Food Quality and Preference 102 (2022) 104650

Contents lists available at ScienceDirect

Food Quality and Preference

journal homepage: www.elsevier.com/locate/foodqual

Insects as food and feed in Portugal and Norway – Cross-cultural comparison of determinants of acceptance

José Carlos Ribeiro [a], Ane Telles Sposito Gonçalves [a], Ana Pinto Moura [b], Paula Varela [c], Luís Miguel Cunha [a,*]

[a] GreenUPorto / Inov4Agro, DGAOT, Faculty of Sciences, University of Porto, Campus de Vairão, Rua da Agrária, 747, 4485-646 Vila do Conde, Portugal
[b] GreenUPorto / Inov4Agro, DCeT, Universidade Aberta, Rua do Amial 752, 4200-055 Porto, Portugal
[c] Nofima, Norwegian Institute for Food, Fisheries and Aquaculture Research, PB 210, N-1431 Aas, Norway

ARTICLE INFO

Keywords:
Disgust
Edible insects
Entomophagy
Food culture
Food neophilia

ABSTRACT

Entomophagy – intentional consumption of insects – is practiced in several regions of the world, particularly in Asia, Africa and Latin America. In the Western world, edible insects have been growing in popularity as novel food and feed. The main objective of this cross-cultural study, performed in Portugal and Norway, was to evaluate the determinants of consumers' acceptance of insects as food and feed. An online-based survey (n = 666, *LimeSurvey* -Portugal- and *EyeQuestion* -Norway-) composed of nine different sections, assessing acceptance of insects as food and feed, sociodemographic characteristics, attitudes towards edible insects and food choice motives was applied. Results showed that Norwegian consumers had a higher acceptance of insects as food or feed than Portuguese consumers did. It was also possible to divide consumers into four segments according to their acceptance level: Disgusted, Rejecters, Feed Acceptors and Acceptors. Considering the determinants of acceptance/rejection, disgust towards insects was the variable with the largest negative impact on either forms of entomophagy for both countries. On the other hand, consumers who seek new food experiences tend to have a higher acceptance of insects as food. Sociodemographic characteristics also influenced the acceptance of insects as food and feed, although differently for Norway and Portugal, while food choice motivations (convenience, health and ecological welfare) had minimal impact. These results highlight the importance of diminishing disgust reactions towards edible insects and to successfully marketing entomophagy to more neophilic consumers. This can be potentially obtained by improving the sensory appeal and experiences associated with edible insects.

1. Introduction

Edible insects are a novel food which present both an environmental sustainable production (Gahukar, 2016) and nutritional advantages (Rumpold & Schlüter, 2013; Zielińska, Karaś, Jakubczyk, Zieliński, & Baraniak, 2018). Their consumption, entomophagy, is already practiced in several parts of the world – mainly Asia, Africa and Latin America – where insects are essential sources of nutrients, are considered delicacies and can also play a role in the economy of some communities (Huis et al., 2013). In Western countries, more specifically Europe and North America, there has been a growing interest concerning edible insects, not only with increased scientific literature dedicated to this theme but also in the food industry (Kröger, Dupont, Büsing, & Fiebelkorn, 2022). However, in these countries the rate of consumers who are willing to eat insects as food is still low: 10–20% for whole insects or products with whole insects (Jensen & Lieberoth, 2019; Lammers, Ullmann, & Fiebelkorn, 2019; Orsi, Voege, & Stranieri, 2019; Ruby & Rozin, 2019) and 30–40% for products with processed insects (Castro & Chambers, 2019; Dupont & Fiebelkorn, 2020; Lammers et al., 2019; Orkusz, Wolańska, Harasym, Piwowar, & Kapelko, 2020; Orsi et al., 2019). There are several factors that influence the acceptance of entomophagy, with the most studied being sociodemographic characteristics, familiarity with entomophagy, attitudes, food neophobia, disgust and prior experience with insect consumption (Kröger et al., 2022). However, when considering entomophagy rejection, the factors that have been more extensively characterized and identified as having a greater effect are food neophobia and disgust (Cunha & Ribeiro, 2019; Kröger et al., 2022; Mancini, Moruzzo, Riccioli, & Paci, 2019).

Abbreviations: FC-C, Food Choice Questionnaire-Convenience; FC-EW, Food Choice Questionnaire-Ecological Welfare; FC-H, Food Choice Questionnaire-Health.

* Corresponding author.
E-mail address: lmcunha@fc.up.pt (L.M. Cunha).

https://doi.org/10.1016/j.foodqual.2022.104650
Received 2 January 2022; Received in revised form 2 June 2022; Accepted 2 June 2022
Available online 6 June 2022

Disgust can be described as an emotional response to an offensive object that provokes a sense of revulsion (Rozin & Fallon, 1987). Disgust reactions can be caused by food-related stimuli, functioning as a protective mechanism against foods that are deemed as harmful or dangerous (Curtis & Biran, 2001; Haidt, McCauley, & Rozin, 1994). Individuals who have a high food disgust, are more easily disgusted by some food-related cues (Hartmann & Siegrist, 2018). High general disgust (La Barbera, Verneau, Videbæk, Amato, & Grunert, 2020; Videbæk & Grunert, 2020) and food disgust sensitivity (Lammers et al., 2019) have a significant negative effect on willingness to eat insects as food. However, most studies in literature have specifically assessed disgust toward eating insects, with this variable having a negative effect on its acceptance (Kröger et al., 2022). Disgust reactions towards entomophagy can occur because of reminders of animal-origin particularly when consuming whole unprocessed insects, and due to the association with diseases, pests, spoiled food and dirty habitats (Cunha, Moura, & Costa-Lima, 2014; Hartmann & Siegrist, 2018; Looy, Dunkel, & Wood, 2014; Verneau et al., 2016). These associations are mostly due to social and cultural norms and not actual fear of contamination/diseases (Deroy, Reade, & Spence, 2015; Jensen & Lieberoth, 2019; La Barbera, Verneau, Amato, & Grunert, 2018), as insects can be considered culturally inappropriate (Hartmann, Shi, Giusto, & Siegrist, 2015; Myers & Pettigrew, 2018) or as a survival food (Yen, 2009).

Food neophobia is characterized as a person's tendency to avoid unfamiliar foods or foods from other cultures (Pliner & Hobden, 1992). Since edible insects are not a traditional food in Western countries, a high degree of food neophobia can predict the rejection of entomophagy (Dupont & Fiebelkorn, 2020; Lammers et al., 2019; Tuccillo, Marino, & Torri, 2020). Similarly to disgust reactions, neophobic reactions to edible insects can also be linked to social and cultural norms since consumers have a general lack of knowledge towards edible insects, which may lead to fear of harmful consequences or bad sensory experiences (Schouteten et al., 2016; Tan, Verbaan, & Stieger, 2017). On the other hand, neophilic and sensation-seeking consumers have higher acceptance of insects as food (Lammers et al., 2019; Ruby & Rozin, 2019; Sogari, Menozzi, & Mora, 2019; Videbæk & Grunert, 2020) and interest/curiosity is one of the major determinants of willingness to try edible insects (House, 2016; La Barbera et al., 2020).

Additionally, other personality factors such as interest in healthy foods or sustainability awareness can improve the acceptance of edible insects (Kröger et al., 2022). Moreover, this means that perceived benefits from insects' consumptions (nutritional, environmental, health) can positively influence willingness to eat in consumers who are conscious of these types of benefits in their food choices (Dupont & Fiebelkorn, 2020; House, 2016; Palmieri, Perito, Macrì, & Lupi, 2019a; Tuccillo et al., 2020). Regarding sociodemographic characteristics, gender has been the most extensively studied characteristics (Kröger et al., 2022), with males generally having higher acceptance (Schäufele, Barrera Albores, & Hamm, 2019; Verneau et al., 2016; Videbæk & Grunert, 2020), although this effect seems to be more significant for unprocessed insects (Hartmann et al., 2015; Lammers et al., 2019). This probably occurs due to men having lower disgust sensitivity than women (Hamerman, 2016; Tuccillo et al., 2020). Furthermore, age (e.g. younger people), education level (e.g. consumers with high education) or place of residence (e.g. urban area) can also positively influence the acceptance of entomophagy, but these effects are not consistent across studies (Cunha & Ribeiro, 2019; Kröger et al., 2022; Mancini, Sogari et al., 2019).

