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Profiling consumers who are ready to adopt insects as a meat substitute in a Western society

Wim Verbeke *

Ghent University, Department of Agricultural Economics, Coupure links 653, B-9000 Gent, Belgium

A R T I C L E I N F O

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This study investigates the readiness of consumers in a Western society, where traditional meat consumption prevails, to adopt insects as a substitute for meat. Using cross-sectional data ($n = 368$) and binary logistic regression modeling, the study identifies gender, age, familiarity, food neophobia, convenience and environmental food choice motives, as well as meat-related attitudes and future meat consumption intentions as significant predictors. The predicted likelihood of adopting insects as a substitute for meat is 12.8% [95% CI: 6.1–19.4%] for males and 6.3% [95% CI: 2.8–9.9%] for females, other predictor variables held constant at their mean value. People who claim to be familiar with the idea of eating insects have a 2.6 times higher likelihood, and consumers who intend to reduce fresh meat intake are up to 4.5 times more likely to adopt insects. Food neophobia makes the largest contribution to consumers' readiness to adopt insects: a one-unit increase in the food neophobia score is associated with a 84% decrease in the predicted odds of being ready to adopt insects. A stronger convenience orientation in food choice and a higher interest in the environmental impact of food choice increase the likelihood of adopting insects by 75% and 71% per unit increase in these predictors' scores, respectively. By contrast, a one-unit stronger belief that meat is nutritious and healthy, and a one-unit higher importance attached to taste for meat lower the predicted odds by 64% and 61%, respectively. This study reveals that the most likely early adopters of insects as a novel and more sustainable protein source in Western societies are younger males with a weak attachment to meat, who are more open to trying novel foods and interested in the environmental impact of their food choice.

Introduction

Entomophagy or the eating of insects has recently received a growing deal of attention as a promising way to cope with some of the major food and nutrition challenges facing the world. A recent report by the Food and Agriculture Organization of the United Nations (FAO) used multiple perspectives – including cultural, economic, ecological, technological, nutritional and legislative ones – to explore the potential of insects in addressing issues of food and feed security (van Huis, 2013; van Huis et al., 2013). The report details the advantages of consuming insects (or insect protein) compared to protein from livestock production and found insects compared favorably in terms of feed conversion efficiency, greenhouse gas and ammonia emissions, water use, animal welfare and zoonotic infection risk. However, the report acknowledges that "despite these benefits, consumer acceptance remains one of the largest barriers to the adoption of insects as viable sources of protein in many Western countries" (van Huis et al., 2013: 59).

The objective of the present study is to profile consumers who claim to be ready or willing to eat insects. The study was conducted in Flanders, Belgium: a 'typical' Western society where traditional meat consumption prevails and the adoption of insects as a foodstuff is regarded with a great degree of skepticism and disgust (Vanhonacker, Van Loo, Gellynck, & Verbeke, 2013). A few years ago, Verkerk, Tramper, van Trijp, and Martens (2007) highlighted the lack of consumer acceptance of insect protein, especially in the Western or industrialized world, as a major issue that needed to be investigated in order to successfully bring this novel protein source to the market and prevent initial rejection by consumers. While discussing the sources of Westerners' negative attitudes, their aversion toward terrestrial invertebrates and its consequences for global food availability, sustainability and cross-cultural relationships, Looy, Dunkel, and Wood (2014) called for more social sciences research about insect eating. A couple of recent studies reported that in cultures where insects are traditionally eaten consumption is now in decline, e.g. in Botswana (Obopile

* Tel.: +32 9 264 6181; fax +32 9 264 6246.
E-mail address: wim.verbeke@ugent.be

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& Seeletso, 2013), in India (Chakravorty, Ghosh, & Meyer-Rochow, 2013; Meyer-Rochow & Chakravorty, 2013), or in Cameroon (Sneyd, 2013). Among the reasons identified for this decline are an increasing westernization of local diets in traditional communities (Chakravorty et al., 2013), dietary change towards cheaper imported and refined foods (Sneyd, 2013), and the long-standing image of insect-eating as a "primitive peoples' practice" (Costa-Neto, 2003). Hence, any study into Western consumers' attitudes and intentions towards entomophagy has implications that extend beyond the potential for developing alternative protein food markets in Western countries (DeFoliart, 1999).

As yet, little data are available about the eating of insects in Europe (Rumpold & Schlüter, 2013) and there have been few studies that address consumers' perception of and readiness to adopt insects in their diet. Schösler, de Boer, and Boersema (2012) investigated consumer readiness to adopt several types of meat substitutes in the Netherlands, including dishes with fried mealworms or locusts and fictive pizza containing protein derived from insects. Meat substitutes with visible insects were rated much more negatively compared to other options in terms of their attractiveness and likelihood of preparing them. The pizza with processed insect protein was rated somewhat more positively, especially by younger people (Schösler et al., 2012). Vanhonacker et al. (2013) reported that consumers in Flanders (Belgium) demonstrated a very low willingness to consume insects and concluded that adopting insect protein was generally perceived as a rather unrealistic, unacceptable and ineffective way to improve dietary sustainability. Consumers who, due to their self-reported awareness of, and readiness to reduce their ecological footprint, might have been assumed to be more amenable to consuming insects, were just as averse as the wider population when asked about their readiness to eat insects. In another study, de Boer, Schösler, and Boersema (2013) found that of snacks based on environmentally-friendly proteins, such as hybrid meat, lentils, beans, and seaweed, the insect-based snack (made from locusts) was the least popular. The idea of an insect-based snack was preferred by only 4% of the study participants (in the Netherlands), while 79% of them flagged it as the snack they would least like to taste. By contrast, the sensory study by Megido et al. (2014) showed that insect tasting was well accepted among consumers with an a priori interest in insects in Belgium.

