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Erhard, Ainslee L.; Águas Silva, Magda; Damsbo-Svendsen, Marie; Menadeva Karpantschof, Bat El; Sørensen, Helle; Bom Frøst, Michael

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Acceptance of insect foods among Danish children: Effects of information provision, food neophobia, disgust sensitivity, and species on willingness to try

Ainslee L. Erhard a, b, Magda Águas Silva a, Marie Damsbo-Svendsen a, Bat-El Menadeva Karpantschof a, Helle Sørensen c, Michael Bom Frost a, * a University of Copenhagen, Department of Food Science, Design and Consumer Behavior, Rolighedsvej 26, 1958 Frederiksberg C, Denmark b University of Göttingen, Faculty of Business and Economics, Sustainable Food Systems, Heinrich-Düker-Weg 12, 37073 Göttingen, Germany c University of Copenhagen, Department Mathematical Sciences, Data Science Lab, 2100 Copenhagen, Denmark

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ABSTRACT

The growing global population and rising demand for meat increasingly pressures the world’s resources. Edible insects are a promising alternative protein source to unsustainable conventional meat. Despite this, disgust and neophobia are cited as significant barriers to the adoption of these novel foods in Western diets. The primary aim of this study was to assess the effects of providing three types of information — the taste, health, and sustainability benefits of entomophagy (i.e. the practice of eating insects) — on the willingness to try and hedonic response to insect-based foods among children. In addition, the differences between insects (buffalo worms and cricket) in unprocessed form and in various food applications were examined. Food disgust sensitivity, food neophobia, willingness to try, familiarity, and hedonic response to insect foods were measured. The implications of the appropriateness (as a food ingredient and to be raised as livestock) of two different insect species on acceptance were also explored. The data were collected through an online questionnaire administered in school classrooms from a sample of Danish children (n = 181). Results showed that communicating information about the benefits of entomophagy did not increase the willingness to try insect foods, irrespective of the type of information. Food neophobia was found to be a strong predictor of willingness to try insect foods, whereas food disgust sensitivity had no effect. There was no correlation between food disgust and food neophobia scores. Furthermore, certain types of insect products were found to be better liked than others (e.g. cookies over falafel). There was a species effect on hedonic response when presented as a whole insect although not when presented as processed products made with insect flour.

1. Introduction

The global population is expected to increase by two billion people within the next 30 years — from 7.7 billion to 9.7 billion by 2050 — and is projected to reach 11 billion by the end of the century (United Nations, Department of Economic, & Social Affairs, 2019). Humanity will be confronted with a lack of nutritive resources as the demand for conventional proteins induce unsustainable pressure on our land, water, and energy supplies (Van Huis, 2013). There is an urgent need to find sustainable and innovative solutions for alternative proteins; edible insects may be among them. Although interest in edible insects in the West has been growing, the potential for these foods is still poorly understood, especially with respect to consumer acceptance (Collins et al., 2019; Mancini et al., 2019). The acceptance of insect foods among children, the next generation of consumers, is especially under-researched as most studies have targeted adults.

1.1. Barriers to consumer acceptance

Coming to accept novel foods is a complicated process and it would be no small task to achieve the successful integration of insects into the diets of Western consumers (Martins & Pliner, 2006; Rozin & Fallon, 1980). Human food preferences and aversions are formed by a complex multitude of experiential, cultural, and personal factors; insect foods are no exception. Acceptance of insect foods is often measured by “willingness to eat” and is informed significantly by food neophobia.

* Corresponding author.
Insect foods are unfamiliar to most Western consumers, where there is no tradition for eating them, unlike in many other parts of the world. Food neophobia is the tendency to avoid unfamiliar or novel foods, a trait evolved to protect against the ingestion of potentially poisonous foods (Sogari et al., 2018; Doyeve et al., 2008). Though neophobia is a generic attribute of omnivores, there are individual and measurable differences in the degree of food neophobia which can impact food choice and acceptance (Hartmann & Siegrist, 2016; Hartmann et al., 2015; Verbeke, 2015; Chow et al., 2021).

Similarly, disgust protects individuals from potential sources of disease and is related to the fear of unfamiliar foods and the perception of danger. While disgust and neophobia are often related, they are not the same; not all unfamiliar foods lead to disgust. On the contrary, familiar foods may lead to disgust in some individuals, either due to their sensory properties (e.g. slimy fish exterior, Heier et al., 2021), or to the anticipation of negative effects e.g. aversions based on prior experience connected to food poisoning (Rozin & Fallon, 1987). Disgust has long been recognized as a basic human emotion characterized by well-known facial expressions (such as a gaping mouth, tongue protrusion, wrinkled nose, and raised lip) and is believed to be integral to the behavioral immune system (Darwin, 1872; Rozin et al., 1999; Rozin & Fallon, 1987).

