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# UK consumers' willingness to try and pay for eggs from insect-fed hens

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ABSTRACT

Willingness to try (WTT) and willingness to pay (WTP) for eggs produced from insect-fed hens and the determinants of these behaviours were investigated in the UK. Data from a sample of egg consumers ($N$=294) was collected using an online survey. Factors influencing WTT and WTP were evaluated using a binary logistic regression and censored (Tobit) regression. Only 17% of participants were aware of insects as a potential animal feed. Most consumers were willing to try (72%) and pay (87%) for the product, with a portion of consumers who were not willing to try but willing to buy at a low enough price. WTT and WTP were most significantly influenced by disgust as a barrier and positive attitudes towards the product as a driver to consumption. This suggests the potential for disgust to be offset by information about the product's benefits. While environmental and animal welfare attitudes did not affect WTT and WTP, food neophobia, previous tasting experience with insects as food, hen welfare concerns and price influenced acceptance and adoption. A substantial proportion of consumers indicated they would pay 18% more for these eggs, suggesting there is potential to introduce them as a premium product in the UK market.

## 1. Introduction

In recent years, insects have seen growing interest as an alternative to soybean meal in poultry farming. In the context of laying hens, a partial or total replacement of soyabean meal with live insects, in particular black soldier fly larvae (BSFL), has proven to lower the environmental impact associated with hen feed production, reduce food waste and increase hen welfare, with no or little effect on eggs' quality and taste (Gasco et al., 2019; Star et al., 2020)

The European Union (EU) Commission have recently approved the use of live insects for poultry feeding (European Union, 2017). Although several European feed companies have committed to include insects in their poultry feed, eggs from insect-fed hens are still a niche product (Verbeke et al., 2015). The UK represents a potential market, although regulation in this regard, considering the post-EU environment will probably need to be clarified.

At present, consumers show increasing acceptance for insect-fed foodstuff, particularly for insect-fed fish and chicken (Kostecka et al., 2017; Sogari et al., 2019; Verbeke et al., 2015). However, little is known about determinants of consumption for these products and the limited literature available mostly considers insect-fed fish (Sogari et al., 2019) and insects as feed in general (De Faria Domingues et al., 2020; Kostecka et al., 2017; Naranjo-Guevara et al., 2021; Onwezen et al., 2019; Roma et al., 2020; Szendrő et al., 2020; Verbeke et al. 2015).

The majority of these studies suggested food neophobia and disgust are main barriers towards acceptance. The study of Szendrő et al. (2020) found that Hungarian consumers were generally willing to eat insect-fed animals but disgust, rejection and unfamiliarity towards new food played a significant role in shaping consumption intentions. The same was found by Bazoche and Poret (2020) in a study conducted in France, according to which while less neophobic consumers were more likely to accept insects as feed, part of the sample appeared disgusted by the idea of eating insect-fed fish. Laureati et al. (2016) found that Italian consumers with lower levels of food neophobia showed higher levels of acceptance for insects as animal feed. Roma et al. (2020) found that although disgust and neophobia affect consumption intentions among Italian consumers, the negative effect of these factors on insect-fed foodstuffs is lower than on insect-based food.

In contrast, information about the benefits of feeding animals with insects may foster acceptance. Szendrő et al. (2020) reported that animal concern and knowledge of animal welfare benefits associated with insects as feed for animals may increase acceptance. Laureati et al. (2016) found that although environmental concern was not a determinant of consumer acceptance of insect-fed animals, acceptance was positively influenced by information about the environmental and nutritional benefits of insects as feed. This finding was further confirmed by Naranjo-Guevara et al. (2021), Roma et al. (2020) and Bazoche and Poret (2020) according to which information on the en-

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**Table 1**
Descriptive statistics of the survey items (percentages, mean scores and standard deviation) ($n$ = 294).

