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EDIBLE INSECTS ACCEPTANCE BY BELGIAN CONSUMERS: PROMISING ATTITUDE FOR ENTOMOPHAGY DEVELOPMENT

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ABSTRACT

Entomophagy is not well accepted in Western European populations but it is common in the world. In the future, populations from developed countries should adapt to other sources of animal proteins because traditional breeding of beef, poultry or pork will become unsustainable.

This study was performed to assess the perception of entomophagy in the Belgian population. A slight neophobia was detected but people agreed to evaluate insect preparations. Various insect formulations (mealworms and house crickets) were prepared, and insects associated with known flavors and crispy textures were preferred. After a hedonic test, people seemed to be willing to eat and cook insects in the near future.

The opportunity to introduce entomophagy in food habits of Western European populations was positively concluded. Integration of edible insects in human food is a potential solution to replace other animal protein sources in a much more sustainable development and will deserve more attention in the future.

PRACTICAL APPLICATIONS

This study shows the edible insects' potential to become a usual food ingredient in Western European populations. Our results show that consumers are ready to buy and cook insects at home if they are able to associate them with familiar flavors.

INTRODUCTION

In future decades, humans will be confronted by a lack of nutritive resources. In 2050, the global population is estimated to be 9 billion people leading to a global food demand increase of up to 70% compared with our current food requirements (FAO 2009). Conventional sources of protein will not be sufficient for the global human population, and alternatives sources such as insects will be required. The main advantage of insect production is the high environmental safety when compared to conventional livestock (Nakagaki and Defoliart 1991; Oonincx *et al.* 2010). Currently, there are approximately 870 million of undernourished people in the world (FAO 2012). Edible insects as a human food source could help developing countries to support their needs for proteins, fats, vitamins and minerals (DeFoliart 1992; Ramos-Elorduy 1997), but could also provide complementary food for developed countries' populations.

Feeding on insects is practiced in numerous countries of the world, except in developed countries mainly of Europe and North America. Insect-based food was estimated to include 2000 species of edible insects consumed by 3071 ethnic groups (Ramos-Elorduy 2009). Sources and formulations of insects are various: canned and sold in supermarkets, fresh or dried directly sold in local markets (Ramos-Elorduy 1997). Availability of insects depends on the insect origin: mass rearing, farming or gathering by villagers in natural areas. The latter can be dangerous for biodiversity and over-collection by villagers was found in diverse locations to lead to species extinction because of over-consumption related to high commercial value

(DeFoliart 1992). Insect farming could overcome the lack of insect availability in the nature, which are dependent of seasons or biomass availability (Yen 2009; Sileshi and Kenis 2010).

Environmental impact of entomophagy development should also be integrated when compared to traditional livestock breeding and use. Indeed, insect mass-rearing produces fewer pollutants and residues than other animals (Oonincx *et al*. 2010). Moreover, the biomass conversion rate and the production duration for insects are much better than for all other animals. Sometimes, edible insects are crop pests and their collection in fields provides both a source of food and a sustainable crop protection without the use of chemical pesticides (Nakagaki and Defoliart 1991; Ramos-Elorduy 1997; DeFoliart 1999; Yen 2009).

Nevertheless, entomophagy was considered in developed countries as "rural" and "barbarian" behaviors but there is recent interest for insect-based products (Ramos-Elorduy 2009). Currently, in Europe and North America, consumers search for safer products and those with little environmental impact (Lowe *et al*. 2008; Falguera *et al*. 2012). Moreover, entomophagy is now considered in those countries as fashionable. In contrast, populations from developing countries abandon their ancestral food habits and entomophagy for new processed products (Ramos-Elorduy 2009).

Despite these new trends, insects have always involved fear and disgust by industrialized populations (Kellert 1993) and the distinction between edible or inedible products is mainly based on culturally transmitted information (Rozin and Fallon 1980). When a new food product was introduced in a culture, it generally induced feelings of fear and rejection called neophobia (Pliner and Salvy 2006). In the case of entomophagy, neophobia can be explained by the two hypotheses of Rozin and Fallon (1980): the first is rejection of insects because of the knowledge of their origin and habitats, and the second is rejection due to anticipated negative post-ingestional consequences.

Behavioral studies with American students showed that a slight majority of them agreed to touch insects with their hands, but when they are asked to touch insects with their lips, a large majority of them refused (Rozin *et al*. 1999). A comparison of different alternatives for meat substitution indicated that visible insects were the least preferred. It was supposed that this rejection was due to less knowledge of edible insects compared to other solutions proposed such as soy burgers, tofu or couscous (Schösler *et al*. 2012) and thus could be due to neophobia.