Insects are also potential sources of high-protein animal feed which can function as alternatives to less environmental sustainable sources such as soybean meal or fishmeal (Hubert, 2019). In regards to acceptance of insects as feed and its determinants, there is substantially less work than for acceptance of insects as food, and most has been focused on insects as fish feed (Sogari, Amato, Biasato, Chiesa, & Gasco, 2019). So far, studies have reported that the majority of consumers (*ca.* 70–90%) are willing to consume animals fed with insects (Ankamah-Yeboah, Jacobsen Jette, & Olsen Søren, 2018; Bazoche & Poret, 2020; Mancuso, Baldi, & Gasco, 2016; Popoff, MacLeod, & Leschen, 2017), being higher than willingness to eat insects as food (La Barbera et al., 2020; Naranjo-Guevara, Fanter, Conconi, & Floto-Stammen, 2021; Onwezen, van den Puttelaar, Verain, & Veldkamp, 2019; Roma, Ottomano Palmisano, & De Boni, 2020). Concerning determinants of willingness to eat animal fed with insects, it seems that disgust can also have a negative effect (La Barbera et al., 2020; Onwezen et al., 2019; Verneau, Zhou, Amato, Grunert, & La Barbera, 2021), and consumers with high acceptance of insects as feed have very low levels of contamination disgust (Videbæk & Grunert, 2020). Sociodemographic characteristics do not have similar effects across different studies (Domingues et al., 2020; Naranjo-Guevara et al., 2021; Szendrő, Nagy, & Tóth, 2020). On the other hand, it seems that providing information about the benefits and safety of insects as feed can increase willingness to eat (Bazoche & Poret; Naranjo-Guevara et al., 2021; Szendrő et al., 2020), but currently consumers have low information levels about these topics (Domingues et al., 2020; Sogari, Amato, et al., 2019). Price and other factors such as convenience and expected taste (Ankamah-Yeboah et al., 2018; Mancuso et al., 2016; Popoff et al., 2017) can also have a significant effect on the acceptance of insects as feed. Furthermore, the type of animal that is fed can also affect willingness to eat, since insects as feed for fish or poultry have higher acceptance than as feed for cattle or pigs (Domingues et al., 2020; Verbeke et al., 2015).

The present study is a continuation of a previous study (Cunha et al., 2014) on insect consumption and acceptance. It is a cross-cultural study performed in two countries: Portugal and Norway. The main objective of this study is to evaluate the determinants of consumers' acceptance of insects as food and feed, through the application of a web-based survey (*EyeQuestion* and *LimeSurvey*), composed by nine different sections, assessing acceptance of insects as food and feed, sociodemographic characteristics, attitudes towards edible insects and food choice motives. Some specific objectives are:

- To characterize different consumers' segments regarding their acceptability of insects as food and feed;
- To assess the impact of food neophobia, disgust towards insects, and other psychographic or personality traits on acceptance of insects' as food and feed;
- To draw a cross-cultural study comparison on the acceptance of insects as food and feed within two European countries.

2. Material and methods

2.1. Participants and data collection

An online-based questionnaire was developed (section 2.2) and applied through *LimeSurvey* (Portugal) and *EyeQuestion* (Norway). Participants were recruited through informal social networks and within the Sense Test's (a sensory evaluation and consumer tests company located in Portugal) consumers database. Since all consumers answered the questionnaire directly on the *LimeSurvey* or *EyeQuestion* link it was not possible to differentiate participants based on their recruitment. In both countries, participants from different ages, sex, marital status, education level, occupation, economic situation were selected in order to obtain a more heterogeneous sample.

A total of 899 questionnaires were obtained with 666 being considered valid in both countries (Norway – 456 total answers with 363 valid; Portugal – 443 total answers with 303 valid). Incomplete questionnaires, respondents from other countries and those displaying suspicious behaviors such as "straight-lining", which can be defined as repeatedly selecting the same option for all questions in a scale (Behrend, et al, 2011; Maniaci & Rogge, 2014), were removed. The sociodemographic characteristics of the participants and average variable scores (food choice motives, food neophilia, food neophobia, disgust towards insects, familiarity and experience with edible insects) are present on Tables 1 and 2, respectively.

2.2. Questionnaire

The questionnaire was initially prepared in English and then translated to each country's language. When previously applied, the translated versions of the different items were used. Other items on the questionnaire were translated based on the expertise of the research team and following a translation-back translation procedure process (Brislin, 1970, 21).

The applied questionnaire was composed of nine different sections, comprising the evaluation of food choice motives (Steptoe, Pollard, & Wardle, 1995), food neophobia (Pliner & Hobden, 1992), familiarity (Verbeke, 2015) and experience with edible insects, perceived acceptance of edible insects and sushi (Cunha et al., 2014), disgust towards insects (Rozin, 2014) and sociodemographic characteristics.

Seven-point anchored scales were used to measure food choice motives (ranging from 1 – "Not important" to 7 – "Very important"), food neophobia, disgust towards insects (ranging from 1 – "Strongly disagree" to 7 – "Strongly agree") and perceived acceptance of edible insects and sushi (ranging from 1 – "Totally reject" to 7 – "Totally accept"). Multiple choice questions were applied to assess the levels of familiarity and experience with edible insects.

The items composing the evaluation of food choice motives, food neophobia, disgust towards insects and perceived acceptance were randomized in order to compensate possible order effects (Kearney, Kearney, & Gibney, 1997).

2.2.1. Health

The importance of health for participants when making food choices was measured using the six items of the health factor/dimension of the Food Choice Questionnaire (FCQ) (Steptoe et al., 1995). Participants were asked to assess the level of importance of six items in their regular consumption habits (e.g. "It is important that the food I eat on a typical day contains a lot of vitamins and minerals"). The total score of these items was used to measure the health food choice score (FC-H). Sampling adequacy (KMO) was above acceptance being 0.867 for Norway and 0.895 for Portugal. For both countries, all the items had factor loadings above 0.6 and a good internal consistency (Cronbach's α above 0.850 for both countries) (Table S1).

2.2.2. Convenience

The importance of convenience for participants when making food choices was measured using the five items of the convenience factor/dimension of the FCQ (Steptoe et al., 1995). Participants were asked to assess the level of importance of six items in their regular consumption habits (e.g. "It is important that the food I eat on a typical day is easy to prepare"). The total score of these items was used to measure the convenience food choice score (FC-C). Sampling adequacy (KMO) was above acceptance being 0.744 for Norway and 0.832 for Portugal. A high internal consistency coefficient was also verified for both countries, with Cronbach's α above 0.800. Data shows that for both countries the FC-C construct is unidimensional and consistent, with all five items presenting high loadings (>0.5) (Table S2).

Table 1
Socio-demographic characteristics of the sample in both countries (N = 666).