Not all disgust elicitors are related to pathogen avoidance, some are culture-specific and arbitrary (Looy et al., 2014). According to Rozin and Fallon (1987), ideational rejection of foods is based on the origin or nature of the food (the rejection of insects as food, simply because they are insects). Rejection of foods based on ideational factors is a culturally constructed, learned process and may well pose a barrier to the adoption of nutritious and sustainable novel foods, such as insects in Western cultures (Rozin et al., 2009; Evans et al., 2015; Evans, Flore, & Frost, 2017; Hartmann & Siegrist, 2018).

1.2. Strategies for gaining acceptance in the West

Strategies aimed at the adoption of novel insect foods may need to be different than novel foods in general due to their perceived cultural inedibility (Looy et al., 2014). There is empirical evidence that in Western cultures, insects are implicitly associated with other sources of primary disgust (e.g. feces, decaying matter). For some consumers, insects are not viewed as food; instead they are associated with vectors of diseases and perceived as a health risk (La Barbera et al., 2018; Looy et al., 2014). Despite the unique challenge that novel insect foods present, a growing preoccupation with sustainability, especially in the younger generation, may provide an opening for their introduction to the Western market (Looy et al., 2014). It follows that a heightened concern for the environment in individuals is predictive of a greater readiness to accept insect foods (Verbeke, 2015). Indeed, emphasizing the benefits, including the sustainability benefits, is one strategy for encouraging entomophagy. Often this entails educating consumers about the nutritional and environmental gains (Verneau et al., 2018; Verbeke, 2015; Lensvelt & Steenbekkers, 2014; Sogari, 2015). There are notable differences between types of information campaigns; to argue for entomophagy on the grounds of sustainability is to appeal to the collective good of humanity, whereas arguments based on health and taste benefits reflect individual interests. Sometimes information transmission about edible insects is provided in conjunction with sensory learning and tastings. Increasing familiarity through experimental tastings (i.e. bug banquets) seem to have good results (Looy et al., 2014; Lensvelt & Steenbekkers, 2014; Caparros Megido et al., 2014).

The formulation and presentation of insect products will also be important in gaining consumer acceptance (Evans, Flore, & Frost, 2017). Reducing the visibility of insect pieces by processing them (e.g. into flour) widely increases willingness to eat them (Tan, van den Berg, & Stieger, 2016; Gmur, Nuessli Guth, Hartmann, & Siegrist, 2016; Hartmann & Siegrist, 2016; Scholes, de Boer, & Boersema, 2012; Lombardi et al., 2019; Ruby and Rozin, 2019) and reduces the disgust factor (Caparros Megido et al., 2016). The species of insect as well as perceived acceptability of the type of food in which insects are an ingredient is also influential (Schaufele et al., 2019; Fischer & Steembekkers, 2018; Tan, Fischer, van Trijp, & Stieger, 2016; Tan, van den Berg, & Stieger, 2016). If the carrier food is well-liked, then it is also more likely that the same food will be liked when it has insects as an ingredient (Tan, van den Berg, & Stieger, 2016).

Studies on the acceptance of insect foods in children are more limited than in adults, though much research has been done on the acceptance of other kinds of novel foods in children. In children, resistance to trying novel foods impacts diet diversity and is related to eating fewer fruits and vegetables (Krohner et al., 2011). Cognitive approaches such as the French “Les classes du goût” and similar sensory education methods have been shown to decrease neophobia and increase willingness to try novel foods (Mustonen & Tuorila, 2010; Reverdy et al., 2008). Other modes of education, such as cooking with novel foods, can also increase willingness to taste (Allirot et al., 2016; DeCosta et al., 2017), but will not necessarily lead to an increase in hedonic response (Chow et al., 2021). Houston-Price et al. (2009) found that simple exposure to novel fruits and vegetables by way of picture books could increase children’s interest in the foods followed by an increase in the willingness to try them. Repeated experiences with foods high in novelty increase familiarity, and together with social influences, are powerful tools to promote the acceptance of new foods in young children (Addessi et al., 2005).