| Frequencies (%) Dependent variables | | Means (S.D.) Dependent variables | |
|---|---|---|---|
| **WTT** binary ("Totally agree" "Agree" "Somewhat agree") | 72.4 | **WTT** (7-point Likert scale) | 5.14 (1.86) |
| **WTP** (£0–£3.25) | 87 | **WTP** (£0–£3.25) | £1.36 (.72) |
| **Explanatory variables** | | **Explanatory variables** | |
| **Gender** (female) | 50.3 | **Food Neophobia** (FNS) (7-point Likert Scale) | 3.47 (1.14) |
| **Age** | | **Disgust** (7-point Liker Scale) | 3.05 (1.77) |
| 18–24 | 11.6 | | |
| 25–34 | 20.1 | | |
| 35–44 | 18.0 | | |
| 45–54 | 20.1 | | |
| 55–64 | 17.0 | | |
| 65+ | 13.3 | | |
| **Education** | | **Product attitudes** (PATT) (7-point Liker Scale) | 5.01 (1.34) |
| Primary and secondary school | 19.7 | | |
| High school diploma | 36.4 | | |
| Bachelor's degree | 31.0 | | |
| Master's degree and doctorate | 12.9 | | |
| **Household income** | | **Hens welfare concerns** (AHW) (7-point Liker Scale) | 5.47 (1.15) |
| <£20,000 | 23.8 | | |
| £20,000–39,999 | 38.4 | | |
| £40,000–59,999 | 22.1 | | |
| ≥£60,000 | 15.6 | | |
| **Previous tasting experiences with insects as food (binary)** | 12.6 | **Environmental attitudes** (NEP) | 5.02 (.90) |
| **Price as a factor of importance when buying eggs (binary)** | 57.5 | | |
| **Amount spent for a typical 6-pack of eggs** | | **Animal welfare attitudes** (AAS) | 4.94 (.97) |
| £0.50–0.99 | 12.6 | | |
| £1.00–1.49 | 40.5 | | |
| £1.50–1.99 | 26.2 | | |
| £2.00 or more | 20.7 | | |

vironmental benefit of feeding animals with insects and their high nutritional content could favourably affect consumers' consumption intentions.

Studies also suggested that safety, taste, price and nutritional content are determinants of consumption intention towards insect-fed foodstuffs. Mancuso et al. (2016) found that Italian consumers were willing to eat and buy insect-fed fish based on safety requirements and expected price. On the contrary, the study of Popoff et al. (2017) showed that among UK consumers nutritional content and taste were more important than price. Ankamah-Yeboah et al. (2018) showed that Danish consumers who were unwilling to consume insect-fed fish, expressed intention to purchase after a price decrease, while Bazoche and Poret (2020) showed that French consumers were willing to choose the product when there was no difference in price compared to the conventional. Only one study on Spanish consumers by Ferrer Llagostera et al. (2019) reported consumers' willingness to pay a premium price for insect-fed fish, which was somewhat hindered by the concurrent finding that consumers held negative beliefs about the taste of the product.

Although the available research provides insight into consumers' willingness to consume insect-fed foodstuffs, further research is needed to evaluate the effect of the aforementioned factors on willingness to tr (WTT) and willingness to pay (WTP) (Sogari et al., 2019). To the best of our knowledge, no research exists on consumer acceptance of eggs from insect-fed hens or any other non-meat products derived from insect-fed animals. This study is the first one to explore attitudes towards eggs from insect-fed hens among UK consumers and to investigate the main determinants ofWTT and WTP for the product.

## 2. Methods

### 2.1. Participants and data collection

An online survey was conducted in the United Kingdom in August 2020. The questionnaire was programmed and distributed through the specialised market company Qualtrics$^{TM}$. Country-specific quotas were set according to gender, age and geographic area based on the representative national census data. Valid responses produced a sample of 294 consumers (Table 1).

Ethical clearance to conduct the survey was obtained in July 2020 by the University of Reading. Informed consent was obtained from respondents prior to the collection of survey data.

### 2.2. Survey design and measures

The questionnaire was organised in five sections: (1) screening questions; (2) egg consumption habits; (3) information regarding egg production from insect-fed hens (Fig. 1), WTT and WTP; (4) attitudes and beliefs relating to the insect-fed hen eggs; and (5) sociodemographic characteristics.

Attitude and belief questions included concern towards hen welfare (AHW) (adapted from Bennett et al., 2016), attitudes towards eggs from insect-fed hens (PATT) (adapted from Mancini and Antonioli, 2019), the Food Neophobia Scale (FNS) by Pliner and Hobden (1992), disgust (adapted from Kostecka et al., 2017), the New Ecological Paradigm Scale (NEP) by Dunlap et al. (2000) and the Animal Attitude Scale (AAS) by Herzog et al. (2015). All items were measured using 7-point Likert scales ("Strongly disagree" to "Strongly agree") and one predictor was calculated for each scale as appropriate.

A confirmatory factor analysis (CFA) showed good internal consistency, with Cronbach's $\alpha$ of each predictor greater than 0.70. Factor loadings were greater than 0.3 except for one item of the predictor NEP. Nevertheless, the item was maintained in the model considering that it was part of a predictor with a high number of items and showed a significant $p$-value (Table 2) (Hair et al., 2010). WTT was assessed using a single statement: "I am willing to try eggs laid by hens fed with insects" also measured with a 7-point Likert scale. WTP was assessed using the payment card method: participants were asked to iden-