Characteristics (n – %)	Norway (n = 363)	Portugal (n = 303)
Sex		
Female	245 (67.5%)	180 (59.4%)
Male	118 (32.5%)	123 (40.6%)
Age group		
18–34	136 (37.5%)	141 (46.5%)
35–54	145 (39.9%)	89 (29.4%)
≥55	82 (22.6%)	73 (24.1%)
Age		
(Average ± Std. Dev.)	41.1 (±14.7)	40.0 (±15.1)
Marital status		
Single	106 (29.2%)	97 (32.0%)
Married	234 (64.5%)	170 (56.1%)
Separated	20 (5.5%)	27 (8.9%)
Widow	3 (0.8%)	9 (3%)
Higher Education		
No (absence of college degree)	155 (42.7%)	158 (52.1%)
Yes (graduate and post-graduate degree)	208 (57.3%)	145 (47.9%)
Economic situation (1 – Very difficult; 7 – Well-off)		
(Average ± Std. Dev.)	5.0 (±1.3)	3.8 (±1.1)

Table 2
Mean (±Std. Dev.) of evaluated variables (assessed on 7-point anchored scales) and levels of familiarity and experience with edible insects for each country. Comparisons are drawn between countries for each variable (Mann-Whitney test and Chi-square test for familiarity and experience).

Variable	Norway (n = 363)	Portugal (n = 303)	Mann-Whitney test (U, *p*, r)
Food choice-health (Mean ± Std. Dev.)	4.9 (±0.9)[b]	5.8 (±1.1)[a]	26874; *≤0.001*; 0.44
Food choice-convenience (Mean ± Std. Dev.)	4.9 (±1.0)[b]	5.5 (±1.2)[a]	36557.5; *≤0.001*; 0.29
Food choice-ecological welfare (Mean ± Std. Dev.)	5.0 (±1.3)[b]	5.2 (±1.7)[a]	46800; *≤0.001*; 0.13
Food neophilia (Mean ± Std. Dev.)	5.2 (±1.0)[a]	4.8 (±1.5)[b]	46799; *0.035*; 0.08
Food neophobia (Mean ± Std. Dev.)	2.5 (±1.0)[b]	3.2 (±1.6)[a]	42952; *≤0.001*; 0.19
Disgust towards insects (Mean ± Std. Dev.)	3.8 (±1.7)[a]	3.5 (±1.7)[b]	50090; *0.047*; 0.08
Familiarity (High/Low)	81.5%/18.5%	91.1%/8.9%	$\chi^2 = 12.4$; $p < 0.001$
Experience (Yes/No)	22.3%/77.7%	4.3%/95.7%	$\chi^2 = 44.2$; $p < 0.001$

2.2.3. Ecological welfare

The importance of ethical food choices and ecological welfare was measured using 5 items from the ecological welfare factor/dimension of the adapted FCQ (Lindeman & Väänänen, 2000). Participants were asked to assess the level of importance of six items in their regular consumption habits (e.g. "It is important that the food I eat on a typical day has been produced in a way that animals have not experienced pain"). The total score of these items was used to measure the ecological welfare food choice score (FC-EW). Sampling adequacy (KMO) was above acceptance being 0.815 for Norway and 0.881 for Portugal. A high internal consistency coefficient was also verified, with both countries presenting a Cronbach's α value above 0.900. It was also assured that the FC-EW construct is unidimensional and consistent, with all five items presenting high loadings (>0.8) for both countries (Table S3).

2.2.4. Food neophobia

Food neophobia of participants was measured with the 10-item Food Neophobia Scale (FNS) developed by Pliner and Hobden (1992). Analysis was performed separately for the neophilic (food neophilia) and neophobic (food neophobia) items.

Sampling adequacy for food neophilia was above acceptance being above 0.800 for both countries. A high internal consistency coefficient for Norway (Cronbach's α = 0.794) and Portugal (Cronbach's α = 0.896) was also verified. Data shows that the construct food neophilia is unidimensional and consistent, with all items presenting high loadings (>0.6), for both countries (Table S4).

Initial analysis of food neophobia revealed that sampling adequacy (0.650) and internal consistency (0.637) were relatively low for the Norwegian sample and that item 8 ("I am very particular about the foods I eat") had factor loading below 0.6 for both countries. As such, new analysis were performed with item 8 being removed. This new construct had sampling adequacy of 0.693 for Norway and 0.829 for Portugal. Internal consistency was of 0.685 for Norway and 0.874 for Portugal. Additionally, only item 3 ("If I doństaknow what a food is, I won't try it") in the Norwegian sample had factor loading below 0.7 (Table S4). The scores from this construct were used for further analysis.

2.2.5. Familiarity with edible insects

In order to assess the level of familiarity of participants with edible insects, a multiple-choice questionnaire with six statements was used. Three of the statements were adapted from the work of Verbeke (2015) ("Yes, I have heard of the eating of insects and I know what it means"; "I have heard of the eating of insects but actually don't know what it means"; "No, I have never heard of the eating of insects") while the other three statements ("I have heard that a few insects are edible"; "I have heard of the eating of insects in other cultures (i.e. African and Asian)"; "I have heard of the eating of insects at some restaurants") were added by the research team of this study.

Participants were instructed to select all the statements that they would deem as applicable.

2.2.6. Experience with edible insects

To measure the participants' level of experience with edible insects a multiple-choice questionnaire with five possible responses was designed:

- "I have never tried edible insects";
- "I have tried edible insects on a single occasion";
- "I have tried edible insects on a few occasions";
- "I eat edible insects seasonally";
- "I eat edible insects regularly".

Participants were asked to choose only one response among the five options.

2.2.7. Perceived acceptance of insects as food and feed and perceived acceptance of sushi

In order to evaluate the level of perceived acceptance of insects and sushi, a questionnaire comprising 7 items (Cunha et al., 2014) was used. Acceptance was evaluated on a 7-point scale (ranging from 1 – "Totally reject" to 7 – "Totally accept", and was based on the question "If someone offers you a meal or a snack based on":

- "Edible insects";
- "Protein bar with flour made out of cricket".
- "Pork from animals fed with feed incorporating insects or insect protein";
- "Poultry from animals fed with feed incorporating insects or insect protein";
- "Beef from animals fed with feed incorporating insects or insect protein";
- "Fish from animals fed with feed incorporating insects or insect protein";
- "Sushi".

Sushi acceptance was evaluated because it is an example of a new food that has been successfully established in Western food practices (House, 2019) and there is a relation between sushi and edible insects' acceptance (Ruby & Rozin, 2019).

2.2.8. Disgust towards insects

In order to evaluate the level of disgust towards insects, a questionnaire based on the work by Rozin (2014) was applied. The questionnaire was composed of 5 items ("The idea of insects makes me nauseous"; "The idea of insects makes me ill"; "Eating insects is disgusting"; "I am offended by the idea of eating insects"; "If an insect crawls on my favorite food I woństaeat it").

Sampling adequacy was above acceptance being 0.824 for Norway and 0.848 for Portugal. A high internal consistency coefficient for Norway (Cronbach's $\alpha = 0.907$) and Portugal (Cronbach's $\alpha = 0.873$) was also verified. Data shows that the disgust towards insects construct is also unidimensional and consistent, with all five items presenting high loadings (>0.6), for both countries (Table S5).

2.2.9. Sociodemographic factors

To assess the socio demographic information of participants, ten questions were developed. They were divided into age, sex, marital status, maximum level of educational achievement, occupation, economic situation, nationality and place of residence.

2.3. Data analysis

Data had to be transformed and recoded in order to be analysed.

- Age was divided into three groups: 18–34; 35–54 and ≥55;
- Maximum level of educational achievement was divided into 2 groups: higher education (graduate and post-graduate degree) and lower education (less than high school, high school, technical/professional degree, and some college/no degree).
- Variable previous experience was recoded into 0 ("I have never tried edible insects") and 1 ("I have tried edible insects on a single occasion"; "I have tried edible insects on a few occasions"; "I eat edible insects seasonally"; "I eat edible insects regularly".)
- The variable familiarity was also recoded into 0 ("No, I have never heard of the eating of insects" and "I have heard of the eating of insects but actually doństaknow what it means") and 1 ("Yes, I have heard of the eating of insects and I know what it means", "I have heard that a few insects are edible", "I have heard of the eating of insects in other cultures (i.e. African and Asian)", "I have heard of the eating of insects at some restaurants");

2.3.1. Statistical analysis

To describe the basic features of the sample, descriptive statistics were applied (frequencies, mean and standard deviation).