The primary objective of the present study was to explore the effects of communicating three types of information — the taste, health, and sustainability benefits of eating insects — on the willingness to try insect foods among Danish children. The secondary objectives were: i) to analyze the interrelationship between food neophobia, disgust sensitivity, and insect species on acceptance of insect foods and ii) to determine which insect-based foods are most desirable. To reach this goal, an online learning activity and lecture as well as a survey was developed and implemented in schools across Denmark. These findings can provide useful insights to the emerging insect food industry and open new avenues for future research.

2. Methods

2.1. Participants

A total of 181 students from Danish schools were recruited through advertisements posted on Taste for Life’s social media sites. The intervention was designed as a teaching activity, where the three versions of provided information could be part of the curriculum in the mandatory class Food Knowledge. Recruitment for the study ran from May 7th to June 12th, 2020 and was open to teachers of 5th and 6th grade classes, all of which were teaching in physical classrooms at the time of the study. Children were 9–13 years old (only one 9-year-old, the rest were 11–13 years old, mean 11.8, Std 0.7). Of the children, 96 were females, 83 were males, and two did not identify as one of those genders. Prior to beginning the survey, parental consent was obtained. Children were permitted to partake in the activity and survey along with the rest of their class with the consent of their teacher, as it was a teaching activity. Data from children whose parental consent was not obtained was deleted immediately as part of the data cleaning and processing. The experimental period was during partial COVID-19 lockdown in Denmark, so although the students were physically at schools, they were allowed only very limited interaction outside their small peer groups. Hence access for experimenters was not allowed. Participants came from four different schools, and a total of nine different classes. Due to the partial lockdown, for one school, the group of participants was not in...
their normal class group, but in different groups. It was not possible to identify which individuals came from which class, hence they are treated as only one class.

2.2. Study design

A link to the online survey and lecture was sent to teachers in advance for distribution to their students. Students partook in the study in the classroom but were instructed to work independently. The survey was structured in three parts: pre-exposure questionnaire, intervention exposure, and post-exposure questionnaire. Classes were randomly assigned to one of the three experimental groups with the goal to equally distribute 5th and 6th graders. Classes participated in a narrated online PowerPoint lecture and quiz on the benefits of eating insects in relation to either i) taste, ii) health, or iii) the environment depending on which experimental group they were assigned to (see Appendix A). Each lecture lasted 15–18 min. The presented information was neutral regarding the three topics above. It was based on peer-reviewed and validated interventions. All delivered information that was not based on peer-reviewed information (e.g. chef statements) was fact-checked. Insect images, images of people eating insects, insect dishes etc. were displayed during the recorded lectures. It contained attention checks via questions prompting participants to respond true/false to statements relating to the content of the lecture. Appendices C to E contain the slide deck for each lecture with Danish slides and with the speaker’s full narrated manuscript in English. All participants received the same questionnaire regardless of experimental condition.

The pre-exposure questionnaire consisted of demographic questions, familiarity with insects as foods, willingness to try (WTT), the Food Neophobia Test Tool (FNTT; Damsbo-Svendsen et al., 2017), and the Food Disgust Scale (FDS-short; Hartmann & Siegrist, 2018). After the intervention, participants were presented with two images: a buffalo worm and a cricket, both of which were dried and frozen. Participants were prompted to give their hedonic response as well as perceived appropriateness of these two insects as a food ingredient and their appropriateness for use in animal husbandry. Participants were next presented with images of nine commercially available insect-based products: protein bars (x2), crisp bread (x2), chocolate, a burger, falafel, chocolate chip cookies, and chips. These products were made with either buffalo worm flour or cricket flour and had no visible insect fragments (Table 1). For each image it was described that the food was produced using insect flour of one of the two insect species. The questionnaire ended with an assessment of perceptions of appropriateness of these foods with insects for different situations and overall willingness to taste insects foods in the future. Perceptions of appropriateness were measured for consumption in everyday situations (i.e. food eaten at home or at school) versus special occasions (i.e. food eaten at a party, see Appendix B for full survey). The study was thus executed as a full online digital experiment, where the respondents received all information, including sample presentations and responded through a digital platform. This was the only feasible way of completing the study during the partial COVID-19 lockdown.

All evaluations of statements were done using 7-point scales, with appropriate anchors. All anchors are indicated in parentheses in the following. All hedonic responses were provided on a 7-point emoji smiley scale. The emoji scale has been validated as an appropriate and modernized approach for measuring emotional response to verbal food and non-food stimuli in children between the ages of eight to eleven (Swaney-Stueve et al., 2018). Although not all children in this study fall into this age group, the authors consider this tool to be readily accessible to the older children while still inclusive to the younger children. WTT, appropriateness measures, and perceptions of everyday and occasional foods were all evaluated on the same 7-point scale (1 = not at all, 4 = neutral, and 7 = definitely). See appendix B for full survey. The questionnaire and lecture materials were developed in English and then translated into Danish by native speakers. It was tested prior to release in order to assure consistency and comprehension.

