PAPER

NEW SUSTAINABLE PROTEIN SOURCES: CONSUMERS' WILLINGNESS TO ADOPT INSECTS AS FEED AND FOOD

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ABSTRACT

The aim of the study was to investigate the willingness of Italian consumers to adopt insects, suitable candidates for providing sustainable animal proteins, as part of animal and human diets. Furthermore, we evaluated the effect of information about the benefit of introducing insects into the diet on consumers' acceptance. The results showed that respondents were clearly not ready to accept insects as food, whereas a major positive trend was observed regarding their use as feed. The principal factors affecting the Italian consumers' readiness to adopt insects as food and feed were age, gender, cultural background and food neophobia. Contrary to our expectation, subjects' involvement in sustainability issues did not play a role in the acceptance of insects. Information about the environmental and nutritional benefits of introducing insects as food had a marginal but positive effect on their visual acceptability.

Keywords: consumer acceptance, entomophagy, familiarity, novel protein sources, sustainability

1. INTRODUCTION

The consumption of insects is traditionally practiced in many parts of the world, particularly in the Southern Hemisphere, with more than 2000 species of insects consumed not only because of their nutritive value but also because of their taste (DEFOLIART, 1997; NONAKA, 2009).
The world population, which will reach 9.6 billion people in 2050, will create a growing demand for animal protein that will require increased food and feed outputs (United Nations, 2015). Many insect species can be regarded as suitable candidates for providing sustainable animal proteins (RUMPOLD and SCHLÜTER, 2013a; SÁNCHEZ-MUROS *et al*., 2014). Consuming insects (or insect protein) instead of protein derived from livestock has numerous advantages. Insects are poikilothermic, have a higher feed-conversion efficiency than that of conventional livestock (i.e., insects need less feed for the production of 1 kg of biomass than livestock do) (NAKAGAKI and DEFOLIART, 1991), have a much higher fecundity level (i.e., produce more than one generation during a single season) and are mostly omnivorous, therefore could be raised on various organic waste; they might contribute a smaller amount of greenhouse gases than conventional livestock (OONINCX *et al*., 2010), and they have low requirements for space and water during the rearing process. In addition to these numerous advantages, their nutritional value has long been recognized (RUMPOLD and SCHLÜTER, 2013b). In fact, several articles have been published addressing the nutritive value and nutrient composition of various insects (i.e high level of polyunsatured fatty acids, high concentration of macronutrient and vitamins) (MAKKAR *et al*., 2014; HENRY *et al*., 2015). However, the presence of potentially harmful ingredients in insects, such as allergens, should be investigated to ensure that they are safe food and feed products (BELLUCO *et al*., 2013; RUMPOLD and SCHLÜTER, 2013b).
Currently, in Europe, there is a restrictive legislation about the use of insects as food and feed (Regulation (EC) No. 178/2002; Regulation (EC) No. 1069/2009; Regulation (EC) No. 999/2001; Regulation (EC) No. 258/1997; Commission Regulation (EU) No. 142/2011). Nevertheless, due to the growing interest in insects as alternative sources of proteins, initiatives have begun to emerge to create an enabling environment for the development of regulations and standards for the use of insects in feed and food. In particular, New Regulation on Novel Food had been approved by the EC and whole insects had been inserted among novel food (Regulation (EC) No 2015/2283).
Consumers' acceptance, in addition to the legislative obstacle, remains one of the largest barriers to adopting insects as sources of protein in many Western countries (VAN HUIS *et al*., 2013). There are few examples of traditional insect dishes that are consumed, such as "maggot" cheese in Italy (i.e. casu marzu) and palm larvae in Reunion Island. In fact, particularly in urban and Western societies, insects are rarely eaten or their consumption is perceived to be culturally inappropriate (VAN HUIS, 2013b) and disgusting (NONAKA, 2009).
Although it is an innate reaction (HERZ, 2012), disgust plays a major role in people's food rejection. Like other emotions, the origins of disgust are rooted in one's culture. In fact, food culture defines the rules of what is edible and what is not. In Western societies, insects have been rarely considered an edible food source. Consequently, they are rejected because they are considered to be non-food, unclean and a health risk (HARTMANN *et al*., 2015; LOOY *et al*., 2014).
From an evolutionary point of view, when a new food product is introduced into a culture, it generally induces feelings of fear and refusal called neophobia (PLINER and SALVY, 2006). Food neophobia, defined as the fear and aversion to new foods, is expected to reduce the likelihood of readiness to incorporate insects into the diet (MEGIDO *et al*., 2014; VERBEKE, 2015). The relation between entomophagy and food neophobia can be