Factor analysis was applied to different scales. Kaiser-Meyer-Olkin (KMO) statistics was used to measure sampling adequacy; if data are likely to factor well, based on correlation and partial correlation (Kaiser, 1981). Internal consistency and reliability of the different scales was evaluated using Cronbach's α (Cronbach, 1951).

In line with Cunha et al. (2014), acceptance scores were compared using non-parametric tests (Mann-Whitney and Wilcoxon). Differences in variable scores between countries were also assessed through the Mann-Whitney test. The Kolmogorov-Smirnov test was performed to assess the normality of the distribution of acceptance scores for both Portugal and Norway. Results have shown a significant deviance from the normal distributions and as such non-parametric tests were chosen to compare acceptance scores. Furthermore, a hierarchical cluster analysis using Ward's method followed by a K-mean clustering was conducted. Cluster analysis was applied based on the degree of acceptance of the different forms of insects as food (direct and indirect) to identify different consumer segments.

Moreover, acceptance data was reduced through factorial analysis with *Varimax* rotation, projecting the six variables into two factors: i) acceptance of insects as food and ii) acceptance of insects as feed. Factor scores were computed as the average of the variables expressing it. Considering consumers' acceptance of insects as food and as feed as a binary choice is consistent with the recommendation by Hoek et al. (2011), based on Wansink, Sonka, and Park (2004) who suggested using a dichotomous seeker/avoider segmentation when the product category under investigation is not frequently purchased and/or when there is a strong attitude towards the product category. Both conditions are clearly fulfilled for the case of acceptance of edible insects in Western countries.

In line with that, acceptance of insects as food and feed was transformed into binary choice being 0 = non-acceptance (factor scores between one and four) and 1 = acceptance (factor scores above four).

For the prediction of the binary acceptance of insects as food and as feed, the authors have used a binary logistic regression model (Hosmer et al., 2013), expressing acceptance as a function of FC-H, FC-C, FC-EW, disgust towards insects, food neophobia, food neophilia, familiarity, experience, acceptance of sushi, sex, age and level of education. The model yields coefficients (B) that express the logistic relationship between each predictor variable and the binary acceptance. For binary predictor variables (such as familiarity or experience), the value of Exp (B) expresses the odds-ratio, representing the odds that acceptance will occur given previous experience or familiarity with the eating of insects, compared to the odds of acceptance occurring in the absence of such experience or familiarity with the eating of insects.

Predicted probability of acceptance of insects as feed or food was performed following the work by Verbeke (2015), only including explanatory variables that were significant according to the regression analysis using backward stepwise selection. For both acceptance as food and feed the probability of acceptance was determined as a function of scores of disgust towards insects.

All statistical tests were applied at 95% confidence level, except when stated otherwise. All data was analyzed using the software Statistical Package for Social Sciences (SPSS) – version 27 ®.

3. Results

3.1. Acceptance of insects as food and feed

Regarding the perceived acceptance of different forms of entomophagy, it was possible to observe that there were significant differences in acceptance of the different forms of entomophagy within and between countries ($p < 0.05$) (Table 3). For both countries, the different products were grouped identically: "edible insects" had the lowest acceptance followed by "protein bar with flour made out of cricket",

Table 3
Mean (±Std. Dev.) of acceptance values (assessed on 7-point anchored scales, from 1 – totally reject to 7 – totally accept) for each of the different forms of entomophagy and for sushi, for each of the countries under comparison. Comparisons are drawn between countries for the average acceptance of each form of entomophagy (Mann-Whitney test) and within each country, the average acceptance of the different forms of entomophagy are compared with each other, following the Wilcoxon non-parametric test for two related groups.

	Norway (n = 363)	Portugal (n = 303)	
Form of entomophagy	**Mean (±Std. Dev.)**	**Mean (±Std. Dev.)**	**Mann-Whitney test (U, *p*, r)**
Edible insects	3.2 (±1.8) [c]	2.9 (±1.9) [c]	2.59; *0.010*; 0.10
Protein bar with flour made out of cricket	3.9 (±2.0) [b]	3.5 (±2.0) [b]	2.75; *0.006*; 0.11
Poultry from animals fed with feed incorporating insects or insect protein	5.1 (±1.9) [a]	4.4 (±2.0) [a]	4.71; ≤*0.001*; 0.18
Pork from animals fed with feed incorporating insects or insect protein	5.0 (±2.0) [a]	4.3 (±2.0) [a]	4.55; ≤*0.001*; 0.18
Beef from animals fed with feed incorporating insects or insect protein	5.0 (±1.9) [a]	4.4 (±2.0) [a]	4.41; ≤*0.001*; 0.17
Fish from animals fed with feed incorporating insects or insect protein	5.2 (±1.9) [a]	4.4 (±2.0) [a]	5.54; ≤*0.001*; 0.21
Sushi	5.3 (±2.1)	4.7 (±2.3)	3.90; ≤*0.001*; 0.15

a,b,c – Homogenous groups within each country according to the Wilcoxon test at 95% confidence level.

while the highest acceptance was found for animals fed with feed incorporating insects or insect protein, with no significant differences between types of animals (poultry, pork, beef or fish). Additionally, for all types of entomophagy and sushi, the Norwegian sample had the highest average acceptance scores.

3.2. Consumer segments

Cluster analysis was applied based on the degree of acceptance of the different forms of insects as food (direct and indirect) to identify different consumer segments. Four different groups of participants were identified based on their acceptance scores of different forms of entomophagy. These groups were divided into Disgusted (C1), Rejecters (C2), Food acceptors (C3) and Acceptors (C4) for each of the countries under comparison (Table 4).

The Disgusted group (C1) had the lowest levels of acceptance for all the forms of entomophagy. The Rejecters group (C2) had similar levels of acceptance for all forms of entomophagy, being higher than the Disgusted group (C1) but the average acceptance was lower than 4.7 (acceptance of "Fish from animals fed with feed incorporating insects or insect protein" by the Norwegian sample). The Feed acceptors group (C3) was characterized by low levels of acceptance of direct entomophagy (average scores between 1.9 and 2.4 but had a high acceptance of insects as feed (average scores between 6.0 and 6.2). The Acceptors group (C4) had the highest levels of acceptance for all forms of entomophagy, with the average score being above 4.7 (acceptance of "Edible insects" by the Norwegian sample).

3.3. Determinants of acceptance

Through factorial analysis, a reduction of the different variables of acceptance of insects as food and feed was computed (Table 5).

The regression model with acceptance of insects as food is significant for Norway (G2 (6) = 162.502; $p \leq 0.001$) and for Portugal (G2 (5) = 243.279; $p \leq 0.001$), and explains 48% (Norway) and 74% (Portugal) of the variation in the outcome, according to the Nagelkerke R square (R2N) (Table 6). The Norwegian model accurately predicted 78% of the answers while the Portuguese model had an accuracy prevision of 87%. The regression model with acceptance of insects as feed is also significant for both countries (Norway – G2 (5) = 141.114, $p \leq 0.001$; Portugal – G2 (5) = 117.346, $p \leq 0.001$) and explains 43% of the Norwegian and Portuguese variation in the outcome (R2N) (Table 7). Additionally, the model had an accuracy prevision of 76% and 77% in Norway and Portugal, respectively.

