

Consumer Perceptions and Acceptance of Insects As Feed and Food: Current Findings and Future Outlook



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Abstract In recent years, the use of insects as food and feed has gained widespread attention from industry, policy makers, the scientific community, and the general public globally. This chapter is devoted to providing insights on the current state-of-the-art around edible insects and the interlinkages among market, legislation and consumer acceptance. Future research developments are also explored.

Keywords Entomophagy · Neophobia · Novel foods · Behaviour · Legislation

1 Introduction

It is widely recognized that the Food and Agriculture Organisation (FAO) report “Edible insects: future prospects for food and feed security”¹ was a landmark publication in the field of human consumption of insects (i.e., entomophagy). Much has changed in the past decade, particularly concerning the production and introduction of edible insects in parts of the (Western) world where insect eating was

¹ van Huis et al. (2013).

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not previously part of the food system and food consumption pattern. Surely, developments are still in their infancy, but is unmistakably true that in recent years the use of insects as food and feed has gained increasing attention from industry, policy makers, and the scientific community.² In the European Union, there has been growing interest and financial investment in this sector from multiple small companies, start-ups, and entrepreneurs.³ The development of this emerging sector in Europe is also favoured by many research teams who are actively involved in projects related to edible insects across a wide range of disciplines ranging from food safety microbiology, farming, and food processing to social, psychological and economic expertise.⁴ Moreover, in the European Union the regulatory framework shaped by Novel Food authorization and ‘feed ban rules’⁵ controlling the use of insect processed animal proteins (PAPs), has strongly influenced the dynamics of the insect sector.⁶

Indeed, in the European context, the introduction of insects on the food market is a novelty and has a particular profile in terms of both regulation and the motivations behind consumption. Food safety guarantees (Sect. 2) are needed, given the focus on the establishment of a structured insect indoor farming sector (Sect. 3) (as opposed to the harvesting of insects in the natural environment). Likewise, insect consumption in Europe will not be motivated by food scarcity or nutritional deficiencies endangering food security. Instead, health and sustainability issues will likely drive efforts to overcome European consumers’ reluctance to eat insects (Sect. 4). In fact, today’s policymakers, scholars, and practitioners in ‘minilivestock’ farming as a complement to conventional livestock farming are motivated by just these issues. At a time when Sustainable Development Goals (SDGs) and the evolution of a circular economy (CE) are valued notions, the growth of the insect sector and the promotion of insect consumption fit perfectly to contribute to both SDGs and CE as well as boost the popularity of both concepts in the near future.⁷

This chapter covers recent regulatory milestones at the European level linked to Novel Food approvals from 2021 and the development of the insect industry both as food and feed, including various agri-food stakeholder activities (Sect. 2). Sections 3 and 4 of the chapter focus on the state of the art in terms of consumer acceptance of animals fed with insects (insects as feed) and consumer acceptance of edible insects and insect-based foods (insects as food), respectively. Finally, Sect. 5 offers discussion and conclusions, providing linkages between the production and consumption of edible insects, as well as future research developments.

²Payne et al. (2019) and Pippinato et al. (2020).

³Derrien and Bocconi (2018) and Montanari et al. (2021b).

⁴Payne et al. (2019) and Sogari et al. (2019c).

⁵Regulation (EC) 999/2001 of the European Parliament and of the Council of 22 May 2001 laying down rules for the prevention, control and eradication of certain transmissible spongiform encephalopathies.

⁶Lotta (2019).

⁷Moruzzo et al. (2021b) and Sogari et al. (2019a).