explained in at least two ways (ROZIN and FALLON, 1987): first, the rejection of insects as food may depend on the knowledge of their origin and habitat; and second, this rejection may be based on negative post-ingestional consequences.
One of the factors shown to be most effective in establishing behavioural changes regarding food is exposure to it. Food exposure increases the familiarity to a stimulus through a mechanism of learned safe behaviour, thus reducing neophobic reactions (LAUREATI *et al*., 2015a). Information is also a factor that has been reported to play a role in consumers' acceptance (LAUREATI *et al*., 2013; 2016). Information about the ecological and nutritional benefits of employing insects as feed and food may be used to promote entomophagy (VERBEKE, 2015). Despite this, to our knowledge, there are no studies investigating how information provided to consumers might modulate their willingness to adopt insects as food and no studies are available on Italian consumers, who are known to have a deeply rooted culinary culture.
In addition, research studies to evaluate the readiness of Western consumers to incorporate insects into animal and human diets have been conducted mainly on Dutch and Flemish subjects (MEGIDO *et al*., 2014; TAN *et al*., 2015; DE BOER *et al*., 2013; VERBEKE, 2015) but never considering the willingness of consumers' from other European countries. This issue is of particular relevance in view of the role played by cross-cultural differences in accepting insects as food (TAN *et al*., 2015; SCHÖSLER *et al*. 2012; MEGIDO *et al*. 2014).
Based on these assumptions, the first aim of the present study was to evaluate the willingness of Italian consumers to adopt insects as part of animal and human diets and to investigate which are the main factors (e.g., socio-demographic factors, food neophobia and involvement in sustainability issues) that affect readiness to use this alternative food source. These factors have been reported to play a role in the willingness to adopt new and sustainable food (LAUREATI *et al*., 2013; VERBEKE, 2015). The second objective of the study was to investigate whether and how information can influence willingness to taste insects and their acceptability. This was achieved by comparing willingness to adopt insects in consumers with different awareness of the topic (i.e. students and staff from the Faculty of Agricultural and Food Science of the University of Milan and consumers from outside the university context) and by investigating how the information about the benefits of including insects in animal and human diets influenced the consumer acceptance of this type of food.

2. MATERIALS AND METHODS

2.1. Participants

Three hundred and forty one adults (223 females and 118 males) aged 18 to 80 years (M = 31.9; sd = 15.6) were recruited from the students and employees of the Faculty of Agriculture and Food Sciences of the University of Milan and from consumers from outside the university. This choice was made in order to compare two groups of consumers with a different awareness of the topic: university students and staff are expected to be more involved in the topics of insects and sustainability since these topics are studied, investigated, and debated in University courses. The inclusion criteria were being ≥ 18 years of age and being Italian. These subjects were involved in the first part of the study, which involved completing a questionnaire aimed at investigating their propensity towards incorporating insects into animal and human diets. A subset of these subjects consisting of university students (n=68, 42 females and 26 males, age 21.4 ± 3.9) was asked to participate in a second experiment, which consisted in evaluating the visual

acceptability of a series of food products made using insects. Unfortunately, at this stage consumers from outside the university were not available or not willing to come to the laboratory. Written informed consent was obtained from each subject after the aim of the experiment was described.

2.2. Questionnaire: assessment of consumers' willingness to incorporate insects into diets

The questionnaire for the evaluation of the willingness of the subjects to use insects as a food source for humans and animals was administered via the web and social networks. The questionnaire, which consisted of 52 questions, was divided into four sections.

2.2.1. Section 1 – Socio-demographic information

The first section concerned information about gender, age, awareness of the topic (i.e., university student/staff or consumers from outside the university), place of residence and monthly family income. The characteristics of the participants are reported in Table 1.

Table 1: Characteristics of the participants (n=341) reported as mean ± standard deviation (sd) or percentage of answer.

Variable		Percentage/mean ± sd
Age (years)		31.9±15.6
Gender	Male	34.6%
	Female	65.4%
Income	Low (< 1500€/month)	30.3%
	Medium (1500€ < income < 3000€)	45.3%
	High (≥ 3000 €/month)	24.4%
Place of residence	City	40.5%
	Small town	59.5%
Awareness of the topic	University students and staff	47.2%
	Consumers from outside the university	52.8%

2.2.2 Section 2 – Willingness to incorporate insects into diets

The second section consisted of questions related to the propensity towards the consumption of insects by humans and animals. The questions about the willingness to consume insects were structured to investigate consumers' readiness to use insects as feed ("If insects were used as a supplement in feed formulae for aquaculture and livestock, would you be willing to eat the meat and fish from animals that had been fed in that way?"), food ("Would you be willing to eat food obtained from insects, e.g., biscuits produced using insect flour?") and in a specific eating context ("If in an ethnic restaurant you were offered a dish based on insects, would you be willing to taste it?"). For each question, each subject had to indicate the degree of agreement using a 5-point scale (1= "I strongly disagree", 2= "I disagree", 3= "I neither agree nor disagree", 4= "I agree" and 5= "I strongly agree").