Regarding acceptance of insects as food (Table 6), for both countries disgust towards insects had a very strong negative effect on acceptance insects as food ($\beta = -0.822$ for Norway and $\beta = -1.356$ for Portugal) Additionally, food neophobia only had a negative effect for the Portuguese sample ($\beta = -0.415$), while a high level of familiarity with entomophagy had a negative effect on acceptance ($\text{Exp}(\beta) = 0.529$) in the Norwegian sample, although this effect was not statistically significant ($p = 0.072$). Regarding the variables with a positive effect, sushi acceptance ($\beta = 0.179$ for Norway and $\beta = 0.194$ for Portugal) and food neophilia ($\beta = 0.284$ for Norway and $\beta = 0.279$ for Portugal) increased the acceptance in both countries. Additionally, for Norway the variable with the greatest positive effect on acceptance was higher education ($\text{Exp}(\beta) = 1.857$), while for Portugal it was male sex ($\text{Exp}(\beta) = 2.141$). Previous experience with edible insects also had a positive effect on acceptance for the Norwegian sample ($\text{Exp}(\beta) = 1.792$) but this effect was not statistically significant ($p = 0.059$).

Regarding the acceptance of insects as feed (Table 7), some of the variables had a similar effect as in the acceptance of food. Disgust towards insects significantly decreased the acceptance in both countries ($\beta = -0.419$ for Norway and $\beta = -0.485$ for Portugal) Furthermore, sushi acceptance increased acceptance for both countries ($\beta = 0.265$ for Norway and $\beta = 0.194$ for Portugal). As it was observed for acceptance

Table 4
Acceptance levels (assessed on 7-point anchored scales, from 1 – "Totally reject" to 7 – "Totally accept") for different forms of entomophagy as a function of the consumer segmentation within countries.

Acceptance (Mean (±Std. Err))	Norway (n = 363)				Portugal (n = 303)			
	C1-Disgusted n = 81 (22%)	C2-Rejecters n = 92 (25%)	C3-Feed acceptors n = 64 (18%)	C4-Acceptors n = 126 (35%)	C1-Disgusted n = 76 (25%)	C2-Rejecters n = 95 (31%)	C3-Feed acceptors n = 41 (14%)	C4-Acceptors n = 91 (30%)
Edible insects	1.5 (±0.1)	3.5 (±0.1)	2.1 (±0.1)	4.7 (±0.1)	1.2 (±0.1)	2.5 (±0.1)	1.9 (±0.2)	5.1 (±0.1)
Protein bar with flour made out of cricket	1.9 (±0.1)	4.3 (±0.1)	2.4 (±0.2)	5.8 (±0.1)	1.6 (±0.1)	3.3 (±0.1)	2.4 (±0.2)	5.8 (±0.1)
Poultry from animals fed with feed incorporating insects or insect protein	2.2 (±0.1)	4.6 (±0.1)	6.2 (±0.1)	6.7 (±0.0)	1.8 (±0.1)	4.0 (±0.1)	6.0 (±0.1)	6.3 (±0.1)
Pork from animals fed with feed incorporating insects or insect protein	2.3 (±0.1)	4.3 (±0.1)	6.1 (±0.1)	6.7 (±0.0)	1.6 (±0.1)	3.8 (±0.1)	6.0 (±0.1)	6.3 (±0.1)
Beef from animals fed with feed incorporating insects or insect protein	2.3 (±0.1)	4.4 (±0.1)	6.0 (±0.1)	6.7 (±0.0)	1.7 (±0.1)	3.9 (±0.1)	6.0 (±0.1)	6.3 (±0.1)
Fish from animals fed with feed incorporating insects or insect protein	2.4 (±0.1)	4.7 (±0.1)	6.2 (±0.1)	6.7 (±0.0)	1.7 (±0.1)	3.9 (±0.1)	6.0 (±0.1)	6.3 (±0.1)

Table 5
Factorial structure of the acceptance of insects as food and feed for Portugal and Norway.

	Norway (n = 363)	Portugal (n = 303)
Acceptance of insects as food	**Loadings**	
Edible insects	0.878	0.861
Protein bar with flour made out of cricket	0.836	0.862
Explained Variance	31.01 %	33.97 %
Cronbach's-α	0.783	0.844
Acceptance of insects as feed		
Poultry from animals fed with feed incorporating insects or insect protein	0.897	0.915
Pork from animals fed with feed incorporating insects or insect protein	0.918	0.907
Beef from animals fed with feed incorporating insects or insect protein	0.906	0.915
Fish from animals fed with feed incorporating insects or insect protein	0.881	0.910
Explained Variance	57.11 %	59.56 %
Cronbach's alpha	0.967	0.990
KMO	0.864	0.890

Table 6
Coefficient estimates from the binary logistic regression of binary (accept/reject) acceptance of insects as food for Norway and Portugal. Variables with a significant impact ($p \le 0.050$) are written in *italic*.

Predictor variable	**Norway (n = 363 / R^2 = 0.481*)**		
	β	**Sig.**	**Exp(β)‡**
Familiarity	−0.637	0.072	0.529
Experience	0.583	0.059	1.792
Higher Education	*0.619*	*0.025*	*1.857*
Disgust towards insects	*−0.822*	*<0.001*	*n.a.*
Sushi	*0.179*	*0.024*	*n.a.*
Food neophilia	*0.284*	*0.007*	*n.a.*

Predictor variable	**Portugal (n = 303 / R^2 = 0.736*)**		
	β	**Sig.**	**Exp(β)‡**
Sex	*0.761*	*0.049*	*2.141*
Disgust towards insects	*−1.356*	*<0.001*	*n.a.*
Sushi	*0.449*	*<0.001*	*n.a.*
Food neophilia	*0.279*	*0.042*	*n.a.*
Food neophobia	*−0.415*	*0.002*	*n.a.*

*Nagelkerke R^2.
‡Odds-ratio used to explain the effect of binary predictor variables.

Table 7
Coefficient estimates from the binary logistic regression of binary (accept/reject) acceptance of insects as feed for Norway and Portugal. Variables with a significant impact ($p \le 0.050$) are written in *italic*.

Predictor variable	**Norway (n = 363 / R^2 = 0.429*)**		
	β	**Sig.**	**Exp(β)‡**
Familiarity	0.600	0.053	1.822
Higher Education	*1.024*	*<0.001*	*2.784*
FC-C	*0.172*	*0.042*	*n.a.*
Disgust towards insects	*−0.419*	*<0.001*	*n.a.*
Sushi	*0.265*	*<0.001*	*n.a.*

Predictor variable	**Portugal (n = 303 / R^2 = 0.428*)**		
	β	**Sig.**	**Exp(β)‡**
Disgust towards insects	*−0.485*	*<0.001*	*n.a.*
Sushi	*0.194*	*0.007*	*n.a.*
Sex	*0.830*	*0.006*	*2.293*
Age	*−0.031*	*<0.001*	*0.970*
Food neophilia	*0.410*	*<0.001*	*1.507*

*Nagelkerke R^2.
‡Odds-ratio used to explain the effect of binary predictor variables.

of insects as food, higher education was the variable with the greatest positive effect for Norwegian sample (Exp(β) = 2.784) and male sex for the Portuguese sample (Exp(β) = 2.293). Additionally, food neophilia also increased acceptance, but unlike acceptance for food this only occurred for the Portuguese sample (β = 0.410). Moreover, neither food neophobia nor experience significantly affected acceptance of insects as feed. Familiarity had the opposite effect on acceptance of insects as feed as it had on acceptance of insects as food (Exp(β) = 1.822, for Norway), but this effect was also not statistically significant ($p = 0.053$).

Furthermore, some variables only affected acceptance as feed. For the Norwegian sample, FC-C increased acceptance (β = 0.172) while for the Portuguese sample age (β = 0.031) had a significant negative effect.

3.4. Predicted probabilities of acceptance

The predicted probabilities of acceptance of insects as food and feed are presented in Figs. 1 and 2, respectively, for different profiles of consumers and across the range (1–7) of the disgust towards insects scale. For the ideal profile, only the variables that had a significant effect on acceptance ($p \le 0.050$) were used, while for the other profile all the variables presented on the binary logistic regression models were used (Table 6 and Table 7).