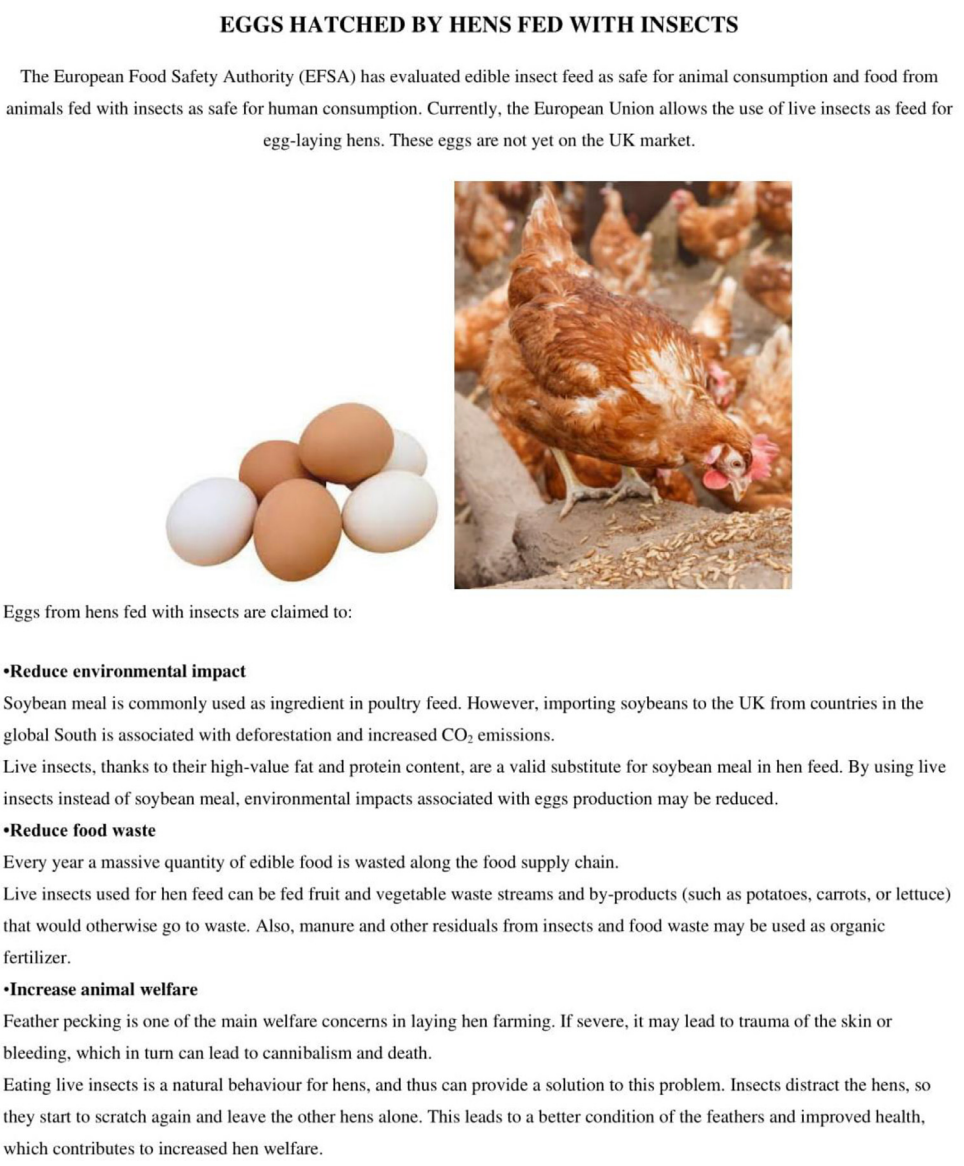


**Fig. 1.** Information provided to consumers on egg production from insect-fed hens (European Union, 2017).

tify the maximum amount they would be willing to pay for eggs from insect-fed hens.

### 2.3. Data analysis

Statistical analyses were performed utilising SPSS 15 and STATA 25 statistic software. A binary logistic model was used to predict the WTT for eggs from insect-fed hens. WTT responses were converted to a dummy variable by recoding the responses in agreement ("Totally agree"; "Agree"; "Somewhat agree") as 1 ("yes"), and responses which were indifferent ("Neither agree or disagree") or in disagreement ("Somewhat disagree"; "Disagree"; "Totally disagree") as 0 ("no"). Possible collinearity between independent variables was assessed with Pearson and Spearman correlation tests and variance inflation factor (VIF). The contingent valuation (CV) method was used to predict the WTP. Participants were asked via a payment card to indicate the highest price they would be willing to pay for eggs from inset-fed hens. A Tobit model was used to determine factors affecting WTP for eggs because the payment card responses result in an inherently truncated dependent variable.

## 3. Results and discussion

### 3.1. Descriptive and frequency statistics

Only 17% of participants were aware of insects as feed prior to the survey, but 30% were knowledgeable of the nutrition benefits of insects generally. A total of 13% had prior tasting experiences with insects as food and 8% indicated they had previously eaten insect-fed animal products.

