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Insects as food: perception and acceptance

Findings from current research

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Abstract

The global demand for animal protein will continue to increase in the coming years. In order to meet this growing demand and to move towards sustainable nutrition, insects appear to be a good alternative to traditionally produced animal protein. The acceptance of insects as an alternative protein source is still low among Western consumers. This systematic literature review reveals the extent to which people are willing to eat insects in Europe, as well as which influencial factors have already been examined and which strategies to increase acceptance are promising. Further research is required to better understand how insects could be made more attractive to the Western market. However, it remains to be seen whether insects will find a place in the diet of Western consumers.

Keywords: consumers, insects, willingness to eat, disgust, food neophobia, entomophagy

Introduction

The production of animal protein is linked to high resource consumption, requiring a lot of agricultural land, water and energy. Traditional livestock farming and meat production are also morally questionable. Interest in alternative protein sources which can be produced using fewer resources has rapidly increased in recent years. Due to a report by the FAO [1] and the commitment of individual scientists, public interest in insects as an alternative protein source has increased.

Insects can be a source of high-quality protein (i.e. source of essential amino acids, vitamins and minerals) depending on the species, stage of development and diet [2]. In comparison to some meat products they also have lower concentrations of cholesterol alongside a favorable n-3/n-6-fatty acid ratio [3–5]. Another advantage of insects is that their production is comparatively environmentally-friendly. A recently published comparison of the environmental impact of different meat alternatives demonstrated that insect and soya flour based alternatives have the lowest environmental impact, that milk and gluten-based alternatives have a moderate impact and that cultured meat or myco-, i.e. mushroom based, analogues (e.g. QuornTM) have the highest impact [6].

Approx. 2,000 species of edible insects have been identified globally to date [7]. In many cultural spheres, e.g. in East Asia, Africa and South America, they are harvested from the wild and are part of the traditional diet [1]. In contrast, in Western countries they tend to trigger disgust rather than a desire to eat. The present article gives an overview of the current data available on the subject of the perception and acceptance of insects as food from a consumer perspective.

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Food neophobia denotes the tendency to reject food which deviates from the cultural norm or which is unknown. This can be stronger or weaker among individuals. Repeated contact with a food can reduce the rejection of new food, as familiarity is created (mere exposure effect).

Entomophagy describes the consumption of insects. This practice is rarely found in western cultures.

Qualitative studies: Qualitative social research includes e.g. focus groups and group discussions, the core concept being that the studied group can report their subjective perspectives in their own words.

Quantitative studies often serve to examine pre-determined hypotheses. Studies are performed e.g. as experiments or surveys. Measurements of test persons are taken and statistical correlations between pre-determined indicators are examined.

Fig. 1: **Fried silkworms**

Methodology

The studies detailed in the following literature review are part of a comprehensive systematic review on the subject of sustainable protein consumption [8]. A literature search was carried out in January 2016 using the Web of Science database (core collection) and a set of pre-defined keywords. The search string was: ([“meat substitute” or “alternative protein” or “cultured meat”] or [sustainab* and (meat or milk* or cheese* or egg*)] and [consum* or behav* or food choice]). Studies which were found in lists of references in relevant articles were also included. The review looked exclusively at quantitative studies published in English-speaking journals with peer review processes. Another prerequisite was that the study examined consumer acceptance of alternatives to traditional meat-based proteins. Further search criteria were: consumer awareness of the environmental effects of meat production, willingness to reduce meat consumption, willingness to eat cultured meat and plant-based meat substitute products and the acceptance of insects as food. This article focuses solely on studies on the subject of insect consumption. There were no restrictions as to publication date.

A total of 16 relevant articles were identified (• Table 1). The majority of these studies was based on online surveys. Three experiments and four hedonic sensory tests were also carried out. The search listed further studies on this subject by Tan et al. [9], Balzan et al. [10] and House [11]; these were not included in this literature review due to their qualitative study design.

Results

Willingness to eat insects

Various consumer surveys in Europe indicate that the willingness to consume insects as a meat substitute is very low. In a Belgian study