2.2.3. Section 3 – Consumers' food neophobia evaluation

Food-neophobia was assessed because this personal trait has been indicated as one of the major predictors of rejection of insects as food (VERBEKE, 2015). Food neophobia was measured using the food-neophobia scale (FNS) developed by PLINER and HOBDEN (1992). The FNS consisted of five neophilic ("I am constantly sampling new and different foods"; "I like foods from different countries"; "At dinner parties, I will try a new food", "I will eat almost anything", "I like to try new ethnic restaurants ") and five neophobic ("I do not trust new foods"; "If I do not know what is in a food, I won't try it"; "Ethnic food looks too weird to eat"; "I am afraid to eat things that I have never had before"; "I am very particular about the foods I will eat") statements about food or situations related to food consumption. The participants were asked to indicate the level to which they agreed or disagreed with the 10 statements. Responses were given on a 7-point agreement scale, ranging from ''strongly disagree'' to ''strongly agree.'' After reverse coding the responses for the neophilic statements, a total FNS score ranging from 10 to 70 was then calculated by summing the ratings for each item; the higher the FNS score, the higher the food-neophobia level. Cronbach's alpha was satisfactory (alpha=0.90).

2.2.4. Section 4 – Consumers' sustainable behaviour

Two batteries of questions were used. Both questions were based on the Theory of Planned Behavior (TPB) (AJIZEN, 1991), which has been proven to be a proper theoretical framework for understanding sustainable and ethical consumer behaviours concerning food (LAUREATI *et al*., 2013). The first question investigated the consumer's actual sustainable behaviour ("Recently, how often have you performed the following actions?"), by asking them to indicate how often (never = 0 times, rarely = 2-3 times a month; sometimes = 1-2 times a week, often = 3-4 times a week; and always = every day) they performed a series of sustainable and non-sustainable actions (e.g., to separate their waste, save energy or consume foods of exotic origin). Cronbach's alpha was satisfactory (alpha=0.81). The second question was related to the subject's level of involvement and interest in some of the major sustainability issues ("For each of the following items, please indicate the statement that best fits your experience"), for instance, the exploitation of Third World people, respect for the environment and the promotion of organic farming. Subjects had to answer the question by choosing one of the following options: "I am not aware/I never heard or paid attention to this matter"; "I know what it is but I'm not interested"; "I know what it is; I'm interested but I have never done anything about it"; "I am interested and I did some small action, for example, I spoke with someone about it" and "I am interested and I've done something meaningful, for example, I changed brand". Cronbach's alpha was satisfactory (alpha=0.77).
These two questions were used to categorize the consumers according to their sustainability level as indicated by LAUREATI *et al*. (2013) and to verify whether this behaviour might influence their willingness to accept insects as food.

2.3. Expected liking of insect-based food

A group of consumers (n= 68, 42 females, 26 males, mean age = 21.4y ± 3.8) who had previously completed the questionnaire participated in a visual hedonic assessment of a series of insect-based foods. The evaluation was conducted in two distinct phases. The first phase consisted of viewing eight images of foods containing insects or insect derived proteins, accompanied by a brief description of the food to inform them about what the product was when this was not interpretable from the image alone. After viewing each

image, the consumers had to express their expected liking using an unstructured linear scale anchored at the extremes by "Extremely disliked" (corresponding to 0) to "Extremely liked" (corresponding to 100). Then, they were presented with information about the nutritional and environmental benefits of using insects as food and feed. The information provided was as follows: *"The global increase in population resulting in a higher demand for food has led to the need to find new and more sustainable sources of protein. The consumption of insects, already practiced in some Eastern cultures, could spread to our culture. Insects are increasingly recognized as an excellent alternative protein source for use in animal feed and human diets. Many species are highly nutritious, and the production of insects has less environmental impact compared to that of traditional sources of protein. Insects can also be raised inexpensively and rapidly on a wide range of organic materials, such as the vegetable waste of households and industries, reducing the overall quantity of waste by up to 60%"*.
After viewing this information, consumers were asked again to express their expected liking for the same eight insect-based foods previously viewed and described. The purpose of providing the information was to determine whether and how being informed of the potential benefits of using insects as food could improve their acceptance of the food shown. The images were displayed on a screen in a randomized order in individual booths at the sensory laboratory of DeFENS (University of Milan). Fizz software version 2.43 was used for hedonic data acquisition (Biosystemes, Couternon, France).
The appearance and visual components of foods are critical for their acceptance; hence, the images were chosen according to the level of visibility of the insects. Thus, insects were not visible in some of the chosen foods (e.g., biscuits made using insect flour), insects were present but in a disguised form or were partially hidden in other foods (e.g., chocolate-coated grasshoppers), or insects were clearly visible in a third category of foods (e.g., cheese with larvae). Furthermore, the foods selected for viewing included sweet products (i.e., biscuits, chocolate, snack-bar and lollipop) as well as non-sweet formulations (i.e., tequila, rice, salad and cheese). The images were selected from the internet and referred in some cases to existing foods, e.g., tequila with worms that is traditionally consumed in South America and casu marzu (literally "rotten cheese"), a typical Sardinian gastronomic product notable for containing live insect larvae (maggots). In other cases, the images referred to dishes that were completely new and unusual for the Italian consumer, such as an apple salad containing insects or a risotto containing larvae. However, all of the products should be considered extremely unusual in the Italian gastronomic culture. The images selected for the hedonic assessment are shown in Fig. 1.

