International Journal of Food Design
Volume 4 Number 1
 doi: 10.1386/ijfd.4.1.39_1

SAARA-MARIA KAUPPI, IDA NILSTAD PETTERSEN AND CASPER BOKS
NTNU Norwegian University of Science and Technology

Consumer acceptance of edible insects and design interventions as adoption strategy

ABSTRACT

Edible insects are regarded as one of the most sustainable animal protein sources for human consumption, but for western[2] people insects are a rather unusual food ingredient. In the media, however, insect consumption is gaining increasing attention and people are starting to acknowledge insects as a potential source of protein. The eating of insects, 'entomophagy', is bringing new insect food companies, 'entopreneurs' to the market, yet current research is still insufficient and relatively fragmented to support the commercialization of insect-based food products. Therefore, more systematic research approaches are needed in this area. This review article introduces the benefits and challenges of insect-eating, discusses the factors that are known to influence consumer acceptance, and categorizes factors including adoption strategies into a framework that can be applied in future consumer studies on entomophagy. In addition, the article introduces three distinctive examples of design interventions to illustrate how design can contribute as a strategy to support the general adoption of insect foods by western consumers.

KEYWORDS

edible insects
entomophagy
consumer behaviour
consumer acceptance
sustainability
marketing
design research

Introduction

Insects for human consumption

Edible insects have recently gained attention in the western[1] media as a potential contributor to global food security. Part of this increased publicity is due to a report published in 2013 by the United Nations Food and Agriculture Organisation (FAO) entitled *Edible Insects: Future Prospects for Food and Feed Security* (van Huis et al. 2013), which underlines the benefits of edible insects for human food and animal feed. Current research considers insects to be a sustainable animal protein source, mainly due to environmental criteria since insects require considerably less feed (Collavo et al. 2005), water (Miglietta et al. 2015) and space (van Huis et al. 2013), and emit fewer greenhouse gases (Oonincx et al. 2010) than other animal-based protein sources. From a global perspective, two billion people already eat insects as part of their daily diets (van Huis et al. 2013) and some 2111 insect species have been recorded as edible (Jongema 2017). For most westerners, however, insect-eating simply feels unusual.

Past research on the consumer acceptance of edible insects has elicited a variety of findings. Much research has attempted to identify possible early adopters in the West by understanding what motivates people to eat insects. Further research has proposed adoption strategies that could overcome barriers to entomophagy and highlight positive sensory experiences of eating insects to win over potential consumers. Such research has furthered knowledge about how to make edible insects acceptable in the West, but currently the vast majority of people in the West are still not ready to add insects to their daily diets. The findings from a number of recent consumer studies have not yet been tied together into a holistic overview of what shapes consumer choices to accept insects as food. This has made it difficult to properly understand entomophagic adoption processes. Furthermore, it is also still not apparent how designers could utilize existing consumer studies to successfully promote the adoption of edible insects in commercial applications such as insect food or home rearing products. The purpose of this article, therefore, is to fill this gap by identifying linkages between existing consumer research studies and providing a preliminary framework for understanding the adoption of edible insects from the perspective of consumer acceptance. This framework examines the current literature that exists on consumer acceptance and edible insects in order to provide a categorical overview of the subject matter and will examine three different design interventions that have been presented to the market. In earlier studies, design interventions were not fully considered as implementation strategies, even though the design of insect products, including the design of packaging and food items, are closely linked to consumer perceptions of edible insects. This article suggests that design should be given full consideration in future research as a key strategy to stimulate entomophagic adoption.

1. The term West is present in multiple research papers on edible insects. In this article and especially considering the consumer acceptance section, the term West covers geographic entities of Europe, North America and Australia–New Zealand, where entomophagy – insect-eating – practices have been less dominant in recent years (van Huis et al. 2013). An exception in this article is the regulation of edible insects that only describes the situation within the European Union.

Research purpose

The environmental and nutritional aspects of edible insects have received increasing acknowledgement in recent years, but considerably less attention has been be paid to the process of their adoption by consumers. So far, consumer studies on edible insects have not yet provided any systematic overview of the topic, but rather tackle individual problems one at a time, leaving the terrain quite fragmented for further research. This is especially challenging to researchers, who struggle to understand how their studies can contribute to overall knowledge, but also for industries that try to adapt their findings to practical use. This study will bring together different consumer perspectives on entomophagy by focusing on the factors that facilitate its adoption. Those factors are then categorized to provide an overall framework of adoption as a process, which will then be applied to three design interventions to demonstrate how such interventions can function as an adoption strategy.

Methodology and research questions

A literature review was selected as a suitable method to understand where research currently stands in this fast developing field. The included literature mainly consists of edible insect research conducted between 2005 and 2018, a timeframe that reflects the relative novelty of the research subject. Suitable literature was identified by keyword searches of 'edible insects' and 'consumer behaviour' or 'consumer acceptance' in academic databases, mostly Scopus and Science Direct, with the preferred language being English.

This literature review focuses on the following questions:

- What are the justifications for insect-eating presented in current literature and how do they reflect consumers' concerns?
- What factors are understood as influencing consumer acceptance of insects as food?
- How can design interventions address these factors and support the adoption of edible insects?

The content and the structure of the article

The article first provides a background to insect-eating by looking at various aspects that currently are linked to insect-eating in the West. It then examines consumer studies to find out what factors are known to affect the adoption of edible insects, clustering the range of the findings into three different categories. These categories are then linked to design interventions that will be presented as one of the strategies to stimulate adoption, using a few examples of how design can support adoption (see Figure 1).

Entomophagy for western consumers

Efforts to promote entomophagy often emphasize the low environmental impact and nutritional facts of insects as food (Müller et al. 2016). The efficient rearing of insects certainly plays a big role in their low environmental impact, but rearing can also trigger ethical concerns among consumers about insect well-being. EU regulations for food and animal safety that control the production and quality of edible insects, as well as information used for marketing purposes that can be a major facilitating or hindering factor for consumer

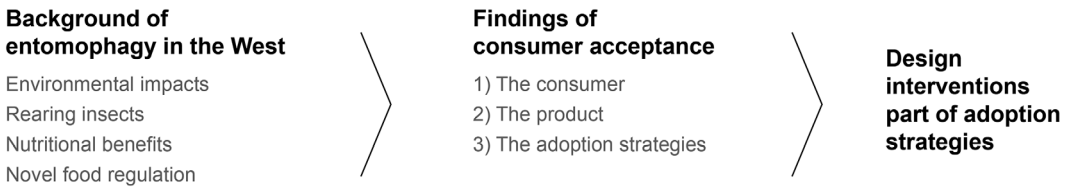

Figure 1: The content and the sequence of the article.

acceptance of entomophagy in Europe. The following chapters therefore provide an overview of the environmental impact of insect rearing, the nutritional aspects of eating them, and novel food regulations that control their production and consumption.

Environmental impact

Insects consume considerably less water (Miglietta et al. 2015) and feed (Collavo et al. 2005), require less space (van Huis et al. 2013), create less waste (van Huis et al. 2013), emit less greenhouse gas, and produce lower levels of pollutants like ammonia (Yates-Doerr 2015; Oonincx et al. 2010) than other types of livestock.

As shown in Figure 2 that compares feed-to-meat conversion rates in the production of 1kg of meat, one needs 10kg of feed for 1kg of beef, 5kg of feed for 1kg of pork and 2.5kg of feed for 1kg of chicken (Smil 2002). House crickets (*Acheta domesticus*), in contrast, only require 1.7kg of feed (Collavo et al. 2005). In addition to feed, it is worth considering the relative water use requirements of each, given that agriculture accounts for approximately 70 per cent of human use of global freshwater resources (Pimentel et al. 2004). According to Halloran et al. (2016) review on insects' life cycle assessment, one thorough study focusing on the topic of water consumption by production insects has been carried out. In terms of water footprint per edible ton, research conducted by Miglietta et al. (2015) found that commercially produced mealworms (*Tenebrio molitor*) have a lower water footprint 4341 (m^3/t) than other traditionally farmed animals, including beef 15 415 (m^3/t) and pork 5988 (m^3/t). However, the water footprint of chicken 4325 (m^3/t) is similar to mealworms.

