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RESEARCH ARTICLE

Exploring consumer perception of entomophagy by applying the Rasch model: data from an online survey

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Abstract

An online consumer survey, consisting of 23 closed questions divided into 9 sections, was conducted to investigate consumer perception of including edible insects in their diet. The data analysis was carried out using a variation of the classic Rasch-Andrich model for multiple choice questions. The online survey involved individuals (n = 327) from Italy and other 29 different European and non-European countries, with different ages, educational background and eating habits, selected from among people attending the University of Perugia. The analysis showed that the majority of participants (90%) were already aware of the term *entomophagy*, although only 19% of the participants had already eaten insects. Moreover, 42% of the participants would be willing to pay less than the equivalent of a hamburger to buy 10 g of insects and 93% would consider eating insects if necessary. The factors limiting entomophagy are mainly represented by neophobia, disgust, fear of allergic reactions and microbiological hazards. Furthermore, the majority would expect to find specific shelves in stores for insect-based products. Moreover, the majority of the participants accepted that pet or farm animals could be fed with insect-based products. Lastly, almost all the participants considered food safety of edible insects to be the responsibility of the national competent authorities, as required for other foods. The aim of this study was to address the current perceptions of modern consumers to entomophagy and discover the perceived advantages and disadvantages associated with the consumption of insects. Although it is difficult to predict whether edible insects can effectively represent the "food of the future" and whether they can really become part of western consumers' diet, the results obtained in this study demonstrated that providing consumers with information not only on insects and the production methods used, but also on food safety measures can improve the consumer's attitude towards entomophagy.

Keywords

entomophagy – consumer perception – survey – Rasch-Andrich model

1 Introduction

Insects represent the largest of the animal groups (in terms of number of species) that populate the Earth. They count over a million species, equal to five sixths of the entire animal kingdom and are widely distributed throughout the globe. It is, therefore, unsurprising that insects have been part of the human diet for millennia. The use of insects in the human diet was especially important in prehistoric times before humans discovered hunting and agriculture, as documented, for example, by some coprolites found in Mexico and the United States containing traces of ants, beetle larvae, lice, ticks and mites (Capinera, 2008). References to entomophagy are also found in many sacred texts of different religions. For example, insects as food are found in the Old Testament, the New Testament and in the Islamic faith. Nowadays, the practice of eating insects is called entomophagy (Barsics *et al.*, 2017) and is practiced by approximately two billion people around the world, mainly in tropical areas such as Africa, Asia, South and Central America (including Mexico), Australia and Oceania according to a FAO/WUR report (van Huis, 2016). More recent studies consider this number an overestimation. However, a figure of several hundreds of millions could be possible: with the lack of consistent criteria to consider a person as "insect-eater", it is almost impossible to determine the exact number of people practising entomophagy (Huis *et al.*, 2022).

Insects are a source of livelihood and are naturally harvested in some countries (e.g. Cambodia), while are considered a delicacy in others (e.g. the *chapulines* – fried grasshoppers in Mexico) (Grispoldi *et al.*, 2021). In Western countries, entomophagy is less common (Osimani *et al.*, 2018). The most important factors related to this low acceptance of insects as food are neophobia (in this case manifested as the unwillingness to try new things or break from routine) and the consumer's fear of eating insects (Caparros Megido *et al.*, 2016; Gallen *et al.*, 2018; Verbeke, 2015), which is well established in many Western cultures, where insects are perceived as slimy and with undesirable sensory properties, especially if served whole (Tan *et al.*, 2015). Food preferences are influenced by many factors, including health, price, convenience, mood, nutrient content, familiarity, ethical concerns and sensory appeal. All these factors influence the acceptance or rejection of different insect species as food (Ghosh *et al.*, 2018)

Many different groups of insects are consumed around the world, ranging from beetles, butterflies, ants and bees to grasshoppers and crickets (Gmuer *et al.*, 2016; Tan *et al.*, 2015). Jongema and other authors from the Wageningen University have published a continually increasingly list of over 2000 species of edible insects (Jongema, 2017).

Insects present many benefits as a food source: they require less land and water compared to farm animals (Ayieko *et al.*, 2016; Rumpold and Schlüter, 2013), they emit low amounts of greenhouse gas during the production cycle (Lammers *et al.*, 2019) and some species possess the ability to recycle industrial or agricultural by-products (Smetana *et al.*, 2019). Furthermore, insects are a great source of important nutrients for humans: they are rich in proteins with essential amino acids, polyunsaturated fatty acids and zinc, iron, selenium, calcium and group B vitamins (Osimani *et al.*, 2018; van Huis, 2016). Consequently, it is not surprising that already as far back as in 1975, it was first suggested that edible insects could ease the problem of world food shortage and that organizations, such as WHO and FAO, should encourage humans to consume insects (Meyer-Rochow, 1975). Researchers and institutions are showing a growing interest in insects as food: in fact, insects are considered an opportunity to sustainably supply mankind's ever-growing demand for animal-based proteins (Efsa Scientific Committee, 2015; Food and Agriculture Organization of the United Nations (FAO), 2013; Henry *et al.*, 2018).

Rasch models were introduced in the 60s as a source of psychological measurement, and very soon they became a common tool in the so-called Item Response Theory (IRT) (Embretson and Reise, 2001; Rasch, 1993). IRT has a great number of applications in science, including health and social science. Generally speaking, these models are based on the idea that the answers given by a number of persons to a number of items demonstrate that the comparison between people's (so-called) locations does not depend on the relative locations of items, and *vice versa*. If these models are applied to surveys and tests, as in our case, "imagined" locations for the variables to be measured need to be identified.

In the variation of the model used in this study, these locations were computed by using a stochastic model for data distribution, and introducing an auxiliary variable. This approach improved on the classic, empiric method, as it enabled random data to be introduced to correct any violations of the invariance property which, in turn, follows directly from the mutual independence of the locations of persons and items described above. Therefore, the stochastic approach provides a more accurate probability distribution of the data.

Rasch-Andrich models are often used to evaluate surveys and tests aimed to determine consumer's choices and attitudes. Examples of using variations of the Rasch model include but are not limited to measure the difficulty for people to follow a healthy diet (Henson *et al.*, 2010), determine the affective impression of a moisturiser cream elicited by the compliance of the moisturiser's packaging (Camargo and Henson, 2015), analyse people's attitudes towards mountain foods and the EU Mountain Product label (Bassi *et al.*, 2022) and to assess consumer sensitivity to animal welfare (Gori *et al.*, 2017). The use of these models is particularly useful when it is necessary to measure variables and responses with a preponderant emotional component, generally difficult to observe directly and very complex to evaluate in comparison with more objective characteristics (Camargo and Henson, 2015). In this paper a variation of the Rasch-Andrich model has been used to investigate consumers' perception of entomophagy: this allows to investigate aspects of the total experience of entomophagy which go beyond the mere functionality and are associated with the emotional aspect of the practice.

The main advantage of these methods is that they furnish a measurement of where a given survey or test does or does not work by guiding the author to possible corrections. They also give some indications concerning the persons to whom the survey is given, by indicating a sort of class of expertise, to which both the questions and the persons can be compared.

By 1870, the English author, Vincent Holt, had published a short work entitled "Why not eat insects?" to promote the benefits of an arthropod-based diet (Holt, 1885). Although the book appears extremely modern, even two centuries later, the disgust factor appears to be the main obstacle to the inclusion of insects in western consumers' diet. On the other hand, greater information on the subject could diminish their diffidence. In addition to the strictly cultural aspect, the consumer needs to be informed on the risks of eating this type of food and on the good practices to prevent the product from causing any harm. This paper addresses the following questions: what are the current perceptions of modern consumers to entomophagy and what are the perceived advantages and disadvantages associated with the consumption of insects?