2.4. Data analysis

To evaluate the effect of the questionnaire variables on consumers' readiness to accept insects as feed, as food and in a specific eating context (i.e., in an ethnic restaurant), the willingness data were assigned a score to each answer, as follows: "I strongly disagree" = -2; "I disagree" = -1; "I neither agree nor disagree" = 0; "I agree" = 1; "I strongly agree" = 2. After having verified that the data were normally distributed, a mixed analysis of variance (ANOVA) using a generalized linear model (GLM) was applied considering the main factors subjects, gender, income (low, medium, high), place of residence (city vs small town), awareness of the topic (from the university vs outside the university), the consumer's food neophobia (low, medium, high) and the consumer's sustainable behaviour (low, medium, high) and the willingness data as the dependent variables. The subjects were considered as a random factor in the model.
The consumers were categorized as having a low, medium or high level of food neophobia and sustainable behaviour according to LAUREATI, BERTOLI *et al*. (2015a) and LAUREATI *et al*. (2013), respectively. The frequency distribution of the FNS scores was

calculated and the subjects were divided into the 3 following groups: "low neophobia" (subjects in the lowest quartile, FNS scores ≤ 23, n=86), "medium neophobia" (subjects in the second and third quartile, FNS scores ≥ 24 and ≤ 41, n=166) and "high neophobia" (subjects in the highest quartile, FNS scores ≥ 42, n=89).

Figure 1: Images of the insect-based foods shown to the consumers in the expected liking assessment.

In the same way, for each subject, an index for the actual sustainable behaviour and an index for awareness and interest in sustainable issues were calculated as the mean value of the scores for the different items in each of the two questions. Then, the distribution frequency of the scores for each index was calculated. The subjects with a score within the lowest quartile of both distributions (actual sustainable behaviour: ≤ 3.33, awareness: ≤ 3.25) were considered as having a "low sustainability level" (37 subjects), whereas the subjects with a score over the highest quartile of both distributions (actual sustainable behaviour: ≥ 4.00, awareness: ≥ 4.12) were considered as having a "high sustainability level" (52 subjects). The rest of the subjects were considered as having a "medium sustainability level" (251 subjects). The size of these groups was consistent with the results of a previously mentioned study (LAUREATI *et al*., 2013).
The effect of age on the propensity towards insect consumption in the three situations (i.e., as feed or food, in an ethnic restaurant) was investigated using Pearson's correlation test.
The liking data were subjected to a mixed ANOVA model using a GLM, considering the subjects, gender, food neophobia level (low, medium, high), the foods (the 8 pictures), the condition (non-informed *vs* informed) and the interaction foods by condition as the factors and the hedonic scores as the dependent variable. The subjects were considered a random factor in the model. The other background variables (e.g., age and income) were not included in this model because only students were involved in the hedonic test or because of the small number of participants was inappropriate (e.g., sustainability level).
When the ANOVAs indicated significant differences ($p < 0.05$), t-tests (SAS option lsmeans pdiff) were used as the multiple comparison tests. All of the statistical analyses were performed using SAS 9.3 software (SAS Institute Inc., Cary, NC, USA).

3. RESULTS

3.1. Willingness to adopt insects as feed and food

In a preliminary phase of the analysis, the data obtained using the questionnaire concerning consumer's willingness to incorporate insects into human and animal diets were reported as frequency responses to allow an overview of the results. In this first stage, the consumers were categorized into the following three groups: willing (the sum of people who answered "I agree very much" and "I agree"), uncertain (the people answered "I neither agree nor disagree") and unwilling consumers (the sum of people who answered "I disagree very much" and "I disagree"). The proportions of answer to the questions related to using insects as feed ("If insects were used as a supplement in feed formulae for aquaculture and livestock, would you be willing to eat the meat and fish from animals that had been fed in that way?"), food ("Would you be willing to eat food obtained from insects, e.g., biscuits produced using insect flour?") and in a specific eating context ("If you were offered a dish based on insects in an ethnic restaurant, would you be willing to taste it?") are reported in Table 2.
Approximately 53% of the consumers (of which 19.1% strongly agreed and 33.7% agreed) declared themselves to be ready to incorporate insects into animal diets and to eat fish and livestock reared upon insect-containing feed. Concerning incorporating insects into the human diet, a considerable decrease in the percentage of willing people was observed, with only 21.1% (16.7% agreed; 4.4 strongly agreed) and 31.1% (21.4% agreed, 9.7% strongly agreed) of people ready to eat food derived from insects and to consume insects in a specific eating context, respectively. The percentage of uncertain people was approximately the same for the three situations, with 25.5% uncertain regarding insects as