Despite most of these findings which show a clear reluctance among Western consumers to include insects in their diet, there are indications of the presence of a nucleus of some kind of market for insects or insect protein in Western countries (United Nations News Centre, 2013). For example, an increasing number of restaurants now serve insects as a delicacy and more insect cookery books become available (Verkerk et al., 2007). Equally, insect-based recipes are being featured more regularly on late night television shows and there are dedicated insect food festivals (Cunningham & Marcason, 2001). The findings of Schösler et al. (2012) about consumer reactions towards chocolate-coated locusts and pizza with insect protein suggest that there may be opportunities to present insects as a delicacy or as an ingredient in convenience foods. In the study of Vanhonacker et al. (2013), about 13% of participants claimed to be neutral towards the idea of consuming insects, while 5% said that they were willing or very willing to eat insects. In advance of a clear standpoint and harmonization at European level of the status of insects (which are expected to fall under the European Union (EU) novel foods Regulation (EC) 258/97 as foods not consumed to a significant degree in the EU before 15 May 1997), the Belgian Food Safety Authority (FAVV-AFSCA) authorized the production and trade of ten insect species for human consumption from the end of December 2013, as confirmed in its circular published in May 2014 (FAVV., 2014). While such a development officially paves the way for the industrial mass production and consumption of insects, a great deal of work remains to be done in order to improve consumer acceptance (Rumpold & Schlüter, 2013). Profiling consumers who are ready (or not) to adopt insects in their diet might be a first step towards a better understanding of consumers' reactions towards eating insects and their future marketplace acceptance.

The present study frames the readiness to eat insects in relation to meat, since insects or insect proteins are generally positioned as an alternative to meat as the traditional animal based protein source in Western countries. 'Excessive' meat production and consumption have been increasingly criticized for their potential negative impact on the natural environment (de Vries & de Boer, 2010; Odegard & van der Voet, 2014) and human health (Micha, Michas, Lajous, & Mozaffarian, 2013), as exemplified in the recent Meat Atlas published by Friends of the Earth Europe (2014). Compared to meat, insects are referred to as a more resource-efficient food source (Odegard & van der Voet, 2014) and as a foodstuff that qualifies much more favorably in terms of diverse sustainability rankings (Vinnari & Tapio, 2012). Nevertheless, meat is still highly valued by consumers for its nutritional value (Van Wezemael, Caputo, Nayga, Chryssochoidis, & Verbeke, 2014), taste and other sensory aspects (Verbeke, Perez-Cueto, de Barcellos, Krystallis, & Grunert, 2010). Meat is viewed as a nutritious and healthy food that is part of a varied diet (McAfee et al., 2010; Pereira & Vicente, 2013) and an important component of the traditional Western meal (Scholderer, Kügler, Olsen, & Verbeke, 2013). In line with this we can expect that the likelihood of adopting insects as a substitute for meat will be higher among people with higher levels of: importance attached to the environmental impact of their food choice, health orientation in food choice and, in line with de Boer et al. (2013) among people who are more oriented towards convenience food. By contrast, the likelihood of adopting insects as a foodstuff is expected to be lower among those who have a stronger focus on the taste or sensory satisfaction acquired from meat consumption and those with a stronger belief that meat is nutritious and healthy. In addition, food neophobia (aversion to new foods) and, maybe to a lesser extent food technology neophobia are expected to lower the likelihood of being ready to adopt insects (Megido et al., 2014). Both attitudes are personal traits that relate to the extent to which consumers accept new of unusual products (Pliner & Hobden, 1992) or products produced using unfamiliar or unknown technologies (Cox & Evans, 2008), which is clearly the case for insects in Western societies. Furthermore, familiarity with the idea of eating insects and the intention to reduce meat consumption are both expected to increase the likelihood of adopting insects as a meat substitute. Familiarity has frequently been shown to be an important driver of food choice in general, and a significant determinant of the decision to replace meat by meat substitutes in particular (Hoek et al., 2011).

No specific hypotheses are set forth with respect to possible effects of socio-demographics such as gender, age and education. Some of these factors have been shown to be associated with food neophobia (e.g. Siegrist, Hartmann, & Keller, 2013), meat consumption (Verbeke et al., 2010) or readiness to adopt meat substitutes in general (Hoek et al., 2011) and insects in particular (Schösler et al., 2012), so the effects of these factors are controlled for during the analysis.

Materials and methods

Data collection and sample

Cross-sectional data were collected from a representative sample of 368 meat consumers in Flanders, Belgium during December

Table 1
Descriptive statistics of dependent and explanatory variables (n = 368).

Variable	Label	Mean (S.D.)
Dependent variable (binary)		
Readiness to adopt insects as a meat substitute (0 = no; 1 = yes)	Insect	0.19
Explanatory variables		
Gender (0 = female; 1 = male)	Male	0.39
Age (mean, sd) (years)	Age	42.02 (15.54)
Education (0 = primary or secondary; 1 = higher)	Edu	0.75
Familiarity (0 = no; 1 = yes)	Fam	0.72
Food neophobia (5-point scale)	FNS	2.42 (0.64)
Food technology neophobia (5-point scale)	FTNS	2.92 (0.72)
Attitude towards the health characteristics of food (5-point scale)	FHealth	3.57 (0.87)
Convenience orientation for food choice (5-point scale)	FConv	2.21 (0.90)
Attention to the environmental impact of food choice (5-point scale)	FEnv	2.64 (0.89)
Importance of taste when evaluating meat quality (5-point scale)	MTaste	4.51 (0.56)
Belief that meat is nutritious and healthy (5-point scale)	MNutr	3.53 (0.67)
Intention to reduce fresh meat consumption (0 = no; 1 = yes)	MRed	0.17

2013 using a web-based survey.[1] Participants were randomly recruited from an online access panel taking into account specific inclusion criteria, as well as age and regional distribution. Inclusion criteria for the analysis were: being involved in food purchasing (but not necessarily being the primary responsible person for food purchasing) and, being a consumer of meat, i.e. no vegetarian or vegan consumers were included in the analysis. The data were collected one week prior to the announcement of the authorization of ten insect species for production and human consumption by the Belgian Food Safety Authority. The sample consisted of 61% females, which reflects the criterion of being involved in food purchasing, and covered all the regions (provinces) of Flanders, Belgium with regional distribution according to the national population statistics.[2] The age of the participants ranged from 18 to 79 years. The mean age of the sample was 42 years (S.D. = 15 years). Three quarters of the participants had followed education beyond the age of 18 years (i.e. university college or university degrees), showing a slight bias towards higher educated people. This bias is attributed to the use of electronic recruitment and survey completion methods. Descriptive statistics of the sample are presented in Table 1.