2 Materials and methods

Consumer survey and data collection

The questionnaire, entitled "*Let's eat insects! Why not?*" consisted of 23 questions on the subject of entomophagy, divided into nine sections. The survey was made available on Google Drive and conducted for 14 months.

Participants were selected from among people attending the University of Perugia: they included professors, researchers, students, technicians, temporary hosts and visiting professors. The survey was mainly related to people who shopped for food and were responsible for choices on the food market. Before starting the questionnaire, participants were given a brief introduction to the reasons behind the study and, at the end of the questionnaire, they were given the opportunity to leave their contact details to receive further information on the topic, together with a space for free comments.

Table 1 gives the complete structure of the questionnaire, the first part of which envisaged collecting generic information (age, gender, educational level, country of origin), followed by details regarding food habits (omnivore, vegetarian, vegan, other).

The second part – the survey core – was divided into several sections.

1. *General section*: introductory questions on the topic of entomophagy (knowledge of the term, place in which it is talked about), knowledge of the traditions of countries where they eat insects with the opportunity of naming the country and insect-based dishes the interviewee knows, and the numbers of edible insects.
2. *Experience section*: experiences of entomophagy (with open response to list the dishes consumed), questions on the unwitting consumption of insects and on the frequency with which they are consumed, and details of the impact this practice has on the consumer's life.
3. *Motivational section*: questions were asked about the reasons why people consume insects and the list of products which may, or may not be excluded from consumption, a question on the difficulty of finding the insects and an economic comparison with commercial products, e.g. the hamburger.
4. *Nutritional section*: a question on the nutritional composition of insects and a careful examination of the advantages and disadvantages of introducing insects into the diet.
5. *Interest section*: to identify the categories potentially most interested in requesting further infor-

TABLE 1 Survey structure: list of questions

Survey structure
Age
Gender
Education
Country of origin
Personal food habits
1. Have you ever heard about 'Entomophagy' – the practice of eating insects?
2. Are you aware that in some parts of the world insects are considered a delicacy?
3. Do you know how many species of insects are edible?
4. Have you ever eaten insect-based products?
5. Are you aware that we frequently eat insects without being aware of it?
6. How often do you eat an insect-based meal?
7. How do insects fit into your diet?
8. In the case of hunger or need, would you eat insects?
9. How easy do you think it is to find these edible insects?
10. How much would you be willing to pay for 10 grams of ready-to-eat insects?
11. Which nutritional component do you think is most common in insects?
12. Which age group would you think is most interested in eating insects?
13. Are you interested in receiving more information about it?
14. Would you be more willing to eat insects, if you had a better understanding of the practice of entomophagy?
15. Would you prefer to eat local or exotic species of insects?
16. Where do you expect to find insect-based products on sale?
17. In your opinion, who is responsible for the safety of insect-based products for human consumption?
18. Would you eat animal products (meat, milk, etc.) produced by livestock fed with insects?
19. Would you add an insect-based product into your pet's diet ?
20. Which feeling does this picture arouse in you? Giant wasps
21. Which feeling does this picture arouse in you? Mealworms
22. Which feeling does this picture arouse in you? Giant crickets with chocolate
23. Which feeling does this picture arouse in you? Insect mix

mation, the effects of a greater awareness on the willingness to consider edible insects.

6. *Section on the choices of the potential consumer*: expression of preference from a list of insects, indication of the preference between exotic and local products, request regarding insect-based products, in which the interviewees are interested, location of the insect in distribution centres.
7. *Food safety section*: on animal feed and the competent authorities: participants were asked to say whether or not they were in favour of animal-derived products from animals raised and fed on insect-based feed and of using it in a pet's diet, with a question asking which competent authority should control such products.
8. *Photographic section*: the interviewee was shown four photos of insect-based products to describe what he/she felt (Figures 1-4).

Statistical analysis

The data was entered in a Microsoft Excel database and the statistical analysis was performed with Winsteps Rash for Microsoft Windows. The data was analysed by using a variation of the classic Rasch-Andrich model for multiple choice questions. Briefly, Rasch models provide a mathematical framework to compare empirical data to assess an instrument's capacity to emulate the properties of fundamental measurement (invariance and unidimensionality), and thus serve as a tool to quantify unobservable human conditions, e.g. attitude or ability.

FIGURE 1 Giant wasps.

FIGURE 2 Mealworms.

FIGURE 3 Giant crickets with chocolate.

The classic Rasch model expresses the probability that a respondent will affirm a dichotomous item. The probability is modelled as a function of the distance between the two independent parameters "person location" and "item location". The "person location" usually refers to proficiency (the ability that said person possesses) while "item location" refers to difficulty (the amount of ability associated with choosing a certain item) (Guttersrud *et al.*, 2013; Rasch, 1993). Let us summarize the basic concepts concerning this point using suitable terminology: the method is essentially based on the underlying

FIGURE 4 Insect mix.

logic that subjects have a higher probability of correctly answering easier items and a lower probability of answering more difficult items (Gori *et al.*, 2017). Therefore, let us suppose we have a set of M persons who answer N questions. Each of these questions has a number of possible answers a person can choose. According to how the m-th person answers all the questions, gives him a certain ability α_m, which can represent his expertise on the topic under investigation. Clearly, each question also has its own difficulty, determined by how all the persons have answered it. This can vary according to the intrinsic significance and/or clarity of the question itself: thus, to fix the notation, the n-th question has its intrinsic difficulty β_n. At this point, each question has a certain set of possible answers: for a general question n, there is a set of $\{1, 2, ..., K(n)\}$ answers. To avoid a redundant notation, when a certain question is set, we simply write the group of possible answers using $\{1, 2, ..., K\}$, and avoid relating the number K to that specific question. We define $P(m, n, k)$, i.e. the probability that the m-th person gives the answer k ($1 \leq k \leq K$) to the question n, as follows

$$P(m,n,k) = \begin{cases} \dfrac{\exp\left(\sum_{j=2}^{k}(\alpha_m - \beta_n + \tau_j)\right)}{1+\sum_{a=2}^{K}\exp\left(\sum_{r=2}^{a}(\alpha_m - \beta_n + \tau_r)\right)}, & k = 2, ..., K \\ \dfrac{1}{1+\sum_{a=2}^{K}\exp\left(\sum_{r=2}^{a}(\alpha_m - \beta_n + \tau_r)\right)}, & k = 1 \end{cases} \quad (1)$$

The quantities τ_j ($j = 2, ..., K$) measure the difficulty of giving the j-th instead of the $(j-1)$-th answer to the question: we call it the relative difficulty of the j-th answer. To clarify the significance of the expression (1), let us compare the probabilities $P(m, n, k)$ and $P(m, n, k-1)$: we can write

$$\frac{P(m,n,k)}{P(m,n,k-1)} = \frac{\exp\left(\sum_{j=2}^{k}(\alpha_m - \beta_n + \tau_j)\right)}{\exp\left(\sum_{j=2}^{k-1}(\alpha_m - \beta_n + \tau_j)\right)}.$$

From the above equation, it is easy to argue that

$$\alpha_m - \beta_n + \tau_k = \ln\big[P(m,n,k)\big] - \ln\big[P(m,n,k-1)\big]. \quad (2)$$

The latter equation (2) gives the correct meaning of the quantity τ_k, as a logarithmic measure of the probability that a person of ability α_m has of answering k instead of $k-1$ to a question of difficulty β_n (we misapply the terminology and refer to k instead of the k-th answer...). The quantity τ_k is often referred to as the *Andrich threshold*.