To our knowledge, only one study focused on tasting sessions and acceptance of insects as food by developed countries' populations (Looy and Wood 2006). Here, the sociocultural and basic food formulation aspects related to edible insects were investigated on Belgian consumers to determine the potential of insects to replace and/or complement our traditional protein sources. Hedonic tests associated with a survey about the perception of entomophagy and purchase intentions were developed selecting different groups of testers.

MATERIAL AND METHODS

Respondent Profile

The experiment was held at the Insectarium Jean Leclercq – Hexapoda (Waremme, Belgium) where 189 people participated in this study. During this study, 384 visitors were recorded and this means that 49.2% of them agreed to participate to the experiment. As the visitors of the insectarium range from children to retired people, an age-representative range of the population was then obtained. The participants were grouped in five age classes: (1) 0 to 12 years old; (2) 13 to 17 years old; (3) 18 to 25 years old; (4) 26 to 45 years old; (5) more than 45 years old.

All respondents of our study participated voluntarily and they do not received monetary compensation for their participation. Allergic subjects were not invited to participate.

Survey on Entomophagy

A questionnaire was proposed and presented chronologically in two parts: the first one before the hedonic test and the second after this test. Some demographic information and description for each participant was included in the first part of the survey. Moreover, three questions were asked before the test: (1) Are you informed about entomophagy? (2) Are you really interested in eating insects? (3) Do you have a negative feeling toward entomophagy?

After the test, four questions were proposed to the participants: (4) Did you taste all of preparations? (5) Are you willing to eat insects in the future? (6) Would you cook insects at home? (7) If yes, in which form would you cook insects?

All questions were explained orally to ensure the best understanding of them.

Insect Preparations

Two species of insects were proposed during hedonic tests: the mealworm, *Tenebrio molitor* L. (Coleoptera: Tenebrionidae) and the house cricket, *Acheta domesticus* (L.) (Orthoptera: Gryllidae). The two species came from our laboratory rearing and were fed with wheat flour and diverse fruits or vegetables, respectively, for mealworms and house crickets. Before killing insects by freezing, they are starved for 24 h to ensure that they have excreted all of their

feces. This procedure allowed us to be sure that no toxic molecules remained and that we had a safe product for human consumption.

Insects were prepared in different forms: house crickets were baked at 200C for 15 min (1) or boiled for 8 min (2); mealworms were baked at 200C for 7 min (3) or boiled for 6.5 min (4); a crushed mix (1:1) of baked house crickets and mealworms (5); baked mealworms flavored with a pinch of dried vanilla (6) or paprika (7). Baked mealworms were also dunked in chocolate (8).

Duration of baking and boiling were determined after preliminary assays to allow optimal cooking for insects according to the selected species.

Unstructured Hedonic Test

After a random selection, a numerical code was assigned to each preparation, which was presented individually and randomly according to a Latin square set up. Before receiving the next preparation, the previous preparation was systematically removed from the tasting area. Each preparation presented three individuals in small blank cups and respondents were not forced to eat all of them. Each participant tasted all samples after being individually isolated in a tasting booth to taste insects. They were asked to rate each sample on an unstructured hedonic scale of 10 cm (not divided into 10 points) where extreme sides were noted from "very dislike" (left) to "very like" (right), inspired from Kihlberg and Risvik (2007). Respondents were asked to place a vertical line on the unstructured hedonic scale to evaluate the insect preparation sample.

Before the test, respondents were briefed orally and they had written instructions to avoid aftertastes and to neutralize their taste (drink water and eat salt-free rusk) between each sample. They were also informed about safety of our insect preparations and the potential allergenicity of arthropods.

Statistical Analysis

Statistical tests were performed using Minitab v16.0 (State College, PA, USA) for Windows. For responses to the survey, Chi-square tests between age classes and gender were performed. For hedonic tests, a 5 (age classes) × 2 (gender) × 8 (insect preparations) × 8 (presentation order) analysis of variance (ANOVA) with a generalized linear model was performed. The presentation order of insect preparation was considered as a random factor. One-way ANOVA was applied to compare the global liking of the participants for each insect preparation.

RESULTS AND DISCUSSION

Respondents Profile

The respondent gender was characterized by 105 men (55.6%) and 84 (44.4%) women.