2 Market of Insects As Food and Feed

2.1 EU Market of Insects As Food

According to the current Novel Food Regulation, after a positive assessment on safety from EFSA, the European Commission (EC) can decide whether to authorise the commercialization of a Novel Food.⁸ In this context, the first authorisation regarding insects-as-food—notably included in the Novel Foods definition—was approved in June 2021 for the dried *Tenebrio molitor* larva to be used as a whole, dried insect in the form of snacks, and as a food ingredient in several food products (applicant SAS Agronutris EAP). Then, in November 2021, the frozen and dried migratory locust *Locusta migratoria* (applicant Fair Insects B.V.) was authorised. Finally, in December 2021, the EU Standing Committee on Plants, Animals, Food and Feed voted favourably on the frozen and dried formulations from the whole yellow mealworm (*Tenebrio molitor*), and frozen and dried formulations from the whole house cricket (*Acheta domestica*) (applicant Fair Insects B.V.).⁹ Once authorised, insect-based products are subject to specific labelling requirements, including mandatory labelling specifications (e.g., allergen labelling, among others).¹⁰

Even if still limited, insect farming is an emerging and growing industry in the European Union (EU)¹¹ with currently around 70 companies operating in the sector of insects for human consumption.¹² This niche market is supported by a generally positive media coverage and changing dietary habits towards a more sustainable and balanced diet with varied protein sources.¹³ For instance, recently there has been an increase in demand for high protein food for sports nutrition, dietetic food, and food supplements to improve physical performance.¹⁴ This trend is likely to create opportunities for insect-based food such as protein pasta, energy or protein bars, as well as more mainstream snacks (e.g., chips) with varying percentages of insect powder.¹⁵ In fact, insects are highly versatile and can be incorporated in familiar

⁸For a detailed analysis on Novel Foods Regulation in the European Union, see in particular *Novel Foods in the EU Integrated Administrative Space: An Institutional Perspective* by A. Volpato, *A Peculiar Category of Novel Foods: Traditional Foods Coming from Third Countries and the Regulatory Issues Involving Sustainability, Food Security, Food Safety, and the Free Circulation of Goods* by L. Scaffardi and *Legislative and Judicial Challenges on Insects for Human Consumption: From Member States to the EU, Passing Through the CJEU* by G. Formici in this volume.

⁹Mancini et al. (2022).

¹⁰IPIFF (2020a).

¹¹Montanari et al. (2021b).

¹²IPIFF (2020b).

¹³Pippinato et al. (2020).

¹⁴Placentino et al. (2021).

¹⁵Pippinato et al. (2020).

foods, granular powders, or extracts to increase nutritional value or functionality,¹⁶ reducing the risk of consumer rejection as compared to attitudes towards eating whole insects.¹⁷

The International Platform of Insects for Food and Feed (IPIFF)¹⁸ estimates that in the EU by 2025 the category of speciality food ingredients (e.g., sports nutrition, food supplements) will represent the highest market share, followed by snacks and bars. Moreover, paleo diet-specific food products, functional food, baked products, and meat-like products will also experience a growth in terms of market share.¹⁹ Currently the main distribution channel is e-commerce,²⁰ but it is likely that in the coming years these insect products will be also available in brick-and-mortar retail stores.

The IPIFF forecasted that by 2030, the insect European Food Business Operators' (iFBOs) will produce about 260,000 tonnes of insect-based products, including whole insects, insect ingredients and products with incorporated edible insects (pasta, snacks, bars, etc.).

Most of the iFBOs in Europe, which are largely comprised of start-ups and small companies,²¹ are only involved in the final processing of insects for food and producing final products (e.g., burgers, snacks, bars, biscuits, etc.), followed by those involved in all the stages of production, including insect farming.²² According to a recent study including the EU producers of edible insects for food,²³ the most common farmed species in the EU are the yellow mealworm (*Tenebrio molitor*), the house cricket (*Acheta domesticus*), the 'grasshopper' (*Locusta migratoria*), and the 'buffalo worm' (*Alphitobius diaperinus*). These four species were named by House²⁴ as the Big Four and have been selected based on their characteristics (e.g., high protein and fat content) and as the result of several technical and practical decisions (e.g., quite easy to rear) (Fig. 1).²⁵

¹⁶IPIFF (2020b). On this point, see also *Food (In)Security: The Role of Novel Foods on Sustainability* by S. Sforza in this volume.

¹⁷Sogari et al. (2018).

¹⁸The International Platform of Insects for Food and Feed (IPIFF) is a non-profit organisation which represents the interests of the insect production sector towards EU policymakers, European stakeholders, and citizens. Composed of 83 members, most of which are European insect producing companies, IPIFF promotes the use of insects and insect-derived products as top tier sources of nutrients for human consumption and animal feed (<https://ipiff.org/>).