Questionnaire and scaling

Consumers' readiness to adopt insects as a meat substitute was originally measured by asking participants to provide their response to "I would be prepared to eat insects as a substitute for meat" on a 5-point Likert (agreement) scale. Prior to answering this question, and in line with Van Huis et al. (2013), participants were informed that insects "are a good source of high-value proteins, their production requires little space, their feed conversion is efficient, and therefore the eating of insects provides benefits in terms of sustainability".

Participants were also asked to indicate the extent of their awareness about the eating of insects by placing themselves in one of three response categories: "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", and "No, I have never heard of the eating of insects". The information recorded through this variable was used as a proxy of self-reported familiarity with (the idea) of eating insects (*Fam*).

Food neophobia was measured using six items selected from the food neophobia scale as developed by Pliner and Hobden (1992). The six items included in this study were: "I am constantly sampling new and different foods" (R – reverse coded), "I don't trust new foods", "If I don't know what is in a food, I won't try it", "At dinner parties, I will try a new food" (R), "I am afraid to eat things I have never had before" and "I will eat almost anything" (R). The selection of these six items was primarily informed by the six-item food neophobia model[3] proposed by Ritchey et al. (2003: 169). Each item was scored on a 5-point scale. The six items were merged into one food neophobia score (*FNS*) (alpha = 0.76).

Food technology neophobia (*FTNS*) was measured using four items selected from the 'New food technologies are unnecessary' dimension of the scale developed by Cox and Evans (2008). The items included in this study were: "There are plenty of tasty foods around so we don't need to use new food technologies to produce more", "The benefits of new food technologies are often grossly overstated", "New food technologies decrease the natural quality of food" and "There is no sense in trying out high-tech food products because the ones I eat are already good enough". The selection of these four items was informed by their factor loadings in the original study. Each item was scored on a 5-point scale. The four items were merged into one FTNS score (alpha = 0.81).

Consumers' attitudes towards the health characteristics of food in general were measured using three items selected from the general health interest scale developed by Roininen, Lähteenmäki, and Tuorila (1999). These items were: "The healthiness of food has little impact on my food choices" (R), "I am very particular about the healthiness of the food I eat" and "I eat what I like and I do not worry much about the healthiness of food" (R). The selection of these items was informed by their factor loadings and item-total correlations as reported in the original study. Each item was scored on a 5-point scale. The three items were merged into one food health interest score (*FHealth*) (alpha = 0.76).

Convenience orientation in relation to food was measured using three items selected from the final CONVOR scale developed by Candel (2001). These items were: "The less physical energy I need to prepare a meal, the better", "At home, I preferably eat meals that can be prepared quickly", and "It's a waste of time to spend a long time in the kitchen preparing a meal". Each item was scored on a 5-point scale. The three items were merged into one score indicating interest in food convenience (*FConv*) (alpha = 0.85).

Consumers' attention to the environmental impact of their food choices (*FEnv*) was measured using the item "When I buy foods, I try to consider how my use of them will affect the environment". This item is based on Roberts (1996), and it was also scored on a 5-point scale.

[1] Of a total of 404 participants who completed the survey, 30 cases were excluded during the analysis owing to missing observations for one or more of the explanatory variables (items or constructs) included in the analyses. Twenty of those participants (5% of the original sample) reported themselves to be vegetarians or vegans, thus they did not complete the meat-related attitude sections of the survey. This number corresponds with the estimated share of around 5% of the adult population in Flanders who never or very rarely eat meat (EVA vzw/iVOX, 2011). Another six cases were identified as outliers based on large standardized residuals (>|3.0|) for the dependent variable. These cases were also omitted from the final analysis, thus yielding a total of 368 valid responses.

[2] Regional distribution of the sample vs. *population*: West-Flanders (20% vs. *19%*), East-Flanders (26% vs. *24%*), Antwerp (23% vs. *27%*), Limburg (12% vs. *13%*), Flemish-Brabant (19% vs. *17%*) (based on Belgian Federal Government statistics from 2012).

[3] Four items included in this study correspond with this model. Items referring explicitly to "different cultures" or "ethnic" food were not included in order to avoid linguistic difficulties (Siegrist et al., 2013) or possible bias from such explicit reference in the context of the eating of insects. The items "I don't trust a new food" and "I will eat almost anything" were added assuming that these items had relevant connotations with the case of insects from the perspective of Western consumers. In contrast with Ritchey, Frank, Hursti, and Tuorila (2003) the latter item did not pose particular problems but fitted well the overall scale.

Consumers' belief in the health and nutritional benefits of meat was measured using five items based on Almli, Van Wezemael, Verbeke, and Ueland (2013). The five items were: "Eating meat is healthy", "Eating meat is necessary for obtaining beneficial nutrients", "Meat contains important nutrients", "Meat is good for general health" and "Meat is an important part of a healthy diet". Each item was scored on a 5-point scale. The five items were merged into a single belief score (*MNutr*) (alpha = 0.89).

Consumers' focus on taste or the sensory experience as a key component of meat quality (*MTaste*) was recorded as the perceived "importance of taste when evaluating meat quality". This items was scored on a 5-point scale ranging from "totally not important" to "extremely important". Intention to reduce fresh meat consumption (beef, pork, poultry) in the next year (*MRed*) was measured as a single dichotomous item with "yes/no" as response categories. Finally, socio-demographic characteristics such as age, gender, education and region were recorded.

Statistical modeling

Readiness to adopt insects was analyzed as a discrete (yes/no) decision (see also Verbeke, 2005a) by specifying the response categories "totally agree" and "agree" as a "yes" (19.3%), and the other response categories as a "no" (80.7%). Considering consumers' readiness to adopt insects as a substitute for meat as a binary choice is consistent with the recommendation by Hoek et al. (2011), based on Wansink, Sonka, and Park (2004) who suggest using some kind of 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 insects as a meat substitute in Western countries.