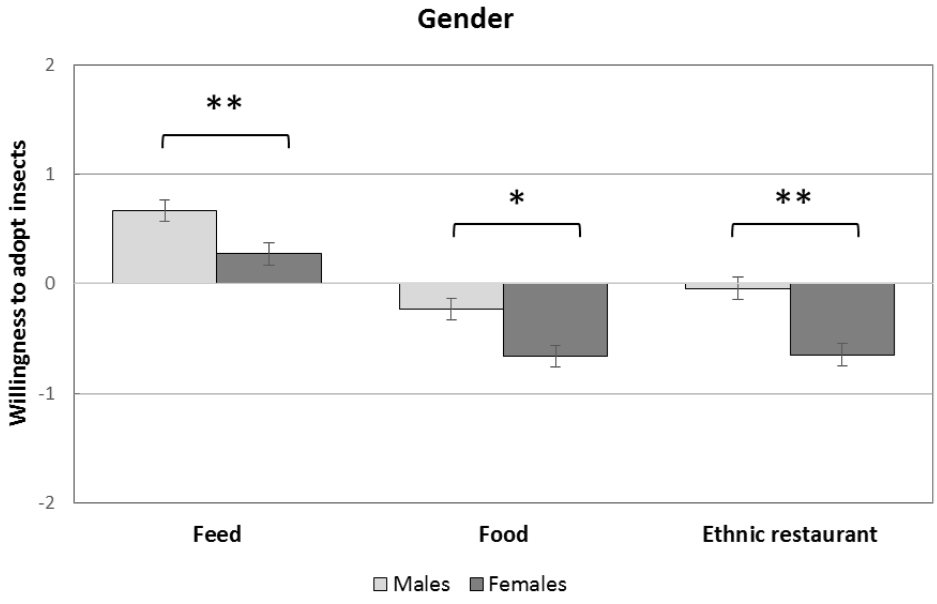
feed, 28.5% uncertain regarding insects as food and 20.5% uncertain regarding eating insects in a restaurant.

Table 2: Percentage of answer to the questions related to the consumer's willingness to accept insects as feed, as food and in a specific eating context (i.e., in an ethnic restaurant).

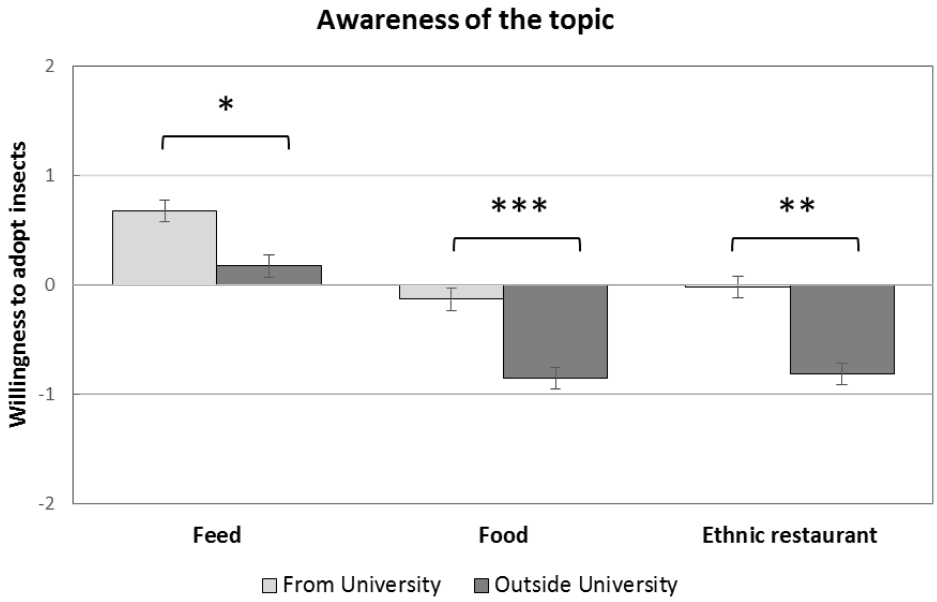
Willingness	Answer	Insect use		
		Feed	Food	Specific context (ethnic restaurant)
Unwilling	I strongly disagree	9.1	26.1	36.1
	I disagree	12.6	24.3	12.3
Uncertain	I neither agree nor disagree	25.5	28.5	20.5
Willing	I agree	33.7	16.7	21.4
	I strongly agree	19.1	4.4	9.7

To quantitatively compare the effect of each variable considered in the questionnaire (e.g., socio-demographic, eating behaviour and sustainability), the data on the willingness to accept insects were analysed using an ANOVA. Only the factors gender (Feed: $F=6.71$, $p<0.01$; Food: $F=4.40$, $p<0.05$; Restaurant: $F=9.71$, $p<0.01$), awareness of the topic (Feed: $F=6.65$, $p<0.05$; Food: $F=16.39$, $p<0.0001$; Restaurant: $F=10.94$, $p<0.01$) and food-neophobia level (Feed: $F=10.54$, $p<0.0001$; Food: $F=32.82$, $p<0.0001$; Restaurant: $F=37.12$, $p<0.0001$) had a significant effect on the consumers' willingness to incorporate insects into both animal and human diets, whereas income, place of residence, and involvement in sustainability issues did not play a role. Income had a marginal effect ($F=2.64$, $p<0.10$) only on the willingness to consume insects within a specific eating context (i.e. restaurant).
The mean values of the consumers' willingness to accept insects according to gender, awareness of the topic and food-neophobia level are shown in Figs. 2 a-c.