It is convenient from now on to change our point of view, and instead of considering probability as a function related to the ability α_m of a single person, we allow α to be a real variable and define $P(\alpha,n,k)$ as the probability that a person with ability α gives the answer j to a question n. Thus, P becomes a function of the variable α, i.e. if n is fixed, then

$$\alpha \mapsto P(\alpha,n,k) = \frac{\exp\left(\sum_{j=2}^{k}(\alpha-\beta_n+\tau_j)\right)}{1+\sum_{n=2}^{K}\exp\left(\sum_{r=2}^{n}(\alpha-\beta_n+\tau_r)\right)}, \quad k=2,\ldots,K$$

and

$$\alpha \mapsto P(\alpha,n,k) = \frac{1}{1+\sum_{n-2}^{K}\exp\left(\sum_{r-2}^{n}(\alpha-\beta_n+\tau_r)\right)}, \quad k=1$$

The variable α lies in the interval $[a,b]$, where $a = \min\{\alpha_m, m=1,2,\ldots,M\}$ and $b = \max\{\alpha_m, m=1,2,\ldots,M\}$.

Let us retrieve some links between the values α, β_n and $\tau_1,\ldots,\tau_K$. First, for every $j = \{2,\ldots,K\}$ an ability $\alpha(2)$ exists, for which the probabilities $P(\alpha(j),n,j)$ and $P(\alpha(j),n,j-1)$ are equal. This implies that

$$\tau_j = \alpha(j) - \beta_n, \quad (3)$$

so that the coefficient τ_j is a translation of the ability $\alpha(j)$, for every $j = 2,\ldots,K$. If we rescale the ability α by $\Gamma := \alpha - \beta_n$ (representing the ability to answer the question n) then

$$\Gamma(j) = \tau_j, \quad j=2,\ldots,K. \quad (4)$$

Another equation is useful to describe the difficulty β_n. Indeed, if we sum up all the quantities $\ln[P(\alpha,n,j)] - \ln[P(\alpha,n,j-1)]$, we obtain

$$\ln\big[P(\alpha,n,K)\big] - \ln\big[P(\alpha,n,1)\big] = (K-1)(\alpha-\beta_n) + \sum_{j=2}^{K}\tau_j$$

Since there is an ability α_0 which gives the probabilities $P(\alpha_0,n,K) = P(\alpha_0,n,1)$, we obtain

$$(K-1)(\alpha_0-\beta_n) + \sum_{k=2}^{K}\tau_j = 0$$

and

$$\beta_n = \alpha_0 + \mathrm{M}(\tau), \quad (5)$$

where $\mathrm{M}(\tau)$ is the arithmetic mean value of the set $\tau := \{\tau_2,\ldots,\tau_K\}$. Below, we will often analyze the results of the survey by producing graphs of the functions $\alpha 7 \to P(\alpha,n,j)$ for $j = 1,\ldots,K$. We will compare and demonstrate the profiles of the functions $P(\alpha,n,j)$ in a simple plot, in order to retrieve both the difficulty β_n of the question and the thresholds $\tau_2,\ldots,\tau_k$ related to the question. This kind of representation will enable us to draw some interesting conclusions on the general awareness of the topic and on the way the questions were proposed, with the aim of improving some of them for a clearer vision in the future.

3 Results

Descriptive analysis

Description of the interviewees

The answers of a total of 327 participants were recorded. 59% of the participants were female, whereas 40% were male, 1% preferred not to state their gender. As regards their level of education, 1% declared they had completed compulsory education, 22% declared a high school diploma, 54% had a university degree and 22% declared a university degree plus postgraduate degree. 85% of the participants were Italian, whereas the others came from 29 different European and non-European countries, with 4% from Mexico and 2% from the United States. As regards food habits, 92% of the interviewees stated they were omnivorous, 5% vegetarian, 1% vegan, 1% other and 1% preferred not to answer. As regards age, 44% of the participants were between 20 and 30 years old (28% female and 16% male), 20% between 30 and 40 (11.4% female and 8.6% male), 28%

between 40 and 60 (15.3% female and 12.7% male), 3% below 20 (2.3% female and 0.7% male) and 5% above 60 (1.5% female and 3.5% male).

General section

In the introduction on the topic of entomophagy, the first question regarding knowledge of the term '*entomophagy*' itself received 90% positive replies with 10% negative replies. 98% of the participants declared they knew some countries considered the consumption of insects a delicacy. 31% of the participants believed the number of edible species to exceed 1000, 13% answered 1000, 27% answered 600, and lastly 29% said 200.

Experience section

Regarding their experience of entomophagy, 81% said they had never eaten insect-based products; 19% had eaten edible insects. 44% of those interviewed stated they were unaware of how frequently they had unwittingly eaten insects. 82% stated they had never eaten insects, 11% had tried them at least once in their life, whereas 5% had eaten them less than once a month and 2% once a month. 4% of the interviewees believed insects to be an innovative ingredient in their diet and 2% as an alternative source of protein.

Motivational section

In the case of necessity or hunger: 47% of those interviewed said they would certainly eat insects, 25% would most probably eat them, 21% with little probability and 7% believed it would be impossible, even under extreme conditions. As regards the availability of insect-based products: 46% of the interviewees thought they were easy to find, whereas 36% thought it was difficult, 14% very easy and 5% very difficult. As regards money: 41% of the participants were not prepared to pay anything to buy 10 grams of insects, 42% would pay less than for a hamburger, 15% the same price as a hamburger and 2% would pay the price of 2-3 hamburgers.

Nutritional section

95% of those taking part said that the main nutritional components in insect-based products are proteins, 3% said fibre, 1% fats and 1% carbohydrates.

Interest section

Among the categories potentially more interested in the consumption of insects: 48% thought adults, 39% adolescents, 5% the elderly, 8% others. 63% said they were interested in receiving further information and 57% would be willing to try if they could get further details about it.

Section regarding the choices of the potential consumer

34% would eat both local and exotic species, 18% would only eat autochthonous species, 1% only exotic. 74% said there should be an exclusive shelf reserved for insect-based products, 12% said that insects should be sold together with meat, 2% with vegetables and 12% other.

Food safety section

87% of the interviewees believed the responsibility for the safety of insect-based products falls on the same authorities responsible for the safety of other animal-derived products, 3% on the individual producer or the association of producers, 3% on international organizations and 7% did not know. 80% were in favour of animal-derived products from animals raised and fed on insect-based feed. T34% would be willing to include insects as pet food, 49% would be willing to include them as pet food if there were any benefits, such as price or nutritional properties, and 18% would not include insects in their pets' diet.

Photographic section

The interviewee was shown four photos of ready-to-eat, insect-based products and was asked to describe what he/she felt. Faced with a mix of dehydrated insects, 48% said they felt disgust, 42% were curious, 3% were hungry and 7% other. Giant wasps caused 66% of the cases of disgust, curiosity in 17% and other in 16%, whereas 0% felt any appetite. The picture of mealworms aroused disgust in 52% of those interviewed, curiosity in 34%, appetite in 9%, other feelings in 5%. Faced with locusts with chocolate, 65% said they felt disgust, 26% were curious, 4% were hungry and 5% other.