2.3. Ethical approval

The Research Ethics Committee for HEALTH and SCIENCE at Copenhagen University reviewed the authors’ methods and approved this research project as complying with their ethical standards (ethical approval number: 514–0149/20–5000). The survey was administered between May 26th to June 12th, 2020 via the platform SurveyXact.

2.4. Data analysis

Data from all three sets of the questionnaire were exported from SurveyXact into Excel and thereafter compiled into one dataset. Answers based on the emoji scale were converted to continuous numerical values from 1 to 7. Incomplete surveys were eliminated from the dataset prior to analysis. Data analysis was then performed with R (R Core Team, 2021).

Linear mixed models (LMMs) were used throughout. In all LMMs, class was included as random effect in order to account for within-class correlation and because intervention was varied at class-level; sex (two levels) and school (four levels) were included as fixed effects. School was included as fixed effect in order to adjust for potential geographic variation, which is relevant because not all interventions are tested at all schools. There is thus a partial confounding in the design that we counteract by adding the effect of school. In general, hypothesis tests were carried out as F-tests with Satterthwaite degrees of freedom (dfs), as implemented in the lmerTest package in R (Kuznetsova et al., 2017). Pairwise comparisons were carried out using the Kenward-Rogers method for dfs and Tukey’s adjustment for multiple testing as implemented in the emmeans package in R (Lenth, 2021).

LMMs with FNTT and FDS as outcomes were used to study potential factors affecting the scores. Segments with different levels of food neophobia were created by separating into quartiles (neophobic = lowest quartile of FNTT scores = low; neutral = two central quartiles = medium; neophilic = highest quartile of FNTT scores = high). Moreover, correlations between FNTT and FDS were computed and tested, both in an overall test and separately for each class. FNTT and FDS were included as covariates in an LMM for willingness to taste (WTT) before intervention in order to examine if the scores are associated with WTT. The LMM for WTT after treatment furthermore included intervention group and baseline WTT, and the LMM for change in WTT (after minus before) included intervention group. LMMs for appropriateness of using insects as a food ingredient and livestock were run separately for the two buffalo worm and cricket, including intervention group and controlling for FNTT and FDS.

Hedonic ratings of products were analyzed with an LMM which, apart from the above-mentioned fixed and random effects, also included
subject as random effect and product type as fixed effect. Similarly, an LMM for expected/potential usage included subject as random effect, as well as product type, frequency (everyday/occasional) and their interaction as fixed effects.

For robustness, ordinal mixed models were applied as supplement to the LMMs, and p-values for intervention effects were also computed with simulation methods (parametric bootstrap). Results were comparable to those from the LMMs. In addition, we also ran analyses with schools as random effect and got comparable results with regards to conclusions.

3. Results

A total of 181 questionnaires were included for data analysis. Responses from 26 participants were excluded (20 were omitted due to incomplete answers and 6 lacked parental consent for data processing). Four schools and nine classes participated. Sixty-two participants received the taste intervention, 71 the health intervention, and 48 the sustainability intervention. Almost all participants were familiar with the concept of insects as food and about half (49.7%) had also tasted insects before. Only two participants did not know insects could be food. Two participants did not know insects could be food. The participants as a whole were moderately willing to try insect foods both before (3.9 ± 1.8) and after (4.0 ± 1.8) the intervention. Males and females were equally willing to try before (p = 0.79) and after (p = 0.13).

3.1. Effect of intervention on outcomes

The Linear Mixed Model revealed no statistically significant differences in post-WTT between interventions after controlling for pre-WTT. As can be seen, there are only very minute differences for Taste (-0.02, p = 0.95) and Health (0.02, p = 0.97), whereas there is a larger, but insignificant difference for Sustainability (0.78, p = 0.15). Hence, our first research objective, to evaluate if there is an effect of the interventions did not show an effect, nor a difference between the interventions.