A total of 9.5% of the respondents belonged to the first age class (younger than 13 years old), 30.2% to the second (from 13 to 18 years old), 16.9% to the third (from 19 to 25 years old), 26.5% to the fourth (from 26 to 45 years old) and, finally, 16.9% for the fifth (older than 45 years old).

All participants were Belgians.

Preliminary Knowledge of Entomophagy

The knowledge on entomophagy increases with age (Chi-square = 69.48, $P < 0.001$, Table 1) and few people younger than 18 years old were informed about entomophagy (less than 30.00% for the combination of the two age classes). In contrast, for Kellert (1993), older respondents had a lower knowledge of invertebrate values compared with other age classes. The difference with our study is that Kellert (1993) asked precise questions on invertebrate values while we only focused on an invertebrate taxon (insects) as source for human food.

A total of 61.9% of respondents knew entomophagy and 46.6% of them had a negative attitude about it. However, 77.7% of respondents were willing to eat insects. This demonstrates a desire and a curiosity toward this novel food.

In industrialized populations, insects induce fear and are perceived as unsafe and disgusting among the general public (Kellert 1993; Haidt *et al*. 1994; Ramos-Elorduy 2009).

TABLE 1. SURVEY ON ENTOMOPHAGY BEFORE THE HEDONIC TEST ($N = 189$)

Age classes	*n*	Question 1	Question 2	Question 3
<13 years old	18	6 (33.33%) a	12 (66.67%) a	6 (33.33%) a
13 to 18 years old	57	14 (24.56%) a	42 (77.70%) a	24 (42.10%) a
19 to 25 years old	32	30 (93.75%) b	27 (84.37%) a	17 (53.13%) a
26 to 45 years old	50	44 (88.00%) b	43 (86.00%) a	21 (42.00%) a
>45 years old	32	23 (71.88%) b	23 (71.88%) a	17 (53.13%) a
Statistical analyses	/	Chi-square = 69.48, $P < 0.001$	Chi-square = 5.42, $P = 0.263$	Chi-square = 3.07, $P = 0.546$

Consumer number who responds "Yes" for questions: (1) Are you informed about entomophagy? (2) Are you really interested in eating insects? (3) Do you have a negative feeling toward entomophagy? Different letters show a significant difference for age classes at $P < 0.05$ (Chi-square test).

TABLE 2. RESULTS OF GENERALIZED LINEAR MODEL TEST ON THE GLOBAL LIKING OF INSECTS (DF: DEGREES OF FREEDOM)

Factor	df	*F*	*P*
Age × Gender	4	0.95	0.436
Age × Preparation	28	1.06	0.382
Gender × Preparation	7	1.27	0.262
Age	4	2.17	0.074
Gender	1	1.43	0.234
Preparation	7	25.54	*<0.001*
Presentation order	7	0.24	0.976

Test is significant at $P < 0.05$

Generally, people consider insects as disease vectors, pests of fields and ornamental plants, depredators of stored products, and house and food contaminants, but they forget the beneficial impacts of insects such as pollination, seed dispersal, biological control, waste decomposition and as a potential source of animal proteins (Kellert 1993).

Unstructured Hedonic Tests

The ANOVA with the generalized linear model showed that the global liking of insects only depended on the preparation method ($F = 25.54$, $P < 0.001$; Table 2). One-way ANOVA shows that the most preferred preparation were the crispy mealworms with chocolate, paprika and baked naturally ($F = 22.69$, $P < 0.001$; Fig. 1). These results are consistent with other studies on importance of flavors in the acceptance of food. This kind of preference was also found for a locust associated with chocolate compared to other dishes including visible insects (Schösler *et al.* 2012). Mealworms with vanilla, house crickets baked naturally and the crushed mix of both species were moderately liked. For mealworms with vanilla, it seems that the association between both ingredients does not work as expected. For house crickets baked naturally, this moderate liking could be explained by the fear of insects and the vision of entire crickets with more impressive legs and antennae than mealworms. Effectively, it is known that visual appearance and food texture have a close relationship and an impact on food acceptance (Logue *et al.* 1981). A hypothesis for the reduced liking of the crushed insect mix was a lack of food texture and a pasty-crumbly sensation in the mouth that was less pleasant.

Finally, baked insects with a crispy texture were more appreciated than those that are boiled. Food texture is important in food acceptance but it is complex to study and several parameters are involved in sensory evaluation of food texture (Szczesniak 2002).