To model this dichotomous decision, and considering the skewed distribution of choices, we decided to use a binary logistic regression model.[4] In this case, the binary dependent response y_i for participant i takes a value of one if a latent continuous variable z_i is greater than zero, whereas y_i takes a value of zero otherwise:

$$\begin{cases} y_i = 1 & \text{if } z_i > 0 \\ y_i = 0 & \text{if } z_i \leqslant 0 \end{cases}$$

The latent metric and continuous variable z_i is specified as a usual regression model where x_{ki} represent $k = 1$ through K explanatory variables explaining the readiness to adopt insects as a substitute for meat for participant i with β_k as the coefficient that indicates the effect of x_{ki} on z_i, and where ε_i represents the stochastic error term for participant i, namely:

$$z_i = \beta_0 + \sum_{k=1}^{K} \beta_k x_{ki} + \varepsilon_i$$

The transformation of y_i that creates z_i is the logistic function. Hence, the relationship between the probability p_i of an observation of y_i assuming the value of one and the values of the explanatory variables x_k is written as:

$$p_i = \text{prob}\,(y_i = 1) = \frac{e^{z_i}}{1 + e^{z_i}} = \frac{e^{\beta 0 + \sum_{k=1}^{K} \beta_k x_{ki}}}{1 + e^{\beta 0 + \sum_{k=1}^{} K \beta_k x_{ki}}} \text{ or}$$

$$\log\left(\frac{pi}{1 - pi}\right) = z_i = \beta_0 + \sum_{k=1}^{K} \beta_k x_{ki} + \varepsilon_i$$

In line with the choice and specification of explanatory variables (Table 2), the complete empirical specification of z_i is given by:

$$\begin{aligned} \text{Insect}_i = {} & \beta_0 + \beta_1\,\text{Male}_i + \beta_2\,\text{Age}_i + \beta_3\,\text{Edu}_i + \beta_4\,\text{Fam}_i + \beta_5\,\text{FNS}_i \\ & + \beta_6\,\text{FTNS}_i + \beta_7\,\text{FHealth}_i + \beta_8\,\text{FConc}_i + \beta_9\,\text{FEnv}_i \\ & + \beta_{10}\,\text{MTate}_i + \beta_{11}\,\text{MNutr}_i + \beta_{12}\,\text{MRed}_i + \varepsilon_i \end{aligned}$$

Gender, education, familiarity and intention to reduce meat consumption were specified as dummy variables. Alternative specifications including interaction effects between explanatory variables were explored but none turned out to perform better than the main effects model. Regression coefficients were estimated using maximum likelihood estimation and are presented with Wald χ^2-statistics and as odds ratios, i.e. the exponentiated logistic regression parameters or the ratio between the probability that a person is ready or not ready to adopt insects as a substitute for meat.

Results

Descriptive statistics

Almost one quarter of the participants (24.2%) indicated that they ate meat on a daily basis and 66.8% reported a meat consumption frequency of several times a week. Poultry was the most frequently eaten fresh meat with an average frequency of 1.98 times (S.D. = 1.00) per week (seven days). The average number of days per week without consuming meat in the sample was 1.59 (S.D. = 1.37). These numbers correspond with meat consumption data reported in the study from Schösler et al. (2012) for the Netherlands. Almost three quarters of our sample (71.5%) indicated that they had heard about the eating of insects and knew what it meant. This group is referred to as people who are familiar with the idea of eating insects. Only 5.1% of the sample claimed to have never heard about the eating of insects. This group was merged for further analysis with the 23.4% who reported to have heard about the eating of insects but not to know what it actually means. Self-reported familiarity was not significantly associated with any of the other explanatory variables included in the model.

Participants' mean scores on food neophobia (FNS) and food technology neophobia (FTNS) were both below the mid-point of the scale (Table 1). The average score for FTNS was significantly higher compared to the average FNS score ($t = 11.42$, $p < 0.001$). Pearson correlation between FNS and FTNS amounted to 0.236 ($p < 0.01$) (Table 2). Average scores for convenience orientation in food choice and attention to the environmental impact of food choice were also relatively low. By contrast, participants reported a moderately strong attitude towards the health characteristics of food. Attitude towards the health characteristics of food was positively correlated with attention to the environmental impact

[4] Alternative modeling approaches were tested since the frequency distribution of 'readiness to adopt insects as a substitute for meat' on the original 5-point scale was: 3.0% "totally agree", 16.3% "agree", 15.5% "neither agree nor disagree", 34.0% "disagree" and 31.3% "totally disagree". First, an ordered logistic regression model was tested with this ordinal dependent variable. This model suffered from a large proportion of zero frequencies (80%) in the dependent variable levels conditional to the predictors' values. The likelihood ratio Chi^2-test of parallel lines ($\text{Chi}^2 = 64.99$; $p = 0.002$) provided evidence that the parallel regression assumption had been violated. Therefore, ordered logistic regression modeling was abandoned. Next, a multinomial logistic regression model was tested with a three-category response variable ("totally disagree" and "disagree" (64.3%) as the reference category, "neither agree nor disagree" (15.5%), "agree" and "totally agree" (19.3%)). This model (LR(24) = 161.51; $p < 0.001$; Nagelkerke $R^2 = 0.43$) showed significant effects of a comparable magnitude for all predictor variables for the model contrasting "agree or totally agree" with "totally disagree or disagree". The model for "neither agree nor disagree" relative to the reference category proved significant effects of only gender and food neophobia. These effects were of the same magnitude as the effects of gender and food neophobia for "agree or totally agree" relative to the reference category. Males were found to be 3.5 times more likely than females to report "neither agree nor disagree" rather than "totally disagree or disagree". If a participant were to increase his/her food neophobia score by one unit, the probability for "neither disagree nor agree" relative to "totally disagree or disagree" would be expected to decrease by a factor of 0.38 given the other variables in the model are held constant. Hence, this MNL regression produced little additional empirical insight compared to the results obtained from binary logistic regression (see "Binary logistic regression results").

