of the participants indicated that their cats hunt insects.

When cat owners were asked about their willingness to feed insects to their cats, they preferred treats containing 20% insect meal, similar to what was reported by Higa *et al.* (2021), who described that BSFL meal delivered as treats is relatively well perceived by consumers. In our study, among the three insects presented, the participants preferred crickets, which could be related to the fact that, in Chile, crickets are considered 'lucky insects'. The greater rejection of the black soldier fly could be explained because it is associated with flies such as houseflies, which carry pathogens and are in contact with dangerous environmental substances, since their larvae feed on faeces, and are considered unpleasant and dirty (Deroy *et al.*, 2015).

The second most willing ingredient was pure insect meal. The incorporation of insects in familiar products such as meal, fat or paste, where the insects are not visible, increases their acceptance by consumers (Delicato *et al.*, 2020). Higa *et al.* (2021) reported that the greatest willingness to deliver insect-based feed to dogs was in the form of processed insects (meal or treats) or indirectly as consuming insect-fed farm animals. The better acceptability of pure insect meal may be related to the fact that its appearance is similar to meals traditionally used in pet feed (such as meat meal, meat-and-bone meal and fish meal). In contrast, the rejection of whole insects is influenced by social and psychological factors, as they are associated with bad taste, even without having tasted them (Cicatiello *et al.*, 2016). The main cause of this rejection is neophobia, in addition to feeling disgust, the perception that the insects are dirty or dangerous and a lack of familiarity with them (Costa-Neto and Dunkel, 2016; Orsi *et al.*, 2019), as shown in Figure 3. In the study developed by Higa *et al.* (2021), the participants did not see pictures of whole insects, unlike this study (Figure 1), which we believe influenced the lower acceptance of the meal, as participants first observed the image of the whole insects and then the image of the insect meal. Whole insects cause rejection, especially in people from Western cultures, who do not accept entomophagy (Lange and Nakamura, 2021). A survey in Western countries indicated that cat owners feed their pets dry-food, cooked or raw meat-based diets and only 1 of 1397 participants reported feeding their cat an insect-based diet (Knight and Satchell, 2021). The humanisation of pets plays an important role in these results. Forbes *et al.* (2018) suggest that assigning pets human emotions may influence feed purchase decisions. Therefore, it is expected that foods that owners are unwilling to consume will not be offered to their pets either. Research on the acceptability of insect consumption in companion animals is very scarce. Insect-based diets, even those that replace 100% of animal ingredients by insects (Böhm *et al.*, 2018), are well accepted and tolerated by dogs (Freel *et al.*, 2021). Some insects have shown good results as olfactory attractants in dogs (Kierończyk *et al.*, 2018). More studies are needed for cats.

In summary, processed insect-based ingredients are more accepted than whole insects (Higa *et al.*, 2021; La Barbera *et al.*, 2021). Therefore, potential strategies to increase the acceptance of insect-based feeds for cat owners would be to use processed insects that mask their appearance (meal, fat, protein concentrates, hydrolysates, etc.). Another strategy is to promote consumer awareness of the nutritional and environmental benefits of insects. In our study the willingness to feed insect products to cats increased (Table 2) when pet owners read about these benefits in the survey, especially the environmental benefits.

The majority of the participants were university graduates (73.0%), so it is not possible to compare with people with other levels of education. However, it is important to note that higher education implies a greater commitment to environmental issues such as climate change and sustainability, which are the most influential factors in deciding to include insects in the diet (Tuccillo *et al.*, 2020). This is particularly important among young people (Batat and Peter, 2020; Hénault-Ethier *et al.*, 2020; Modlinska *et al.*, 2021), who feel a greater sense of responsibility for the environment (Batat and Peter, 2020). In this context, several cat owners indicated that they do not agree with the industrial production of insects for pet feed because it is another type of animal farming.

A limitation of the present study is that the sample may have been unrepresentative in terms of the gender and age of the study population, since the

vast majority of the participants were young, college-educated women. Therefore, the results from this subsample should be considered primarily exploratory. Other limitation of this study concerns the mode of data collection. The data were collected from an Internet survey, which leaves out the population that does not have access to the Internet and therefore cannot respond, and these individuals may have different attitudes toward the use of insects as food ingredients for their cats.

Finally, it is important to note that *in vivo* studies that have evaluated the effects of insect-based foods on cat health are limited (Valdés *et al.*, 2022) and have only been conducted in the short term (21-70 days) (Do *et al.*, 2022; Hu *et al.*, 2020; Pezalli and Shoveller, 2021; Reilly *et al.*, 2022). Digestibility studies are controversial, with some studies indicating good digestibility (86-89%) (Hu *et al.*, 2020), while others consider it moderate (73-77%) for cats (Paßlack and Zentek, 2018). Therefore, more studies are needed to evaluate insect-based pet foods. For example, evaluating safety and innocuousness, which is a highly questioned topic, acceptability studies, long-term nutritional studies to establish the effect on the health of cats, and others (Bosch and Swanson, 2021; Pezalli and Shoveller, 2021; Valdés *et al.*, 2022).

5 Conclusions

A total of 1684 Chilean cat owners were surveyed to understand the willingness to feed insect-based ingredients to cats. Chilean cat owners were willing to feed their cats treats made with 20% insect meal. Crickets were evaluated as the best potential whole food product (7.3 points, on a scale of 1 to 10). Willingness increased when participants were informed of environmental (7.9 points) and nutritional benefits (7.6 points) of insects. The second most willing ingredient to be included in cat diets was pure insect meal (4.8 to 5.0 points). The willingness to use whole insects was low (4.3 to 4.5). The primary reason for reluctance to feed insects was mainly disgust and dislike followed by lack of information about insects as feed ingredients. These results suggest that processed insects may become an acceptable ingredient for inclusion in cat feeds.

Supplementary Material

Supplementary material is available online at: https://doi.org/10.6084/m9.figshare.23514501

Supplementary Material and Methods S1. Cat owner feed survey.

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Author contributions

The first and second author contributed equally to this article.

Conflict of interest

The authors declare no conflict of interest.

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