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## **Edible Insects in the Food Sector: Methods, Current Applications and Perspective**

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### **1. Introduction**

The research behind novel food is a relatively young field of study and includes a multitude of scientific disciplines and interests (safety, nutrition, consumer perception, sensory analysis, regulations, etc..).

This presentation will explore one of the most discussed and investigated novel foods in the recent years: the edible insects. The increasing demand for alternative protein sources worldwide had led the Food and Agriculture Organisation of the United Nations (FAO) to promote the potential of using insects both for feed and food, establishing a program called “Edible Insects”. Although several social, environmental, and nutritional benefits about the use of insects in the human diet have been identified, in the Western countries the majority of the population rejects the idea of adopting insects as food, predominantly for cultural reasons.

At the moment, it is difficult to predict whether edible insects will become from the traditional source of food in tropical and subtropical countries the “food of the future”. Nevertheless, there has been a

growing interest toward insect-based products in US and Europe due to the increasing attention and involvement from research institutes, food industry and policy makers.

Furthermore, in the coming years, the new EU Regulation on Novel Food, which came into force from January 1, 2018, is likely to facilitate the development of a niche market for insects and insect-based ingredients in many European countries; whereas in the US some of these products are already marketed.

The aim of this presentation is to present the latest research articles published in the book “*Edible insects in the food sector: methods, current applications and perspective*” (Eds. Sogari, Mora and Menozzi, Publisher: Springer Nature, forthcoming). The book is composed by eight chapters which explore what is the current state of the art of entomophagy in the Western countries, and future directions for research studies on edible insects as a sustainable source of food and feed. Especially the case studies and issues presented in this manuscript will cover some highly up-to-date topics such testing consumer responses to insect products and how to encourage their acceptability; marketing and business strategies opportunities; the law behind the commercialization of such new products with the aim to ensure a high level of protection and transparency of consumers; nutrition facts and safety concerns of widely and most produced edible insect species for human consumption.

All the stakeholders interested in novel food will have the chance to expand their scientific networks and their expertise and know-how (exploring the methods and approaches) to study entomophagy. This manuscript will provide helpful recommendations on new products and the challenges and opportunities for food entrepreneurs, insights on research programs for scientists as well as recommendations for policy makers.

## 2. Sections of the book

### **Insects as food: risk assessment and their future perspective in Europe**

Whilst insects as food is still a niche market in Europe, the interest of consumers and industry has increased in the last years as insects are seen as an alternative source of protein with nutritional and economic benefits. At the same time, farming, processing and consumption of insects and products thereof as food may pose risks and, therefore, the European Food Safety Authority (EFSA), as well as, national authorities published assessments or guidelines discussing these aspects. According to the EU regulatory framework, insects and their products are considered “novel foods”. They can be marketed only if authorised, a process that implies a safety assessment. EFSA guidance documents detail the data needed for the safety assessment.

### **Insects as food in the Global North - the evolution of the entomophagy movement**

The last decade has seen a surge of interest and investment in insects as food and feed. Has the Global North ever before given a novel and neglected food group so much attention? In this chapter we describe how and why multiple sectors - academia, media, industry - have begun to popularise and call for a resurgence in the use of insects as food in Europe and the US, despite tenacious taboos.

We begin with an overview of the history of insect consumption in the Global North; indigenous peoples in regions of both the US and Europe have traditionally consumed insects in some form, but this has diminished, disappeared or even been actively suppressed in recent history.

We describe the beginnings of an active interest in rediscovering insect consumption, beginning with a handful of entomologists who saw the potential of insects as an alternative to meat for reasons of taste, nutrition and environmental impact.

These ideas truly reached the mainstream in 2013 when the FAO published a paper on edible insects. This was immediately picked up by the world's media, by scientists, and by multiple entrepreneurs. Since then, the entomophagy movement has gathered pace. Insects have been hailed as a 'superfood', are widely available to buy online and are increasingly found on the shelves of some retail outlets. In this chapter we recount this recent historical trajectory. In doing so we also discuss the shifts in societal attitudes towards insects as food, critical gaps in research, and market opportunities for current and future entrepreneurs in the field.

### **Bugs on the menu – Drivers and barriers of consumer acceptance of insects as food**

Our daily food choices have a huge impact on the environment and on climate change. Animal based protein production in particular is very resource consuming. To satisfy the growing meat hunger in the world, alternative protein sources are needed that both have a smaller environmental impact and are readily accepted by consumers. Compared to beef and pork, plant and insect proteins can be produced more sustainably, although consumer acceptance may pose a particular challenge for the latter. In this chapter, we will explore Western consumers' acceptance of insects as food source and influencing factors. In particular, the role of emotional reactions towards insects, such as disgust and motivational barriers for the acceptance of insects as food will be discussed. Furthermore, the role of concepts taken from risk research, such as risk and benefit perception and trust, will be explored. Relevant characteristics of the insect product itself in terms of processing degree for consumers' willingness to eat will be highlighted. To further increase the sustainability of the insect production, food waste could be used as insect feed instead of more resource intensive feeds. The impact of different insect feeding styles on consumer acceptance and risk perception will be explained based on recent study results. Lastly, research gaps will be emphasized and strategies to overcome rejection of insects as food will be suggested.

### **A scoping review of edible insects and consumer behaviour: research gaps and study opportunities**

After the approval of the new European Novel Food Regulation at the end of 2015 (Reg. (EC) 2283/2015), which is applicable from the 1<sup>st</sup> January 2018, a growing interest from a consumer perspective has addressed the potential introduction in the market of edible insects and insect-based food products as an alternative protein source (Belluco, Halloran, & Ricci, 2017; Hartmann & Siegrist, 2017a; Sogari, Menozzi, & Mora, 2018; Tan et al., 2015). In the recent years there has been a growing number of studies published in scientific Journals related to insects as food, mainly covering topics from safety, microbiology, farming, processing, nutrition properties, sensory properties and consumer's acceptance.