According to the coefficient estimates from binary logistic regression of acceptance of insects as food (Table 6) for Norway and Portugal, the ideal consumer profiles for each country were:

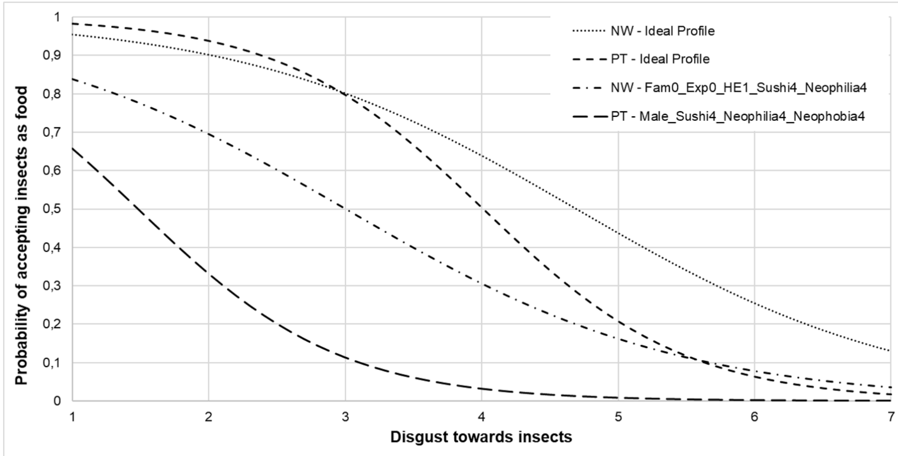

Fig. 1. Predicted probability (%) of accepting insects as food depending on disgust towards insects scores for different profiles of consumers in Norway and Portugal. Ideal profile (according to Coefficient estimates from binary logistic regression) were: higher education, high (7) acceptance of sushi and high (7) scores for food neophilia for Norway and male, high (7) acceptance of sushi, high (7) scores for food neophilia and low (1) scores for food neophobia for Portugal.

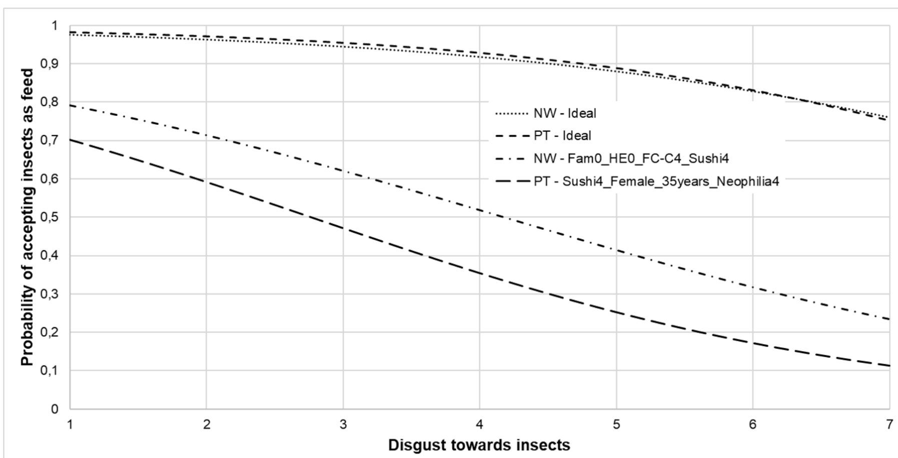

Fig. 2. Predicted probability (%) of accepting insects as feed depending on disgust towards insects scores for different profiles of consumers in Norway and Portugal. Ideal profile (according to Coefficient estimates from binary logistic regression) were: higher education, high (7) acceptance of sushi and high (7) scores for FC-C for Norway and male, young (18 years), high (7) acceptance of sushi and high (7) scores for food neophilia for Portugal.

- Norway – higher education, high (7) acceptance of sushi and high (7) scores for food neophilia.
- Portugal – male, high (7) acceptance of sushi, high (7) scores for food neophilia and low (1) scores for food neophobia for Portugal.

The predicted acceptance of insects as food for these ideal profiles was different, with the Norwegian sample only having a probability lower than 50% for a disgust towards insects score of 4.7. On the other hand, for the Portuguese ideal profile, a disgust towards insects score of 4.1 was enough to lower the probability of acceptance to 50% (Fig. 1). These results further demonstrate the lower acceptance of the Portuguese sample and the greater effect of disgust on acceptance of insects as food for Portuguese consumers.

Additionally, the other profiles that were tested consisted on lowering interest in edible insects and novel food (average values for food neophilia, sushi acceptance, low familiarity and experience to edible insects). The impact of lowering these variables was greater for the Portuguese population, with a disgust toward insects score of 2 only leading to a 33.2% probability of accepting insects and with scores greater than 3.1 the probability is lower than 10%. For Norway, lowering interest in novel foods/edible insects also significantly lowered the probability of acceptance, but only at a disgust towards insects score of 3.1 does the probability of acceptance is below 50%. Furthermore, at high disgust towards insects scores (five or greater) the probability of acceptance in this profile is very similar to the probability of acceptance for the Portuguese ideal profile (Fig. 1).

According to the coefficient estimates from binary logistic regression of acceptance of insects as feed (Table 7) for Norway and Portugal, the ideal consumer profiles for each country were:

- Norway – higher education, high (7) acceptance of sushi and high (7) scores for FC-C
- Portugal – male, young (18 years), high (7) acceptance of sushi and high (7) scores for food neophilia for Portugal.

Unlike acceptance for insects as food, the ideal consumer profile for acceptance of insects as feed had a very high probability of acceptance at a very high (7) level of disgust towards insects (76% for Norway and 75% for Portugal) (Fig. 2). This further highlights the higher acceptance of insects as feed than insects as food for both countries, but it also reveals that disgust towards insects has a much more powerful effect on acceptance of insects as food than acceptance of insects as feed.

Even for other profiles with sociodemographic characteristics that have a negative impact on edible insects' acceptance (no higher education for Norway and older female for Portugal) and less interest/curiosity in novel foods (low familiarity with edible insects, average acceptance of sushi and average scores for food neophilia), a probability of acceptance lower than 50% only occurred at disgust levels of 4.2 (Norway) and 2.8 (Portugal) (Fig. 2). As such, even for consumer profiles that are significantly different from the ideal profile not only for interest/curiosity in novel foods, but also in sociodemographic variables, it is possible to reach high acceptance of insects as feed.

4. Discussion

4.1. Acceptance of direct and indirect entomophagy

For both Portugal and Norway, acceptance of products incorporating processed insects was higher than acceptance of whole unprocessed insects (Table 3). This effects is widely reported in scientific literature and it is also obvious on the food market (Gmuer, Nuessli Guth, Hartmann, & Siegrist, 2016; Lammers et al., 2019; Tan, van den Berg, & Stieger, 2016; Verbeke, 2015), and it can be explained by lower disgust reactions, since the presence of whole insects reminds consumers of their animal-origin (Hartmann & Siegrist, 2018). However, for products to be accepted by consumers they need to be sensory appealing and appropriate (Cunha & Ribeiro, 2019; Kröger et al., 2022). For instance, while insects were initially considered as a meat alternative (Deroy et al., 2015; Verbeke, 2015), the products which are currently considered more appropriate by consumers are bakery/snacks, especially those with functional properties (protein shakes or protein bars) (Ardoin & Prinyawiwatkul, 2020).

Additionally, acceptance of indirect entomophagy (insects as feed) was higher than acceptance of direct entomophagy for both countries (Table 3), a similar result to other published work (La Barbera et al., 2020; Naranjo-Guevara et al., 2021; Onwezen et al., 2019; Roma et al., 2020), although we did not find an higher acceptance of fish or poultry compared to beef (Domingues et al., 2020; La Barbera, Amato, Fasanelli, & Verneau, 2021; Szendrő et al., 2020; Verbeke et al., 2015).