Descriptive statistics of the survey items are presented in Table 1. The scores of AAS, AHW, NEP and PATT indicate that consumers on average had medium-high concerns towards animal welfare, hen welfare and environment, as well as a slightly positive attitudes towards the product. The scores of neophobia and disgust indicate that consumers on average had medium-low disgust towards insects as feed and medium-low rejection towards unfamiliar food in general.

The frequency statistics showed that 72% of participants had some level of agreement with the WTT statement, 20% stated some level of disagreement and 7.5% were neutral. Among all participants, 87% showed some degree of WTP (i.e., greater than zero) for a six-pack of eggs from insect-fed hens. The 72% of respondents who indicated agree-

**Table 2**
Confirmatory factor analysis of the predictors (AHW, PATT, FNS, disgust, NEP, AAS).

| Predictors | Factor loading | *p*-Value | Cronbach's $\alpha$ |
|---|---|---|---|
| **Food Neophobia Scale (FNS)** | | | |
| 1. I am constantly sampling new and different foods.* | 0.75 | 0.000 | 0.892 |
| 2. I do not trust new foods. | 0.66 | 0.000 | |
| 3. If I don't know what a food is, I will not try it. | 0.67 | 0.000 | |
| 4. I like foods from different cultures.* | 0.74 | 0.000 | |
| 5. Ethnic food looks too weird to eat. | 0.67 | 0.000 | |
| 6. At dinner parties, I will try new foods. * | 0.76 | 0.000 | |
| 7. I am afraid to eat things I have never had before. | 0.66 | 0.000 | |
| 8. I am very particular about the foods I eat. | 0.47 | 0.000 | |
| 9. I will eat almost anything. * | 0.53 | 0.000 | |
| 10. I like to try new ethnic restaurants. * | 0.77 | 0.000 | |
| **Disgust** | | | 0.970 |
| 1. I am offended by the idea of eating food from animals fed with insects. | 0.92 | 0.000 | |
| 2. The idea of food from animals fed with insects makes me ill. | 0.95 | 0.000 | |
| 3. Eating food from animals fed with insects is disgusting. | 0.93 | 0.000 | |
| 4. The idea of food from animals fed with insects makes me nauseous | 0.95 | 0.000 | |
| **Product attitudes (PATT)** | | | 0.968 |
| *Attitudes towards intrinsic characteristics* | | | 0.955 |
| 1.I believe eggs hatched by hens fed with insects to be tasty | 0.82 | 0.000 | |
| 2.I believe eggs hatched by hens fed with insects to be safe | 0.89 | 0.000 | |
| 3.I believe eggs hatched by hens fed with insects to be nutritious | 0.88 | 0.000 | |
| 4.I believe eggs hatched by hens fed with insects to be healthy | 0.92 | 0.000 | |
| 5.I believe eggs hatched by hens fed with insects to be a good-quality product | 0.91 | 0.000 | |
| *Attitudes towards sustainable benefits* | | | 0.946 |
| 6.I believe eggs hatched by hens fed with insects to be beneficial for the environment | 0.88 | 0.000 | |
| 7.I believe eggs hatched by hens fed with insects to be beneficial for hen welfare | 0.90 | 0.000 | |
| 8.I believe eggs hatched by hens fed with insects to be beneficial for reducing food waste | 0.89 | 0.000 | |
| **Hens welfare concerns (AHW)** | | | 0.923 |
| 1. I am concerned about the way laying hens are treated in the process of producing eggs | 0.73 | 0.000 | |
| 2. It is wrong to eat eggs from hens that have not had a good life | 0.80 | 0.000 | |
| 3. I am happy to pay more for eggs that have been hatched by hens with higher welfare | 0.69 | 0.000 | |
| 4. It is important that hens can display natural behaviour | 0.86 | 0.000 | |
| **New Ecological Paradigm Scale (NEP)** | | | 0.882 |
| 1. We are approaching the limit of the number of people the earth can support. | 0.59 | 0.000 | |
| 2. Humans have the right to modify the natural environment to suit their needs. * | 0.52 | 0.000 | |
| 3. When humans interfere with nature it often produces disastrous consequences. | 0.71 | 0.000 | |
| 4. Human ingenuity will ensure that we do not make the earth unliveable. * | 0.36 | 0.000 | |
| 5. Humans are severely abusing the environment. | 0.71 | 0.000 | |
| 6. The earth has plenty of natural resources if we just learn how to develop them. | 0.17 | 0.003 | |
| 7. Plants and animals have as much right as humans to exist. * | 0.63 | 0.000 | |
| 8. The balance of nature is strong enough to cope with the impacts of modern industrial nations. | 0.61 | 0.000 | |
| 9. Despite our special abilities, humans are still subject to the laws of nature. * | 0.61 | 0.000 | |
| 10. The so-called "ecological crisis" facing humankind has been greatly exaggerated. | 0.65 | 0.000 | |
| 11. The earth is like a spaceship with very limited room and resources. * | 0.65 | 0.000 | |
| 12. Humans were meant to rule over the rest of nature. | 0.53 | 0.000 | |
| 13. The balance of nature is very delicate and easily upset. * | 0.77 | 0.000 | |
| 14. Humans will eventually learn enough about how nature works to be able to control it. * | 0.35 | 0.000 | |
| 15. If things continue on their present course, we will soon experience a major ecological catastrophe. | 0.71 | 0.000 | |
| **Animal Attitude Scale (AAS)** | | | 0.795 |
| 1. It is morally wrong to hunt wild animals for sport. | 0.60 | 0.000 | |
| 2. I do not think that there is anything wrong with using animals in medical research.* | 0.80 | 0.000 | |
| 3. I think it is perfectly acceptable for cattle and hogs to be raised for human consumption. * | 0.52 | 0.000 | |
| 4. Basically, humans have the right to use animals as we see fit. * | 0.75 | 0.000 | |
| 5. I sometimes get upset when I see wild animals in cages at zoos. | 0.43 | 0.000 | |
| 6. Breeding animals for their skins is a legitimate use of animals. * | 0.53 | 0.000 | |
| 7. Some aspects of biology can only be learned through dissecting preserved animals such as cats. * | 0.43 | 0.000 | |
| 8. It is unethical to breed purebred dogs for pets when millions of dogs are killed in animal shelters each year. | 0.33 | 0.000 | |
| 9. The use of animals such as rabbits for testing the safety of cosmetics and household products is unnecessary and should be stopped. | 0.53 | 0.000 | |

