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Factors influencing consumer perception and acceptability of insect-based foods
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The interest in eating insects as food is increasing, not least for sustainability reasons. However, the acceptance among consumers remains low. The aim of this review was to identify the key factors influencing consumer perception and acceptability of insect-based foods described in recent literature. Even though sustainability factors are important, they are seldom the main reasons influencing insect consumption. Instead, a complexity of emotional factors, such as disgust and neophobia, as well as familiar tastes, textures and contexts, were found to have a major influence. In addition, exposure and positive tasting experiences have been identified as important factors for increasing acceptance. It could be concluded that there is a great complexity of different factors influencing consumers’ perceptions and acceptability of insects as food.

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Introduction
Eating insects, or entomophagy, has gained considerable attention in recent years and interest in this area is growing [1]. The global population is increasing, the pressure on land and natural resources is becoming extensive, climate change is accelerating, and global health issues are of importance for both individuals and society [2]. Global food systems seem to provide many key factors that may help in solving these challenges. In comparison to traditional protein sources, such as meat, insects are considered to be sustainable because they exert less pressure on natural resources and contribute lower emissions of greenhouse gases [3]. Insects contain large amounts of high quality and highly digestible proteins and unsaturated fats, as well as vitamins, minerals and other bioactive compounds [3]. The production of insects as food for humans is therefore developing in many countries [4,\(^*\)]. However, consumer acceptance in many western countries is a challenge and insects are often regarded as disgusting, even though the taste of insects has been found to be mild and easy to accept. Social and cultural aspects have been shown to be among the most predominant explanations for consumers’ feelings of disgust [4,\(^*\)]. Product development to produce delicious and healthy foods containing insects and the adoption of strategies to increase acceptance are therefore required.

The use of insects as food provides a major future opportunity for the provision of a sustainable protein source that meets the quality demands of nutrition and climate sustainability and environmental sustainability, which are all important goals in Agenda 2030 [5].

The main objective of this review was to identify the key factors influencing consumer perception and acceptability of insect-based foods described in the literature published in the recent years.

The review is divided into themes, describing the factors influencing the consumer perception and acceptability. The text aims to take a global perspective into account.

Sustainability
Insects contain high-quality nutrients and are considered to be a balanced source of nutrition comparable to both fish and meat. Further, they are environmentally friendly and the cost of rearing insects is considered low [3,4,\(^*\)]. Their high nutritional value can be considered the main factor justifying the use of insects as food [4,\(^*\)] followed by their low impact on the environment [6,7,\(^*\)]. However, susceptibility to nutritional messages among consumer groups varies depending on people’s educational backgrounds [8]. Studies suggest that health considerations are relevant in increasing the consumption of insects. The nutritional value of food products, especially the protein content in foods such as pasta, may be increased by the addition of cricket powder, while the products still remain attractive to consumers [9]. However, safety concerns may have a negative effect on consumption [10,11].

Despite a strong sustainability awareness, sustainability consciousness has not been shown to be a significant predictor for the willingness to consume insects. Similarly, some studies have shown that the recognised environmental and nutritional benefits did not seem to influence consumers to consider insects as food [12,\(^*\),13,\(^*\),14,\(^*\)]. In contrast, Legendre et al. [15] and Palmieri et al. [16]...
showed that sustainability may be a motivating factor in the purchase of insect-based food. Information, not only about sustainability but also about origin, production and safety, is important to increase the willingness of consumers to buy and consume insects [17,18]. In addition, the particular species of insect has been shown to be of significance [19]. Another study showed that, as young people become more aware of sustainability, the environment and climate change, the acceptance of insects as food may increase [13,20]. Further, consumer interest in and acceptance of insect-based food will grow with the help of effective marketing strategies highlighting the nutritional benefits of the consumption of insect-based food [21]. Jones [22] focused on young people and concluded that schools are important in increasing sustainability awareness and the acceptance of insects as food, not only in the classroom, but also in areas such as school canteens.

**Emotional responses to insects as food**

There are several psychological barriers to the acceptance of eating insects and the idea of entomophagy can give rise to a variety of emotions. Neophobia and disgust are often referred to as the two main psychological factors for the rejection of insects as food [3]. Our relationship to food is both characterised by an insecurity or even fear of new and unknown foods, including insects, which are considered as harmful [17] and curiosity for and interest in trying new food items. Interest has been identified as one of the main factors in overcoming the barrier of disgust [23]. The importance of interest and curiosity was also raised in the study by Nyberg et al. [24] focusing on young children’s perceptions of insects as food. Moreover, interest in new food experiences [16] and the emotions of being adventurous, wild and sensation seeking [12,25] have also been identified as important for acceptance.