Table 2
Bivariate Pearson correlations between metric explanatory variables ($n = 368$).

	Age	FNS	FTNS	FHealth	FConv	FEnv	MTaste	MNutr
Age	1							
FNS	0.115*	1						
FTNS	0.083	0.236**	1					
FHealth	0.191*	0.018	0.078	1				
FConv	−0.123*	0.066	0.002	−0.261**	1			
FEnv	0.270**	0.017	0.033	0.329**	−0.123*	1		
MTaste	−0.034	0.065	0.078	0.035	−0.011	−0.045	1	
MNutr	−0.131*	−0.059	−0.009	−0.151**	−0.072	−0.214**	0.047	1

* $p < 0.05$.
** $p < 0.01$.

of food choice ($r = 0.329$; $p < 0.01$) and negatively correlated with convenience orientation in food choice ($r = -0.261$; $p < 0.01$). The food-related attitudes measured in this study were significantly and moderately correlated with age (Table 2).

Study participants attached a lot of importance to taste or sensory experience when evaluating meat quality and they were quite convinced that meat is a nutritious and healthy food product. About 17% of the participants indicated that they intended to decrease their consumption of fresh meat in the coming year. A stronger belief that meat is nutritious and healthy was associated with a lower importance attached to the environmental impact of food choice ($r = -0.214^{**}$; $p < 0.01$) and a weaker attitude towards the health characteristics of food ($r = -0.151^{**}$; $p < 0.01$). Participants who intended to reduce fresh meat consumption were less convinced that meat is a nutritious and healthy food compared to those who did not plan to reduce their fresh meat intake (mean scores of 3.35 vs. 3.56, respectively; $t = -2.26$; $p = 0.024$), while differences in other explanatory variables between both consumer groups were not significant.

Female participants were significantly less convinced than males that meat is a nutritious and healthy food (mean = 3.47 for females vs. mean = 3.61 for males; $t = 1.99$; $p = 0.047$). No significant gender differences were found for the other explanatory variables. With the exception of a tendency ($0.05 < p < 0.10$) for those with lower education levels to have higher FNS and FTNS, education level produced no significant differences on the other explanatory variables.

Binary logistic regression results

Table 3 presents the results of the binary logistic regression model with the estimated logistic regression coefficients (β), their respective standard errors (S.E.), Wald χ^2-statistics, significance levels, odds ratios(Exp(β)) and goodness-of-fit statistics. Multi-collinearity was not a major issue in the model as it was tested through collinearity diagnostics (smallest tolerance value = 0.82), which was already suggested by the correlation coefficients presented in Table 2 and the small standard errors (S.E.) of the coefficient estimates (Table 3).

Gender and age were found to have significant effects. Males were 2.17 times more likely to adopt insects as a meat substitute than females. A 10-year increase in age was associated with a 27% decrease in the odds of being ready to adopt insects as a foodstuff.

Participants who indicated familiarity with the idea of eating insects were 2.6 times more likely to be ready to adopt insects than those who said they had never heard about the eating of insects or hardly knew what it involved. Food neophobia and food technology neophobia were both significant determinants of consumers' readiness to adopt insects as a meat substitute. Food neophobia was the single largest most influential factor in the model (Wald $\chi^2 = 25.1$). A one-unit increase in food neophobia score was associated with an 84% decrease in the predicted odds of being ready to adopt insects. A one unit increase in the FTNS score was associated with a 55% decrease in the likelihood of being ready to adopt insects as a substitute for meat.

Significant effects of food choice motives are produced by a person's convenience orientation and by the importance people attach to the environmental impact of food choice. A one-unit increase in the convenience orientation score was associated with a 75% increase in the predicted odds of being ready to adopt insects. An increase of one unit in the importance attached to the environmental impact of food choice increased the likelihood of being ready to adopt insects by 71%. The effect of a person's health orientation was only marginally significant.

Finally, specific meat-related attitudes had significant and substantial effects on the model. Consumers who claimed to intend to reduce their intake of fresh meat in the coming year had a 4.5 times higher likelihood of being ready to adopt insects as a substitute for meat than consumers who did not plan to reduce their fresh meat consumption. A stronger conviction that meat is nutritious and healthy and a stronger focus on taste in meat were associated with a lower likelihood of adopting insects as a substitute protein source. A one-unit increase of the belief that meat is nutritious and healthy lowered the predicted odds by 64%, while a one-unit increase of the importance score for taste in meat produced a 61% decrease in the predicted odds of being ready to adopt insects as a substitute for meat.

Table 3
Coefficient estimates and diagnostics from binary logistic regression explaining consumers' readiness to adopt insects as a substitute for meat ($n = 368$).

Variable	β	S.E.	Wald	Sig.	Exp (β)
Gender (male)	0.774	0.363	4.553	0.033	2.169
Age	−0.028	0.012	5.256	0.022	0.973
Education	0.005	0.421	0.000	0.991	1.005
Fam	0.957	0.447	4.580	0.032	2.604
FNS	−1.811	0.361	25.125	<0.001	0.164
FTNS	−0.788	0.252	9.741	0.002	0.455
FHealth	0.416	0.239	3.014	0.083	1.515
FConv	0.557	0.197	7.973	0.005	1.746
FEnv	0.539	0.198	7.430	0.006	1.714
MTaste	−0.952	0.293	10.580	0.001	0.386
MNutr	−1.025	0.264	15.024	<0.001	0.359
MRed	1.507	0.389	15.022	0.001	4.512
Constant	7.999	2.362	11.466	<0.001	

Goodness-of-fit statistics: −2 Log likelihood statistic = 232.91; Likelihood ratio (12) = 128.06 ($p < 0.001$); Nagelkerke $R^2 = 0.47$; % correct predictions = 86.1% vs. 80.7% for naïve prediction.