Age Class and Preference

People older than 45 years were found to appreciate slightly more insect preparations compared with other age classes ($F = 2.17$, $P = 0.074$). This observation was interesting because opinions differ about neophobia, which seems to be more expressed in elderly populations (Tuorila *et al.* 2001) while other studies stipulated that neophobia decreased with age (Pliner and Hobden 1992; Pelchat and Pliner 1995; McFarlane and Pliner 1997; Pliner and Salvy 2006). If we consider entomophagy as a novel ethnic behavior, our results are consistent with other studies indicating that older people were less neophobic for this type of novel food (McFarlane and Pliner 1997; Pliner and Salvy 2006). Another hypothesis is that the decrease of olfactory sensitivity in older populations increases their acceptance of novel foods (Pelchat 2000) but we did not test the olfactory sensitivity of our respondents.

This willingness to try novel food in older people could be justified by the increase of knowledge about

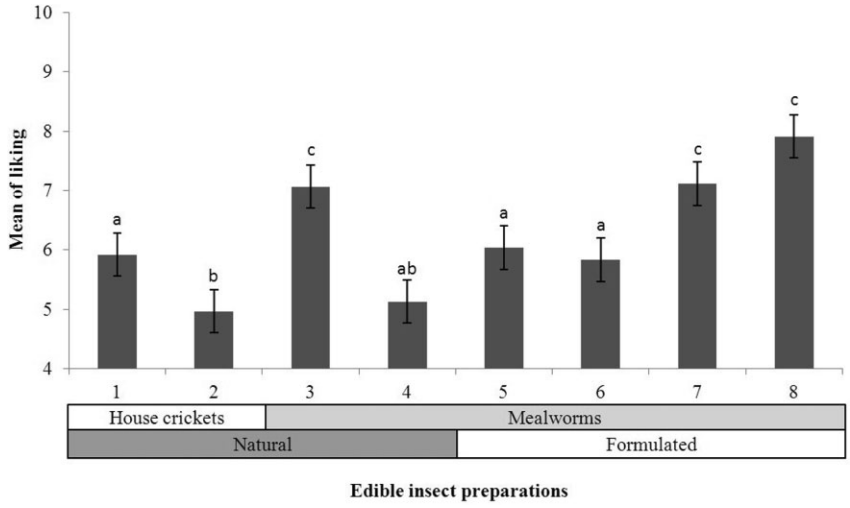

FIG. 1. LIKING OF DIFFERENT MEAL PREPARATIONS: (1) HOUSE CRICKETS BAKED; (2) HOUSE CRICKETS BOILED; (3) MEALWORMS BAKED; (4) MEALWORMS BOILED; (5) CRUSHED MIX OF BOTH SPECIES; (6) MEALWORMS WITH VANILLA; (7) MEALWORMS WITH PAPRIKA; (8) MEALWORMS WITH CHOCOLATE. DIFFERENT LETTERS SHOW A SIGNIFICANT DIFFERENCE FOR MEAL PREPARATIONS AT $P < 0.05$ (PAIRWISE COMPARISONS BY TUKEY'S TEST)

entomophagy in this population sector but the results of Kellert (1993) contradict this assumption. The type of information on novel food is also important among different age classes and the same information can cause distinct reactions among these age classes (McFarlane and Pliner 1997). During this study, we gave no information to participants about entomophagy and the individual knowledge came from former personal experience only.

Post-Tasting Survey about Entomophagy

The participants from the different age classes responded similarly and positively when they agreed to test the insect preparation (72.0 to 90.0% tasted; Table 3). No significant difference was observed between age classes for tasting all preparations (Chi-square = 7.53, $P = 0.110$). Adults (more than 25 years old) accepted slightly more to taste all preparations (Table 3). As discussed in the previous section, the relation between willingness to try novel foods and age of participants was difficult to characterize. Some studies noted a decrease in neophobia for older people (McFarlane and Pliner 1997; Pliner and Salvy 2006) while Tuorila *et al.* (2001) obtained a positive correlation between age and neophobia. Given our results on willingness to taste all preparations, it seems that no particular neophobic age classes were highlighted.