Insect rearing

Insects gain body weight quickly and require less space for rearing than traditional livestock (van Huis et al. 2013). However, insects' energy use is comparable to pork and chicken (Oonincx and de Boer 2012) and might even be considered less efficient because most mass-farmed insects are raised in rooms that are heated in order to stimulate quicker body weight gain, after which they are freeze- or oven-dried (Deroy et al. 2015). Some processing methods include grinding and dehydrating (Müller et al. 2016), all of which consume significant amounts of energy and have various associated environmental impacts. Though not yet scientifically documented, anecdotal evidence of discussions within the field in conferences and seminars suggest that some ento-preneurs are aware of the above challenges and are aiming to solve them by exploiting excess waste heat from other industries and building insect feed systems on the principles of the circular economy. Good quality, sorted and

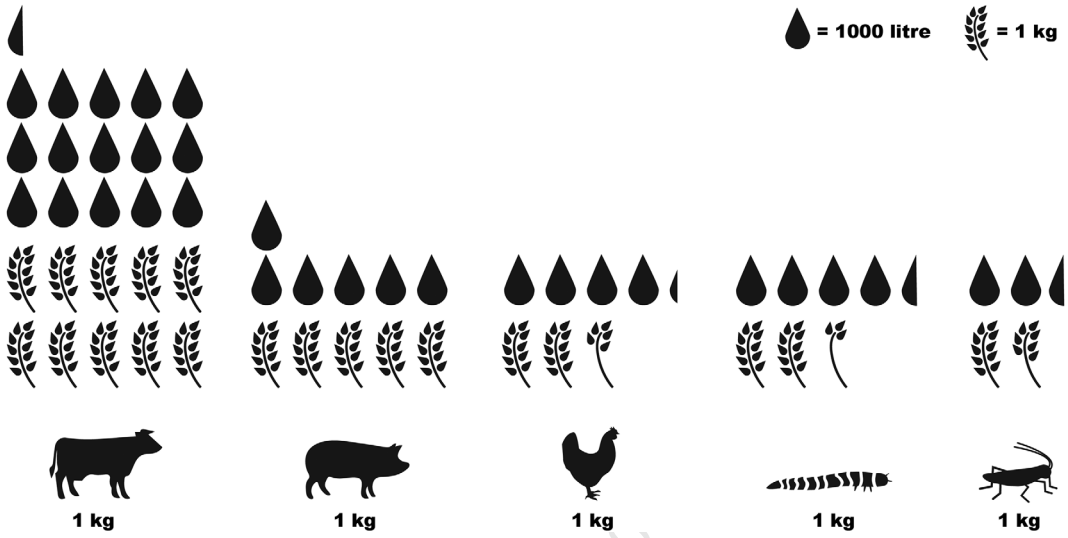

Figure 2: Amount of feed and water needed to produce 1kg of live animal weight, based on an illustration by Dobermann et al. (2017) redrawn by Saara-Maria Kauppi. Data from Hoekstra (2012), Hoekstra and Mekonnen (2012), Mekonnen and Hoekstra (2012), Oonincx and de Boer (2012), van Huis et al. (2013) and Miglietta et al. (2015).

tracked organic side streams could be utilized as insect feed within the limits set by current legislation.

Rearing insects thus offers a number of opportunities for business solutions and innovative design concepts because the small size or insects enables both home and industrial rearing, and permits the vertical stacking of facilities to save further space. As with any other intensively farmed animal though, insect rearing methods will have to meet animal welfare standards. Fifty years ago, Brambell (1965) established the 'Five Freedoms' of animal welfare under human control for a UK Government report: freedom from hunger or thirst; discomfort; pain, injury or disease; fear and distress; and the allowance of natural behaviour. The International Platform of Insects for Food and Feed (IPIFF) has later created a report to encourage insect farmers to commit to those welfare practices by 2020 (IPIFF 2019). Furthermore, preventing cannibalism in captivity requires that sufficient food of adequate nutritional quality and water be provided (van Huis et al. 2013). However, not much is known about how insects experience pain and discomfort (Erens et al. 2012) and discussions about insect consciousness often lead to propositions that insects are 'lesser animals' that vegetarians or even vegans could consider consuming without contradiction (Davis 2014; Engström 2018). Such discussions about rearing conditions and ethical considerations about insect-eating will have an effect on consumers who are environmentally and ethically conscious because they can be expected to want to know more about insect rearing processes as they engage in ethical considerations about whether or not to eat them.

Since insects are regarded as an unusual food in the West, such consumer perspectives are important to address, especially given that insects could be fed with cost-effective, organic side streams, such as from restaurant or household kitchen leftovers (Offenberg 2011), and thereby contribute to reducing

organic waste and pollution (van Huis et al. 2013). One study reported that mealworms (*T. molitor*) have even been observed to successfully consume and digest Polystyrene, more specifically Styrofoam, efficiently degrading it into CO_2, fecula and biomass in the larval gut in less than 24 hours (Yang et al. 2015). This interesting finding has great potential for waste management, but is also suggestive of a wider spectrum of possibilities for edible insects. To date, however, no research has been conducted on how consumers respond to the idea of eating insects that have been fed with so-called 'waste' products. Feeding insects with substances that are inadequate as feed for other livestock might negatively influence consumer perceptions of insects as 'edible' and strengthen negative impressions of edible insects in the West, especially when a substrate, like Styrofoam, is considered 'inedible' for humans and other animals. Furthermore, feeding commercially reared insects with compost or other organic matter that is not standardized as feed is not currently allowed by food and feed legislation in the European Union (van Huis et al. 2013), although current regulations do not apply to individual home rearing that uses food scraps as feed.

Benefits of eating insects

The nutritional value of insects varies depending on the metamorphic state of the insect, whether the insect is consumed as an egg, larvae, pupa or adult. Different preparation and processing methods (e.g. drying, blanching and frying) also affect the nutritional composition. The main macronutrients of insects are protein, fat and fibre, with the most common fibre being chitin. An undeniably rich source of protein and iron, edible insects can help prevent anaemia (van Huis et al. 2013), but levels of both differ between species (see Table 1). Currently, the two most common edible insect species for human consumption reared in Europe, namely the house cricket (*A. domesticus*) and mealworm (*T. molitor*), have protein contents of 55–70 per cent and 47–49 per cent of dry matter, respectively (Rumpold and Schluter 2013). Insects are also rich in several micronutrients, such as copper, iron, magnesium, manganese, phosphorous, selenium and zinc, as well as riboflavin, pantothenic acid, biotin, and in some cases folic acid (Rumpold and Schluter 2013).

Novel Food Regulation

The introduction of new types of food in the European Union is regulated by the Novel Food Regulation. The regulation is unfortunately unclear when it comes to whole animals like insects, and as such, some EU countries allow whole insects as food, while others do not. The new EU Regulation N° 2015/2283, in force since January 2018, designates all insect-based products as 'novel foods' unless it is possible to prove a history of their usage as food before 1997.

At the time of writing (December 2018), dossiers have been submitted to the European Food Safety Authority (EFSA) requesting the approval of five different insect species as 'novel foods' (European Commission 2018): the house cricket (*A. domesticus*), yellow mealworm (*T. molitor*), migratory locust (*Locusta migratoria*), lesser mealworm (*Alphitobius diaperinus*) and the tropical house cricket (*Gryllodes sigillatus*). The EFSA has formulated a risk profile of insects as food and feed for consumers (EFSA 2015), and all packaging must inform consumers about possible allergens of edible insects (Evira 2018).