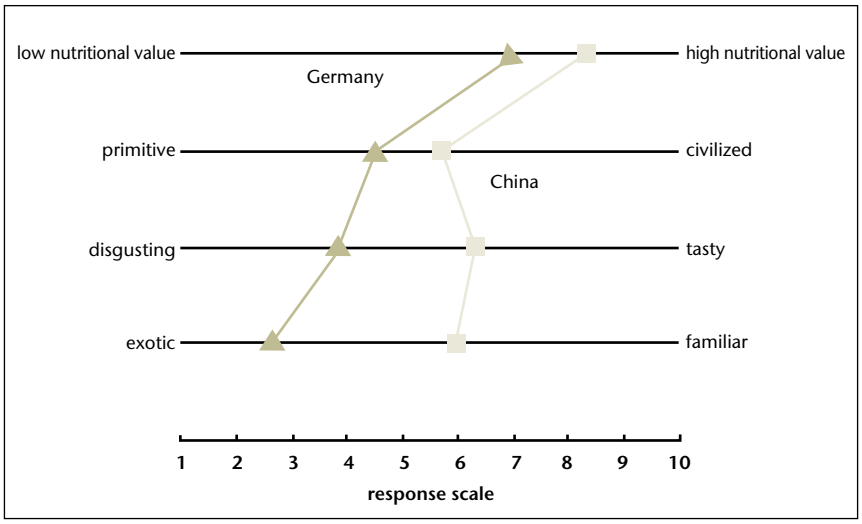

Abb. 2: **Fried silkworms as food (adjusted according to [13])**
Comparison of the semantic differential of fried silkworms in Germany (N = 502) and China (N = 443). This method helps to reveal the image which respondents have of fried silkworms in different cultural spheres. Participants indicated their perception of silkworms on a response scale of 1 to 10 (x-axis), wherein the ends of the response scale consisted of two contrasting terms.

Authors, year	Study type (number of test persons)	Insect product
Caparros Megido et al., 2014 [24]	tasting in Belgium with visitors at an insectarium (N = 189)	mealworms and crickets combined with different spices and sauces
Caparros Megido et al., 2016 [32]	tasting in Belgium with students (N = 79)	hybrid burgers made from mealworms, mealworm/beef and mealworm/lentil combinations
De Boer et al., 2013 [14]	online survey in the Netherlands (N = 1,083)	snack made from crickets
Gmuer et al., 2016 [21]	online survey in Switzerland (N = 428)	tortilla chips combined with crickets, varying in degree of processing
Hartmann et al., 2015 [13]	online survey in Germany (N = 502) and China (N = 443)	products from processed insects (e.g. insect flour cookies) and unprocessed insects (e.g. fried silkworms)
Hartmann & Siegrist, 2016 [25]	experiment in Switzerland (N = 104)	insect chips (tortilla crisps with crickets flour); unprocessed insects (fried silkworms and crickets)
Lensvelt & Steenbekkers, 2014 [26]	survey and tasting in Australia (N = 75) and the Netherlands (N = 134)	insects (general), roasted crickets, biscuit made from insect flour
Looy & Wood, 2006 [27]	experiment with Canadian students (N = 234)	photos and videos on entomophagy and insect tasting
Ruby et al., 2015 [17]*	online survey in the USA (N = 220) and India (N = 179)	products made from processed and unprocessed insects of different species
Schosler et al., 2012 [15]	online survey in the Netherlands, same sample as in De Boer et al., 2013 [14]	menus with insects as meat substitutes
Schouteten et al., 2016 [28]	tasting experiment in Belgium (N = 97)	burger patty made from mealworms (available to purchase in Belgium)
Tan et al., 2016 [33]	tasting in the Netherlands (N = 103)	burger patty made from mealworms
Tan et al., 2016 [16]	online survey in the Netherlands (N = 976)	preparations made from mealworms varying in flavor (sweet/savory), seasoning (western, Asian), degree of processing (visible/not visible) and carrier product
Vanhonacker et al., 2013 [30]	online survey in Belgium (N = 221)	insects
Verbeke, 2015 [12]	online survey in Belgium (N = 368)	insects
Verneau et al., 2016 [29]	implicit association test in Denmark and Italy (N = 282)	information videos, chocolate bars made from insect protein

Tab. 1: **Overview of key quantitative studies on perception and acceptance of insects as food**
*Article published in a journal which is not listed on the Web of Science and thereby has no impact factor.