4.2. Cross-cultural differences in entomophagy acceptance

This study also revealed cross-cultural differences in the acceptance of entomophagy, with the Norwegian sample having higher acceptance for all the forms of entomophagy than the Portuguese sample. Although most cross-cultural studies have been performed between countries from different continents, such as between United States of America and India (Ruby & Rozin, 2019) or between Germany and China (Hartmann et al., 2015), there have been studies assessing differences between European countries. These studies also reflect the findings in this work, with Southern European countries (Italy) having lower acceptance or intention to eat insects than Northern European (Denmark) (La Barbera et al., 2020; Verneau et al., 2016) or Central European countries (Netherlands) (Menozzi, Sogari, Simoni, & Mora, 2017). These differences can be explained by a greater entomophagy promotion in Central and Northern European countries (Belgium and Netherlands were some of the earliest countries with legislation regarding edible insects). New Nordic food has promoted the consumption of insects earlier on, for example with the well-known Nordic Food Lab (Evans, 2013; Evans, 2013). Differences can also be due to different food cultures; Southern European countries have a strong food culture and may be less inclined to adopt new food trends (Verneau et al., 2016). This effect is even evident in different regions of the same country, with Menozzi et al. (2017) and Sogari, Menozzi, et al. (2019) reporting lower willingness to eat insects in Southern Italy (area of strong culinary traditions) than in Central or Northern Italy. In this work, the Norwegian sample had higher acceptance of sushi (Table 3), more previous experience with edible insects, higher food neophilia scores and lower food neophobia scores (Table 2), which symbolizes that Norwegian consumer are more inclined to seek new food experiences than Portuguese consumers, and thus have higher acceptance of edible insects as food or feed.

4.3. Consumer segmentation according to entomophagy acceptance

In both Norway and Portugal, it was possible to divide the consumers into segments according to their acceptance of the different forms: disgusted, rejecters, feed acceptors and acceptors (Table 4). The 'Disgusted' segment had very low scores for both direct and indirect entomophagy while the 'Rejecters' had mostly neutral scores for either form. Additionally, the segment 'Acceptors' had the highest acceptance for either entomophagy form. On the other hand, it was possible to identify a segment 'Feed Acceptors" which had very low acceptance for direct entomophagy but a very high acceptance for insects as feed. The relative size of each segment also reflects a higher acceptance in the Norwegian sample, with 35% of the consumers belonging to the 'Acceptors' cluster (30% in the Portuguese sample) and 18% to the 'Feed Acceptors' cluster (14% in the Portuguese sample). Videbæk and Grunert (2020) and Roma et al. (2020) reported the existence of clusters of consumers who had very low acceptance of insects as food but high acceptance of insects as feed, highlighting that the market for insects as feed is very high. Furthermore, it has been hypothesized that introducing insects as feed can increase acceptance as food (Sogari, Amato, et al., 2019) but this might not necessarily occur, since consumers who are predisposed to eat animal fed with insects do not automatically accept insects as food. Videbæk and Grunert (2020) reported that the segment 'Potential Entomophagists' had low acceptance of insects as feed while La Barbera et al. (2020) showed that for the Danish population, there was a negative relation between acceptance of insects as feed and acceptance as insects as food, probably because of a human-animal divide.

4.4. Determinants of acceptance/rejection

4.4.1. Disgust towards insects

Concerning the determinants of acceptance/rejection of insects, there were differences between countries and entomophagy forms (Table 6 and Table 7). Firstly, considering the variables with a negative effect on acceptance, disgust towards insects had the greatest negative effect on acceptance of insects as food and feed in both countries, although its effect was greater in acceptance of direct entomophagy in Portugal (Table 6). This result might explain the lower acceptance of insects as food in this country even though disgust towards insects was lower for the Portuguese sample (Table 2). The predicted probability of accepting insects as food (Fig. 1) or feed (Fig. 2) depending on disgust towards insects' scores for different profiles of consumers in Norway and Portugal also demonstrates the greater negative effect of disgust towards insects in Portugal. For the ideal consumer profiles in both countries, disgust towards insects had a much more negative effect on acceptance of food than in acceptance as feed and the negative effect of disgust towards insects was more pronounced for Portuguese consumers. For acceptance as feed, even at the highest levels of disgust towards insects the probability of acceptance in the ideal profiles was higher than 75% while for acceptance as food, disgust towards insects levels of 4.1 (Norway) and 3.3 (Portugal) led to acceptance probabilities lower than 75%. The difference between countries is greater at high disgust towards insects' scores ($\geq$5), where both the Portuguese ideal consumer profile and the Norwegian consumer profile with low interest/curiosity in novel foods have similar probabilities of acceptance of insects as food (Fig. 1).

4.4.2. Food neophobia

On the other hand, food neophobia only affected acceptance of insects as food in Portugal, and to a lesser degree than disgust. Even ideal consumer profiles have low probabilities of acceptance of insects as food at high levels of disgust towards insects (Fig. 1), and it is crucial to diminish disgust reactions for insects to be successfully introduced in the Western food market. These results support recent findings that disgust plays a greater role than food neophobia (La Barbera et al., 2018; La Barbera et al., 2020; Ribeiro, Soares, de Moura, & Cunha, 2021; Woolf, Zhu, Emory, Zhao, & Liu, 2019). These recent findings highlight the importance of changing the social and cultural norms surrounding edible insects, especially associating insects with positive tasting experiences and increasing their sensory appeal, not only through the development of tasty and appropriate products but also with designing packages that avoid disgusting cues. However, the main focus should be on increasing the consumption of edible insects and assuring that these experiences are positive, or otherwise this consumption will increase disgust towards insects (Cunha & Ribeiro, 2019; Kröger et al., 2022; Mancini, Moruzzo, et al., 2019).

4.4.3. Interest in new food experiences

Conversely, interest in new food experiences (food neophilia, sushi acceptance, previous experience with edible insects) increased acceptance of insects (mainly as food) in both countries (Tables 6 and 7, Figs. 1 and 2). Neophilic and sensation-seeking consumers had already been identified as more willing to consume edible insects food (Lammers et al., 2019; Ruby & Rozin, 2019; Sogari, Menozzi, et al., 2019; Videbæk & Grunert, 2020), and interest/curiosity regarding entomophagy is one of the major factors driving acceptance of edible insects (La Barbera et al., 2020; Ribeiro et al., 2021; Verneau et al., 2021; Videbæk & Grunert, 2020). These results support the idea that adventurous and sensation-seeking consumers can be early adopters of insects as food or feed and that promotion of entomophagy could be directed towards these consumers instead of just focusing on lowering disgust/neophobic reactions (Lammers et al., 2019; Naranjo-Guevara et al., 2021). As such, it is necessary to go beyond simple communication strategies and introducing consumers to the sensory properties of edible insects (e.g. organizing tasting sessions, providing free samples) is an excellent strategy to improve acceptance (Barton, Richardson, & McSweeney, 2020; Palmieri et al., 2019b; Piha, Pohjanheimo, Lähteenmäki-Uutela, Křečková, & Otterbring, 2018; Woolf et al., 2019). However, it is important to point out that in order for insects to be accepted as food in the West it is necessary to implement systematic changes (with the involvement of the food industry and legal authorities) because social and cultural norms have to be modified. Moreover, the developed products need to be easily available to consumers and its prices have to be adequate to make repeated purchase and consumption more frequent. Additionally, social acceptability/perception (e.g. negative opinions of friends and family members, social norms in collective tasting sessions or social influence of people who visibly eat insect products) can also impact willingness to eat edible insects (Jensen & Lieberoth, 2019; Schäufele et al., 2019; Sheppard & Frazer, 2015; Sogari, Menozzi, & Mora, 2017) and an effort should be made to increase social acceptability. This increased acceptability would normalize the consumption of insects, and it can be attained through positive experiences of peers, positive reviews by food critics or association with public figures (Cunha & Ribeiro, 2019; Kröger et al., 2022). It is necessary to emphasize that there are no simple solutions to increase acceptance of edible insects, since it is necessary to change the social and cultural norms surrounding a class of animals that have not been traditionally eaten in Western countries, and have been associated with very negative cues (e.g. unhygienic conditions, diseases, pets).