* Revers scored. *p*-Values refer to: Ho= factor loadings are equal to zero. PATT: The strong correlation (Pearson correlation 0.881, $P< 0.001$) between the predictors "Attitudes towards intrinsic characteristics" and "Attitudes towards sustainable benefits" allowed to merge all items under one predictor "PATT"

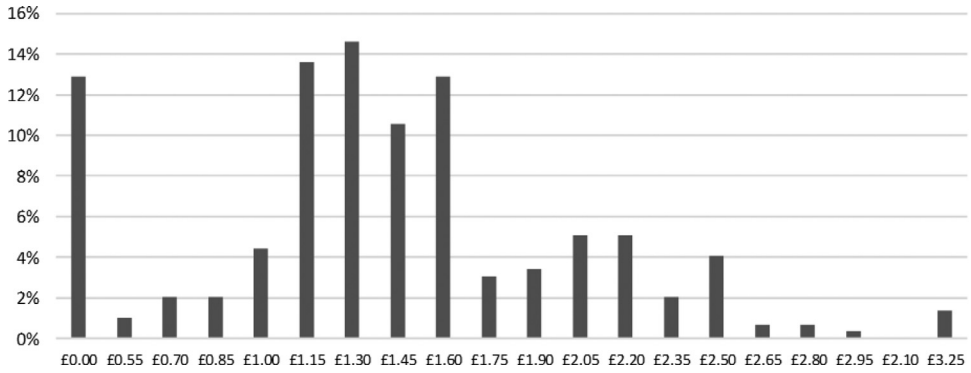


**Fig. 2.** Frequency distribution of maximum amounts (£) that consumers were willing to pay for a 6-pack of free-range eggs laid by hens fed with insects (*N*=294).

**Table 3**
Binomial logistic regression and Tobit model results.

| WTT | | | | | | WTP | | |
|---|---|---|---|---|---|---|---|---|
| | B | S.E. | Wald | Sign. | Exp(B) | Coef. | Std. Err | Sig |
| Age **18–24** | −5.573 | 2.256 | 6.104 | **0.013** | 0.004 | 0.165 | 0.211 | 0.435 |
| **25–34** | 0.436 | 1.678 | 0.067 | 0.795 | 1.546 | 0.281 | 0.172 | 0.104 |
| **35–44** | 0.059 | 1.286 | 0.002 | 0.963 | 1.061 | 0.254 | 0.158 | 0.109 |
| **45–54** | 0.025 | 1.417 | 0.000 | 0.986 | 1.026 | 0.088 | 0.144 | 0.538 |
| **55–64** | 1.434 | 1.505 | 0.908 | 0.341 | 4.195 | −0.033 | 0.151 | 0.825 |
| **FNS** | −0.142 | 0.055 | 6.672 | **0.010** | 0.868 | 0.034 | 0.004 | 0.397 |
| **Disgust** | −0.581 | 0.138 | 17.797 | **0.000** | 0.559 | −0.190 | 0.008 | **0.000** |
| **AHW** | −0.404 | 0.188 | 4.599 | **0.032** | 0.667 | 0.002 | 0.016 | 0.967 |
| **PATT** | 0.359 | 0.082 | 19.317 | **0.000** | 1.432 | 0.115 | 0.005 | **0.004** |
| **Previous taste experience with insects as food** | 3.121 | 1.565 | 3.974 | **0.046** | 22.659 | 0.310 | 0.133 | **0.020** |
| **Price** | −1.926 | 0.914 | 4.437 | **0.035** | 0.146 | −0.177 | 0.084 | **0.037** |
| Amount spent **£1.00–1.49** | | | | | | 0.162 | 0.127 | 0.204 |
| **£1.50–1.99** | | | | | | 0.354 | 0.142 | **0.013** |
| **£2.00 or more** | | | | | | 0.624 | 0.154 | **0.000** |
| **Constant** | 12.789 | 6.461 | 3.918 | 0.048 | 358303.648 | 1.24 | 0.544 | 0.024 |