Question	Key findings
acceptance measured by unstructured hedonic test	• > 70% of all study participants tasted all preparations; mealworms baked with chocolate, pepper or 'natural' were rated most positively • after tasting, the majority of over 25s said they would be prepared to eat or cook insects in future
acceptance measured by hedonic test; comparison of different products	• appearance, taste and smell of beef burgers were better rated than those of the mealworm/beef combination and the mealworm/lentil combination as well as the lentil-only patty • men rated the insect hybrid burger more positively than women
participants chose between a snack made from crickets and other meat-free alternatives (e.g. seaweed, beans)	• 4% chose the insect snack • no influence of gender, educational background, age or number of meat days/week
emotions triggered by the idea of eating the products and willingness to eat	• crickets alone and a mix of unprocessed crickets and chips triggered the most negative emotion profile (e.g. irritated, disgusted, uneasy, strange) • emotion profile was associated with a willingness to eat
willingness to eat different products and cross-cultural differences	• lowest willingness to eat for unprocessed insects, highest willingness to eat for processed insects; this difference in the degree of processing was irrelevant in the Chinese sample • higher willingness to eat if already had experience in eating insects and low food-neophobic tendencies • no gender differences
willingness to eat unprocessed insects after test persons had eaten either insect chips (experimental group) or regular tortilla chips (control group)	• significant influence of experimental manipulation, when controlled for covariates • willingness to eat was associated with food neophobia, having eaten insects already in the past, disgust sensitivity in relation to animal food contamination • positive eating experience with product from processed insects increases willingness to eat unprocessed insects
attitude towards entomophagy	• 38% did not eat the insect products • only survey respondents with a neutral attitude to entomophagy tasted the products • attitude towards entomophagy more positive after tasting
effect of providing information on the initial reaction of participants to the idea of eating insects	• disgust was named by 75% before information provision and by 47% after info provision • 56% of participants in the control group stated that probably the most effective way to change attitude was to taste insects ("bug banquets")
factors associated with willingness to eat and cross-cultural differences	• 65% of women and 78% of men in the USA would eat a product made from processed insects • willingness to eat processed insects > willingness to eat unprocessed insects; USA > India; men > women • perceived environmental advantages, "sensation seeking" and male gender were positive predictors; disgust sensitivity and food neophobia were negative predictors
attractiveness of menus and probability that they would prepare these dishes themselves	• pizza with non-visible insect proteins received the best rating; salad with fried mealworms was rated worst • low probability of preparing dishes oneself • menus with visible insects were more positively rated by men than by women
taste evaluation of an insect burger in comparison to plant and meat-based burgers in a blind test and in a non-blind test	• 10% did not eat the insect burger in the non-blind test; plant and insect based burgers were more negatively rated in terms of taste than meat-based burgers • sensory quality of insect burgers has potential for improvement • information communication about contents positively influenced evaluation of insect burger
sensory evaluation of burger patties labelled with the contents meat, lamb brain, frog or mealworm (contents only fictional)	• willingness to eat was strongly influenced by perceived low (cultural) appropriateness of ingredients • negative taste expectations because of unusual ingredients were not associated with reduced taste evaluation after tasting • even if sensory evaluation was positive, this did not lead to an increase in acceptance of the unusual ingredients
influence of preparation method on acceptance	• product acceptance was not increased by combining with familiar carrier products, however was strongly influenced by perceived appropriateness of carrier products • even if visually identical, mealworm preparations were always rated worse than the original not containing insects • further incentives relating to the appearance of food are required to motivate consumers to eat insects
acceptance of different options for a more sustainable diet (e.g. plant-based meat substitute, organic meat, meat reduction)	• lowest acceptance of insect proteins compared to insect-free alternatives • insect consumption motivated only by sustainability considerations seems not to be a promising option
willingness to consume insects as a meat substitute	• 19% agree, 16% unsure, 65% disagree • gender, previous insect consumption, food neophobia, food technology neophobia and awareness of environmental footprint of food were important factors for willingness to eat insects
effect of communication about social and individual advantages of insect consumption on the intention to eat insects; influence of implicit attitude on willingness to eat an insect bar	• 80% of participants indicated that they ate the bar • information provision positively influenced intention and consequently behavior; negative implicit attitudes did not weaken the effect • information communication about individual and social advantages of insect consumption can positively influence willingness to eat

only 19% of people surveyed stated that they would be prepared to eat insects as a meat substitute [12]. A similarly low level of willingness was also observed in Germany [13]. If the respondents had a choice, they preferred products not containing insects to products containing insects [14–16]. E.g. in a Dutch survey, only 4% chose a snack containing insects [14]. Men seem to react somewhat more positively to insects as food than women [12, 13, 15, 17]. Apart from gender, no socio-demographic factors have so far been identified as having an influence on the acceptance of insects as food.

The cultural sphere in which we grow up and live has a strong influence on what we accept as food and what we do not accept. In contrast to most Europeans, people e.g. in China are familiar with the idea of eating insects [13]. There are significant differences when you compare the image which insects have as a food in different cultural spheres. Insects such as e.g. fried silkworms (◆ Figure 1) are perceived as more familiar and nutritious in China than in Germany (◆ Figure 2). In Western cultures, insects tend to be associated with food contamination, health risks or even with a primitive diet [13, 17–19].

A typical reaction to things which people have learnt are inedible or which are unknown to them as food is disgust. From an evolutionary perspective, this emotion is a protective mechanism which used to prevent people from consuming potentially harmful substances [20]. Disgust reactions may represent the greatest hurdle to the introduction of insects in the Western food market. In a study in the USA, 57% of the 200 people surveyed rejected insects as food, owing to the resultant disgust [17]. Disgust and other negative emotional associations with insects as food are accompanied by a reduced willingness to eat [21]. A negative taste expectation, an unfamiliar consistency and uncertainty as to the origin of the food are typical triggers for a rejection based on disgust [22, 23].