Following the interventions, questions regarding appropriateness for using insects as a food ingredient and livestock were asked. Overall, participants were almost neutral, though slightly negative, both about the concept of using buffalo worms as a food ingredient (3.7 ± 1.9) and for being raised as livestock (3.6 ± 1.8). Participants, on average, did not feel that crickets should be used as a food ingredient (2.7 ± 1.7) or raised as livestock (3.1 ± 1.8). For buffalo worm there was a significant difference across intervention groups with respect to raising them as livestock (bootstrap p = 0.009), while it was close to significant for cricket (bootstrap p = 0.06). In both cases, the sustainability intervention gave the highest scores for rating them as appropriate for livestock, and the health intervention the lowest score. There was no significant intervention effect with respect to using insects as food ingredient. A t-test showed significant differences between species for both appropriateness measures for the overall sample, indicating the mealworm was rated significantly higher on both questions (p < 0.001).

3.2. Effect of neophobia on WTT

FNTT scores ranged from 9 (neophilic) to 58 (neophobic). The total sample (n = 181) had a mean of 33.3 ± 10.4 and scores were normally distributed. Males scored significantly lower (p = 0.04) on the FNTT (31.6 ± 10.9) than females (34.8 ± 9.9), i.e. they were more neophilic. FNTT does not differ significantly between grades (p = 0.92) or between schools (p = 0.80). There were no significant differences in FNTT scores between the intervention groups (p = 0.47). In contrast FNTT scores were strongly negatively correlated with WTT both before (r = -0.55, p < 0.001) and after (r = -0.54, p < 0.001) the intervention. As there was no main effect of the three main interventions on WTT, results from the interventions were pooled. Paired t-tests between pre- and post-WTT scores for each neophobia segment revealed no significant differences between any of the segments.

3.3. Effect of disgust sensitivity on WTT

FDS scores ranged from 8 (low disgust sensitivity) to 56 (high disgust sensitivity). The total sample had a mean of 35.9 ± 12.5 (median = 39, IQR = 18) and scores were slightly left skewed, indicating the sample had a tendency for higher disgust sensitivity overall. There were no significant differences between males and females with respect to FDS (p = 0.74). There were also no significant differences in FDS scores between the intervention groups (p = 0.73). There was no significant and close to zero correlation between FDS and WTT before, (r = -0.02, p = 0.80) and after, (r = -0.04, p = 0.56).

Fig. 1. Estimated post minus pre-differences in rated Willingness-to-taste (WTT) with 95% confidence intervals, extracted from LMM.
3.4. Relationship between food neophobia and disgust sensitivity

The overall correlation between FNTT and FDS is estimated to 0.11 and is not statistically significant (p = 0.11). Fig. 2 shows a scatter plot with colors indicating sex, that also shows the lack of correlation between the two measures. This test does not take geographical or other variation into consideration. Correlation tests carried out for each class and school separately gave positive and statistically significant correlation for two classes (Class 2: r = 0.59, p = 0.0024 and Class 4: r = 0.69, 0.0031), while insignificant for the remaining six classes, and for the schools.

3.5. Hedonic ratings of whole insects and insect-based products

Fig. 3 shows mean hedonic ratings for all insects and insect products, with added confidence intervals. Overall, the image of the whole cricket received significantly lower hedonic ratings (3.0) than the buffalo worm (4.1). Of the processed foods, the cookies were the only food with an above neutral hedonic rating (5.1). The protein bar (4.0), crispbread (4.4), burger (4.4), and chips (4.3) made from cricket flour all received

![Fig. 2. Scatter plot of the lack of relationship between Food Disgust (FSD, X-axis) and Food Neophobia (FNTT, Y-axis). Colors indicating sex (female, male) are added.](image1)

![Fig. 3. Estimated mean hedonic ratings for all insects and insect products with 95% confidence intervals, extracted from LMM. Insect types indicated with blue and red colors. BUF = Buffalo worms, CR = Cricket. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)](image2)
average neutral ratings. The falafel received the lowest average rating (2.8), followed by the whole cricket. The lower hedonic rating of whole crickets compared to whole buffalo is eliminated by the incorporation into a product (Bar), and even reversed when insects are incorporated into bread (Fig. 3).

Segmentation into three neophobia groups based on quartiles resulted in the classification of 43 children as neophilic (FNTT score < 26), 89 as neutral (FNTT score between 26 and 42), and 47 as neophobic (FNTT score > 42). There was a significant main effect of the neophobia segment on hedonic response (p < 0.001). Hedonic ratings were always higher for the neophilic segment than the neophobic segment, indicating that the FNTT is a valid instrument for measuring food neophobia. Fig. 4 shows the mean hedonic rating for the three neophobia segments averaged over all nine insects/insect foods, including confidence intervals. It clearly shows the decrease in hedonic rating with increasing neophobia. Post-hoc pairwise testing confirmed significant differences in hedonic response between all three segments.