	Protein (% dry matter)	Fat (% dry matter)	Energy (kcal/100g)
Coleoptera (adult beetles, larvae)	40.69	33.4	490.3
Rhynchophorus phoenicis (palm weevil larvae)	32.86	36.86	478.87
T. molitor (mealworm larvae)	48.35	38.51	557.12
Diptera (flies)	49.48	22.75	409.78
Hemiptera (true bugs)	48.33	30.26	478.99
Hymenoptera (ants, bees)	46.47	25.09	484.45
Oecophylla smaragdina (weaver ant)	53.46	13.46	
Isoptera (termites)	35.34	32.74	
Lepidoptera (butterflies, moths)	45.38	27.66	508.89
Bombyx mori (silkworm larvae)	61.8	8.81	389.6
Cirina forda (shea caterpillar)	47.48	11.5	359
Galleria mellonella (waxworm larvae)	38.01	56.65	650.13
Samia cynthia ricinii (ailanthus silkworm pupae)	54.7	25.6	463.63
Odonata (dragonflies, damselflies)	55.23	19.83	431.33
Orthoptera (crickets, grasshoppers, locusts)	61.23	13.41	426.25
A. domesticus (house cricket adult)	65.04	22.96	455.19
Schistocerca sp.	61.05	17	427
Sphenarium purpuracens (chapulin adult)	61.33	11.7	404.22
Ruspolia differens (brown longhorn grasshopper)	44.3	46.2	

Table 1: Protein, energy and fat content of selected insect species. Data from Rumpold and Schluter (2013) and picture from Dobermann et al. (2017).

Companies willing to commercialize edible insects are required to conduct a standard food safety assessment called the Hazard Analysis and Critical Control Points (HACCP) in order to be able to sell edible insects in European countries and avoid health risks for consumers.

Current food regulations present numerous obstacles for edible insect food innovation. They do not support ancillary extractions from insects, such as proteins, fats or chitin, for human food or as ingredients in human food, thus dossiers regarding insect-derived food ingredients will need to be sent separately to EFSA at a future date. Anecdotal evidence suggests that this is a rather costly and long process for ento-preneurs, meaning that in the long-term they could impede food innovation, create monopolies for certain companies that can afford the HACCP process, and limit the use of insect species to only a few of over 2000 species that could enhance edible insect monocultures. Furthermore, the European Union's Novel Food Regulation also creates an imbalanced starting point for ento-preneurs in different EU countries, as some countries allow insects as food while others do not. A further problem is that the HACCP process requires that dossiers be company-specific, rather than species-specific, thereby requiring that every company wanting to sell insects as food needs must invest resources in making HACCP applications. This can make it difficult for smaller companies to enter the insect rearing business if they lack the capital to cover the costs of the expensive process.

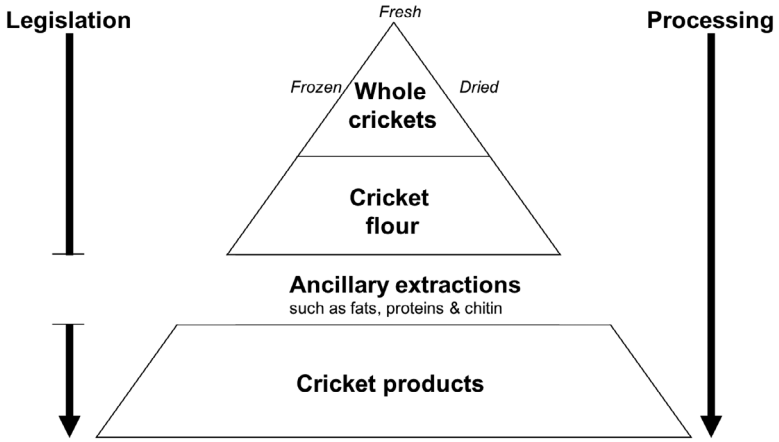

*Figure 3: Example of house cricket as food (*A. domesticus*) within the current regulation. There is a gap in the legislation that does not support insect-derived ingredients such as fats or protein used in food production. Currently only whole insects and insect flour or products developed from insect ingredients can be sold as food in the countries that allow insects as food in the European Union. Illustration by Saara-Maria Kauppi.*

Indeed, the regulations that current control rearing conditions, product development, marketing and the overall availability of insect species are one of the biggest barriers for availability of insects on the market, and therefore have a direct effect on the scale of consumer acceptance.

Consumer acceptance

Edible insects are an unusual food for westerners; therefore knowledge of consumer acceptance of insects as food is extremely important for understanding the adoption process. Understanding the reasons behind consumer acceptance or rejection of edible insects can help make future research and development more efficient and can contribute to general knowledge about the commercialization potential of edible insects. However, not enough is currently known about consumer needs, experiences, behaviours and goals to effectively stimulate their engagement with insect-based products. In addition, scientific literature on consumer acceptance is quite fragmented, and in some cases even presents contradictory research results (House 2016: 48).

Looking at the results of the literature review in a broader perspective, we developed a framework in which recent consumer research findings are divided into three main categories; findings about (1) the consumer, (2) the product and (3) the adoption strategies (Figure 4).

This framework captures and categorizes the predominant factors mentioned in the literature that are said to affect consumer acceptance of edible insects. Factors about consumers and products are further divided into two subcategories. Sociocultural circumstances, such as social acceptability and culture are tightly linked to long-term adoption of the product (House 2016). Individual consumer factors describe consumer-related attributes such as idiosyncratic motivations to eat insects, gender and age. Product-related circumstances such as availability, suitability and product placement are also known to affect the adoption process, as do certain relevant product properties such

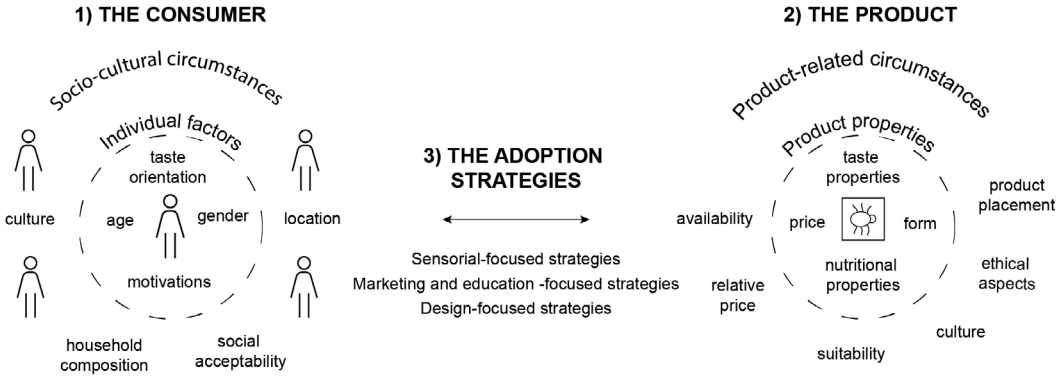

Figure 4: The framework of factors affecting the acceptance of edible insects found in the literature.

as taste and form. The adoption strategies create links between the consumer and the product.

The consumer

Sociocultural circumstances

Insects are often seen as being 'dirty, unhygienic, unhealthy, disease transmitters' (van Huis et al. 2013) and research has indicated that westerners are generally reluctant to consume insects or insect-based foods because of this prejudice (Hartmann et al. 2015; Ruby et al. 2015). While there is an indication that improving consumer knowledge of insects as food can result in an increased willingness to consume it, food choice is a complex mix of sensorial, situational, social, cultural, demographical and cognitive factors (Tan et al. 2017; Verneau et al. 2016; Lensvelt and Steenbekkers 2014; Looy and Wood 2006); therefore a combination of factors may offer the best potential for successful adoption. For instance, while 'Bug Banquets', a social insect-eating practice, have been reported to have a positive effect on increasing the acceptance of insect-eating (Looy and Wood 2006), this result might be linked with the fact that peer pressure can affect person's willingness to try insects. Furthermore, Halkier and Jensen (2011) confirm that food consumption is highly relational, connected to other practices such as work, school, care and socializing. House (2016) further states that household composition, i.e. with whom a person eats their food, and the degree of fit with current eating patterns are also determinative of the success of routinized consumption of insect food. Tan et al. (2016) conclude that insect food should be aligned with what is considered to be culturally appropriate and tasty, but point out that more research is needed to understand the whole spectrum of the suitability of insects for western consumption.

Nordic consumers scored higher on approving insect food than other Europeans (Piha et al. 2018). This kind of differentiation was confirmed in Poland (Kostecka et al. 2017) and in Italy (Sogari 2015) where informants did not show a positive attitude towards insect-eating. The reason for this difference might be that the food culture in northern Europe is not regarded as so established as it is in central and southern Europe, and has experienced many changes in recent decades (Verneau et al. 2016). This implies that environmental stimuli and educational promotions of insect food might have a

bigger impact in 'immature' versus 'mature' food cultures (Piha et al. 2018). A further reason behind this difference is that there has been significantly more media coverage about edible insects in northern Europe. Since the media has an important role in framing novelties such as insect food (Dudo et al. 2011), it may have guided general opinions about edible insects in a more favourable direction (Piha et al. 2018).