Predicted probabilities of being ready to adopt insects as a meat substitute

Predicted probabilities of being ready to adopt insects as a substitute for meat are presented in Figs. 1 and 2 for different profiles

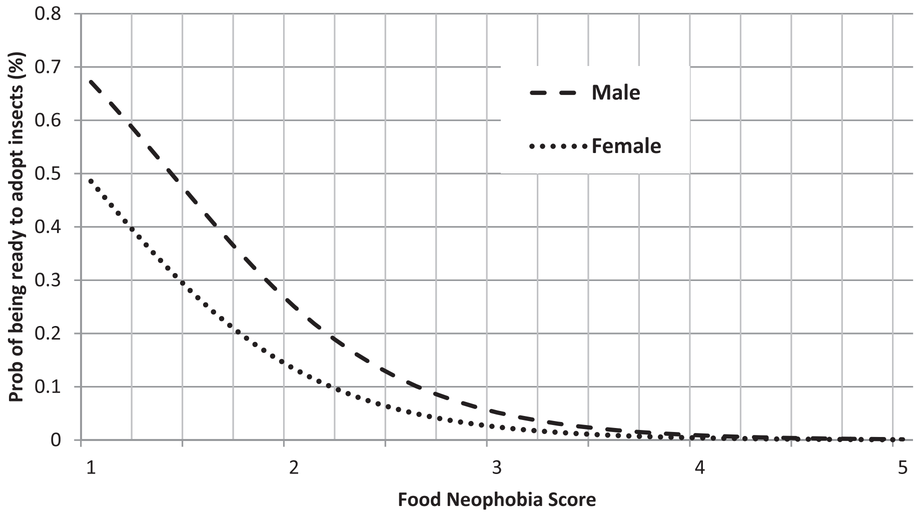

Fig. 1. Predicted probability p_i (%) of being ready to adopt insects as a substitute for meat depending on the food neophobia score for males and females assuming mean values for the other predictor variables in the model.

of consumers and across the (1–5) range of the food neophobia score. Fig. 1 illustrates that at a food neophobia score of 2.0 (and assuming mean values for the other predictor variables in the model) the probability of being ready to adopt insects as a substitute to meat amounts to 24.4% [95% CI: 13.6–35.2%] for a male and 13.0% [695% CI: 6.4–19.5%] for a female, claiming to be familiar with the idea of eating insects but not intending to reduce their meat consumption (the latter being the case for the majority of the sample). For these probabilities to amount to around 50%, the food neophobia score needed to be lower than 1.4 for males, and the scale minimum of 1.0 for females. Males (resp. females) who intend reducing their meat consumption have a probability of at least 50% from a food neophobia score of 2.2 or lower (1.8 or lower for females, respectively) of being ready to adopt insects as a meat substitute.

In a similar vein, Fig. 2 displays the predicted impact of food neophobia on two profiles of male consumers, i.e. probability profiles that are already higher than the equivalent profiles for females. The upper profile indicates the probability of a 30-year old male with a rather strong interest in the environmental impact of food choice (FEnv score = 3.5), who plans to reduce fresh meat consumption and claims to be familiar with the idea of eating insects, adopting insects as meat substitute. Up to a food neophobia score of 2.0, this person's probability of being ready to adopt insects as a meat substitute is 80% or more and, even with the mid-point score of food neophobia, this person would still have a probability of 35% of being ready to adopt insects as a foodstuff. Within the study sample, six cases or 4% of the male participants correspond with this profile (aged 30 years or less). The contrasting lower profile in Fig. 2 shows a 50-year old male who is a typical 'meat lover'. This person does not plan to reduce his fresh meat intake, is not familiar with the idea of eating insects and attaches a very high importance to taste when choosing meat (MTaste score = 5.0). Four cases or 2.7% of the male study participants correspond with this profile. Even with the lowest degree of food neophobia, this person's likelihood of being ready to adopt insects as a meat substitute is no more than 30% and it falls below 10% for a food neophobia score of 1.7 or higher.

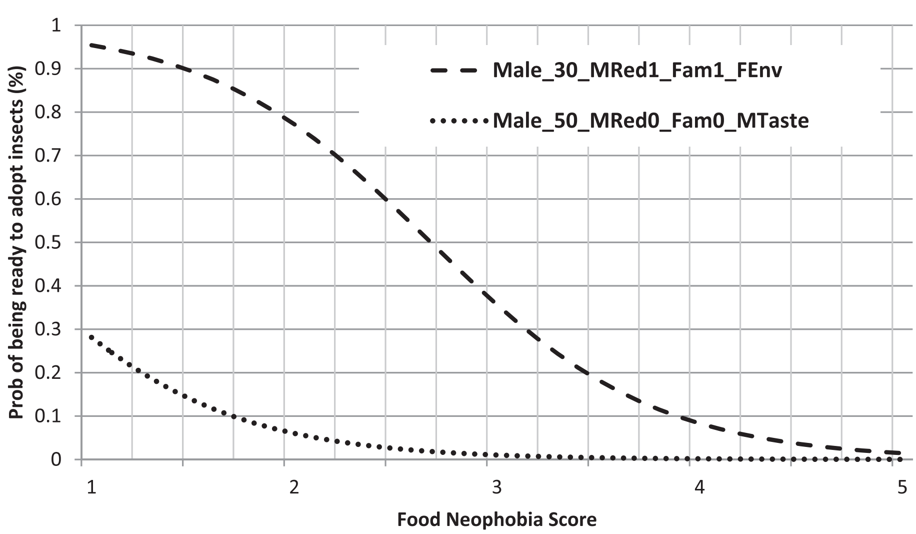

Fig. 2. Predicted probability p_i (%) of being ready to adopt insects as a substitute for meat depending on the food neophobia score for a 30-year old male who plans to reduce meat intake (MRed = 1), is familiar with the idea of eating insects (Fam = 1), and focuses on the environmental impact of food choice (FEnv = 3.5), and a 50-year old male who does not plan to reduce meat intake (MRed = 0), is not familiar with the idea of eating insects (Fam = 0) and focuses heavily on taste in meat choice (MTaste = 5.0) (the typical 'meat lover' profile).