¹⁹IPIFF (2020a).

²⁰Pippinato et al. (2020).

²¹Derrien and Boccuni (2018).

²²IPIFF (2020b).

²³Pippinato et al. (2020).

²⁴House (2018).

²⁵Pippinato et al. (2020).

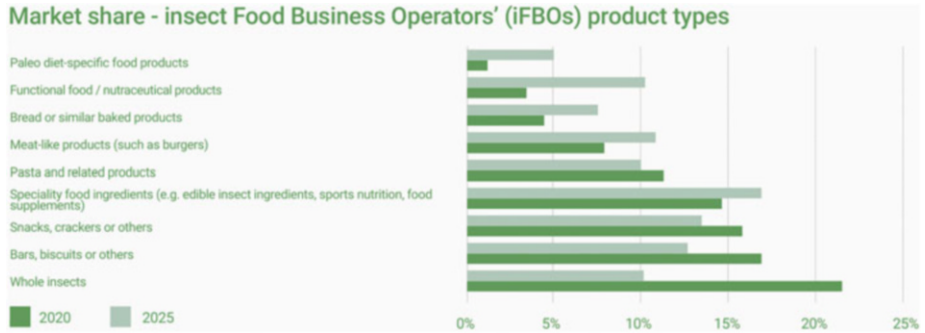


Fig. 1 Market share—insect Food Business Operators' (iFBOs) product types. Source: IPIFF 2020b, <https://ipiff.org/wp-content/uploads/2020/06/10-06-2020-IPIFF-edible-insects-market-factsheet.pdf>

2.2 EU Market of Insects As Feed

The sector for insects as feed for animal nutrition is much more advanced and mature compared to food applications.²⁶ This can be explained by several reasons, mainly attributable to a more liberal legal framework as well as an urgent call to address the environmental issues of animal farming.

In the context of the EU's deficiency in the supply of high protein animal feed ingredients (e.g., soya bean meals)²⁷ alongside the relative high dependency on imported animal feed, the use of insects as feed could represent a valid and sustainable solution. First, insects reared for food and feed production fall within the category of 'farmed animals' according to Regulation (EC) No 1069/2009.²⁸ Thus, insects are subject to EU rules which regulate the feeding of livestock, including the general principle enshrined in Article 4, para 1, lett. a) of Regulation (EC) 767/2009 whereby animals can be reared on substrates of vegetable origin or specifically allowed materials of animal origin such as fishmeal and hydrolysed proteins from non-ruminants.²⁹

²⁶Montanari et al. (2021a).

²⁷European Union (2021).

²⁸Regulation (EC) 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (Animal by-products Regulation).

²⁹Lähteenmäki-Uutela et al. (2021) and Montanari et al. (2021a).

One of the first and most critical changes was EU Regulation 2017/893³⁰ which partially uplifted the ‘feed ban rules’ (Regulations (EC) 999/2001)³¹ regarding the use of insect-processed animal proteins (PAPs) for aquaculture animals.³² In terms of species, Regulation (EU) 2017/893 allows the feeding of seven insects: black soldier fly (*H. illucens*), common housefly (*Musca domestica*), yellow mealworm (*T. molitor*), lesser mealworm (*A. diaperinus*), house cricket (*A. domesticus*), banded cricket (*G. sigillatus*) and field cricket (*Gryllus assimilis*).

In 2021, a new Regulation on the use of insect processed animal proteins (PAPs) for animals entered into force (Commission Regulation 2021/1372)³³ allowing the use of PAPs in poultry and pig nutrition.³⁴ The production of insect PAPs for feed was several thousand tonnes in 2020, and by the year 2030 this sector is expected to reach a total turnover of circa two billion euros/year.³⁵ For instance, according to the IPIFF forecasts,³⁶ more than 10% of the fish consumed in the EU will be derived from fish farms that use insect protein in their aqua feed formulations. Currently, the aquafeed sector is the most relevant animal feed market for the producers of insects as feed.³⁷ However, according to these IPIFF forecasts, it is likely that in the coming years with the new Regulation 2021/1372 the quantities of insect meal sold for the poultry and pig markets will experience a strong increase, especially in the context of certain niche markets (e.g., free-range poultry, organic production, etc.). In terms of feed, the black soldier fly is currently the most farmed insect species.³⁸