Sushi acceptance also increased acceptance of insects as food or feed in either country. This relation between insect and sushi acceptance has already been shown for both American and Indian consumers (Ruby & Rozin, 2019), further suggesting that interest in new food experiences or low disgust sensitivity are associated with increased acceptance of insects as food or feed. Although it might be tempting to compare insects and sushi (as the latter of a novel food that has been successfully established in Western countries), such comparisons have to be done with caution because edible insects are being introduced into already existing food practices (House, 2019).

4.4.4. Sociodemographic characteristics

Regarding sociodemographic characteristics, it is possible to see that age only impacted acceptance as feed for the Portuguese sample (increase in age negatively associated with acceptance) (Table 7). Nonetheless, even in this case, the effect of age was minimal ($\beta = 0.031$). On the other hand, sex (male) and higher education played a significant role in increasing acceptance of both entomophagy forms for the Portuguese and Norwegian samples, respectively (Table 6 and Table 7). These results are consistent with other studies that have reported that males and people with higher education (Bazoche & Poret; Palmieri et al., 2019b; Ribeiro et al., 2021; Videbæk & Grunert, 2020) present higher acceptance or willingness to try insects as food. Nonetheless, it is important to note that the effects of sociodemographic characteristics were either minimal (age) or country specific (sex for Portugal and education level for Norway), demonstrating that the effects of sociodemographic characteristics are extremely variable (Cunha & Ribeiro, 2019; Mancini, Moruzzo, et al., 2019; Sogari, Amato, et al., 2019). For instance, one possible explanation for sex only having an effect for the Portuguese sample may be the greater effect of disgust on the Portuguese sample, since the effect of sex may be related to males having lower disgust sensitivity than women (Hamerman, 2016; Ruby & Rozin, 2019; Tuccillo et al., 2020).

4.4.5. Food choice motives

As for the variables pertaining motives related to food choices (convenience, health and ecological welfare) only convenience was associated with increased acceptance of edible insects as feed for the Norwegian sample (Table 6), similar to what was reported by Ankamah-Yeboah et al. (2018). These results can be somewhat surprising since the nutritional value of insects and its environmental sustainable production are two of main-selling points concerning edible insects (Müller, Evans, Payne, & Roberts, 2016), and several studies have identified environmental and nutritional aware consumers as more willing to consume insects (Dupont & Fiebelkorn, 2020; House, 2016; Naranjo-Guevara et al., 2021; Palmieri, Perito, Macrì, & Lupi, 2019b; Ribeiro et al., 2021; Tuccillo et al., 2020). Nonetheless, previous studies have also identified no association between sustainability and environmental consciousness and acceptance of edible insects (Domingues et al., 2020; Lammers et al., 2019; Sogari, Bogueva, & Marinova, 2019). In a systematic review performed by Kröger et al. (2022) regarding acceptance of insect-based food in Western societies, it was reported that of the evaluated food choice motive (familiarity, sensory appeal, ethical concerns, natural content, health, convenience, price, weight control, mood and sustainability), only health, convenience and sustainability had a positive effect on acceptance in more than one study, although other studies reported no significant effects. One possible explanation for these differences may be the lack of knowledge that consumers have regarding the nutritional and environmental benefits associated with edible insects (Domingues et al., 2020; Roma et al., 2020; Wilkinson et al., 2018). Previous studies have also shown that informing consumers about the benefits associated with edible insects can increase willingness to eat (Deroy et al., 2015; Hartmann et al., 2015; Verbeke, 2015; Verneau et al., 2016; Woolf et al., 2019) and even sensory-liking of the products (Schouteten et al., 2016). Highlighting the benefits associated with entomophagy can still be an effective strategy to increase acceptance among target segments. For instance, in a study performed with Italian athletes, providing positive information about edible insects increased willingness to try a cricket bar and the most important factor was related to the protein content (Placentino, Sogari, Viscecchia, De Devitiis, & Monacis, 2021). Additionally, functional products such as protein bars or protein shakes are the most accepted products by consumers (Ardoin & Prinyawiwatkul, 2020). It is also important that the information in portrayed through credible media sources, since it can increase consumers' willingness to purchase edible insects, especially with consumers who are engaged in social movements such as sustainable consumption (Legendre et al., 2019). Nonetheless affective factors have been increasingly identified as being more important to explain interest in edible insects than rational "factors" (particularly in direct entomophagy) (Onwezen et al., 2019).

5. Limitations

This study presents some minor limitations. Firstly, there are some differences in the sociodemographic characteristics of the participants in Norway and Portugal, with the Portuguese sample having a higher proportion of males and individuals with higher education. While these differences might have influenced the acceptance results, both these characteristics had a positive effect on the acceptance of edible insects which was already higher in the Norwegian samples.

Another potential limitation of this study is the use of text-based questionnaire to assess disgust towards insects, which is a very strong negative emotion. When evaluating emotional responses to food cues, it might be advisable to use pictures (Ammann, Hartmann, & Siegrist, 2018) and/or use of non-verbal lexicon (e.g. emoji) (Jaeger, Jin, Ryan, & Schouteten, 2021).

Additionally, our study focused on a general population which might explain the lack of effects of food choice motives related to sustainability or health. In the future, studies on the acceptance of edible insects should also be performed with specific population segments, namely athletes that consume functional products and consumers who make food decisions based on sustainability. Furthermore, it is important to evaluate the level of knowledge that consumers have regarding the environmental and nutritional benefits of consuming edible insects.

6. Conclusion

This study provides further insights into the question of consumers' acceptance of insects as food and feed, in particular providing cross-cultural comparisons and assessing determinants of acceptance. In both Portugal and Norway, acceptance of indirect entomophagy (insects as feed) was higher than acceptance of direct entomophagy (insects as food), and there was higher acceptance of processed insects than unprocessed edible insects. Additionally, for all forms of entomophagy the Norwegian sample had higher acceptance than the Portuguese sample highlighting how different food cultures can perceive edible insects. In both countries it was also possible to divide consumers into 4 segments, including a cluster of consumers who rejected insects as food but had high acceptance of insects as feed. As for determinants of acceptance, disgust was the variable with the most negative effect while interest/curiosity (food neophilia, acceptance of sushi, previous experience to insects) in new food experiences was a major determinant for the acceptance of insects as food. However, even for consumers with an ideal profile, probability of acceptance of insects as food is very low. The social and cultural norms surrounding edible insects need to change in order for them to be successfully implemented in Western food market. This can be attained through communicational strategies (e.g. popularizing the benefits associated with consumption and production of edible insects) and promoting positive sensory experiences, but a systematic change involving the food industry and legal authorities is necessary to change consumer perception about eating insects.

CRediT authorship contribution statement

José Carlos Ribeiro: Investigation, Data curation, Formal analysis, Writing – original draft. **Ane Telles Sposito Gonçalves:** Investigation, Data curation, Formal analysis. **Ana Pinto Moura:** Conceptualization, Methodology, Supervision, Validation, Writing – review & editing. **Paula Varela:** Conceptualization, Methodology, Supervision, Writing – review & editing, Funding acquisition. **Luís Miguel Cunha:** Conceptualization, Methodology, Supervision, Formal analysis, Validation, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

Author J.C. Ribeiro acknowledges Doctoral Grant No. SFRH/BD/147409/2019 funded by FCT – Foundation for Science and Technology. This work was supported by national funds from the FCT through the research unit GreenUPorto (UIDB/05748/2020 and UIDP/05748/2020). Author P. Varela acknowledges financial support from the Norwegian Fund for Research Fees for Agricultural Products (FFL) through the project "FoodForFuture" (project number 314318).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodqual.2022.104650.

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