Discussion and conclusion

Discussion

The present study has investigated 'typical' Western consumers' readiness to adopt insects as a meat substitute and the personal and food-related attitudinal determinants of this. Only 3% of the sample indicated to be 'definitely willing or ready' to adopt insects as a foodstuff, while another 16.3% claimed to be 'willing or ready'. Although these numbers are small, they signal at least some degree of readiness to try insects as a substitute for meat, which is consistent with the idea of a nucleus market for insects or insect protein that may further develop in Western countries. The share of one out of five people claiming to be ready to adopt insects contrasts with Vanhonacker et al. (2013) who found only five percent of a sample of consumers with similar socio-demographic characteristics and from the same study region to be definitely willing or willing to eat protein from insects. The findings also contrast with Megido et al. (2014), who reported that 78% of their study participants in Wallonia (Belgium) claimed to be "really interested in eating insects", despite 47% of their sample having a negative attitude about insect eating. An explanation for the contrast with the latter study is straightforward since Megido et al. (2014) surveyed a self-selected sample of people interested in insects, namely people who purposively visited an insectarium, half of whom were willing to participate in the study knowing that it included a sensory experiment, thus real insect eating.

A first possible explanation for the difference between our study's findings and the findings reported by Vanhonacker et al. (2013) is related to the timing of the studies. The data from Vanhonacker et al. (2013) were collected almost two years before the collection of the present data and the time interval between both studies has been marked by substantial negative mass media coverage relating to animal welfare in livestock production, fraud and contamination in the meat supply chain, and the possible negative consequences of meat consumption on human health and the environment. Continued negative publicity about meat, which has been shown to have a negative impact on consumers' intentions towards meat consumption (Verbeke, 2005b), is likely to have triggered consumers' interest in possible substitutes. Second, during this period, the FAO's 'Edible insects' report was published. It received extensive and positive coverage in the national media during the months preceding our data collection. This may have brought the idea of eating insects to the attention of consumers and shaped more favorable attitudes. A third possible explanation is that this study explicitly informed consumers that insects are a good source of high-value proteins, and that their production is efficient and therefore provides benefits in terms of sustainability. Both the negative press about meat, the favorable information about insects as a more sustainable alternative protein source, and the positive framing of the question about insect eating in our study may have triggered a stronger (claimed) readiness to adopt insects as a meat substitute.

Readiness to adopt insects was stronger among males than females, and stronger among younger consumers compared to older consumers. These findings are in line with Schösler et al. (2012) who also reported that women gave slightly lower ratings to visible insects as a possible meat substitute, and that older consumers were less likely to deliberately adopt alternatives to meat consumption. The same group in that study was also less favorably inclined to the convenience component (an insect protein-based pizza). Possible explanations (hypotheses) for the observed gender difference may be that males have a more adventurous taste orientation or find the idea of consuming insects less disgusting than women. De Boer et al. (2013) found a more adventurous taste orientation to be associated with a higher interest in consuming insects. Although Hoek, Luning, Stafleu, and de Graaf (2004) found non-users of vegetable-based meat substitutes to be relatively less educated, our study did not find educational level to have any influence on people's willingness to adopt insects as a meat substitute, a finding that is consistent with Schösler et al. (2012).

Many previous studies have confirmed the importance of familiarity as a driver for food product usage. Hoek et al. (2011), for example, found this to be the case for plant-based meat substitutes. Our study suggests much the same. Here, familiarity was not measured as claimed consumption frequency or product usage (since this was assumed to be extremely low), but more indirectly as self-reported awareness of what the eating of insects is about. This item may have reminded the participants of cultures where insects are traditionally eaten, and/or it may have reminded them of information received about the idea of eating insects in their own living environment. Assuming that familiarity is the result of information received, this finding suggests that people were generally favorably receptive to the information they were exposed to about the eating of insects.

This study found food neophobia to be the most important factor that determines consumers' readiness to adopt insects as a meat substitute. The study herewith supports the hypothesis about the effect of neophobia on consumers' willingness to eat insects as set forth by Megido et al. (2014). A similar conclusion was reported by Hoek et al. (2011) who investigated meat substitute acceptance in the U.K. and the Netherlands. This effect is consistent with many studies that have reported food neophobia to be a major barrier to the acceptance of and readiness to try novel foods (Siegrist et al., 2013), which is indeed the position of insects in Western countries. Interestingly, our study also confirms an additional and independent effect of food technology neophobia. This finding indicates that insects are not only perceived as a novel food but also as a food that is produced by unknown and unfamiliar food technologies that are perceived as unnecessary. The latter is surprising given the fact that relatively little technology is involved in the production and processing of insects. Our results signal that consumers may hold a range of (sometimes conflicting) views about the technological processes involved in producing insects. Hence, informing people about how insects are grown and stressing the low level of technology involved in this process (though this may change as industrial mass production of insects is envisaged (Rumpold & Schlüter, 2013)), might have a positive impact on the readiness to adopt this product.

While controlling the confounding effects of age, gender, education, and personal traits such as neophobia, both general food choice motives and specific meat-related attitudes were found to contribute significantly and additionally to explaining consumers' readiness to adopt insects as a meat substitute. Food choice motives that trigger readiness to adopt insects as a meat substitute are: convenience orientation in relation to food, attention to the environmental impact of food choice and, to a lesser extent, interest in the health characteristics of food. The observed effect of convenience orientation suggests that insects might be most appealing as a snack or an ingredient in convenience foods, which corroborates the findings presented by Schösler et al. (2012). This is consistent with the current positioning of insect-based foods such as termite-based crackers, Buqadilla (a snack made from chickpeas and mealworms) and Crikizz (a snack based on meal worms and cassava) (van Huis et al., 2013: 108). Attention to the environmental impact of food choice was also associated with a higher likelihood of adopting insects as a meat substitute. This confirms that people recognize the environmental benefits of the eating of insects instead of meat. By contrast, health interest in food choice had a marginal effect on people's reactions to the eating of insects, suggesting that people are not yet convinced about the possible health benefits as compared to meat consumption.