Individual factors

Findings from consumer acceptance studies conducted in western contexts suggest that men tend to accept eating insects at a higher rate than women (Hartmann et al. 2015; Schösler et al. 2012; Verbeke 2015; Ruby et al. 2015). According to Verbeke (2015), younger men who are willing to try novel foods and have expressed an intention to reduce their meat consumption are likely to be the first group to adopt insect-eating and therefore could be specifically targeted as possible market trendsetters. As a group, they are interested in the environmental impacts of their food choices and the health aspects of their chosen diets and also tend to have lower levels of both food neophobia (phobia of experiencing new tastes and food) and food technology neophobia (phobia of processed foods), which generally make them more ready to try unusual or unfamiliar foods. In Verbeke's (2015) study, male respondents were 2.17 times more likely to adopt insects as a substitute for meat than females, while a ten-year increase in age was correlated to a 27 per cent decrease in likelihood that someone would be ready to adopt insects as food. One explanation for this could be that young men have a more adventurous taste orientation and/or find insect-eating less disgusting than other groups. Another study confirms that an adventurous taste orientation is associated with a higher interest in consuming insects (de Boer et al. 2013), and curiosity has also been observed as a motivating factor (Sogari 2015). Those who expressed an interest in eating insects believed that insects were a sustainable, relatively healthy and nutritious food choice (Sogari 2015; Ruby et al. 2015). Previous experience with insect-eating (Verneau et al. 2016; Hartmann et al. 2015; Verbeke 2015; Lensvelt and Steenbekkers 2014) and available information about insect food can also result in an increased willingness to consume insects (Verneau et al. 2016; Lensvelt and Steenbekkers 2014). So far, however, education levels have not been shown to consistently influence the adoption of insect-eating. While one study (Rozin et al. 2008), observed that disgust sensitivity was inversely related to education and socio-economic status, studies conducted by Verbeke (2015) and Schösler et al. (2012) did not find that educational levels affected acceptability to consume insects.

The product

Product-related circumstances

Product-related circumstances cover the social, practical and contextual factors that are linked to insect food products. Many survey-based studies on consumer acceptance focus on the products themselves and do not really acknowledge the role of other factors, such as where a product is being sold or what other products they are being compared to. One exception to this is a study by House (2016) that conducted 33 semi-structured interviews in the Netherlands. Although the price and taste of an insect-based burger influenced repeat consumption, also important were social, practical and

contextual factors. Placing insect food products next to vegetarian equivalents in Dutch supermarkets 'scripted' the idea of the insect burgers as meat replacements, rather than as a distinctive new product. Strategic supermarket shelf placement made the products comparable with an array of alternatives and activated various selection criteria such as price, taste and availability that the product was not able to meet. Most of the participants in the study bought the product only once, due to significant problems with the product being too expensive, availability being low, and it not tasting good.

Product properties

Most available research focuses on the suitability of edible insect product properties for western consumers and concentrates less on the circumstances that shape purchasing behaviour. Indeed, taste and nutrition factors are significant in determining whether insect-based foods are accepted or not (Deroy et al. 2015; Hartmann et al. 2015; Schouteten et al. 2016; Tan et al. 2015). Interestingly, House (2018) points out that perhaps the most delicious insect species are not currently being promoted as food because promotion decisions sought to upscale insects farming practices, rather than insect taste properties. However, while positive taste experiences may not necessarily increase consumption intentions, negative tasting experiences will very likely have a negative impact on successfully introducing insects as food (Tan et al. 2017). This is due to the fact that successful adoption is an outcome of a combination of multiple factors and consumers' negative impressions of insect food will likely deter them from further consuming insects in the future. Another interesting finding in the literature is that the cultural 'appropriateness' of insect-based burgers had a greater influence on one's willingness to consume them again over taste, food neophobia, and gender factors (Tan et al. 2016).

Associating insects with known flavours appears to induce less aversion than unflavoured insects. In addition, preparing food in ways where insects are visible seems to trigger more dislike than when they are invisible in cultures without entomophagy traditions (Megido et al. 2014, 2016; Lensvelt and Steenbekkers 2014; Schösler et al. 2012). This finding is consistent with an earlier study that claims that people who are unfamiliar with eating insects, like western consumers, are more likely to eat processed rather than unprocessed insects, whereas people from cultures that are more accustomed to eating insects exhibited no greater or less willingness (Hartmann et al. 2015).

The adoption strategies

Lensvelt and Steenbekkers (2014) suggest two adoption strategies in consumer behaviour research: *sensorial-focused strategies*, that let people use their senses and taste insect food; and *marketing and education-focused strategies*, that provide information about insects. Although this has not been fully addressed in the academic literature on entomophagy, the examples provided in this article will demonstrate that design interventions can have an impact on the adoption of entomophagy. Therefore, a third strategy, *design-focused strategy*, is suggested in this section with three distinctive design examples to further illustrate and discuss how design can impact the general adoption process. 'Design' in this article refers to choices about how to design an artefact or service in such a way that it changes behaviour. In this sense, design is conceived as an intervention, not as an aesthetic feature of an artefact. On the whole, it is important to understand that the three strategies, *sensorial-focused*,

marketing and education-focused and *design-focused strategies*, are not exclusive. Sometimes they overlap and can achieve better results in facilitating adoption processes when they are combined.

Sensorial-focused strategies

Sensorial-focused strategies seek to gain people's trust about insects as safe and nutritional food for human consumption. Studies confirm that people who have tried insects are more likely to consume them later on (Megido et al. 2016; Hartmann and Siegrist 2016; Hartmann et al. 2015; Tan et al. 2015; Verbeke 2015). Taste and nutrition factors play significant roles in the adoption of edible insects; therefore some argue that marketing tactics should promote those aspects more than environmental ones. Deroy et al. (2015) for instance argue that because people's food choices are generally driven by taste, preferences and exposure, then a sensorial-driven strategy would have a much greater chance of encouraging people to eat insects on a regular basis. Consumers should be encouraged with realistic motivations to try insects by appealing to their gastronomic curiosity to test the variety of insect species.

Marketing and education-focused strategies

Marketing and education-focused strategies provide information about insects and cultural, nutritional and ecological factors associated with entomophagy. Studies demonstrate that people who are informed about the safety and environmental benefits of eating insects appreciate insect-based burgers more than respondents who were not similarly informed (Schouteten et al. 2016). A number of studies suggest that improving consumer knowledge about insect food will increase their willingness to consume it (Verneau et al. 2016; Lensvelt and Steenbekkers 2014; Looy and Wood 2006).

Marketing based on the education-focused strategy can be used to promote selected values of insect products. Shelomi (2015) suggests that insects could be promoted as alternatives to nuts or marketed similarly because some have a texture, macronutrient content, and even taste that is comparable to nuts. Further factors, such as naming insects, can also facilitate the adoption of insects as food. Creative analogies such as 'land shrimp', 'tree lobster' (Holt 1885; Looy et al. 2014) or 'sky prawns' (BBC 2004) might reduce the disgust factor that is commonly associated with insects. In one study, a group of native Americans, very accustomed to eating grasshoppers, locusts and crickets, called shrimps 'sea crickets' during their first tasting of the species (Lockwood 2004). Also, native names or less known scientific names of insects could also be advantageous when promoting them to larger consumer groups, rather than calling them by their commonly known names (Holt 1885; Looy et al. 2014). Insects could be marketed as part of trendy diets, such as the 'Palaeolithic' diet that consists of food that purportedly was eaten by pre-civilization humans (Ramos-Elorduy 2009). Insects can also be marketed as 'natural' food products to people who prefer eating less processed foods (Barska 2014; Siegrist 2008). Furthermore, because of their high-protein and low-carbohydrate content, insects could be specifically marketed to bodybuilders and consumers with active lifestyles, as well as people following low-carbohydrate diets, such the Atkins diet, or those on non-GMO or gluten-free diets (Shelomi 2015).