The aim of this chapter is mainly to focus on the market, legislation, and consumer acceptance of the use of insects as feed and food; however, currently other insect applications are also possible, such as the use of frozen or dried insects as pet food (e.g., dogs and cats) (Figs. 2 and 3).³⁹

³⁰Regulation (EU) 2017/893 amending Annexes I and IV to Regulation (EC) No. 999/2001 of the European Parliament and of the Council and Annexes X, XIV and XV to Commission Regulation (EU) No 142/2011 as regards the provisions on processed animal protein.

³¹Regulation (EC) 999/2001 of the European Parliament and of the Council of 22 May 2001 laying down rules for the prevention, control and eradication of certain transmissible spongiform encephalopathies.

³²Lähtenmäki-Uutela et al. (2021) and Sogari et al. (2019a).

³³Regulation (EU) 2021/1372 of 17 August 2021 amending Annex IV to Regulation (EC) No 999/2001 of the European Parliament and of the Council as regards the prohibition to feed non-ruminant farmed animals, other than fur animals, with protein derived from animals.

³⁴Mancini et al. (2022).

³⁵IPIFF (2021).

³⁶*Ibidem*.

³⁷*Ibidem*.

³⁸Montanari et al. (2021b).

³⁹IPIFF (2020b).

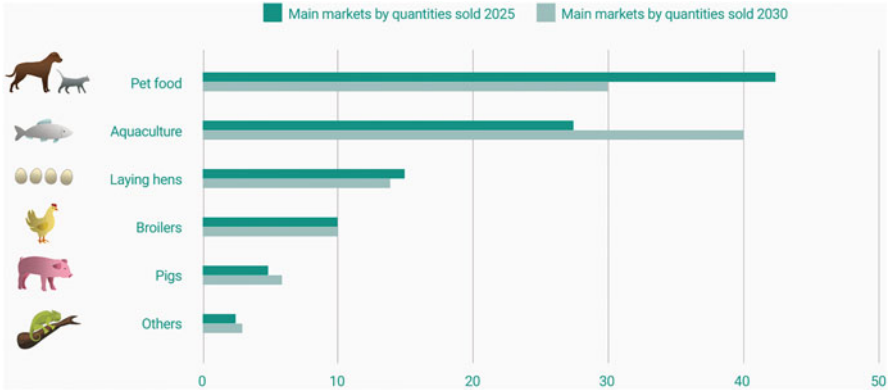


Fig. 2 European market of insects as feed. Source: IPIFF 2021, https://ipiff.org/wp-content/uploads/2021/04/Apr-27-2021-IPIFF_The-European-market-of-insects-as-feed.pdf

Insects as feed- Regulation (EU No 68/2013 on the Catalogue of feed materials and in accordance with Regulation (EC) No 999/2001 and Regulation (EC) No 1069/2009	Ruminant animals	Aquaculture	Poultry	Pigs	Pets	Fur and other animals (e.g. zoo)	Technical uses (e.g. cosmetic industry, bio-based fuels, production of other bio-based materials such as bioplastics)
Insect proteins (under entry 9.4.1. 'Processed animal protein')	⊗	⊙**	⊙**	⊙**	⊙	⊙	⊙
Insect fats (under entry 9.2.1 'animal fat')	⊙	⊙	⊙	⊙	⊙	⊙	⊙
Whole insects (untreated) (under entry 9.16.2. 'terrestrial invertebrates, dead')	⊗	⊗	⊗	⊗	⊗	⊙*	⊙
Whole insects (treated- e.g. freeze-drying) (under entry 9.16.2. 'terrestrial invertebrates, dead')	⊗	⊗	⊗	⊗	⊙*	⊙*	⊙
Live insects (under entry 9.16.1 'terrestrial invertebrates, live')	⊗	⊙*	⊙*	⊙*	⊙*	⊙*	⊙
Hydrolysed insect proteins (under entry 9.6.1. 'Hydrolysed animal proteins')	⊙	⊙	⊙	⊙	⊙	⊙	⊙