The crucial role of neophobia and disgust in understanding the acceptance of insect-based food has been explored in several recent studies covering different national contexts and age groups. Lammers et al. [12] found that disgust was considered to be the most important factor influencing the willingness among German consumers to eat insect burgers and buffalo worms. A similar result was found by Orsi et al. [26] where both disgust and neophobia were identified as the psychological and personal barriers with the highest prevalence. Food neophobia also negatively influenced the willingness to eat insect burgers among children and adolescents in Germany [27]. In a study among young Australians [13], there was a low willingness to accept insects as a meat substitute, mainly due to psychological barriers such as neophobia and disgust. Modlinska et al. [28] and Orkusza et al. [29], who both investigated attitudes among students in Poland, showed a low willingness to eat insects as a substitute for meat, primarily based on feelings of disgust and neophobia. Similar results have been found in studies by Mancini et al. [30] and Grasso et al. [31], both of which explored attitudes to insects among Italian consumers in different age groups. However, when exploring disgust as a factor for rejecting insects as food it is necessary to consider attitudes towards different insect species [19,25]. Importantly, disgust as a response to eating insects is also apparent in cultures with a long tradition of insect consumption [32]. In the study by Chang et al. [14] investigating attitudes to edible insects among Taiwanese consumers and the study by Bae and Choi [33] who conducted their study among people in Korea, food neophobia and disgust for certain insect forms were also identified as the main factors for not purchasing and eating insects.

**Familiarity and the importance of exposure**

Since insects are an unknown food for most people in the Western world, increasing familiarity has been recurrently highlighted as a key to increasing acceptance and decreasing neophobia. Several studies have pointed to the importance of this familiarisation process as well as trying to increase exposure as a way of diminishing and overcoming feelings of disgust and fear [7,14,17,34]. Food exposure and testing insects as food might reduce neophobic reactions, which can in turn increase acceptability. This was, for example, shown in the study by Mancini et al. [30] where the disgust factor decreased among the participants after performing sensory evaluation and testing of insects in food products. A similar result was presented by both Barton et al. [17] and Woolf et al. [35] where people showed an increased willingness to try eating insects after becoming familiar with them as food and their possible benefits, stating that exposure was a key factor for acceptance. For example, in the study by Barton, the participants were more willing to buy cricket protein powder after testing it.

In order to increase familiarity, several studies have shown the importance of integrating insects in already well-known products [36,37] and combining favourite dishes with insects [7]. However, it might also be important to consider the level of familiarity in relation to the kinds of insects that are accepted and the preferred serving methods. Those who were already familiar with insects as food more often preferred whole insects and thought it was safe to eat them [38]. In addition, the impact of context has been acknowledged. A study by Nyberg et al. [24] stated the importance of not only integrating insects into well-known products but also the influence of a familiar physical and social context. This was also found in the study by Motoki et al. [39] where the participants were more willing to eat insect-based foods in contexts characterised by fun-arousing emotions, such as in pubs and at food festivals, and in the company of friends. Familiar contexts and situations are important for trying and accepting insect-based food; however, external influences are also of importance, including those of experts and various policy initiatives [7,40] as well as media information perceived as credible [15].
**Sensory aspects**

Sensory appeal may be the key to insects being valued as pleasurable components of food products [4**,12**,13**,41,42]. However, it can be noted that, even if many studies concern the acceptability of insect-based foods, only a few studies have studied the sensory characteristics of insects. Product type and processing has a large impact on sensory characteristics [18] as do changes occurring during packaging and storage [4**]. The particular insect species is also relevant to the sensory attributes and acceptability [18,43,44].

An important sensory aspect of insects is their visibility in food products. A large number of publications have recommended that insect-based products should not contain visible insect pieces, since this may trigger negative associations [25,26,29,34,38,45–48]. The concerns for many consumers are quite evidently taste, texture and other sensory characteristics [16,20,34,45,49].

In a model study on mealworms, Wendin et al. [50] concluded that the particle size of the added mealworms had a significant influence on sensory aspects concerning texture, taste and appearance. In the same study, shelf life was studied and it was shown that the addition of an antioxidant decreased the changes in colour, rancidity and separation. Roncolini et al. [51] showed that the addition of 5–10% mealworms to bread resulted in an improved texture, probably due to the lipids in the mealworms.