Overcoming disgust

Positive taste experiences with insects can reduce negative affective reactions. Consequently, people who have eaten insects in the past indicate a generally higher willingness to eat [13, 24, 25] and also express a higher willingness to eat insects in future [24]. Tasting insects, e.g. as part of a so-called "bug banquet", can generate this kind of positive taste experience and lead to a more positive attitude to entomophagy [24, 26, 27]. But it should be noted that people with a very negative attitude are often not prepared to take these kinds of tasting opportunities [26, 28].

A combination of processed or unprocessed insects served with familiar carrier products such as e.g. salad or spaghetti [15] or prepared with familiar sauces and flavors [24] were identified as further strategies which could increase acceptance of unfamiliar foods. These measures can remove uncertainty and reduce negative taste expectations. However, combining insects with familiar flavors is not sufficient enough to increase acceptance. In one study from the Netherlands [16], participants felt that several taste combinations were unsuitable, which again had a negative impact on acceptance. Sweet preparations containing insects were rated particularly negatively. In general, this strategy also risks triggering the thought of contamination and people may perceive the insects as a contaminant [9, 21].

Surveys from different countries show that consumers are more likely to be prepared to eat processed insect products where the disgust triggering optical stimuli are no longer present [13, 15, 17]. An experiment carried out at ETH Zürich [25] also showed that the consumption of processed products, e.g. insect chips (◆ Figure 3), can create a positive taste experience and increase willingness to eat unprocessed insects. However, it should be noted that if products are not sensorially satisfying, the aversion to insects is further increased. If the insect product tastes bad when it is first tasted, it is doubtful whether consumers would be prepared to overcome their aversion a second time [28].

Another method for increasing willingness to eat insects is based on information provision about entomophagy and insect products [27, 29]. However, affective disgust reactions are barely influenced by awareness and education alone. As previously explained, it may also be wise to consider the image of different insect species, which can have an impact on feelings of disgust. E.g. Thai participants stated that they associate worm-like insects with rotting and

Fig. 3: **Insect chips (partially with insect flour)** [own photo]
Participants who had previously knowingly eaten insect chips (intervention group) showed a higher willingness to eat unprocessed insects than those who had eaten normal chips (control group). Influence was evident in whether participants had already eaten insects, whether they were extremely sensitive to disgust and whether they tended to food-neophobic reactions [25].

decay and would prefer giant water bugs to the mealworm preferred in the Netherlands. Among Dutch study participants, the association was precisely the opposite [9]. However, no quantitative study has been carried out to date on the effect of the image of an insect species on acceptance. This should be taken into account in future studies. It is also currently unclear as to what extent other factors such as meal context (e.g. restaurant, canteen) may have an impact on acceptance and whether certain styles of preparation (e.g. snack, accompaniment to main meal) may be accompanied by a higher level of acceptance than others.

Summary

Various approaches have hitherto been put forward in an attempt to make insects more attractive to western consumers. As long as the insect is visible as a whole, these strategies are probably more interesting for consumers who are looking for a culinary adventure. It is unlikely that people who are more cautious when it comes to trying new food would feel attracted by this approach. A promising method to increase willingness to eat insects is to offer products made from processed insects. However, many of these products (e.g. insect chips) are not an alternative to meat – this food choice is barely more sustainable. Processed insects can however increase consumers' acceptance of unprocessed insects. In addition, marketing about insects must try to generate positive associations, which may overcome the negative emotion profile relating to the idea of eating insects. To this end, it seems necessary that additional incentives such as e.g. positive effects on health are communicated alongside the argument for a more sustainable food choice [13, 16, 30]. Overall, it is evident that it will be a great challenge to convince western consumers of the advantage of entomophagy. Meat enthusiasts who place great importance on regular and abundant meat consumption find meat substitute products less attractive [15]. However, insects could be a promising option for those consumer groups which value a sustainable food choice and look for alternatives to traditionally produced animal proteins [6]. The question remains as to whether insects and insect proteins would actually be consumed as a substitute or whether they would be consumed in addition to traditional animal proteins. Whether insects actually have the potential to gain a permanent position in the western diet remains an unanswered question. Current data emphasize that further research is required to better understand how consumers might be persuaded to consume insects.

Outlook

The use of insects as food or fodder on a larger scale would require the industrial cultivation of insects under controlled conditions. There is a need for research on the technological treatment and processing methods and on toxicological, microbial and hygienic safety [31]. The possible allergenic potential of insects should also not be ignored.

Conflict of Interest
The authors declare no conflict of interest.

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