Fig. 3 EU Regulatory possibilities for insects’ use in animal feed. Source: IPIFF 2022 (p. 25), <https://ipiff.org/wp-content/uploads/2019/12/IPIFF-Guide-on-Good-Hygiene-Practices.pdf>

3 Consumer Acceptance of Edible Insects As Feed

3.1 Insects As Feed, Making Their Way

With a dramatically growing world population, the need to meet increasing nutritional needs is a topic of interest to policymakers and academics alike. In order to accommodate the expanding needs of animal-sourced food, the EU relies on imports

of protein-rich animal feeds, especially soybean. Soybeans account for two-thirds of the world's total protein feed production.⁴⁰ Their dietary value is unsurpassed by any other plant protein source and is the standard to which other protein sources are compared.⁴¹ Although soybean cultivation has an exceptional protein yield per hectare, its production is often associated with environmentally harmful practices,⁴² its predominant use as feed is economically inefficient compared to direct human consumption. Considering the EU's Farm to Fork strategy (F2F) where domestic protein feed production is encouraged, import dependence is overcome, and demand for land in deforestation-prone regions is reduced, various alternative protein feeds have been investigated, including insects. Insect species currently farmed and involved in commercial development share short life cycles, have high feed conversion rates, and can grow at high densities on low-value wastes.⁴³ In addition, insect amino acid profiles are suitable for monogastric animals and fish, different from soybean meals, which often require supplementation when used in feed for monogastric animals.⁴⁴ Lastly, insects can be reared easily at an economically and environmentally sustainable cost.⁴⁵

In contrast to the many studies that make up the literature on the acceptability of insects as food, the number of studies related to consumer preference for insects as feed is distinctly limited. This is probably because the feed used for breeding is not clearly shown on the label, and therefore consumers cannot identify the type of feed when purchasing products. Yet, many companies could use new label information as a tool to differentiate from competitors, making the product stand out. The European Union approved the use of insects in aquaculture with Commission Regulation (EU) 2017/893,⁴⁶ consequently most studies on consumer preferences have focused on insect-fed fish. Nevertheless, some pioneering studies have investigated consumer preferences regarding other types of meat raised with insects, specifically pork and chicken, in the light of possible changes in European Union legislation which has recently allowed their use through Commission Regulation (EU) 2021/1372. One of the key topics related to introducing a process innovation, such as the use of alternative feeds for insect-based animal husbandry, is consumer acceptance, and what communication and positioning drivers might be used to facilitate success. Considering that both (direct entomophagy) and the use of insects as feed (indirect entomophagy) are traditions and uses far removed from the European citizen, the

⁴⁰Oil World (2015).

⁴¹Cromwell (1999).

⁴²Nordborg et al. (2014).

⁴³Nordborg et al. (2014).

⁴⁴Parolini et al. (2020).

⁴⁵On this point, see also *Food (In)Security: The Role of Novel Foods on Sustainability* by S. Sforza in this volume.

⁴⁶Regulation (EU) 2017/893 amending Annexes I and IV to Regulation (EC) No. 999/2001 of the European Parliament and of the Council and Annexes X, XIV and XV to Commission Regulation (EU) No 142/2011 as regards the provisions on processed animal protein.

number of studies assessing consumer acceptability of entomophagy practices is flourishing in this geographic area. Section 3.2 illustrates this with respect to indirect entomophagy while Sect. 4.1 does so with respect to direct entomophagy.