Quite a few studies of consumer acceptance of different products containing added insects have been performed. For example, the consumer acceptance of pasta with added cricket powder was compared to that of conventional pasta. The colour was described as healthy and resembling that of wholemeal pasta and the ratings of taste and overall perception were high [9]. Cabuk and Yilmaz [43] compared protein-enriched pastas and concluded that pasta with added mealworms or grasshoppers resulted in lower liking scores for flavour than when lentils or beans were added. Two varieties of cricket powder were added to cereal and fruit bars; the bars containing defatted cricket powder were preferred to the bars with added whole-ground crickets, especially concerning liking scores for odour and flavour attributes [52]. The addition of protein hydrolysates obtained from crickets to tortillas was found to produce products with sensory acceptable characteristics Luna et al. [53]. A study where mealworm powder was added to bread revealed high liking scores [51]. Mancini et al. [30] reported similarly high liking scores for bread with added insects; however, many consumers indicated that they would not buy insect-labelled bread. Awbosyi et al. [41] found that the addition of insect flour to sorghum biscuits could increase acceptability.

**Social and cultural norms and peer influence**

What is perceived to be edible not only changes over time but is also defined and negotiated within social and cultural settings. The importance of social and cultural norms in the acceptance of insects as food has been acknowledged in several recent studies [19*,20,21,32,54] This is also closely related to food taboos, where certain items are excluded from what is considered to be food in a particular cultural setting. The study by Batat and Peter [7*] reported how food taboos are often shaped and influenced by different social groups, such as friends, family members and co-workers, and also by social media influencers. The crucial role of peers has also been discussed in other studies. Berger et al. [40] highlighted the role of both peer and expert influence for the acceptance of insect-based food and, in particular, mealworm nutrition bars and burgers. They also pointed out how insects as food could be promoted by using social influences of different kinds. In line with this, Sidali et al. [37] also found that peer recommendations about the safety and palatability of edible insects increased people’s willingness to eat them.

The question of eating animals has frequently been connected to moral and ethical issues. The study by Ruby and Rozin [55] comparing the acceptance of insects as food among Americans and Indians found a much higher acceptance among Americans. This was discussed as being due to moral values where eating insects was perceived as violating protected and sacred values. Moreover, men also showed a higher level of acceptance than women, which has also been raised in other studies [12**,25].

**Knowledge and education**

Most consumers are well-informed about the use of insects and larvae in the diet; however, many also regard consumption of these as undesirable [17*,20,47]. A major barrier to edible insect consumption is the paucity of information available, both about the importance of alternative protein sources in the human diet and recommended cooking methods and preparation of dishes using insects [47].

Increased awareness and knowledge of the benefits of entomophagy have been shown to have a positive impact on the acceptance of insect-based food [7*,35,56]. Both Mancini et al. [57] and Barton et al. [17*] suggest that education paired with informative tasting sessions could be one strategy to reduce rejection of, and disgust for, the use of insects as food. It has also been suggested that contextual cultural and ethnic information about the consumption of insects may increase the interest in insect-based food [37].

Jones [22] suggests that teaching about sustainable food choices should be performed in several subjects in the classroom, but also in all areas of school, for example in the school canteen.
Conclusion and future perspectives
The primary objective of this review was to identify the key factors influencing consumer perception and acceptability of insect-based foods reported in the literature published in the years 2019 and 2020. The review shows a complex picture of many different and related key factors influencing consumers’ perceptions and acceptability of insects as food. It also indicates how our relationship to food is often characterised by strong and sometimes contradictory emotions. From a sustainability perspective, eating insects has been identified as a way to tackle many of the challenges related to food provision and consumption. Sustainability, nutrition and health have also been identified as important factors impacting consumer perception of insects as food. However, it is important to note that sustainability is seldom the main factor influencing acceptability of insect consumption. Several studies still identify major challenges relating to neophobia and disgust, where processed insects, familiar tastes, textures, and contexts as well as increased exposure and positive tasting experiences are acknowledged as key factors for achieving wider acceptance. Sensory aspects are, therefore, of importance as is increased familiarity. However, there is a lack of knowledge and information about how to handle and prepare insects, as well as how to incorporate insects into consumers’ everyday diets; here peer influence and social norms must also, therefore, be understood. In order to increase the acceptance of insects as food among larger groups of consumers, it is important to acknowledge the sensory aspects of the food and to develop attractive products with familiar tastes and textures.

Conflict of interest statement
Nothing declared.

CRediT authorship contribution statement
Karin ME Wendin: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Writing - original draft, Writing - review & editing. Maria E Nyberg: Conceptualization, Investigation, Methodology, Writing - original draft, Writing - review & editing.

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