When it comes to marketing, there seems to be disagreement as to whether insect images or visible insects through transparent packaging should

be shown in packaging. Baker et al. (2016)'s research into visual cues acknowledges that insect products in a retail setting should rely more on images, as people tend to minimize time spent shopping, whereas in a restaurant setting menu items should rely more on descriptive information. Although insects can be visualized in many ways on product packaging, for their study Baker et al. (2016) used realistic images of insects and compared them with ground insect flour. Another study, however suggests that since insects are an unusual ingredient for westerners, abstract representations would be a preferred solution, depending on which consumer group is targeted (Kauppi 2016). A greater consensus appears in current studies that demonstrate that food packaging with visible insect contents seems to trigger more consumer aversion (Megido et al. 2014, 2016; Lensvelt and Steenbekkers 2014; Schösler et al. 2012); however, this kind of finding does not discuss more appropriate ways to display insects, and does not explore the multiple ways that design could approach the problem. Indeed, appropriate choices of insect depictions will likely depend on the target market and product category. On the one hand, consumers with experimental attitudes to entomophagy might favour insect images, as it works as a visual guide and indicator of what is inside of the product. On the other hand, packaging and products that target consumers who are interested more in product functionality, such as amounts of protein or vitamin B12, might benefit from using considerably less explicit ingredient associations.

Design-focused strategies

In addition to *sensory-* and *marketing and education-focused strategies*, the following sections will suggest that design could also be considered as part of adoption strategies. Drawing on examples from outside academia, where most design interventions are developed and deployed, the following section will illustrate different ways of using design to facilitate adoption.

Design is more than merely an aesthetic or practical feature of marketing. Design interventions should instead be considered as strategic attempts to facilitate change and influence adoption and eating behaviours of consumers. The first case below illustrates how design is challenging food regulations to find more positive grounds to market edible insects. A second example discusses how design engages consumers to farm their own insects and create a more meaningful relationship with hyper-local food production. The final example shows how design can promote certain values that consumers identify through packaging design in search of desirable products. Although there are other ways in which design can facilitate adoption, these three examples were selected to show from a wider perspective how design can affect sociocultural circumstances and product-related circumstances, and can create linkages between individual factors and product properties (see Figure 4).

Design changing the country-specific regulation

The product Sirkkapurkki (*Cricket Jar*), consisting of different cricket-based granola ingredients laid neatly as layers in a see-through glass jar, was originally launched and promoted as 'kitchen decoration', and was sold in a small number of ecological retail chains in Finland in 2016. As well as being promoted as a 'kitchen garnish' and granola, the underlying meaning and purpose behind the product's marketing was to challenge the country-specific

Figure 5: Sirkkapurkki (Cricket Jar) *by EntoCube (2016b) granola ingredients in jar sold as 'kitchen decoration' in Finland, designed by the first author. Crickets in a jar sold as 'Eye candy' by Griidy (2018) in Sweden. Reproduced with permission from EntoCube and Griidy.*

interpretation of the EU regulation and create awareness of the law that places restrictions on insects as food. When purchasing the product, consumers were informed about the illegal status of edible insects in the country and invited to share photos of them preparing and eating the cricket granola on social media platforms on the Internet. The product itself suggested that people get a hands-on experience of cooking insect food by mixing the ingredients and preparing the granola in the oven. Another similar insect product later followed in Sweden in 2018, which boldly advocated for the legalization of insects as food by offering oven-dried crickets in a see-through glass jar.

By adopting a short-term perspective, ento-preneurs selling these kinds of promotional products are actually benefiting from the current situation where it is illegal to sell insects as human food. By encouraging consumers to actively participate in the public debate by buying and trying the product and fostering a social movement of sorts around the topic, they also sought to earn free social media coverage. While the promotion of products like these can influence regulation by changing consumer demand, other factors also play also an important role. The local food authority in Finland eventually decided to amend the country-specific interpretation of the EU regulation by accepting insects as food, partly because more and more edible insect food products were appearing on the market and marketed as 'non-food', but also partly because of strong lobbying efforts by ento-preneurs and local media pressure (Engström 2018; EntoCube 2016a; Taponen 2017).

Even though the cricket granola product regularly sold out, it is not known what the true motivations of consumers were to buy the product. Was it 'the kitchen decoration' that enhanced their willingness to consume insects? Or did the product motivate people to participate in a social movement promoting sustainability and change? Or was the motivation to purchase about both of these things? Social movement that encourage and empower consumers to question the status quo is very much linked with current trends in the Nordic countries of resistant responses to food market regulations. Such efforts have

seen success in countries that are known for strong state regulations, homogenized market offering and are sometimes accused of being 'nanny states' (Weijo et al. 2018).

Design changing the perception of food production

The hive (LivinFarms 2018) is a multi-tray electronic home farming product designed for growing mealworms. It regulates temperature and humidity levels in order for consumers to grow mealworms in a controlled and fast manner in an urban environment using kitchen food scraps as feed. The hive provides a calibrated light system that helps with harvesting and monitoring the growth cycles of the mealworm colony. The modern and clean design shifts the attention away from mealworms being dirty and disgusting to a futuristic vision of producing food at home. Several rounds of testing, prototyping, material selection, and cost-analysis led to this product's current appearance (EntoNation 2018).

The hive can be ordered online and tackles the associated problems of stock availability and high prices of edible insects, while also raising awareness of where food comes from. Home farming with such products may facilitate adoption, since the mealworms have the advantage of being constantly available for cooking and because consumers engage themselves with learning more about insects through farming them. On the product website and social media platforms consumers can share their experiences and support one another, discuss insect feed and how it affects the taste and growth of the mealworm larvae, and how to manipulate the product's build-in sensors to

Figure 6: LivinFarms' product for home rearing mealworms. Reproduced with permission from LivinFarms.

produce more data. LivinFarms aims to bring about a *food revolution* of sorts by using mealworms to create awareness of food systems and initiate a shift from large-scale industrial meat production to home food production as well as providing insect education at schools (EntoNation 2018).

The hive is a carefully designed product. It has a modern look that combines white matte plastic with metal, blinking colourful lights that indicate that the system is working, and the overall shape distracts from the idea that insects are being farmed in the system. Although the normalization of edible insects is the main idea behind the concept, the design of the product might also be aesthetically too futuristic and the size too big to successfully encourage a greater audience to start experimenting with insects, especially for those with apartment kitchens, where space can also be limited. Another problem raised online by users is hygienic concerns that can appear with any food-related system. Some users experienced problems with pests, insect escapes, or disease epidemics that wiped out colonies (LivinFarms 2018), most likely caused by users' own hygienic standards. Furthermore, farming living animals at home can bring unpleasant surprises for beginners who are not well prepared. Thus, while home farming can engage consumers to embrace entomophagy more fully than the occasional purchase of edible insect products in supermarkets, unpleasant hygienic problems linked to insect farming at home may deter people from doing so.

Design linking individual factors and product properties

Packaging design is commercially used to influence consumers to purchase products. Packaging design creates an impression of a product's contents using visual cues, such as images, shapes, colours, forms, text and typography. By utilizing design principles such as contrast, hierarchy and alignment, a target group's focus can be targeted towards the elements that are the most important to it.

Figure 7: Different insect products from ThailandUnique (2018), BugFoundation (2018), Jimini's (2017) and NutriBug (2018). Reproduced with permission from Thailand Unique, Bug Foundation, Jimini's, Nutribug UK Ltd and designer Graeme Lee Rose.

Since edible insects are a relatively unfamiliar food in the West, promoting insects relies on a number of different marketing and design strategies for product packaging. For example, nutritional facts and environmental aspects of insects as food are often emphasized on packaging to specifically target environment and health-conscious consumers. Such products can be categorized as environmentally sound and functional food containing added insect protein. Companies that promote functional insect foods could therefore use food and packaging design strategies to normalize insect-eating by linking the insect products with existing food styles and forms. Insect protein bars, for example, imitate the form and the style of protein bars, and insect pasta replicates the form and the packaging of regular pasta. These products would not be categorized as an authentic or exotic insect food, but rather as recognizable western food with added insect ingredients. A contrasting approach would be to design products in ways that specifically promote non-western and exotic cultural aspects of insect-eating, and encouraging the consumers to experience the taste of an unusual food because it is unusual. Some companies have tested several design strategies in order to find such prospective consumers (BrandNew 2017).