After this experience, adults (more than 25 years old) were more willing to eat insects in the future (Chi-square = 11.77, $P = 0.019$). There is a positive correlation between liking a novel food for the first exposure and likelihood of consuming it in the future (Tuorila *et al.* 1994) and it could justify the willingness of participants in our study to consume insects in the future because they generally appreciated insect preparations. For novel foods, several studies have highlighted the importance of successive exposures in the acceptance of a new product (e.g., Pliner *et al.* 1993; Methven *et al.* 2012) and this will certainly be necessary in the case of edible insects. Also, the willingness to eat insects in the future will increasingly be influenced by associated environmental and sustainability perspectives, in association with other benefits derived from insects like less pollutant production, better food conversion and their nutritive value (Oonincx *et al.* 2010; Premalatha *et al.* 2011). Organic production, safe and healthy products and production methods, ecological printing and environmental impact are always more integrated in the everyday behavior of a larger proportion of industrialized populations. Food production and products are not exceptions (Falguera *et al.* 2012; Thomas and Gunden 2012).

After eating insects, participants aged from 19 to 45 years old were more likely to cook insects at home (Chi-square = 12.01, $P < 0.017$). Insects could be assimilated as a rapid novel food and active people having time pressure could benefit from this new type of food that is easily and rapidly cooked. Moreover, younger adults seemed to take slightly more pleasure in cooking (Daniels *et al.* 2012) and the perspective to cook a nonconventional and "fun" food could increase this willingness to cook insects.

Larger neophobic behavior in men or women is continuously discussed: several studies found no difference between genders (e.g., Pliner and Hobden 1992; Johns *et al.* 2011) but two Scandinavian studies seemed to indicate that men were more neophobic (Hursti and Sjödén 1997; Tuorila *et al.* 2001) while women were more disgusted for products of animal origin (Haidt *et al.* 1994) and they were more fearful of insects (Kellert 1993; Schösler *et al.* 2012). In our study, based on responses obtained from questions 2 to 5, no significant difference was observed between genders. Nevertheless, slightly more men were willing to eat insects and had fewer prejudices before the test while slightly more women tasted all preparations and were willing to eat insects in the future after this test.

Kinds of Insect-Based Preparations

To produce and commercialize insect-based products in the future, it is interesting to know consumer's preferences about integration of insects into different types of meal. Firstly, insects were more perceived as an appetizer (for 37% of the consumers), probably due to their small size and original form. Then, people were found to accept insect addition to their main dish (26%) or as a dessert (23%). To

TABLE 3. SURVEY ON ENTOMOPHAGY AFTER THE HEDONIC TEST ($N = 189$)

Age classes	*n*	Question 4	Question 5	Question 6
<13 years old	18	13 (72.22%) a	14 (77.78%) a	8 (44.44%) a
13 to 18 years old	57	45 (78.94%) a	44 (77.19%) a	20 (35.09%) a
19 to 25 years old	32	23 (71.87%) a	26 (81.25%) a	20 (62.50%) b
26 to 45 years old	50	45 (90.00%) a	46 (92.00%) ab	33 (66.00%) b
>45 years old	32	29 (90.63%) a	31 (96.87%) b	16 (50.00%) ab
Statistical analyses	/	Chi-square = 7.53, $P = 0.110$	Chi-square = 11.77, $P = 0.019$	Chi-square = 12.01, $P = 0.017$

Consumer number who responds "Yes" for questions: (4) Do you taste all of preparations? (5) Are you willing to eat insects in the future? (6) Would you cook insects at home? Different letters show a significant difference for age classes at $P < 0.05$ (Chi-square test)

a lesser extent, respondents also proposed addition of insects to salad (7%) or soup (6%), and finally, consumed in their natural shape (1%).

CONCLUSIONS

Eating insects is a future source of animal proteins and was mainly well accepted by participants in our study whatever their age and sex. We should remain cautious with these first results because we surveyed people interested in insects. Likewise, edible insects seemed to induce neophobia among some potential consumers but a pretest survey about neophobia is necessary to confirm this hypothesis. Investigations concerning the adventurous character of respondents could also be interesting to see if a correlation exists with the willingness to eat insects.

Popularization and information spreading, starting by presenting the systematic proximity in animal classification between insects and crustaceans, could facilitate the integration of entomophagy in our feeding habits and behaviors. Another solution is increasing frequencies of edible insect exposure and experimental tasting. It could also diminish neophobia among developed populations and it will change their negative perception of insects. Moreover, the consideration of conventional factors in food chemistry and food acceptance (taste, visual, texture, etc.) and application to edible insect preparation will increase their acceptance. We might consider that other new food processes could help to insert insects into our traditional food products.

This study provides the first results on a possible acceptance of entomophagy in our Western populations but further research is needed and is in progress in our laboratory to improve our understanding of insect neophobia and to know the real expectations of the population and the consumers of tomorrow.

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