Statistical analysis

Table 2 shows the percentage of observed and expected values in the classical method and in our method. As it can be seen, the usage of stochastic model for the data distribution, although similar to the classical one, shows less differences between the expected and observed values, and also between the standard deviations, which implies a better reliability of the modified Rasch method we use. It is our opinion that the differences between the standard and the modified method will appear more consistent when a larger number of

TABLE 2 Summary of results obtained with classical Rasch method and with the modified version of the Rasch-Andrich model used in this study

Entry number	Item	Measure	Classical Rasch method				Modified version used in this study			
			PTMEASUR-AL		Exact match		PTMEASUR-AL		Exact match	
			CORR.	EXP.	OBS%	EXP%	CORR.	EXP.	OBS%	EXP%
6	How often do you eat an insect-based meal?	2.73	0.36	0.27	90.5	88.7	0.36	0.28	90.5	89.7
4	Have you ever eaten insect-based products?	2.56	0.35	0.22	89.9	88.9	0.35	0.24	89.9	89.6
10	How much would you pay for 10 grams of insects?	2.35	0.58	0.41	70.0	56.3	0.58	0.43	70.0	56.7
20	Which feeling does this picture arouse in you? Giant wasps	1.78	0.32	0.34	72.5	71.9	0.32	0.35	72.5	72.0
7	How do insects fit into your diet?	0.84	0.08	0.18	96.3	95.1	0.08	0.19	96.3	95.8
23	Which feeling does this picture arouse in you? Insect mix	0.78	0.61	0.33	71.3	62.7	0.61	0.39	71.3	63.2
22	Which feeling does this picture arouse in you? Giant crickets	0.60	0.54	0.36	77.7	73.1	0.54	0.37	77.7	73.3
15	Would you prefer to eat local or exotic species of insects?	0.57	0.73	0.59	46.8	43.4	0.73	0.62	46.8	44.0
14	Better understanding of the practice of entomophagy	0.39	0.63	0.33	79.8	64.4	0.63	0.33	79.8	64.4
21	Which feeling does this picture arouse in you? Mealworms	0.34	0.65	0.41	74.3	64.7	0.65	0.41	74.3	64.7
3	Do you know how many species of insects are edible?	0.28	0.37	0.56	33.3	36.1	0.37	0.58	33.3	36.4
5	Are you aware that we eat insects without being aware of it?	0.03	0.18	0.31	56.0	63.1	0.18	0.32	56.0	63.4
19	Would you add an insect-based product into your pet's diet?	−0.01	0.48	0.39	53.5	52.5	0.48	0.42	53.5	53.0
13	Are you interested in receiving more information about it?	−0.19	0.52	0.29	73.4	62.0	0.52	0.31	73.4	64.0
9	How easy do you think it is to find these edible insects?	−0.23	0.07	0.46	47.1	54.1	0.07	0.43	47.1	53.8
8	In the case of hunger or need, would you eat insects?	−0.46	0.61	0.49	45.9	40.8	0.61	0.50	45.9	41.1
12	Which age group is most interested in eating insects?	−0.47	0.32	0.46	47.1	51.9	0.32	0.44	47.1	51.7
16	Where do you expect to find insect-based products on sale?	−0.81	0.18	0.41	52.3	60.9	0.18	0.41	52.3	60.9
17	Who is responsible for the safety of insect for consumption?	−1.11	0.15	0.32	77.1	79.3	0.15	0.32	77.1	79.3
18	Animal products produced by livestock fed with insects	−1.71	0.30	0.29	75.2	74.4	0.30	0.29	75.2	74.4
11	Which nutritional component is most common in insects?	−1.71	0.05	0.16	96.3	96.7	0.05	0.16	96.3	96.7
1	Have you ever heard about 'Entomophagy'?	−2.37	0.24	0.17	91.4	91.4	0.24	0.17	91.4	91.4
2	In some parts of the world insects are considered a delicacy?	−4.20	0.06	0.07	98.5	98.5	0.06	0.07	98.5	98.5
MEAN		0.00			70.3	68.3			70.3	68.6
P.SD		1.57			18.7	17.8			18.7	18.0

N = 327; PTMEASUR: the point-measure correlation, i.e. the correlation between the observations in the data and the measures of the persons which produce the data.

item and data will be available, as however predicted by simulations.

Before looking into this analysis, let us understand how to read a graph obtained with the modified version of the Rasch model used in this study. We will take one specific question, and describe how and where to find the quantities of interest.

Figure 5 shows an analysis of question 20 of the survey (*Which feeling does this picture arouse in you? Giant wasps*). The horizontal axis represents the rescaled ability (the variable Γ in equation 4), whereas the vertical axis represents the probability. So the graphs show the probabilities of answering each item when a particular ability is given. In this graph, we are actually interested in finding the thresholds τ_2, τ_3 and τ_4, hence the rescaled ability Γ is given instead of α. The thresholds are represented as the abscissas of the intersection points depicted in the figure.

We now analyze the same question with a focus on ability instead, hence the horizontal axis in the Figure 6 denotes the ability α.

The abscissa of the intersection point in Figure 6 denotes the difficulty β of the question. The curves represent the probabilities of answering a certain item as functions of the ability α. More specifically, the red curve shows the probability of answering the first (less difficult) item, the blue curve shows the probability for the second item, the pink curve is for the third and the black curve for the fourth (more difficult) item. The examination of these graphs will allow us to retrieve information on topic awareness and on the survey structure.

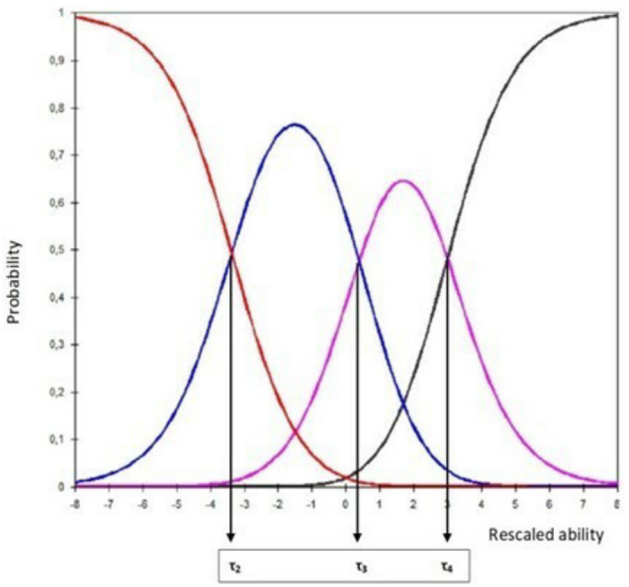

FIGURE 5 Probability curves for question 20: the horizontal axis represents the rescaled ability (variable Γ). The colour of the curves represents the difficulty of the items: easy (red), medium 1 (blue), medium 2 (purple) and difficult (black).

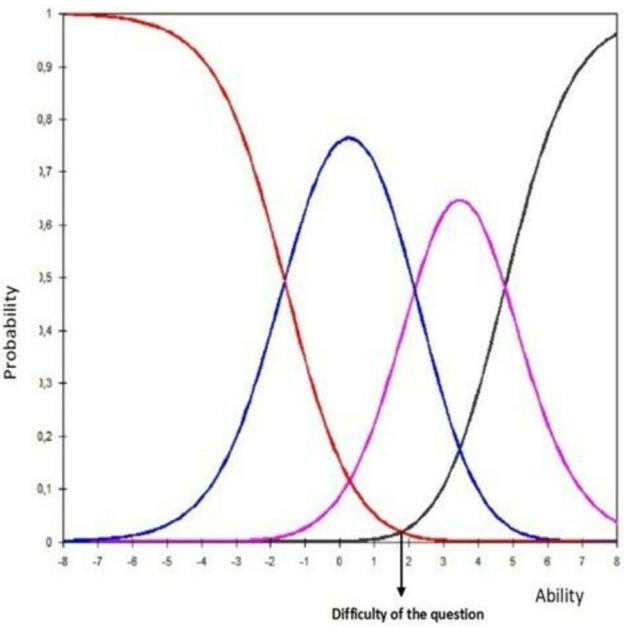

FIGURE 6 Probability curves for question 20: the horizontal axis represents the ability (variable α). The colour of the curves represents the difficulty of the items: easy (red), medium 1 (blue), medium 2 (purple) and difficult (black).