Pilditch (1961) once described packaging as 'the silent salesman' that can effectively connect the right target market with the product and promote the ideal product properties to the consumer. Normalizing insect-eating, whether for their nutritional aspects or as exotic food, will often be associated with insect food packaging choices. Packaging design choices do not, of course, guarantee routinized consumption, especially if the taste is not able to meet consumers' quality criteria or if prices are regarded as being too high.

Discussion

This article examines three research questions: (1) what are the justifications for insect-eating presented in current literature and how do they reflect consumers' concerns?; (2) What factors are understood as influencing consumer acceptance of insects as food?; and (3) How can design interventions address these factors and support the adoption of edible insects?

The scientific literature is unanimous about the environmental and health benefits of insects as food. Insects consume less water and feed, use less space, grow faster than regular livestock, and some insect species can even utilize some waste substances that are unsuitable as feed for other farmed animals. The overall consumption of energy that rearing insects requires, however, makes them less than ideal, as insects are often raised in heated rooms and then freeze-dried, oven-dried, blanched, ground up, and sometimes dehydrated, all of which consume significant amounts of energy. The impact of these processes is often left out from general discourses about the sustainability of insects as food, and should be included in future discussions.

The nutritional aspects of insects as food clearly support arguments of them serving as meat replacements. However, not all insect products end up saving the world when they substitute other dietary items. It is crucial for those who advocate insects' environmental benefits to understand what the alternatives are that edible insects are substituting, why it is beneficial to substitute them, and what one's overall replacement strategy is. Many of the products that currently use edible insects as one of the ingredients, such as protein bars or cricket pasta, may in fact have a bigger environmental impact than equivalent products that do not contain animal protein. However, these products can be seen as stepping stones for consumers to get used to the idea of eating

insects, and such positive rebound effects may ultimately justify their market introduction. However, this should not be confused with or used to promote the sustainability of the product. The sustainability potential of insects as food depends very much on how insects are farmed and what kind of food they are compared with, which provides challenges for communicating this potential to the general public.

The European Union's Novel Food Regulation supports the safety of insect-eating within European Union and seeks to create an equal starting point for companies to promote this activity. The lack of clarity and uniformity of the regulation's effect in different countries, however, has created an imbalanced starting point for companies located in different countries in the European Union. This has resulted in criticism about the country-specific interpretation of the regulation, as well as innovative design interventions, like 'kitchen decorations', that protest and aim to change the regulation. Ento-preneurs have also criticized the regulation for hindering product development, as the extractions of insects such as fats and chitin cannot be produced for commercial use within the current regulation without another HACCP process.

Animal welfare is a topic that has not gained much attention in current research about insects, but it is likely to be addressed in the near future. Ethical aspects of insect-eating will have an effect on conscious consumers, which will become more important as consumers are expected to increasingly question how insects were reared and killed before they end up on their plate. Categorising insects as animals subject to ethical considerations is a discussion that requires further academic attention, but that also needs to be addressed in the future by food regulatory authorities.

Current consumer research has identified several strategies and ways of convincing consumers to eat insects however, consumer acceptance as a term is problematic, especially in the field of edible insects since 'acceptance' does not explain the degree to which insects have been accepted in any given case. 'Consumer acceptance' may refer to a product trial or to the full integration of a product into a consumer diet with repeated and continued eating of insects. While making people try insects is relatively easy, integrating them into a daily diet is a very difficult challenge for entomophagy promoters. Therefore, research about factors that can facilitate continuous consumption of insects as food is a topic that further research should undertake in the future.

Also, the term consumer acceptance is a rather limited construct for exploring the development of insect products as it implies the existence of a finished product is simply waiting for consumers to accept it. Focusing on consumer acceptance moves attention away from questions about design and does not consider exploratory rounds of design and redesign trials that accompanies dialogues and negotiations between the companies, designers and consumers. There are many ways to design insect products and make them available to consumers, including approaches that allow consumers to be active and creative in experimenting with and possibly integrating insect-based products into their routines and diets.

Existing research literature typically paints a picture of the consumer and the product and then seeks out strategies to connect them. They identify consumer- and product-related factors that can be further divided further into individual, sociocultural, product property and product-related categories. Consumers who have both an experimental taste orientation and an interest in healthy diets and reducing meat consumption, often younger men, are likely to be the first consumers of insect food (Verbeke 2015). The literature suggests that 'hiding' the insect contents of a product, such as with an

insect powder, is a preferred way to confront the public with insect-eating as a dietary alternative. However, hiding as a strategy can affect the authenticity of the insect food and make the food seem less genuine. Taste and price along with nutritional aspects have been raised as important factors of insect food; however, in order to achieve routinized consumption, particular interactions between several factors need to take place (House 2016). In this article, we have illustrated how design interventions in addition to strategies such as marketing, education and sensory testing can be used as ways of connecting consumers and products. Design interventions have high potential to connect several of these key factors that are associated with the individual consumer-, such as sociocultural circumstances, and product-related circumstances in ways that can make insects less distant to western consumers and connect them to insects in a meaningful way.

Entomophagy presents a considerable and challenging gap between values and action in the sense that people can be generally supportive of the idea of sustainable protein sources, but do not want to consume insect products. This is evident in marketing product trials, as well as in redesigning cycles where designers test multiple and various product packaging designs and marketing strategies in efforts to connect with possible consumers. Such strategies focus on convincing the consumer, but this is challenging if neither society nor local cultures support the practice of insect-eating by complementary means. Moreover, ento-preneurs often talk about changing food culture, localizing food production by design interventions, and aligning value chains to circular economy principles by utilizing organic side-streams for insect feed. More research supporting these attempts is needed in order to make production as environmentally sound as possible and to prevent the promotion of false assumptions and promises to consumers.

Conclusion

Insects have great potential as food sources because of their environment and health benefits, but research on commercializing insect food is still in its early stages. Literature on consumer acceptance of insect-eating does not portray a clear image that connects the various findings of existing literature, leaving the field rather fragmented. The framework introduced in this article, therefore, aims to help academics to position their research within a bigger picture. Scientific literature about the factors that affect the adoption of insects as food can be categorized as findings about the consumer, the insect food product and adoption strategies. Design interventions can create linkages between various factors that affect the adoption process of edible insects; therefore design can potentially be regarded as the most effective strategy for introducing insects to western consumers. Furthermore, design interventions can facilitate adoption and should be considered as a key adoption strategy to stimulate adoption. This article presented three selected design interventions to demonstrate how design choices can affect consumer acceptance and how design can be a catalyst for adoption of insects as food.

REFERENCES

Baker, M. A., Shin, J. T. and Kim, Y. W. (2016), 'An exploration and investigation of edible insect consumption: The impacts of image and description on risk perceptions and purchase intent', *Psychology & Marketing*, 33:2, pp. 94–112.

Barska, A. (2014), 'Attitudes of young consumers towards innovations on the food market', *Management*, 18:1, pp. 419–31.

BBC (2004), 'Locusts rebranded as sky prawns', 22 November, http://news.bbc.co.uk/2/hi/asia-pacific/4032143.stm. Accessed 15 October 2017.

Boer, J. de, Schösler, H. and Boersema, J. (2013), 'Motivational differences in food orientation and the choice of snacks made from lentils, locusts, seaweed or "hybrid" meat', *Food Quality and Preference*, 28:1, pp. 32–35.

Brambell, F. W. (1965), *Report of the Technical Committee to Enquire into the Welfare of Animals Kept under Intensive Livestock Husbandry Systems*, London: Her Majesty's Stationary Office.

BrandNew (2017), 'New logo and packaging for Exo by Gander: Pumped for crickets', 22 September, https://www.underconsideration.com/brandnew/archives/new_logo_and_packaging_for_exo_by_gander.php. Accessed 21 December 2018.