3.2 *Emerging Consumer Studies on Insects As Feed*

In order to investigate consumer and market reactions and acceptance, which are crucial in determining the success of the use of insect-based feeds for different species, the EU-funded research project PROteINSECT questioned over 2400 respondents worldwide about their preferences towards the use of insects as feed. More than 70% of participants found insects as feed for farmed animals to be acceptable and stated that they would eat pork, poultry, and fish reared in this way. Respondents also manifested their willingness to receive more information on the topic, while perceiving insects as feed as no to low risk for human health.⁴⁷ A substantial lack of knowledge on feed and its environmental impact in general, and insect feed in particular, has been also outlined by Weinrich and Busch⁴⁸ and Popoff et al.⁴⁹ In the former study, a survey of 618 German consumers revealed that, despite little general knowledge of the subject, a better perceived environmental impact of feeding insects might lead to an improved attitude towards market introduction of poultry products fed with insects.⁵⁰ In addition to lack of awareness, Popoff et al. evidenced other factors involved in the decision-making process, independently of the type of feed used. Most respondents (75%) stated that the use of insect feed would not influence their willingness to purchase, and only 10% expressed opposition to eating Scottish salmon reared with insects.

Through the use of informed and uninformed choice experiments, Bazoche and Poret⁵¹ examined consumer preferences toward fillets of smoked trout raised with or without insects. Although a small proportion of participants (15.3%) showed distaste for this type of insect-reared fish, 60% of the sample agreed it “followed the natural order of things.” This study, conducted in France, also shows that providing information to consumers about the environmental impact differences between the conventional use of fishmeal and insects significantly influences consumer choice. Furthermore, it has been highlighted how important it is to position the product adequately within the market. Regardless of the experimental condition, when the price of conventional trout was higher than trout reared with insects, the former was preferred. Conversely, 73% of consumers in the informed condition chose insect-reared trout if the price was lower than conventionally reared trout. Similarly,

⁴⁷ PROteINSECT (2016).

⁴⁸ Weinrich and Busch (2021).

⁴⁹ Popoff et al. (2017).

⁵⁰ Weinrich and Busch (2021).

⁵¹ Bazoche and Poret (2020).

Ankamah-Yeboah et al.⁵² showed that German consumers were likely to purchase insect-farmed fish if the price was affordable. Using an online questionnaire, it was found that although most of the sample was indifferent towards the type of feed used, 23% showed an unfavourable attitude towards the use of insects in aquaculture.

At the same time, some results indicate that consumption would rise if price were reduced, or convenience aspects were improved. In accordance with previous results, Altmann et al.⁵³ found that a sub-set of their sample will not accept chicken-breast produced with insect-meals unless at largely discounted prices. Ferrer Llagostera et al.⁵⁴ found that in Spain there is a higher willingness to pay (WTP) for fish fed with insect protein or vegetable matter over those fed with conventional fish meal (11.89 and 17.20 euros/kg respectively), nevertheless, the taste expectation for fish reared with insects is still low. In a similar fashion, Giotis and Drichoutis⁵⁵ estimated Greek consumers' willingness to pay for a gilt head bream fed with insects. Their results show that 84% of the respondents were willing to accept insects as animal feed and 55.5% of the sample would pay a premium. Differently from the previous studies, in a study involving 565 Italian consumers investigating the role of information on consumers' attitudes and intention to eat insect-fed ducks, Menozzi et al.⁵⁶ found that most of the respondents would pay the same average price for both a duck fed with insect meal and a conventionally fed duck. Thus, it can be concluded that results are quite mixed. Alternative feeds such as insect meals can be used as long as prices remain lower than or similar to conventional products. However, Ankamah-Yeboah et al.⁵⁷ also found a negative interaction effect between a certified production method and using insect protein as feed, which suggests that the type of feed does not affect the WTP if the product lacks a trusted certification. Interestingly, in a study by Spartano and Grasso⁵⁸ it was found that in a sample of United Kingdom (UK) consumers, those who had a previous tasting experience of edible insects as food have higher WTP for eggs from insect-fed hen than those who did not. Similarly, Sogari et al.⁵⁹ also found that other variables such as interest in environmental issues and positive attitude towards animal welfare influence WTP for meat products from animals fed with insects.

The studies reported so far seem to agree that the attitudes of European consumers towards the use of insects as feed are generally positive and acceptance is high, as has also been pointed out by Mancuso et al.,⁶⁰ who evidenced that 90% of all consumers interviewed had a positive attitude towards insects as feed. However,

⁵²Ankamah-Yeboah et al. (2018).