4 Discussion and conclusions

The percentage of people with some experience of entomophagy was 19% and the majority of these had had an isolated experience. Over half the participants, however, declared they were unaware of having eaten insects unwittingly. This is interesting if we consider the fact that there are insect-based products commonly consumed by people, as in the case of the colourant (E120) derived from *Dactylopius coccus* or cochineal (Grispoldi *et al.*, 2021). If compared with the results obtained in countries where insect consumption is associated with traditional practices, e.g. Mexico, the difference is obvious: out of a total of 3125 Mexicans, who answered a survey regarding many aspects of edible insects, 74% declared they had consumed insects at least once, whereas our study showed that only 11% of the interviewees answered positively to the same question (Escalante-Aburto *et al.*, 2022). It is interesting how the interviewees were almost divided in half between those who think insect-based products are difficult to find and those who think it is easy. As regards the product commercial value, almost half of the interviewees were willing to pay less than a hamburger for 10 grams

of edible insects and only 1.2% would pay three times as much. Almost all the interviewees acknowledged that the predominant nutritional component is protein. Approximately three quarters of those interviewed agreed on a department with dedicated shelves for insect-based products and that the competent authority for food safety should also exercise control over this category of products. Insect-based products are associated with adult consumers. Over half the participants were interested in receiving further information and would perhaps eat them after learning more about them. This is consistent with other studies, which have demonstrated that the consumer's interest in edible insects can be improved with a better knowledge of the topic (Barsics *et al.*, 2017; Pambo *et al.*, 2018; Sogari *et al.*, 2019). In our study, the positive answer to the question "*Would you be more willing to eat insects if you had a better understanding of the practice of entomophagy?*" was higher in younger people (62% of the interviewees aged between 20-30 and 61% of the interviewees aged between 30-40), whereas it dropped below 50% in the other age categories. As regards education, the higher percentage of positive answers (71%) was observed in people with post-graduate education and the lower percentage (25%) in people with compulsory education (education that is required of all people and is imposed by the government). These results are consistent with the findings of other authors (Reed *et al.*, 2021): among 1021 Americans interviewed, those most receptive to entomophagy were male, college-educated, younger with higher incomes, politically liberal and non-white.

On the other hand, information on the benefits alone of entomophagy appears to be insufficient to induce an increase in this practice (Tan *et al.*, 2017). This is especially true in places where a low degree of willingness to eat insects is common, such as western countries (Schösler *et al.*, 2012; Vanhonacker *et al.*, 2013; Verbeke, 2015). In these countries, the frequency of the addition of insects in the diet, even in historic times of food crisis, was very low (Svanberg and Berggren, 2021). In our study, when the interviewee was shown four photos of insect-based products and was asked to describe what he/she felt, the majority answered they felt disgust. This is consistent with results reported by other authors (Gmuer *et al.*, 2016; Lammers *et al.*, 2019; Verneau *et al.*, 2016). Other studies confirm that sight plays a very important role in the decision to reject insects as food: some authors (Meyer-Rochow and Hakko, 2018) administered both insect-based products (*beondaegi*, commercially available Korean *Bombyx mori* silkworm pupae and *inago*, commercially available Japanese *Oxya yezoensis* grasshoppers) and other foods (cheese, dried fish and white bread) to tasters who were blindfolded and with their noses closed. Out of a total of 26 tasters, 14 identified all the insect products, 8 identified at least one insect product and 4 failed to detect any. On the basis of the results obtained, they concluded that insects are not very easy to identify by taste alone.

An approach that could lead to better results in promoting entomophagy in western countries could certainly be to present insects in a more familiar food context for the consumer, such as bread and bakery products (Alemu and Olsen, 2019; Elzerman *et al.*, 2011) or protein beverages and snacks (Parker *et al.*, 2018). A further benefit in this case is that the insect is not visible in its entirety (flour would be used), thus bypassing the phobia (Caparros Megido *et al.*, 2016; Menozzi *et al.*, 2017; Moruzzo *et al.*, 2021).

As regards the results obtained with the modified Rasch-Andrich model, we will focus our attention on those questions which exhibit unexpected behaviour. Let us take, for instance, question 7 (*How do insects fit into your diet?*). The graph in Figure 7 shows the probability of the items in the question, where the x-axis represents ability.

This plot has a very uncommon behaviour: first of all, item 3 (the pink curve) has a very small probability. Second, item 2, has a great probability of being answered by people with an ability which is close to the difficulty of the question itself. This means that the majority of

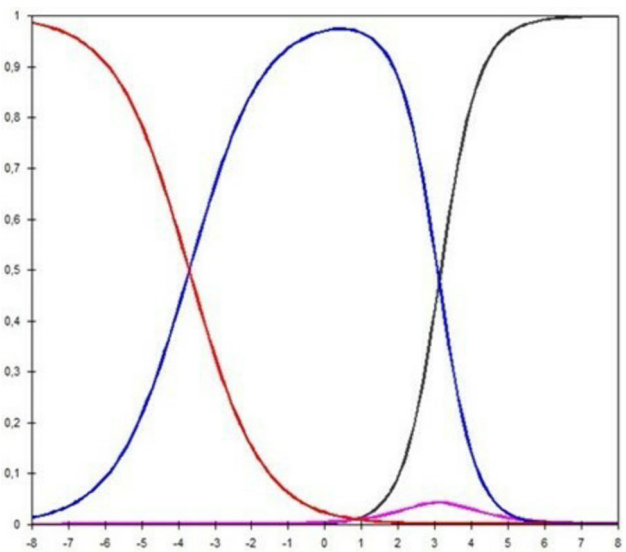

FIGURE 7 Probability curves for question 7. The colour of the curves represent the difficulty of the items: easy (red), medium 1 (blue), medium 2 (purple) and difficult (black).

people of very varied ability answered the question with item 2. This is quite surprising, as intermediates usually tend to have similar probabilities if they are close to the ability corresponding to the difficulty of the question. We have to examine the question in more detail to give an explanation for this phenomenon. The table represented in figure 10 orders questions according to their difficulty (Table 3).

Questions with the highest difficulty scores are number 6 (*How often do you eat an insect-based meal?*) and 4 (*Have you ever eaten insect-based products?*), followed by number 10 (*How much would you be willing to pay for 10 grams of ready-to-eat insects*) and numbers 20 to 23 (*Which feeling does this picture arouse in you?*). This is not surprising and confirms the low propensity to consume whole insects, to pay a price similar or higher to the average meat price to buy insects and the fact that few people among the interviewees use them with high frequency in their diet. On the other hand, the lowest difficulty scores were observed for questions number 2 (*Are you aware that in some parts of the world insects are considered a delicacy?*), number 1 (*Have you ever heard about 'Entomophagy'?*), number 11 (*Which nutritional component do you think is most common in insects?*) and number 18 (*Would you eat animal products* (*meat, milk, etc.*) *produced by livestock fed with insects?*). These results demonstrate a good ability of the interviewees regarding the knowledge of entomophagy, its distribution as a practice in some parts of the world and one of the potential nutritional advantages of insect consumption (the high amount of protein). The good predisposition of the sample of people interviewed to consume foods produced from livestock fed with insects is particularly interesting. Let us examine the answers to each item of question 7 (*How do insects fit into your diet?*) in more detail (Table 4). This is quite a difficult one, with a score of 0.84.