a



b



c

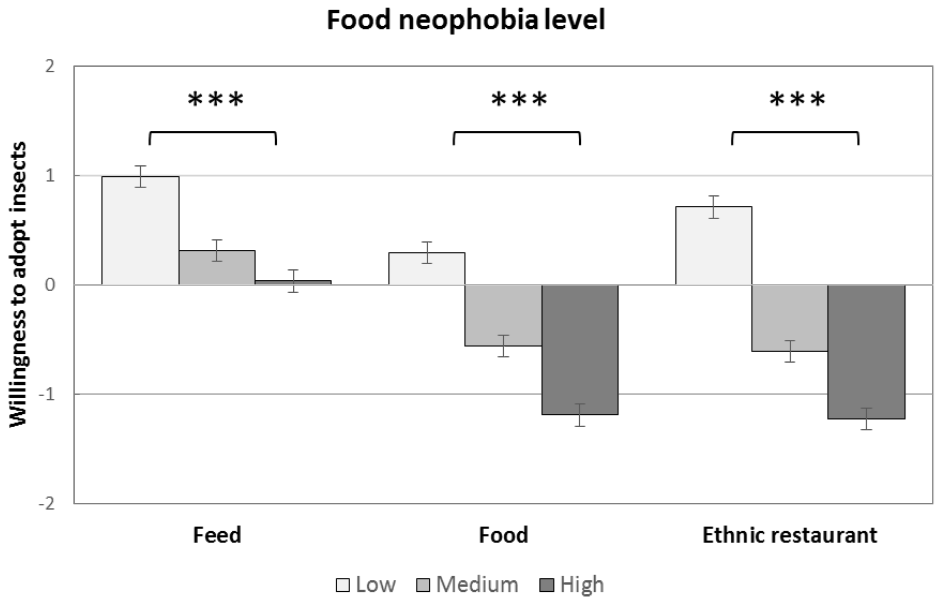


Figure 2a-c: Mean values (±SEM) of consumers' willingness to accept insects in the three situations, according to gender (a), awareness of the topic (b) and food-neophobia level (c).
* significant difference at $p<0.05$; ** significant difference at $p<0.01$; *** significant difference at $p<0.001$.

Males were significantly more willing than females to consume insects in all situations (Fig. 2a). People with a higher level of education about the topic (i.e., university students and staff) were significantly more ready to accept insects as feed, as food and in an ethnic restaurant than less-aware people (Fig. 2b). Furthermore, people with a low level of food

neophobia (i.e., neophilic people) were significantly more willing to accept insects as feed, as food and in an ethnic restaurant than people with a medium level of food neophobia who, in turn, showed a significantly higher readiness than neophobic consumers (Fig. 2c). Although the correlation coefficients were somewhat low (feed: r= -0.41, food: r= -0.43, restaurant: r= -0.45), a significant ($p<0.01$) negative relationship was seen between age and the willingness to accept insects in all of the situations, indicating that younger people were more ready to accept insects.

3.2. Expected liking of insect-based foods

A total of 68 students who had completed the questionnaire were involved in a hedonic test that evaluated their degree of liking for a series of insect-based foods shown in images. Liking was evaluated before and after the consumer received information regarding the environmental and nutritional benefits of consuming insects as part of animal and human diets. The mean hedonic values before (non-informed condition) and after the information was provided (informed condition) are reported in Table 3. As expected, the mean acceptability ratings were in general very low (ranging from 21.0 to 50.7 on a scale of 0 to 100). ANOVA results showed a significant effect of the main factor Food ($F=10.40$; $p<0.0001$). According to the results of post-hoc test, before receiving the information about the benefits of consuming insects, biscuits made using insect flour (M=44.8) and chocolate-coated grasshoppers (M=38.9) were significantly more liked than were the other products. A cereal bar containing insects (M=31.8), an apple salad containing insects (M=29.2) and tequila containing a larva (M=24.8) were very much disliked; however, they received significantly higher ratings compared with risotto containing larvae (M=22.1), cheese with larvae (M=21.9) and lollipops containing larvae (M=21.0), which were extremely disliked. A similar ranking of products was seen after the consumers had received the information (Informed condition, Table 3).

Table 3: Mean acceptability ratings (range 0-100) before (non-informed condition) and after (informed condition) the consumer had received information about the environmental and nutritional benefits of using insects in animal and human diets. The different superscripted letters within the columns indicate significant differences ($p<0.05$).

Food	Condition		
	Non-informed (N)	Informed (I)	I-N [1]
Biscuits made using insect flour	44.8^{a}	50.7^{a}	*
Chocolate-coated grasshopper	38.9^{a}	44.5^{a}	*
Cereal bar containing insects	31.8^{b}	44.8^{a}	**
Apple salad containing insects	29.2^{bc}	31.7^{b}	n.s.
Tequila containing a larva	24.8^{cd}	27.3^{bc}	n.s.
Risotto containing maggots	22.1^{d}	22.4^{c}	n.s.
Maggot cheese	21.9^{d}	23.3^{c}	n.s.
Lollipops containing larvae	21.0^{d}	25.5^{bc}	n.s.