Our findings related to the effect of meat-related attitudes corroborate with Hoek et al. (2011) who also reported that a stronger interest in the sensory appeal of meat acts as a barrier to becoming a user of a meat substitute. Their study showed that non-users of meat substitutes had very positive attitudes and beliefs towards meat. Our findings confirm that a stronger conviction that meat is a nutritious and healthy food is associated with a lower readiness to accept insects as a meat substitute. It comes as no surprise that having no intention to reduce meat intake dramatically lowers the probability of adopting insects as a meat substitute.

Limitations and avenues for further research

The dependent variable for our model was specified as a binary choice despite the fact that our original variable was measured on a 5-point scale. Although dichotomizing implies a possible loss of information, we believe this approach is justified on practical and empirical grounds for this study. Besides the fact that alternative modeling approaches suffered from diverse problems or contributed little in terms of empirical insight, binary choice modeling facilitated unambiguous interpretation of the effects, as well as the calculation and mapping of predicted probabilities.

Although the goodness-of-fit statistics of our model are satisfactory, additional predictive ability might be gained from the inclusion of other possible predictors of consumers' readiness to adopt insects. Our study did not include specific beliefs or perceptions about the eating of insects, or direct measurements of possible motives and barriers to doing so. Specific beliefs towards insects, as well as how attributes of insects are perceived in relation to meat are likely to play a role in consumers' willingness to try this novel food (Hoek et al., 2011). It has been shown that consumers' willingness to try unfamiliar or novel foods are influenced by beliefs about their 'disgusting' properties and the reactions evoked by the thought of consuming them (Martins & Pliner, 2005, 2006). The first dimension, of being potential disgust elicitors, seems to be especially relevant in the case of insects. Martins and Pliner (2005,2006) showed that disgust reactions are particularly strong towards unfamiliar animal foods, owing to (expected) aversive textural properties and reminders of livingness or animalness. Future studies that complement the list of predictors included in our model with product-specific beliefs or perceptions and emotional reactions such as disgust, as well as analyses that investigate effects by moderation or mediation are recommended. Additional socio-cultural factors that merit attention in future consumer studies dealing with the eating of insects are for example religion (cf. possible positions towards entomophagy in Judaism or Islam that may depend on regional schools of thought as seen for example in halal meat markets (Lever & Miele, 2012)), ethnicity and acculturation.

Another limitation of our study is related to its use of a single item referring explicitly to readiness 'to eat insects as a substitute for meat', thus discarding the possibility that insect can be eaten for other reasons than substituting meat. Different types of consumers may indeed accept insects in different ways, e.g. as a snack or component of a dessert rather than as a meat replacer. Furthermore, the item used in this study refers to the term 'insects', which presumably has been primarily interpreted as whole or visible insects rather than insect protein (as flour or ingredient) or any other product form in which the insect origin of the food is less visible. Schösler et al. (2012) have shown that consumers' responses to insects are dependent on the form in which the products are presented to them and that these responses vary between visible insects, chocolate-coated insects and insect-based protein in pizza, for example. The likelihood of acceptance generally increases with a decreasing degree of visibility of the whole insect, thus our findings may present a kind of worst-case picture in terms of Western consumers' readiness to adopt insects or insect protein. An important exception is probably the presence of insects or insect protein associated with the notion of contamination. In accordance with Rozin and Fallon (1987), even the tiniest, sensorial undetectable trace of a disgusting item may render an otherwise acceptable food unacceptable, which means that even insect powder would be problematic among consumers who consider insects as 'objects having contamination properties'. Finally, the focus on a relatively small study region (Flanders, Belgium) implies that the findings of this study cannot be readily generalized to other regions or parts of Western society where the eating of insects is uncommon. Nevertheless, our insights show the most relevant determinants that are probably (at least partly) transferable to other study regions and populations. Further studies in other countries are therefore recommended.

Conclusion

This study provides consumer insight about the eating of insects that can generate input for product development, market positioning and communication strategies, both within Western societies and beyond. A more successful positioning and a growing marketplace acceptance of insects or insect protein in Western societies may help to pave the way towards realizing insects' full potential in terms of ensuring global food and feed security, also in developing countries where the eating of insects is under pressure owing to westernization of diets. Positive outcomes in terms of the acceptance of insects as a foodstuff in Western societies may contribute to the preservation of traditional insect-based diets, and halt the reduction in the use of insects in developing countries.

The relatively low general readiness to adopt insects as a meat substitute indicates that rather strong manipulations that directly target (for example) particular population groups, or the mechanisms underlying disgust reactions, may be required to reduce individuals' beliefs about the disgusting properties of novel animal foods (Martins & Pliner, 2006). Our study revealed the population groups that are most and least likely to adopt insects, and thus those groups that might be seen as possible target segments and audiences. Hoek et al. (2011: 672) state that "simply providing information about, and increasing awareness of the environmental benefits of eating meat substitutes is not likely to be very effective". This is supported by our findings since environmental concern was not the primary focus of our study participants when purchasing food. Stressing personal health benefits might appeal more to consumers' interests and be more effective since consumers reported that health is a relatively strong factor influencing their food choice. However, health seemed to play only a marginal role in influencing people's willingness to adopt insects as a foodstuff, suggesting that people are not aware or not convinced yet of the possible health benefits of substituting insects for meat. One promising strategy might be to focus on communicating with consumers who are planning to reduce their meat intake about the production and the eating of insects.

This study revealed the consumer groups in Western societies that are most likely to be the early adopters of insects, who can be targeted as possible trendsetters. The profile of this group is younger males with weak attitudes towards meat who are open to trying novel foods, and who are interested in the environmental impact of their food choices. With low levels of neophobia, the likelihood that this type of person is ready to adopt insects as a meat substitute is more than 75%. Whether these people will indeed be the actual consumers of insects is likely to be affected by the end products that become available. By contrast, this study shows that it is very unlikely that 'typical' Western meat lovers would consider including insects in their diet.

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