The most illuminating information in Table 4 is the column ability-mean (cf. more specifically, the last line containing the data of entry number 7). Usually, this value increases as the expected difficulty of the item increases: this is not the case for question 7 (*How do insects fit into your diet?*). Item 2 (*As an alternative source of proteins*) was answered in almost equal measure by people with high and low ability, so that its mean value of 0.16 is small. Moreover, people with high ability prefer item 3 (*I do not include insects in my diet*) to item 4 (*Other*). This data can be interpreted in various ways. As regards items 2 and 3, this type of behaviour usually has two explanations: 1) the items are too similar, 2) one of the items is ill-posed. Looking at the general behaviour of the question itself, one can infer that, instead of true awareness, the answers to these questions have been suggested by so-called *mass culture* or also *shared feeling*. Nevertheless, it would be interesting to reformulate the question (*How do insects fit into your diet?*) in order to compare the results and achieve a more realistic split.

We now move on to analyse other questions of major significance. More specifically, we will focus on questions 10 (*How much would you be willing to pay for 10 grams of ready-to-eat insects?*) and 17 (*In your opinion, who is responsible for the safety of insect-based products for human consumption?*).

Question 10 has a difficulty of 2.35 (Figure 8). It is one of the most difficult questions of the survey, due mainly to the fact that one cannot generally give a price value to insects. More specifically, only people with a very high ability answered items 1 and 2, for a total of 32 out of 327. In general, people are not willing to pay too much for eating insects. However, this question has the intrinsic problem of not having a yardstick, at least in western societies. Question 17 is actually a simple question, although it depends on the fact that many people with low ability also answered item 4 (Figure 9). This means the question should probably be reformulated in a more appropriate way. Therefore, the ability to measure the individual level of ability represents an interesting, important result, especially if there are any correlations between this variable and other variables characterizing the opinions and habits of individuals, both in general and in relation to consumer decisions (Gori *et al.*, 2017).

Although it is difficult to predict whether edible insects can effectively represent the "food of the future" and whether they can really become part of western consumers' diet, the results obtained in this study demonstrated that giving consumers information not only on insects and the production methods used, but also on food safety measures can improve the consumer's attitude towards entomophagy. The application of the modified version of the Rasch-Andrich model used in this study was very effective to address the current attitude and perception of modern consumers towards entomophagy, a topic characterized by preponderant emotional components which go beyond the mere functionality of the practice. Small differences between the expected and observed values, and also between the standard deviations, implies a good fit and reliability of the model used.

TABLE 3 Questions ordered according to their difficulty

Entry number	Item	MODEL S.E.	INFIT		OUTFIT		PTMEASUR-AL		Exact match	
			MNSQ	ZSTD	MNSQ	ZSTD	CORR.	EXP.	OBS%	EXP%
6	How often do you eat an insect-based meal?	0.16	0.95	−0.22	0.90	−0.34	0.36	0.28	90.5	89.7
4	Have you ever eaten insect-based products?	0.19	0.92	−0.54	0.85	−0.80	0.35	0.24	89.9	89.6
10	How much would you pay for 10 grams of insects?	0.09	0.86	−1.98	0.83	−2.35	0.58	0.43	70.0	56.7
20	Which feeling does this picture arouse in you? Giant wasps	0.11	1.02	0.25	1.01	0.18	0.32	0.35	72.5	72.0
7	How do insects fit into your diet?	0.22	1.04	0.23	0.96	0.00	0.08	0.19	96.3	95.8
23	Which feeling does this picture arouse in you? Insect mix	0.10	0.80	−2.73	0.79	−2.84	0.61	0.39	71.3	63.2
22	Which feeling does this picture arouse in you? Giant crickets	0.11	0.83	−1.69	0.76	−2.38	0.54	0.37	77.7	73.3
15	Would you prefer to eat local or exotic species of insects?	0.05	0.74	−3.80	0.63	−3.32	0.73	0.62	46.8	44.0
14	Better understanding of the practice of entomophagy	0.12	0.77	−6.86	0.74	−6.39	0.63	0.33	79.8	64.4
21	Which feeling does this picture arouse in you? Mealworms	0.10	0.75	−3.17	0.72	−3.46	0.65	0.41	74.3	64.7
3	Do you know how many species of insects are edible?	0.06	1.43	5.57	1.54	5.56	0.37	0.58	33.3	36.4
5	Are you aware that we eat insects without being aware of it?	0.12	1.10	2.86	1.12	2.58	0.18	0.32	56.0	63.4
19	Would you add an insect-based product into your pet's diet?	0.09	0.93	−1.03	0.94	−0.98	0.48	0.42	53.5	53.0
13	Are you interested in receiving more information about it?	0.12	0.85	−4.45	0.81	−4.00	0.52	0.31	73.4	64.0
9	How easy do you think it is to find these edible insects?	0.08	1.37	4.47	1.40	4.82	0.07	0.43	47.1	53.8
8	In the case of hunger or need, would you eat insects?	0.06	0.84	−2.53	0.79	−2.83	0.61	0.50	45.9	41.1
12	Which age group is most interested in eating insects?	0.07	1.11	1.28	1.21	2.17	0.32	0.44	47.1	51.7
16	Where do you expect to find insect-based products on sale?	0.06	1.33	3.02	2.87	6.00	0.18	0.41	52.3	60.9
17	Who is responsible for the safety of insect for consumption?	0.08	1.21	1.42	3.85	3.98	0.15	0.32	77.1	79.3
18	Animal products produced by livestock fed with insects	0.11	0.98	−n.17	1.04	0.37	0.30	0.29	75.2	74.4
11	Which nutritional component is most common in insects?	0.15	1.10	0.38	9.01	3.86	0.05	.16	96.3	96.7
1	Have you ever heard about 'Entomophagy'?	0.20	0.97	−0.16	0.80	−0.94	0.24	0.17	91.4	91.4
2	In some parts of the world insects are considered a delicacy?	0.45	1.00	0.16	1.01	0.19	0.06	0.07	98.5	98.5
MEAN		0.13	1.00	−0.40	1.50	0.00			70.3	68.6
P.SD		0.08	0.19	2.80	1.76	3.20			18.7	18.0

N = 327; MODEL S.E.: standard error of the model, which shows the precision of the Rasch estimate; INFIT: inlier-sensitive fit; OUTFIT: outlier- sensitive fit; MNSQ: mean-square infit; ZSTD: standardized fit; PTMEASUR: the point-measure correlation, i.e. the correlation between the observations in the data and the measures of the persons which produce the data.