[1] Significance of the difference between the hedonic mean values before (N) and after the information (I) was provided, according to the t-test.
* indicates a significant difference at $p<0.05$;
** indicates a significant difference at $p<0.01$; n.s. indicates a non-significant difference

The main factor condition had a significant effect on the acceptability of insects as food ($F=5.51$; $p<0.02$) effect. Overall, the mean acceptability ratings for all of the products increased under the informed condition (Non-informed condition: M=29.3; Informed condition: M=33.8), even though the increase was significant only for the biscuits made using insect flour, chocolate-coated grasshopper and the cereal bar containing insects. The interaction Food by Condition was not significant, meaning that under the informed condition, the acceptability ratings were systematically higher than they were under the non-informed condition regardless of what food was concerned. However, this result also indicated that the information provided generally had little impact on the acceptability ratings. Finally, regarding the willingness to accept insects as food, gender ($F=47.11$; $p<0.0001$) and food-neophobia level ($F=15.30$; $p<0.0001$) strongly affected the level of expected liking. According to the results of a post-hoc test, males (M=37.2) liked the insect-based foods more than females (M=24.1), and neophilic people (M=37.8) provided significantly higher ratings than people with a medium (M=29.2) or a high degree of food neophobia (M=25.0).

4. DISCUSSION

The results of the present study indicated that the interviewed Italian consumers are clearly not ready to incorporate insects into their diets. A more positive attitude was observed for utilizing insects in farming. More than half of the consumers declared themselves to be favourable towards the use of insects in animal feed and to eating livestock that had been reared with insects as a supplement in the diets. This outcome was understandable because fishes and many other farmed animals, such as poultry and pigs, eat insects when they are reared in natural environments. Thus, this phenomenon could make the consumer more willing to accept the systematic use of insects or relevant derivatives thereof (e.g., flour) in farming.

It should be noted that, although the percentages of people who were willing to introduce insects into their diets (21%) or to consume them in an ethnic restaurant (31%) were apparently low, these values are similar to or even higher than those observed in other studies conducted with other European consumers (VANHONACKER *et al*., 2013; VERBEKE, 2015; DE BOER *et al*., 2013). MEGIDO *et al*. (2014) reported a higher percentage of willing people than that found in our study, corresponding to 78% of their Belgian participants. This very high rate, however, is explained by the sample of people who were surveyed in their study, who had purposely visited an insectarium and thus were very interested in insects (and in eating them). This consideration can also be applied to our sample of consumers because approximately half of them were students and staff from a university in which the topic of insects is studied. However, when only the percentage of willing consumers from outside the university was considered, 13% and 21% of them declared themselves to be willing to introduce insects into their diets or consume them in an ethnic restaurant, respectively. These data demonstrate that one of ten or five people claimed to be ready to incorporate insects in their diets, thus indicating some degree of readiness to try to eat insects, which is consistent with the idea that a market niche for insects or insect protein may develop in Western countries (VERBEKE, 2015). Analysing the recent literature concerning the readiness to accept insects as meat substitutes or more generally as part of the human diet, it is evident that most of the studies were conducted using Belgian or Dutch people. In this context, the results of the present study provide an insight into the willingness to adopt insects as food of a consumer target living in a Mediterranean region with different eating habits compared with those in Belgium and The Netherlands. In this sense, Italian subjects' attitude towards insects appeared to be

comparable to or even a little more positive than those of consumers from other European countries.

A series of variables were investigated to determine their impact on consumers' willingness to accept insects as food or feed. Age, gender, awareness of the topic and food neophobia were found to be the most influential factors in this regard for the Italian consumers. The readiness to accept insects was stronger among males than females and was stronger among younger consumers than among older consumers. These findings are consistent with those of SCHÖSLER *et al*. (2012) and VERBEKE (2015). Age-related differences might be explained by the higher level of openness and curiosity of the young consumer regarding novel foods compared with those of older people, for whom a higher degree of food neophobia has been reported (DOVEY *et al*., 2008). Consistent with this assumption, the results of the present investigation indicated that food neophobia had the greatest effect on Italian consumers' willingness to accept insects as food or feed, as was demonstrated in other studies (MEGIDO *et al*., 2014; VERBEKE, 2015). What was particularly interesting about our results was the attitude of neophilic people towards insects; indeed, we observed positive and somewhat high willingness scores for these people in all of the situations tested (M_{feed}=1.0, M_{food}=0.3, $M_{restaurant}$= 0.7 on a scale ranging from -2 to +2), suggesting that this consumer group is a potential target for marketing insects.

As expected, consumers attending university courses or working in an environment in which the topic of insects as well as sustainability are studied, investigated, and debated, positively affected consumers' willingness to incorporate insects into animal and human diets. Students and staff from the university showed a more conscious attitude and were more open to the theme of insect as food or feed than were people from outside the university context, indicating that information plays a fundamental role in accepting new food.