WTT: Goodness-of-fit statistics: −2Log likelihood statistic = 74.087; Likelihood ratio (12) = 272.047 ($p < 0.001$); Nagelkerke $R^2 = 0.872$; % correct predictions = 95.2%. WTP: Log likelihood: −285.24237; Likelihood ratio = 155.94 ($p < 0.001$); Number of observations =294 Uncensored =252; Limits: lower = 0 upper = 3.25; Pseudo $R^2 = 0.2147$.
*FNS: Food Neophobia Scale; Disgust: disgust towards insects as feed; PATT: product attitudes; AHW: hens welfare concern; NEP: New Ecological Paradigm Scale; AAS: Animal Attitude Scale.

ment with the WTT statement had an average WTP of £1.56 (Fig. 2). The average WTP for all respondents was £1.36, demonstrating that participants were willing to pay on average 18.3% more for these eggs than conventional free-range eggs on the UK market (£1.15 for a six-pack).

### 3.2. Regression analysis of WTT

Table 3 presents the results of the binary logistic regression model. The model indicated a good fit and suggested to be a good predictor of the outcome. Multicollinearity was not a problem in the model (tolerance value < 0.82 and Variance Inflation Factor VIF < 10).

Age and previous taste experiences with insects as food were significant at 1% level. Consistent with other research by De Faria Domingues et al. (2020) socio-demographic characteristics (gender, education, income) did not affect WTT and WTP (results not shown). However, the youngest consumers were less willing to try eggs from insect-fed hens than older ones, similar to findings by Kostecka et al. (2017) and Verbeke et al. (2015). Consumers who had tasted insect food products were more willing to try the product than those who had not. This result is in line with studies on insects as food showing that previous experience positively affects intention to consume (Verbeke, 2015). Environmental concern (NEP) did not directly affect WTT, consistent with Laureati et al. (2016). Similarly, animal welfare concern (AAS) was not a significant predictor of WTT (results not shown). In contrast, the influence of AHW at the 1% significance level showed that a one-unit increase in hen welfare concern was associated with a 33.3 % (0.667–1) decrease in the likelihood of being willing to try the product. Moreover, participants with higher hen welfare concerns purchased mainly free-range (AHW mean=5.7) or organic eggs (AWH mean=6) ($p< 0.05$). These results may be explained by the fact that although consumers who are more concerns towards hens welfare are more willing to consume and pay for enhanced animal welfare eggs (e.g., free-range and organic), they have a higher level of mistrust in eggs production, thus, they require animal welfare labels certificated by trustworthy institutions (Harper and Henson, 2001; Rondoni et al., 2020). Therefore, in order to evaluate eggs from insect-fed hens and consider their possible consumption, consumers would likely need information and labelling accredited by reliable sources.

Similar to Mancini and Antonioli (2019), our results reveal that PATT had the largest influence in the model (Wald $x^2 = 19$; 0.1% significant level). A one-unit increase in PATT was associated with a 43.2% (1.432–1) increase in the likelihood of being willing to try eggs laid by hens fed with insects. The provision of information about the product's benefits might have influenced consumers attitudes and increased intentions (Laureati et al., 2016; Bazoche and Poret, 2020; Roma et al., 2020; Szendrő et al., 2020; Naranjo-Guevara et al., 2021).

Disgust and food neophobia acted as a barrier towards consumption, as shown in other studies (Laureati et al., 2016; Bazoche and Poret, 2020; Roma et al., 2020; Szendrő et al., 2020). Disgust had the second-largest influence in the model (Wald $x^2 = 17$; 0.1% significant level). A one-unit increase in disgust was associated with a 44% (0.559–1) decrease in the likelihood of being willing to try the product. FNS was significant at 1% level. A one-unit increase in FNS was associated with

a 13% (0.868–1) decrease in the likelihood of being willing to try the product.