TABLE 4 Detail of the answers to every item for the more difficult questions

Entry number	Item	Data code	Score value	Data %	Ability MEAN	Ability P. SD	S.E. MEAN	INFT MNSQ	OUTF MNSQ	PTMA CORR.
6	How often do you eat an insect-based meal?	Never	2	90	0.10	0.66	0.04	0.90	0.90	–0.39
		Once or twice in my entire life	3	9	1.10	0.71	0.14	0.60	0.50	0.38
		Less than once per month	4	2	0.73	0.76	0.38	1.80	1.80	0.09
4	Have you ever eaten insect-based products?	No	3	90	0.10	0.66	0.04	0.90	0.90	–0.35
		Yes	4	10	0.94	0.83	0.14	0.80	0.80	0.35
10	How much would you pay for 10 grams of insects?	I wouldn't	1	52	–0.24	0.50	0.04	0.80	0.80	–0.62
		The equivalent of less than 1 hamburger	2	39	0.62	0.65	0.06	0.60	0.60	0.47
		The equivalent of 1 hamburger	3	9	0.77	0.59	0.11	1.10	1.00	0.26
		The equivalent of 2-3 hamburgers	4	0	1.15	0.00		1.10	1.00	0.07
20	Which feeling does this picture arouse in you? Giant wasps	Other	1	15	0.08	0.68	0.10	1.20	1.20	–0.07
		Disgust	2	72	0.07	0.64	0.04	0.90	1.00	–0.27
		Curiosity	3	13	0.99	0.71	0.11	0.80	0.80	0.42
		Hunger	4	0	0.73	0.00		1.40	1.30	0.04
7	How do insects fit into your diet?	Other	1	2	0.62	0.96	0.36	0.50	0.80	0.09
		I do not include insects in my diet	2	96	0.16	0.70	0.04	0.80	0.90	–0.20
		As an alternative source of proteins	3	1	1.99	0.67	0.67	0.20	0.20	0.19
		As new ingredient	4	1	1.00	0.76	0.54	1.80	1.50	0.11

N = 327; S.E.: standard error; INFT: inlier-sensitive fit; OUTF: outlier- sensitive fit; MNSQ: mean-square infit; PTMA: the point-measure correlation, i.e. the correlation between the observations in the data and the measures of the persons which produce the data.

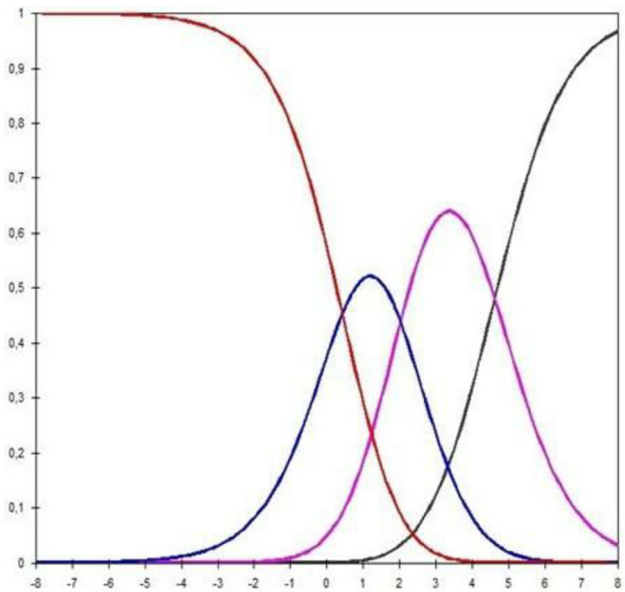

FIGURE 8 Probability curves for question 10. The colour of the curves represent the difficulty of the items: easy (red), medium 1 (blue), medium 2 (purple) and difficult (black).

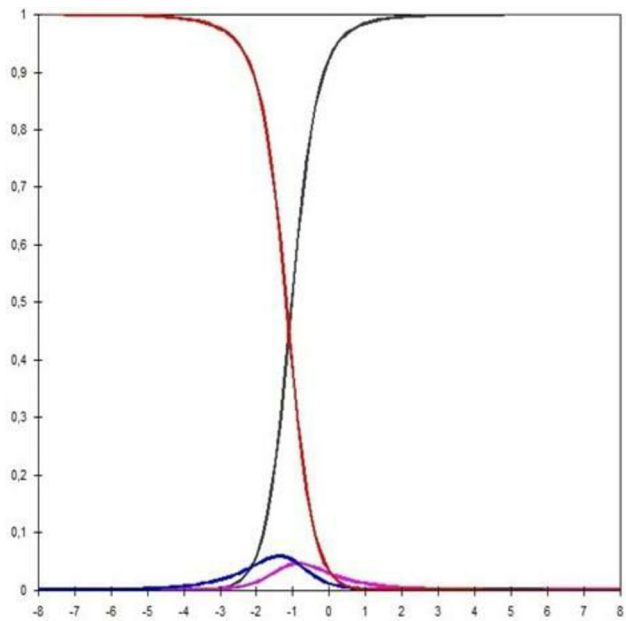

FIGURE 9 Probability curves for question 17. The colour of the curves represent the difficulty of the items: easy (red), medium 1 (blue), medium 2 (purple) and difficult (black).

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Conflicts of interest

The authors declare no conflict of interest.

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References

Alemu, M.H. and Olsen, S.B., 2019. Linking consumers' food choice motives to their preferences for insect-based food products: an application of integrated choice and latent variable model in an African context. Journal of Agricultural Economics 70: 241-258. https://doi.org/10.1111/1477-9552.12285

Ayieko, M.A., Ogola, H.J. and Ayieko, I.A., 2016. Introducing rearing crickets (gryllids) at household levels: adoption, processing and nutritional values. Journal of Insects as Food and Feed 2: 203-211. https://doi.org/10.3920/jiff2015.0080

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

Bassi, I., Carzedda, M., Gori, E. and Iseppi, L., 2022. Rasch analysis of consumer attitudes towards the mountain product label. Agricultural and Food Economics 10: 13. https://doi.org/10.1186/s40100-022-00218-7

Camargo, F.R. and Henson, B., 2015. Beyond usability: designing for consumers' product experience using the Rasch model. Journal of Engineering Design 26: 121-139. https://doi.org/10.1080/09544828.2015.1034254

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

Capinera, J.L., 2008. Encyclopedia of entomology. Springer Science+Business Media B.V., Dordrecht, the Netherlands.

Efsa Scientific Committee, 2015. Risk profile related to production and consumption of insects as food and feed. EFSA Journal 13: 4257. https://doi.org/10.2903/j.efsa.2015.4257

Elzerman, J.E., Hoek, A.C., van Boekel, M.A.J.S. and Luning, P.A., 2011. Consumer acceptance and appropriateness of meat substitutes in a meal context. Food Quality and Pref-

erence 22: 233-240. https://doi.org/10.1016/j.foodqual.2010.10.006

Embretson, S. and Reise, S., 2001. Psychometric methods: item response theory for psychologists. Erlbaum, Mahwah, NJ, USA.

Escalante-Aburto, A., Rodríguez-Sifuentes, L., Ozuna, C., Mariscal-Moreno, R.M., Mulík, S., Guiné, R. and Chuck-Hernández, C., 2022. Consumer perception of insects as food: Mexico as an example of the importance of studying socio-economic and geographical differences for decision-making in food development. International Journal of Food Science & Technology 57: 6306-6316. https://doi.org/10.1111/ijfs.15995

Food and Agriculture Organization of the United Nations (FAO), 2013. Edible insects: future prospects for food and feed security. FAO, Rome, Italy. Available at: https://www.fao.org/3/i3253e/i3253e.pdf.

Gallen, C., Pantin-Sohier, G. and Peyrat-Guillard, D., 2018. Cognitive acceptance mechanisms of discontinuous food innovations: the case of insects in France. Recherche et Applications en Marketing (English Edition) 34: 48-73. https://doi.org/10.1177/2051570718791785

Ghosh, S., Jung, C. and Meyer-Rochow, V.B., 2018. What governs selection and acceptance of edible insect species? In: Halloran, A., Flore, R., Vantomme, P. and Roos, N. (eds.) Edible insects in sustainable food systems. Springer, Cham, pp. 331-351. https://doi.org/10.1007/978-3-319-74011-9_20.