Contrary to our hypothesis, the consumers' sustainability level did not affect their readiness to incorporate insects into animal and human diets. Most of the consumers who declared themselves to behave sustainably and to be aware of sustainability issues indicated their uncertainty and disagreement regarding the possible use of insects in both animal and human diets. This outcome was not consistent with data previously reported, which showed that people who are interested in the environmental impact of their food choice are the most likely adopters of insects as a novel and more sustainable protein source to be used as a meat substitute (VERBEKE, 2015). Furthermore, in a context different from adopting insects as food, LAUREATI *et al*. (2013) found that sustainability awareness may influence individuals' expectations about ''sustainable'' products (i.e., organic yogurt). A possible explanation for the discrepancy between our findings and the data in the literature is that asking people to accept insects as meat substitute is conceptually different - and most likely less troubling - than asking them to include insects in their diet or to eat them in a restaurant. Thus, a positive attitude towards sustainability might prevail when a person must choose insects instead of a single component of the diet (i.e., meat), whereas when one must consider the possibility of consuming different foods that contain insects in various forms (e.g., in flour or as an ingredient), the disgust might be a too strong determinant to overcome.

Information about the environmental and nutritional benefits of introducing insects into animal and human diets only marginally affected the visual acceptability of a series of insect-based foods. In comparing the acceptability ratings before and after the consumer had received the information, an overall significant increase was observed. As familiarity might reflect the receipt of the information, this finding suggested that people were sensitive to the information they were exposed to concerning the use of insects (VERBEKE, 2015). The acceptability results also indicated that although the ratings were generally very low, sweet products were more appealing than were non-sweet ones. The only

exception was the lollipops, which the consumers considered extremely unpleasant, most likely because the insects were much more visible in the lollipops than they were in the cereal bar containing insects, biscuits made using insect flour and chocolate-covered grasshoppers. Similar findings were reported by SCHÖSLER *et al*. (2012), who found that chocolate-coated locusts were preferred to other dishes containing more visible insects. Accordingly, MEGIDO *et al*. (2014) prepared a series of sweet and savoury insect-based foods, which were actually tasted by consumers, and found that sweet preparations (i.e., crispy mealworms covered with chocolate) were more liked than were the others. These findings corroborated the hypothesis that pairing something that is traditionally well liked and known (e.g., sweets) with a food that is initially unfamiliar and unpleasant might be an effective strategy to enhance liking (LAUREATI *et al*., 2014) even with insect-based foods. This hypothesis was recently confirmed by TAN *et al*. (2015), who reported that reducing the visibility of the insect and incorporating it into a familiar and well-liked product generally improved the consumer's willingness to consume insect-based food formulations. Interestingly, "casu marzu", a typical Sardinian cheese containing live insect larvae, was not accepted by the consumers involved in the present study. This is might be explained by the fact that this is a niche, traditional product from Sardinia, which is not indeed well known in the rest of Italy. Considering that the experiment was performed in Milan, it is likely that subjects involved in the hedonic test did not associate the cheese to a food from their culture, thus rejecting it. This outcome further stresses the importance of culture and tradition and how this may lead to consumer's acceptance or rejection even within the same country (LAUREATI *et al*., 2006).

One of the strengths of our study was that it combined a large survey to assess consumers' willingness to adopt insects as food or feed with an evaluation of the expected liking for a series of insect-based foods in a sub-group of these consumers. This strategy allowed evaluating the drivers of both the willingness to consume insects and the expected liking for insects of the interviewed Italian consumers. Furthermore, the readiness to accept insects was investigated using three separate items concerning introducing insects into animal feed, introducing insects into the human diet and consuming insects in a specific eating context. We did not refer to the use of insects as a substitute for a specific type of food, such as meat or animal protein, because in our opinion, such an approach would have been reductive by ignoring the possibility that insects can be eaten for reasons other than as a substitute for meat.

Of course, there were also weaknesses in our study that must be noted. First, the hedonic assessment was conducted using a small number of consumers. Most importantly, these consumers were selected from university students (of the Faculty of Agronomy and Food Science) who had a scientific cultural background, and therefore, on one hand our findings may represent a best-case scenario in terms of the level of acceptance of young Western consumers of insect-based foods. Second, while the survey enabled us to acquire a relatively large amount of data, in some cases, the participants' characteristics (mainly the place of residence and the gender) were not well balanced. Unfortunately, this bias is common in studies in which electronic recruitment and web-based surveys are used (VERBEKE, 2015). Another limitation of this study is that we did not provide the consumers with actual products to taste during the hedonic assessment. However, there is evidence that preference expressed in an image-based analysis is a good predictor of the actual preference (OLSEN *et al*., 2012). Furthermore, the choice to have a specific subgroup of the consumers perform the hedonic test did not allow investigating the effect of the information they were given on a series of background variables regarding their expected liking (e.g., age). Most importantly, the observed marginal effect of the information on liking might have been stronger if consumers with a lower level of topic awareness had been involved.

In conclusion, the results of this study revealed that there is more potential for the use of insects in livestock farming than in the human diet. Although it has been reported that simply stressing the sustainability and nutritional value of insects as a source of food was unlikely to provide sufficient motivation to drive a change in diet (DEROY *et al*., 2015), we found that the consumer's acceptability ratings for a variety of insect-based foods increased systematically after they had received that information. Of course, changing people's existing food choice is not an easy task and requires much effort to increase the degree of the perceived familiarity of insects as food. Because a neophobic reaction was the main driver of rejecting insects as food, it is important that authorities launch campaigns to raise the awareness of the benefits of eating insects and thus facilitate increasing the willingness to accept insects as human nutrition.

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