Participants with prior knowledge on insects as feed showed higher level of PATT (mean=5.4) and lower level of disgust (mean=2.6) than the other participants ($p< 0.05$). This suggested that the absence of participants' awareness may have indirectly affected WTT (Verbeke, 2015; Laureati et al., 2016). Also, the lower effect of FNS on WTT compared to disgust suggested that familiarity with eggs mitigated the negative effects of neophobia on consumers intentions (La Barbera et al., 2018).

### 3.3. Regression analysis of WTP

Table 3 presents the results of the Tobit regression model and the WTP model indicated a good fit.

Following the pattern of the WTT, disgust and PATT were the most important predictors of WTP (0.1% level). For a one-unit increase in PATT, WTP increased by £0.11 and for one unit increase in disgust, WTP decreased by £0.19. Also, previous tasting experiences with insects as food positively (1% level) affected consumers' WTP. For consumers who had already tasted insects as food, WTP increased by £0.31.

Although in the WTP model FNS and AHW were no longer significant variables, the importance of price and amount usually spent for eggs showed negative and significant influence (1% level) on consumers' WTP. For consumers who considered price an important factor when purchasing eggs, WTP decreased by £0.17. For consumers who usually spend £1.50–1.99 for a typical 6-pack of eggs, WTP increased by £0.35 and for consumers who usually spend £2.00 or more, WTP increases by £0.62 compared to consumers who spend only £0.50–0.99. This result mirrors studies on insect-fed fish and findings that among other factors, expected price and affordability are some of the main barriers affecting adoption (Ankamah-Yeboah et al., 2018; Mancuso et al., 2016). Again, socio-demographic characteristics, NEP and AAS were not significant predictors of WTP (results not shown).

## 4. Conclusion and limitations

This is the first study exploring consumers WTT and WTP for eggs from insect-fed hens in the UK. It provides preliminary evidence on determinants of consumption and contributes to the limited literature on the topic.

Only a small percentage of consumers is aware of the use of insects as animal feed, but a substantial proportion of consumers indicate they would pay more for these eggs, suggesting there is potential to introduce them as a premium product in the UK market.

Disgust towards insects as feed would likely be a barrier towards consumption. However, previous tasting experience with insects as food may decrease the disgust towards insects in general and thus further encourage acceptance of these eggs. Furthermore, consumers have little knowledge about the benefits of insects as hen feed, but they have positive attitudes towards the product and its benefits. This suggests the importance of strategies aimed at informing and educating consumers about the benefits of feeding hens with insects to overcome disgust and increase acceptance. Although disgust towards insects as feed is a predominant factor affecting intention, consumers still perceive eggs from insect-fed hens as more familiar than insects as food, demonstrating that insect-fed foodstuffs may be more accepted than insect-based food. However, the high level of consumers' concerns towards hen welfare among UK consumers suggests that consumers are more likely to trust and, thus accept eggs from insect-fed hens if produced and introduced in the market with animal welfare labels (e.g., free-range and organic) accredited by certified institutions. Moreover, in the future it would be interesting to investigate if the type of insect used as poultry feed (for example different species of larvae or caterpillars) could influence consumers' responses.

This study presents some limitations. Firstly, WTT was defined as a binary dependent variable as this produced a statistical model that better represented real purchasing behaviour. However, as the original variable was measured on a 7-point Likert scale, some information might not have been captured. Secondly, although the information provided on benefits might have enhanced PATT, the provision of information and the type of information provided might have contributed to creating biases among participants' responses. Also, contrasting results related to AHW, AAS and NEP suggest the need for assessing the role of consumers' animal and hen welfare concerns, as well as environmental concerns on WTT and WTP for these eggs.

This study was valuable in providing initial insights into determinants of WTT and WTP for UK consumers. How and to what extent these factors affect consumers' readiness to adopt eggs from insect-fed hens is worth further investigation.

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## 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.

## References

Ankamah-Yeboah, I., Jacobsen, J.B., Olsen, S.B., 2018. Innovating out of the fishmeal trap: the role of insect-based fish feed in consumers' preferences for fish attributes. Br. Food J. 120 (10), 2395–2410.

La Barbera, F., Verneau, F., Amato, M., Grunert, K., 2018. Understanding westerners' disgust for the eating of insects: the role of food neophobia and implicit associations. Food Qual. Prefer. 64 (April 2017), 120–125.

Bazoche, P., Poret, S., 2020. Acceptability of insects in animal feed: a survey of French consumers. J. Consum. Behav. (July 2017) 1–20.

Dunlap, RE., van Liere, KD., Mertig, AG., Jones, R.E., 2000. New trends in measuring environmental attitudes: measuring endorsement of the new ecological paradigm: a revised NEP scale. J. Soc. Issues 56 (3), 425–442.

European Union, 2017. Commission Regulation (EU) 2017/1017 of 15 June 2017 Amending Regulation (EU) No 68/2013 on the catalogue of feed materials. Off. J. Eur. Union 159 (68), 48–119.