BugFoundation (2018), 'Deutschlands erster Insekten Burger', https://bugfoundation.com/files/default_theme/content/slider/insectburger_packaging.png. Accessed 21 December 2018.

Collavo, A., Glew, R. H., Huang, Y. S., Chuang, L. T., Bosse, R. and Paoletti, M. G. (2005), 'House cricket small-scale farming', in M. G. Paoletti (ed.), *Ecological Implications of Minilivestock: Potential of Insects, Rodents, Frogs and Snails*, New Hampshire: Science Publishers, pp. 519–44.

Davis, L. (2014), 'Should vegetarians consider eating insects?', *Practical Ethics: Ethics in the News*, University of Oxford, 24 June, http://blog.practicalethics.ox.ac.uk/2014/06/should-vegetarians-consider-eating-insects/. Accessed 18 October 2018.

Deroy, O., Reade, B. and Spence, C. (2015), 'The insectivore's dilemma, and how to take the West out of it', *Food Quality and Preference*, 44, pp. 44–55.

Dobermann, D., Swift, J. A. and Field, L. M. (2017), 'Opportunities and hurdles of edible insects for food and feed', *Nutrition Bulletin*, 42:4, pp. 293–308.

Dudo, A., Choi, D. H. and Scheufele, D. A. (2011), 'Food nanotechnology in the news. Coverage patterns and thematic emphases during the last decade', *Appetite*, 56:1, pp. 78–89.

EFSA (2015), 'Risk profile related to production and consumption of insects as food and feed', *EFSA Journal*, 13:10, p. 4257.

Engström, A. (2018), *Äta insekter: Entomaten och det stora proteinskiftet, Sweden: Pug Förlag.*

EntoCube (2016a), 'Our story', https://entocube.com/en/our-story/. Accessed 1 December 2018.

——— (2016b), 'Sirkkapurkki', in e-mail to authors.

EntoNation (2018), '*Podcast #50: "With a Little Help from My Friends"*', 10 December, https://entonation.com/podcast-29-table-top-farmingkatharina-unger-livin-farms/. Accessed 12 December 2018.

Erens, J., Es van, S., Haverkort, F., Kapsomenou, E. and Luijben, A. (2012), *A Bug's Life: Large-Scale Insect Rearing in Relation to Animal Welfare: Project 1052*, Wageningen: Wageningen University.

European Commission (2018), 'Summary of ongoing applications and notifications Novel Food', European Commission, https://ec.europa.eu/food/safety/novel_food/authorisations/summary-ongoing-applications-and-notifications_en. Accessed 25 October 2018.

Evira (2018), 'Hyönteiset elintarvikkeena (10588)', 16 March, https://www.ruokavirasto.fi/globalassets/tietoa-meista/asiointi/oppaat-ja-lomakkeet/yritykset/elintarvikeala/alkutuotanto/eviran_ohje_10588_2_fi.pdf. Accessed 25 October 2018.

1. Engström, A. (2018), 'Josh Galt: "I am an entovegan"', *BugBurger*, 4 April, https://
2. www.bugburger.se/utblick/josh-galt-entovegan/. Accessed 25 October 2018.
3. Griidy (2018), 'Tastes so good, it should be legal', in e-mail to authors.
4. Halkier, B. and Jensen, I. (2011), 'Methodological challenges in using practice
5. theory in consumption research. Examples from a study on handling nutri-
6. tional contestations of food consumption', *Journal of Consumer Culture*,
7. 11:1, pp. 101–23.
8. Halloran, A., Roos, N., Eilenberg, J., Cerutti, A. and Bruun, S. (2016), 'Life
9. cycle assessment of edible insects for food protein: A review', *Agronomy for*
10. *Sustainable Development*, 36:4, pp. 1–13.
11. Hartmann, C., Shi, J., Giusto, A. and Siegrist, M. (2015), 'The psychology of
12. eating insects: A cross-cultural comparison between Germany and China',
13. *Food Quality and Preference*, 44, pp. 148–56.
14. Hartmann, C. and Siegrist, M. (2016), 'Becoming an insectivore: Results of an
15. experiment', *Food Quality and Preference*, 51, pp. 118–22.
16. Hoekstra, A. (2012), 'The hidden water resource use behind meat and dairy',
17. *Animal Frontiers*, 2:2, pp. 3–8.
18. Hoekstra, A. Y. and Mekonnen, M. M. (2012), 'The water footprint of humа-
19. nity', *Proc Natl Acad Sci U S A*, 109:9, pp. 3232–37.
20. Holt, V. M. (1885), *Why Not Eat Insects?*, London: Field &Tuer, Leadenhall
21. Press.
22. House, J. (2016), 'Consumer acceptance of insect-based foods in the Netherlands:
23. Academic and commercial implications', *Appetite*, 107, pp. 47–58.
24. ——— (2018), 'Insects as food in the Netherlands: Production networks and
25. the geographies of edibility', *Geoforum*, 94, pp. 82–93.
26. Huis, A. van, Itterbeeck, J. Van, Klunder, H., Mertens, E., Halloran, A., Muir, G.
27. and Vantomme, P. (2013), *Edible Insects: Future Prospects for Food and Feed*
28. *Security*, FAO Forestry Paper 171, Rome: Food and Agricultural Organization
29. of the United Nations.
30. IPIFF (2019), *Ensuring High Standards of Animal Welfare in Insect Production*,
31. IPIFF International Platform of Insects for Food and Feed, http://ipiff.org/
32. wp-content/uploads/2019/02/Animal-Welfare-in-Insect-Production-HD.
33. pdf. Accessed 25 February 2019.
34. Jimini's (2017), 'Le Molitor', in e-mail to authors.
35. Jongema, Y. (2017), *Worldwide List of Recorded Edible Insects*, https://web.
36. archive.org/web/20171111142953/http://www.wur.nl/en/Expertise-
37. Services/Chair-groups/Plant-Sciences/Laboratory-of-Entomology/Edible-
38. insects/Worldwide-species-list.htm. Accessed 25 October 2018.
39. Kauppi, S.-M. (2016), 'Insect economy and marketing: How much and in
40. what way could insects be shown in packaging?', MA thesis, Espoo: Aalto
41. University.
42. Kostecka, J., Konieczna, K. and Cunha, L. M. (2017), 'Evaluation of insect-
43. based food acceptance by representatives of polish consumers in the
44. context of natural resources processing retardation', *Journal of Ecological*
45. *Engineering*, 18:2, pp. 166–74.
46. Lensvelt, E. J. and Steenbekkers, L. P. (2014), 'Exploring consumer accep-
47. tance of entomophagy: A survey and experiment in Australia and the
48. Netherlands', *Ecol Food Nutr*, 53:5, pp. 543–61.
49. LivinFarms (2018), 'Mites explosion', Forum, 18 August. https://livinfarms.
50. freeflarum.com/d/61-mites-explosion. Accessed 21 December 2018.
51. Lockwood, J. A. (2004), *Locust: The Devastating Rise and Disappearance of the*
52. *Insect That Shaped the American Frontier*, New York: Basic Books.

Looy, H. and Wood, J. R. (2006), 'Attitudes toward invertebrates: Are educational "bug banquets" effective?', *The Journal of Environmental Education*, 37:2, pp. 37–48.

Looy, H., Dunkel, F.V. and Wood, J. R. (2014), 'How then shall we eat? Insect-eating attitudes and sustainable foodways', *Agriculture and Human Values*, 31:1, pp. 131–41.

Megido, R. C., Gierts, C., Blecker, C., Brostaux, Y., Haubruge, E., Alabi, T. and Francis, F. (2016), 'Consumer acceptance of insect-based alternative meat products in Western countries', *Food Quality and Preference*, 52, pp. 237–43.

Megido, R. C., Sablon, L., Geuens, M., Brostaux, Y., Alabi, T., Blecker, C., Drugmand, D., Haubruge, E. and Francis, F. (2014), 'Edible insects acceptance by Belgian consumers: Promising attitude for entomophagy development', *Journal of Sensory Studies*, 29:1, pp. 14–20.

Mekonnen, M. M. and Hoekstra, A.Y. (2012), 'A global assessment of the water footprint of farm animal products', *Ecosystems*, 15:3, pp. 401–15.