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

Gori, E., Chang, T.F., Iseppi, L., Cenci Goga, B., Iulietto, M., Sechi, P. and Lepellere, M., 2017. The assessment of consumer sensitivity to animal welfare: an application of Rasch model. Rivista di Studi sulla Sostenibilita 2017: 107-127. https://doi.org/10.3280/RISS2017-001008

Grispoldi, L., Karama, M., El-Ashram, S., Saraiva, C.M., García-Díez, J., Chalias, A., Barbera, S. and Cenci-Goga, B.T., 2021. Hygienic characteristics and detection of antibiotic resistance genes in crickets (*Acheta domesticus*) breed for flour production. Microbiology Research 12: 503-512.

Guttersrud, Ø., Dalane, J.Ø. and Pettersen, S., 2013. Improving measurement in nutrition literacy research using Rasch modelling: examining construct validity of stage-specific 'critical nutrition literacy' scales. Public Health Nutrition 17: 877-883. https://doi.org/10.1017/S1368980013000530

Henry, R.C., Engström, K., Olin, S., Alexander, P., Arneth, A. and Rounsevell, M.D.A., 2018. Food supply and bioenergy production within the global cropland planetary boundary. PLOS ONE 13: e0194695. https://doi.org/10.1371/journal.pone.0194695

Henson, S., Blandon, J. and Cranfield, J., 2010. Difficulty of healthy eating: a Rasch model approach. Social Science & Medicine 70: 1574-1580. https://doi.org/10.1016/j.socscimed.2010.01.037

Holt, A.V., 1885. Why not eat insects? Facsimile reprint, with new introduction by Laurence Mound, 1988. British Museum (Natural History) & E. W. Classey Ltd., London, UK..

Huis, A.V., Halloran, A., Itterbeeck, J.V., Klunder, H. and Vantomme, P., 2022. How many people on our planet eat insects: 2 billion? Journal of Insects as Food and Feed 8: 1-4. https://doi.org/10.3920/JIFF2021.x010

Jongema, Y., 2017. List of edible insects of the world, 2017. Laboratory of Entomology, Wageningen University, Wageningen, the Netherlands. Available online: https://www.wur.nl/upload_mm/8/a/6/0fdfc700-3929-4a74-8b69-f02fd35a1696_Worldwide%20list%20of%20edible%20insects%202017.pdf.

Lammers, P., Ullmann, L.M. and Fiebelkorn, F., 2019. Acceptance of insects as food in Germany: is it about sensation seeking, sustainability consciousness, or food disgust? Food Quality and Preference 77: 78-88. https://doi.org/10.1016/j.foodqual.2019.05.010

Menozzi, D., Sogari, G., Veneziani, M., Simoni, E. and Mora, C., 2017. Eating novel foods: an application of the theory of planned behaviour to predict the consumption of an insect-based product. Food Quality and Preference 59: 27-34. https://doi.org/10.1016/j.foodqual.2017.02.001

Meyer-Rochow, V., 1975. Can insects help to ease the problem of world food shortage? Search 6: 261-262.

Meyer-Rochow, V. and Hakko, H., 2018. Can edible grasshoppers and silkworm pupae be tasted by humans when prevented to see and smell these insects? Journal of Asia-Pacific Entomology 21: 616-619. https://doi.org/10.1016/j.aspen.2018.04.002

Moruzzo, R., Mancini, S., Boncinelli, F. and Riccioli, F., 2021. Exploring the acceptance of entomophagy: a survey of Italian consumers. Insects 12: 123. https://doi.org/10.3390/insects12020123

Osimani, A., Milanović, V., Cardinali, F., Roncolini, A., Garofalo, C., Clementi, F., Pasquini, M., Mozzon, M., Foligni, R., Raffaelli, N., Zamporlini, F. and Aquilanti, L., 2018. Bread enriched with cricket powder (*Acheta domesticus*): a technological, microbiological and nutritional evaluation. Innovative Food Science & Emerging Technologies 48: 150-163. https://doi.org/10.1016/j.ifset.2018.06.007

Pambo, K.O., Okello, J.J., Mbeche, R.M., Kinyuru, J.N. and Alemu, M.H., 2018. The role of product information on consumer sensory evaluation, expectations, experiences

and emotions of cricket-flour-containing buns. Food Research International 106: 532-541. https://doi.org/10.1016/j.foodres.2018.01.011

Parker, M.N., Lopetcharat, K. and Drake, M.A., 2018. Consumer acceptance of natural sweeteners in protein beverages. Journal of Dairy Science 101: 8875-8889. https://doi.org/10.3168/jds.2018-14707

Rasch, G., 1993. Probabilistic models for some intelligence and attainment tests. ERIC.

Reed, M., Norwood, B.F., Hoback, W.W. and Riggs, A., 2021. A survey of willingness to consume insects and a measure of college student perceptions of insect consumption using Q methodology. Future Foods 4: 100046. https://doi.org/10.1016/j.fufo.2021.100046

Rumpold, B.A. and Schlüter, O.K., 2013. Potential and challenges of insects as an innovative source for food and feed production. Innovative Food Science & Emerging Technologies 17: 1-11. https://doi.org/10.1016/j.ifset.2012.11.005

Schösler, H., Boer, J.d. and Boersema, J.J., 2012. Can we cut out the meat of the dish? Constructing consumer-oriented pathways towards meat substitution. Appetite 58: 39-47. https://doi.org/10.1016/j.appet.2011.09.009

Smetana, S., Schmitt, E. and Mathys, A., 2019. Sustainable use of Hermetia illucens insect biomass for feed and food: attributional and consequential life cycle assessment. Resources, Conservation and Recycling 144: 285-296. https://doi.org/10.1016/j.resconrec.2019.01.042

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

Svanberg, I. and Berggren, Å., 2021. Insects as past and future food in entomophobic Europe. Food, Culture & Society 24: 624-638. https://doi.org/10.1080/15528014.2021.1882170

Tan, H.S.G., Fischer, A.R.H., Tinchan, P., Stieger, M., Steenbekkers, L.P.A. and van Trijp, H.C.M., 2015. Insects as food: exploring cultural exposure and individual experience as determinants of acceptance. Food Quality and Preference 42: 78-89. https://doi.org/10.1016/j.foodqual.2015.01.013

Tan, H.S.G., Verbaan, Y.T. and Stieger, M., 2017. How will better products improve the sensory-liking and willingness to buy insect-based foods? Food Research International 92: 95-105. https://doi.org/10.1016/j.foodres.2016.12.021

van Huis, A., 2016. Edible insects are the future? Proceedings of the Nutrition Society 75: 294-305. https://doi.org/10.1017/s0029665116000069

Vanhonacker, F., Van Loo, E.J., Gellynck, X. and Verbeke, W., 2013. Flemish consumer attitudes towards more sustainable food choices. Appetite 62: 7-16. https://doi.org/10.1016/j.appet.2012.11.003

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. https://doi.org/10.1016/j.foodqual.2014.07.008

Verneau, F., La Barbera, F., Kolle, S., Amato, M., Del Giudice, T. and Grunert, K., 2016. The effect of communication and implicit associations on consuming insects: an experiment in Denmark and Italy. Appetite 106: 30-36. https://doi.org/10.1016/j.appet.2016.02.006