To our knowledge, few systematic reviews have tried to summarize the main results of original studies on consumers' approach to entomophagy (Hartmann & Siegrist, 2017b; Mancini, Moruzzo, Riccioli, & Paci, 2019), without a focus and critical approach on the methods and techniques used to investigate this behaviour.

In this chapter, using a scoping review, the authors will highlight the overall state of the research activity and current research trends related to eating insects and consumer behaviour and compare the characteristics and methodological approaches arising from different quantitative and qualitative studies worldwide.

Thereby the aim of our study is to systematically search, select, examine and describe the existing scientific literature on consumer perception and behaviour regarding edible insect and insect-based food, identifying and describing the gaps, overlaps, and limitations of the methods used so far. It is hoped that results will inform researchers, policy makers and companies on how primary research on consumer behaviour could be advanced using the most suitable methods and techniques in behavioural economics and social sciences.

### **Sensory and consumer perspectives on edible insects**

Edible insects are part of traditional diets in several regions of the world such as Africa or Asia. However, in Western societies, the role of insects as food it is still not fully accepted mostly due to its rejection by consumers and to poor sensory properties of the insect-based food products. Rejection seems to be mainly regulated by disgust and food neophobia, hindering consumers' willingness to try edible insects or food products containing those as ingredients. In order to reverse this rejection, numerous strategies may be implemented, such as popularizing entomophagy, helping consumers to become familiarized with the concept or highlighting the nutritional and environmental advantages associated with eating insects. In addition to these rational discourses, it is of extreme importance to increase the sensory appeal of products containing edible insects and associate entomophagy with a positive sensory experience. However, there are several reports that the incorporation of insects in food products has a negative effect on their overall liking and yield sensory profiles associated with negative attributes. Therefore, even though rational strategies can be effective in profiling consumers ready to consume insects or increasing the number of consumers willing to try them, it is still necessary to improve the sensory properties of the insect-based foods to drive Western consumers into the adoption of edible insects in their regular diets.

### **Quality and consumer acceptance of products from animals fed insect meals**

Fish and soybean meal are the most used protein sources in aquaculture and poultry feed ingredients, but these conventional sources are no longer sustainable and will be further limited by increasing price. New and sustainable protein sources for animal feeds are necessary and insects seem a promising, novel one due to their good nutritional profile and lower environmental impact. After a brief introduction, this chapter critically reviews the latest knowledge about the dietary use of insect meals in fish, shellfish and avian species. Particular focus is put on their impact on the flesh and meat of aquaculture and poultry products in terms of sensorial perception and quality traits. In general, sensory properties results showed that for both products no differences were perceived if untrained panelist were involved in the sensorial analysis. Concerning meat and flesh quality, results are controversial, but a dramatic influence of insect meal fatty acid (FA) profile with a decrease in long chain n-3 FA content has been observed in both species. Moreover, an overview on the available data about consumer acceptance towards food products from insects-fed animals is provided. of the consumers were willing to eat food products obtained from animals fed on a diet containing insect protein.

### **Potential allergenic risks of entomophagy**

Edible insects are a novel food source in the West, prompting the need for an assessment of their food security risks. One of the major concerns relates to their allergenic potential, as insects have a close phylogenetic relationship with crustaceans and house dust mites. Accordingly, several studies have

demonstrated the occurrence of immunologic co-sensitisation between insects and crustaceans/house dust mites, with tropomyosin and arginine kinase being identified as the major cross-reacting allergens. This co-sensitisation has been described to be clinically relevant for patients allergic to crustaceans but is still controversial in the case of individuals allergic to house dust mites. Epidemiological information is still scarce, with few studies mentioning insects as causative agents of food allergy (reporting that 0.3-19.4% of food related anaphylactic reactions in Asia were caused by insects) and case reports lacking in contextual information. Besides food allergy, insects also present major risks of occupational allergy development through primary sensitisation, although it is not clear which are the responsible allergens. Therefore, several controversies exist on insects' allergenicity but it is clear that crustacean-allergic subjects and insect rearing workers are two major risk groups for the development of food and occupational allergy, respectively.

### **Insects as Food: the Legal Framework**

Even though entomophagy is a very old practice, it is considered a new culinary phenomenon in most Western Countries and, as such, it has received little attention from legislators.

In the European Union, the regulatory status of insects has been quite controversial until the adoption of the new novel food regulation. In the old novel food regulation no mention was expressly made to insects as novel food and this resulted in different approaches of the European Member States. In some Member States whole insects and their parts were considered outside the scope of the novel food regulation and their placing on the market was not subject to pre-market authorization while other Member States considered insects as a novel food and as such subject to the risk assessment procedure provided by the law.

Through the adoption of the new novel food regulation, the legal status of edible insects has been clarified: insects and their part now fall in the definition of novel food and they need to be authorized before being placed on the market. Beside the authorization process, the classification of insects as food poses new challenges when it comes to the legislation applicable to insects farming, slaughtering and processing.

In the United States, the approach was not different: the Food and Drug Administration (FDA) has devoted significant attention to insects in human food as defects, but has given little public attention to insects as human food or as an intentional component of human food. Their regulatory classification is therefore still unclear since they shall either be approved as food additive or their use shall be generally recognized as safe (GRAS) to be legally placed on the US market.

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