Miglietta, P. P., De Leo, F., Ruberti, M. and Massari, S. (2015), 'Mealworms for food: A water footprint perspective', *Water*, 7:11, pp. 6190–203.

Müller, A., Evans, J., Payne, C. L. R. and Roberts, R. (2016), 'Entomophagy and power', *Journal of Insects as Food and Feed*, 2:2, pp. 121–36.

NutriBug (2018), 'Cricket protein pasta', in e-mail to authors.

Offenberg, J. (2011), 'Oecophylla smaragdina food conversion efficiency: Prospects for ant farming', *Journal of Applied Entomology*, 135:8, pp. 575–81.

Oonincx, D. G. A. B. and de Boer, I. J. M. (2012), 'Environmental impact of the production of mealworms as a protein source for humans – A life cycle assessment', *Plos One*, 7:12, p. e51145.

Oonincx, D. G., van Itterbeeck, J., Heetkamp, M. J., van den Brand, H., van Loon, J. J. and Huis, A. van (2010), 'An exploration on greenhouse gas and ammonia production by insect species suitable for animal or human consumption', *PLoS One*, 5:12, p. e14445.

Piha, S., Pohjanheimo, T., Lahteenmaki-Uutela, A., Kreckova, Z. and Otterbring, T. (2018), 'The effects of consumer knowledge on the willingness to buy insect food: An exploratory cross-regional study in Northern and Central Europe', *Food Quality and Preference*, 70, pp. 1–10.

Pilditch, J. (1961), *The Silent Salesman: How to Develop Packaging That Sells*, London: Business Publications.

Pimentel, D., Berger, B., Filiberto, D., Newton, M., Wolfe, B., Karabinakis, E., Clark, S., Poon, E., Abbett, E. and Nandagopal, S. (2004), 'Water resources: Agricultural and environmental issues', *Bioscience*, 54:10, pp. 909–18.

Ramos-Elorduy, J. (2009), 'Anthropo-entomophagy: Cultures, evolution and sustainability', *Entomological Research*, 39:5, pp. 271–88.

Rozin, P., Haidt, J. and McCauley, C. (2008), 'Disgust', in M. Lewis, J. Haviland-Jones and L. F. Barret (eds), *Handbook of Emotions*, 3rd ed., New York: Guilford, pp. 757–76.

Ruby, M., Rozin, P., Chan, C. (2015), 'Determinants of willingness to eat insects in the USA and India', *Journal of Insects as Food and Feed*, 1:3, pp. 215–25.

Rumpold, B. A. and Schluter, O. K. (2013), 'Nutritional composition and safety aspects of edible insects', *Mol Nutr Food Res*, 57:5, pp. 802–23.

Schösler, H., de Boer, J. and Boersema, J. (2012), 'Can we cut meat out of the dish? Constructing consumer-oriented pathways towards meat substitution', *Appetite*, 58:1, pp. 39–47.

Schouteten, J. J., De Steur, H., De Pelsmaeker, S., Lagast, S., Juvinal, J. G., De Bourdeaudhuij, I., Verbeke, W. and Gellynck, X. (2016), 'Emotional and sensory profiling of insect-, plant- and meat-based burgers under blind, expected and informed conditions', *Food Quality and Preference*, 52, pp. 27–31.

Shelomi, M. (2015), 'Why we still don't eat insects: Assessing entomophagy promotion through a diffusion of innovations framework', *Trends in Food Science & Technology*, 45:2, pp. 311–18.

Siegrist, M. (2008), 'Factors influencing public acceptance of innovative food technologies and products', *Trends in Food Science & Technology*, 19:11, pp. 603–08.

Smil, V. (2002), 'Worldwide transformation of diets, burdens of meat production and opportunities for novel food proteins', *Enzyme and Microbial Technology*, 30:3, pp. 305–11.

Sogari, G. (2015), 'Entomophagy and Italian consumers: An exploratory analysis', *Progress in Nutrition*, 17:4, pp. 311–16.

Tan, H. S. G., Fischer, A. R. H., Tinchan, P., Stieger, M., Steenbekkers, L. P. A. and Trijp, H. C. M. van (2015), 'Insects as food: Exploring cultural exposure and individual experience as determinants of acceptance', *Food Quality and Preference*, 42:78&89, pp. 78–89.

Tan, H. S. G., Fischer, A. R. H., Trijp, H. C. M. van and Stieger, M. (2016), 'Tasty but nasty? Exploring the role of sensory-liking and food appropriateness in the willingness to eat unusual novel foods like insects', *Food Quality and Preference*, 48, pp. 293–302.

Tan, H. S. G., Verbaan, Y. T. and Stieger, M. (2017), 'How will better products improve the sensory-liking and willingness to buy insect based foods?', *Food Research International*, 92, pp. 95–105.

Taponen, I. (2017), 'How we changed the legal environment of our startups', Ilkka Taponen, 22 October, https://ilkkataponen.com/2017/10/22/how-we-changed-the-legal-environment-of-our-startups/ 2018. Accessed 1 December 2018.

ThailandUnique (2018), 'Cricket four', in e-mail to authors.

Verbeke, W. (2015), 'Profiling consumers who are ready to adopt insects as a meat substitute in a Western society', *Food Quality and Preference*, 39, pp. 147–55.

Verneau, F., La Barbera, F., Kolle, S., Amato, M., Del Giudice, T. and Grunert, K. (2016), 'The effect of communication and implicit associations on consuming insects: An experiment in Denmark and Italy', *Appetite*, 106, pp. 30–36.

Weijo, H. A., Martin, D. M. and Arnould, E. J. (2018), 'Consumer movements and collective creativity: The case of restaurant day', *Journal of Consumer Research*, 45:2, pp. 251–74.

Yang, Y., Yang, J., Wu, W.-M., Zhao, J., Song, Y., Gao, L., Yang, R. and Jiang, L. (2015), 'Biodegradation and mineralization of polystyrene by plastic-eating mealworms: Part 1. Chemical and physical characterization and isotopic tests', *Environmental Science & Technology*, 49:20, pp. 12080–86.

Yates-Doerr, E. (2015), 'The world in a box? Food security, edible insects, and "One World, One Health" collaboration', *Social Science & Medicine*, 129, pp. 106–12.

SUGGESTED CITATION

Kauppi, S., Nilstad Pettersen, I. and Boks, C. (2019), 'Consumer acceptance of edible insects and design interventions as adoption strategy', *International Journal of Food Design*, 4:1, pp. 39–62, doi: 10.1386/ijfd.4.1.39_1

CONTRIBUTOR DETAILS

Saara-Maria Kauppi is a Ph.D. student and a designer at the Department of Design, NTNU the Norwegian University of Science and Technology. Her research includes edible insects as a novelty, consumer behaviour, design for behaviour change and design for sustainable behaviour. Her Ph.D. is a three-year ERANet LAC-funded project. She has been working with edible insects since 2015 partly as a designer, partly as a researcher.

Contact: Department of Design, NTNU, Kolbjørn Hejes Vei 2b, 7491 Trondheim, Norway.
E-mail: saara.m.kauppi@ntnu.no

Ida Nilstad Pettersen is associate professor in transition design at the Department of Design, NTNU the Norwegian University of Science and Technology. Her research addresses the relation between design, changes in everyday life and societal transitions in different areas, including consumption and urban development.

Contact: Department of Design, NTNU, Kolbjørn Hejes Vei 2b, 7491 Trondheim, Norway.
E-mail: ida.nilstad.pettersen@ntnu.no

https://orcid.org/0000-0003-3979-9772

Casper Boks is professor in design for sustainability at the Department of Design, and vice dean for research and innovation at the Faculty of Architecture and Design at NTNU the Norwegian University of Science and Technology. Until 2007 he was assistant professor at the Faculty of Industrial Design Engineering at Delft University of Technology (Ph.D. degree in 2002). His research interests include sustainable product innovation and education in general, and currently focus on design for sustainable behaviour and practices, and organizational, managerial and stakeholder conditions for successful implementation of sustainable product innovation.

Contact: Department of Design, NTNU, Kolbjørn Hejes Vei 2b, 7491 Trondheim, Norway.
E-mail: casper.boks@ntnu.no