3.6. Everyday versus occasion foods

The participants rated their intention to eat foods with insects as an ingredient in the seven different categories of products they had been presented with. This we call their perceived appropriateness of insects as ingredients in the food categories. An omnibus test in the LMM revealed a main significant effect between the seven insect food categories with regard to appropriateness as everyday and occasion foods (p < 0.0001). There was no main effect of appropriateness for different situations (special occasion vs everyday, p = 0.50). Neither was there an interaction between situation and insect foods (p = 0.25). The mean perceived appropriateness ratings are listed in Table 2. The appropriateness to use insects in cookies was rated significantly higher than all others (4.9 on a 7-point scale), followed by insects for chips and burgers (both at 4.3). These were the three categories with above neutral ratings with regards to perceived appropriateness. The remaining four food product categories received a below-neutral rating, i.e. perceived to be inappropriate. The falafel was lowest (2.7), followed by the protein bar (3.4), with crisp bread and chocolate bar both at 3.7.

4. Discussion

This study examined the effects of educating children about the taste, health, and sustainability benefits of entomophagy on their willingness to try and hedonic response to insect foods. Moreover, the relationship between the acceptance of insects as food and food neophobia, disgust sensitivity, species, and appropriateness was explored.

The results support extant literature by showing that, on a whole, willingness to taste (WTT) insect foods was moderate and that conveying information about the benefits of edible insects did not increase WTT insect foods. More significantly, this study makes several novel contributions to this stream of literature. Firstly, while neophobia was found to be a strong predictor of WTT insect foods, surprisingly, disgust sensitivity was not at all. Secondly, no interrelationship between food disgust and food neophobia was found in this group of children. Thirdly, there were considerable differences in hedonic ratings between whole insect species (buffalo worms and crickets), yet this effect could be entirely attenuated by processing and incorporating these insects into products such as bars and bread. Fourthly, there were substantial differences in hedonic ratings between insect products, indicating that producers of insect foods should focus on those that were better liked. Lastly, differences in perceived appropriateness between food categories were found.

While many researchers assert a growing interest in edible insects in Western countries as an alternative to conventional animal protein...
(Patel et al., 2019), it is unclear to what extent consumers are actually willing to incorporate them into their regular diets and what tactics might best promote their adoption. One option is to educate consumers about the benefits of entomophagy but there are mixed results in the literature about the effectiveness of such communication strategies. Some studies indicate that information provision about the benefits of edible insects can increase acceptance (Collins et al., 2019; Verneau et al., 2016; Lombardi et al., 2019; Woolf et al., 2019) and that communicating the societal benefits (e.g. sustainability) is more influential than communicating individual benefits (e.g. health and taste) in Western populations (Yen, 2009; Verneau et al., 2016). However, few studies look at the long-term impact of education on regular incorporation of these foods into diets. The results from this study suggest that neither type of information treatment is an effective tactic in increasing acceptance of these foods, even in the short-term, as indicated by the null effect of information treatments on WTT across all conditions. There is evidence that educating consumers about edible insects can have the opposite effect than intended and potentially hinder acceptance further (Barsics et al., 2017). In one study, participants who tasted a bread product labeled as containing insects before an information session on benefits rated their overall liking higher than those who tasted the product afterwards (Barsics et al., 2017). The authors conjecture that seeing insects as part of the educational exercise conjures a state of disgust prior to the tasting experience (ibid). While extant literature indicates that adults will not be easily convinced to try insect foods through rational appeals, this research is the first to evidence that this is also the case in children.

Food neophobia and disgust sensitivity have been found to impose independent effects on WTT insect foods. La Barbera et al. (2018) found that the explanatory power of disgust sensitivity is significantly greater than that of food neophobia. Likewise, participants with high core disgust and animal reminder disgust (but not contamination disgust) have demonstrated less interest in attending a Bug Banquet event where they would have the chance to eat insects (Hamerman, 2016). It is surprising then that, in the current study, disgust sensitivity was not significantly correlated with WTT insect foods, whereas neophobia was strongly correlated. Somewhat more consistent with the present findings, Hartmann & Siegrist (2016) found that while animal contaminant disgust was indeed correlated with willingness to eat insects, it was less so than food neophobia. The discrepancies between the current findings and those of La Barbera et al (2018) and Hamerman (2016) may be due to the younger group of subjects. For instance, it may be that disgust does not prohibit willingness to try insect foods in children, unlike in adults. Further investigating the differences in how disgust affects willingness to try insects in children versus adults is an interesting area for future research.