Bennett, R. M., Jones, P. J., Nicol, C. J., Tranter, R. B., Weeks, C. A., 2016. Consumer Attitudes to Injurious Pecking in Free-Range Egg Production.. Animal Welfare 25 (1), 91–100.

De Faria Domingues, C.H., Borges, J.A.R., Ruviaro, C.F., Guidolin, D.G.F., Carrijo, J.R.M., 2020. Understanding the factors influencing consumer willingness to accept the use of insects to feed poultry, cattle, pigs and fish in Brazil. PLoS One 15 (4), 1–11.

Ferrer Llagostera, P., Kallas, Z., Reig, L., Amores de Gea, D., 2019. The use of insect meal as a sustainable feeding alternative in aquaculture: current situation, Spanish consumers' perceptions and willingness to pay. J. Clean. Prod. 229, 10–21.

Gasco, L., Biasato, I., Dabbou, S., Schiavone, A., 2019. Quality and consumer acceptance of products from insect-fed animals. Edible Insects in the Food Sector. Springer, Cham.

Hair, J. F., Jr. Black, W. C., Babin, B. J., Anderson, R. E., 2010. Multivariate data analysis: A global perspective, 7th Pearson Education, New Jersey.

Harper, G., Henson, S., 2001. Consumer Concerns about Animal Welfare and the Impact on Food Choice. *Final report EU FAIR CT98-3678*. Department of Agricultural and Food Economics, University of Reading, UK.

Herzog, H., Grayson, S., McCord, D., 2015. Brief measures of the animal attitude scale. Anthrozoos 28 (1), 145–152.

Kostecka, J., Konieczna, K., Cunha, LM., 2017. Evaluation of insect-based food acceptance by representatives of polish consumers in the context of natural resources processing retardation. J. Ecol. Eng. 18 (2), 166–174.

Laureati, M., Proserpio, C., Jucker, C., Savoldelli, S., 2016. New sustainable protein sources: consumers' willingness to adopt insects as feed and food. Ital. J. Food Sci. 28 (4), 652–668.

Mancini, M.C., Antonioli, F., 2019. Exploring consumers' attitude towards cultured meat in Italy. Meat Sci. 150 (December 2018), 101–110.

Mancuso, T., Baldi, L., Gasco, L., 2016. An empirical study on consumer acceptance of farmed fish fed on insect meals: the Italian case. Aquac. Int. 24 (5), 1489–1507.

Naranjo-Guevara, N., Fanter, M., Conconi, A.M., Floto-Stammen, S., 2021. Consumer acceptance among Dutch and German students of insects in feed and food. Food Sci. Nutr. 9 (1), 414–428.

Onwezen, M.C., van den Puttelaar, J., Verain, M.C.D., Veldkamp, T., 2019. Consumer acceptance of insects as food and feed: the relevance of affective factors. Food Qual. Prefer. 77 (May), 51–63.

Pliner, P., Hobden, K., 1992. Development of a scale to measure the trait of food neophobia in humans. Appetite 19 (2), 105–120.

Popoff, M., MacLeod, M., Leschen, W., 2017. Attitudes towards the use of insect-derived materials in scottish salmon feeds. J. Insects Food Feed 3 (2), 131–138.

Roma, R., Palmisano, G.O., De Boni, A., 2020. Insects as Novel food: a consumer attitude analysis through the dominance-based rough set approach. Foods 9 (4), 1–19.
Rondoni, A., Asioli, D., Millan, E., 2020. Consumer behaviour, perceptions, and preferences towards eggs: a review of the literature and discussion of industry implications. Trends Food Sci. Technol. 106 (October), 391–401.
Sogari, G., Amato, M., Biasato, I., Chiesa, S., Gasco, L., 2019. The potential role of insects as feed: a multi-perspective review. Animals 9 (4), 1–15.
Star, L., Arsiwalla, T., Molist, F., Leushuis, R., Dalim, M., Paul, A., 2020. Gradual provision of live black soldier fly (hermetia illucens) larvae to older laying hens: effect on production performance, egg quality, feather condition and behavior. Animals 10 (2).
Szendrő, K., Nagy, M.Z., Tóth, K., 2020. Consumer acceptance of meat from animals reared on insect meal as feed. Animals 10 (8), 1–10.
Verbeke, W., 2015. Profiling consumers who are ready to adopt insects as a meat substitute in a western society. Food Qual. Prefer. 39, 147–155.
Verbeke, W., Spranghers, T., de Clercq, P., de Smet, S., Sas, B., Eeckhout, M., 2015. Insects in animal feed: acceptance and its determinants among farmers, agriculture sector stakeholders and citizens. Anim. Feed Sci. Technol. 204, 72–87.