The discrepancy found between this research and others draws attention to the importance of accurate measurement tools and yields insights into how to best measure disgust in future studies. Inconsistency in disgust findings may stem from the differences in how disgust sensitivity is measured across studies. There is not unanimous consensus as to what domains an optimal disgust scale should measure, and likely there is a need for different disgust scales under different circumstances (i.e. the Food Disgust Scale in the context of food instead of a general Disgust Scale). Presently, disgust sensitivity was measured using the eight items of the Food Disgust Scale (DFS-short) developed by Hartmann and Siegrist (2018). Within the various options proposed in the literature, the DFS was chosen because it expressly focuses on food related disgust. One limitation of the DFS is that it does not include disgust elicitors in the domain of moral violations, which may be relevant when addressing the acceptance of novel foods and the distinction of “appropriate” and “inappropriate” animal-based food products. Instead, the FDS scale focuses on disgust elicitors within the domain of pathogen avoidance (i.e. animal flesh, human contamination, poor hygiene, decaying fruit, decaying vegetables, mold, fish, and living contaminants).

There were considerable differences between species both in perceived appropriateness and hedonic evaluation. Participants believed that buffalo worms were more appropriate than crickets both as i) a food ingredient for human consumption and ii) use for animal husbandry (p < 0.001 for both measures). Likewise, the buffalo worm was rated significantly higher in hedonic response than the cricket (p < 0.001). Due to the great variability in physical characteristics and sensory properties across the many edible insect species, it follows that certain species will be better accepted by Western consumers than others (Ruby et al., 2015; Fischer & Steenbekkers, 2018). The cricket image in this study — with limbs, distinct features, and relatively large size — is arguably perceived as more animal-like and thereby less appropriate and appetizing than the buffalo worm — which lacked any of these features. Indeed, reminders of animalness have been found to be one of the major determinants of perceived disgust (Martins & Pliner, 2006). Chow et al. (2021) found that oatmeal balls made with ground mealworms were better liked than those made with ground grasshoppers. They explain their findings by arguing that the disgust eliciting properties of different insect species vary due to differing degrees of animalness.

However, species may be less important in processed products. In this study, we see an increase in hedonic ratings for both insects when they are incorporated into food products. There were no differences between the processed foods made with flour from the two species (i.e. BUF-bar versus CR-bar and BUF-bread versus CR-bread). It appears that from a consumer’s point of view, the species effect was important when the insect was present as a whole, but it was not a determining factor on hedonic evaluation when the insect was present as an indiscernible ingredient. This effect was found even in a context when the whole insect was quite salient, having presented images of the whole insect alongside the processed product. Therefore, producers of processed products are not constrained to producing specific species. Rather, they are free to produce the most economically viable and sustainable insect species. This may be a good path forward because research indicates that consumers are more willing to eat foods which have no visible pieces of insects (Schäufele et al., 2019; Collins et al., 2019; Caparros Megido et al., 2016). Processed insects, in the form of flour, can be incorporated into familiar and well-liked foods. This appears an appropriate way to introduce edible insects to the market, when familiarity is low. Eventually, and as consumers become more familiar with insect foods, degree of processing may become less important.

There were notable differences in hedonic evaluations between processed products, providing insight into which types of products will be better received on the market. Of the processed products, the falafel received the lowest hedonic ratings (2.8) whereas the cookies received the highest (5.1). The chocolate was the second least liked food (3.5). The chips (4.3), burger (4.4), crispbread (4.4), and protein bar (4.0) — all made with cricket flour — received just above neutral ratings (4). In keeping with the literature, many of the processed products were liked more than the whole insects, though this was not always true. Notably, the whole buffalo worm received significantly higher mean hedonic ratings than the chocolate and falafel. Processed insect foods may appeal to some consumers, while whole or foods made with visible insect pieces may be more appealing to others. One study found that this preference was predicted by previous exposure: individuals who had eaten insect-containing foods before were most willing to consume fried, grilled, or roasted whole insects, while those who had not were most willing to eat protein bars with insect protein isolate (Woolf et al., 2019).

Although there was a large span in hedonic ratings and there was not a consistent pattern that would suggest any food category was preferred over another (e.g. sweets over savory foods, or snacks over meals), it is surprising that the chocolate received the second-lowest hedonic rating. Nor was there any difference in appropriateness for special occasion food than an everyday food. Even so, these measures did provide a reflection of overall appropriateness, as there were significant differences between product types on these measures. Certain items, such as...
the cookies, were perceived as appropriate for eating on all occasions and were also among the highest hedonically rated products. Conversely, the falafel was significantly lower than all other products on both measures of appropriateness and was also the lowest hedonically rated product. It appears that participants put weight on the visual appearance and expected texture, giving higher scores to products that look more appropriate and familiar or overall more appetizing. Similarly, the low score given to the falafel may be explained by the low familiarity of this food. Falafel is a traditional Middle Eastern food and may not be as familiar to Danish children when compared with other products like cookies or crispbread. However, familiarity cannot explain the low score given for the crispbread and chocolate because both are common foods in Denmark. As Tan, van den Berg, and Stieger (2016) also suggest, acceptability of insect foods is not merely attained by pairing familiar and well-liked carrier foods with insect ingredients, although it does play a role. The relationship between insects as ingredients in foods and the resulting hedonic response is complex beyond what the current experiment could disentangle.

Correctly profiling a consumer segment ready to adopt insect-based foods in the Western market is crucial, as there are clearly many consumers who will not be persuaded to try insects. Indeed, Verbeke (2015) indicates that profiling these consumers may be the first step for marketplace acceptance. Children were investigated in this study as they have been previously under-explored as potential entomophagists, an area in which the present study contributes to the current body of literature. They may be a good target for early adopters, as their food preferences are more adaptable than adults, albeit not through traditional educational methods (Collins et al., 2019). Moreover, disgust sensitivity may not pose an additional adoption barrier in children, as it does in adults.

Findings are pertinent to product development, marketing, and communication within the growing insect food industry in the West. Though neophobia poses a barrier to the acceptance of insect foods, young people appear at least moderately interested in trying them. As insect products become more readily available on the market, consumers will become more familiar with them, thus reducing the degree of neophobia towards insect foods. Thought should be given to the product type, degree of processing, and species of insect when positioning novel insect products on the market. Of course, insect-based products must also be appetizing and flavorful. Integrating insects into familiar and pleasing food items may facilitate the acceptance of insects as food. While consumers remain ambivalent towards consuming insect foods themselves, another avenue for future research is to investigate acceptance of insects as feed for livestock rather than human consumption. This may be another route towards increasing familiarity with edible insects.

The present study has some limitations: The use of commercially available products, while making the results more applicable to the real world, also made it impossible to control for differences in appearance across items. This may have allowed for individual preferences to confound hedonic response. Self-report measures and images of foods were used instead of behavioral measures, leaving room for an intention-behavior gap. Future studies should offer tastings of real insect foods whenever possible. However, the COVID-related partial lockdown at the time of the experiment did not allow us to present real foods to the participants. This is an important caveat to much of the literature on the acceptance of insect foods, including this study — that WTT does not equate to adoption into regular diets. Long-term studies would better predict openness to dietary change.

5. Conclusion
This study provides consumer insights, specific to children, about edible insects as a future source of animal proteins. An online educational activity and survey was used to examine the willingness to try and hedonic response to images of commercially available insect products among Danish school children. The implications of food neophobia, disgust sensitivity, species, and appropriateness were also explored. The results revealed that overall, Danish children were moderately willing to try insect-based foods and that there is a potential for edible insects in this population segment. It was demonstrated that communicating the benefits was not effective at increasing willingness to try insect products irrespective of the type of benefits (taste, health, sustainability).

Food neophobia was found to be negatively correlated with willingness to try and hedonic ratings of insect foods, whereas disgust sensitivity was found to have no correlation. In addition, we found no correlation between food disgust and food neophobia. Finally, the effect of species was a determining factor on hedonic response when insects were presented whole but not when presented as a food ingredient.

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CRediT authorship contribution statement
Ainslee L. Erhard: Conceptualization, Methodology, Formal analysis, Visualization, Writing – original draft. Magda Aguas Silva: Conceptualization, Methodology, Formal analysis, Writing – review & editing. Marie Dambsv-Svendsen: Methodology, Project administration, Resources. Bat-El Menadeva Karpantschof: Methodology, Project administration, Resources. Helle Sørensen: Formal analysis, Writing – review & editing. Michael Bom Frost: Conceptualization, Methodology, Funding acquisition, 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.

Data availability
Data will be made available on request.

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Appendix A. Supplementary material
Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodqual.2022.104713.

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