⁵³Altmann et al. (2022).

⁵⁴Ferrer Llagostera et al. (2019).

⁵⁵Giotis and Drichoutis (2021).

⁵⁶Menozzi et al. (2021).

⁵⁷Ankamah-Yeboah et al. (2018).

⁵⁸Spartano and Grasso (2021).

⁵⁹Sogari et al. (2022).

⁶⁰Mancuso et al. (2016).

Mancuso et al. work also highlighted the existence of a behavioural gap, i.e., despite the generally positive attitude reported by most respondents, not all (25%) are actually ready to buy farmed fish fed on insect meal, and an even steeper share (53%) of hesitant Italian consumers can emerge in the research, as seen in Laureati et al.⁶¹ Among the socio-demographic factors that impact the willingness to consume insect-fed animals, Szendrő et al.⁶² determined that age, gender, and income have a significant effect, in accordance with Baldi et al.⁶³ where it was found that men and younger consumers tend to be more prone to accept the product. Similar results have been previously highlighted by Laureati et al.⁶⁴ where it was observed that age, gender, food neophobia, and cultural background affected Italian consumers' willingness to accept insect-fed animal products.

Following the results of the studies focusing on consumer preferences towards insect-fed fish or livestock, it could be argued that consumer acceptance will not hinder this newly developed business,⁶⁵ but there are multiple factors that should be considered. These include pricing, previous knowledge and information provided, socio-demographic characteristics, and the taste of the meat or fish derived from insect-fed animals.

4 Consumer Acceptance of Edible Insects As Food

4.1 A 'Mini-Compilation'

Consumer acceptance of insect-based foods poses a great challenge in societies unaccustomed to consume insects as food (i.e., entomophagy). This lack of an entomophagous tradition directly informs one of the main issues underlying Westerners' reluctance to accept insects for human consumption and adopt edible insects into their diets. Broad scholarly consensus exists about unfamiliarity with entomophagy being a primary reason for low acceptance rates generally found in contemporary consumer studies on eating insects in Western countries. The topic of consuming edible insects is radically different for Western consumers in non-entomophagous societies than for those hundreds of millions of people worldwide who are traditionally familiar with regularly eating insects.⁶⁶

⁶¹Laureati et al. (2016).

⁶²Szendrő et al. (2020).

⁶³Baldi et al. (2021).

⁶⁴Laureati et al. (2016).

⁶⁵Sogari et al. (2019a).

⁶⁶Payne et al. (2019) and van Huis et al. (2022).

This section is devoted to giving a concise overview of research in the field of direct entomophagy primarily based on recently published review studies.⁶⁷ The focus of this ‘mini-compilation’ is on the main benefits that are highlighted when it comes to the consumption of edible insects as well as on major hurdles that will have to be overcome before the practice of eating insects becomes a normal and integrated part of the Western diet. By summarizing and synthesizing some of the main findings in this body of literature, we aim to provide an up-to-date picture of the state of play in consumer research on eating insects.

To begin with, a salient feature of this research domain is its vibrancy, reflected in a significant growth in recent years in the number of entomophagy studies published in peer-reviewed journals.⁶⁸ In contrast to the current high and warm scholarly interest in insects as food is the low and cool overall receptiveness of today’s Western consumers towards the acceptance and adoption of edible insects. Entomophagy studies have highlighted multiple obstacles preventing Western consumers from engaging in the practice of eating insects. Various factors are reported to influence consumer unwillingness to eat insects and insect-based foods. Studies consistently show that two major barriers to preventing the acceptance of insects as food in Western diets are food neophobia (fear of trying new foods) and disgust.⁶⁹ Both aversions decrease the probability of accepting entomophagy. Disgust is an immediate emotional reaction of revulsion, and as such a core barrier. Food neophobia rejects, avoids and is biased negative about (the taste, price, or other product features of) unfamiliar foods.

Although two different notions, both are likely to be cognate, and appear to be aversive responses reflecting other negative consumer perceptions and reserves. Put differently, disgust and food neophobia seem to be fuelled by negative attitudes to entomophagy as well as fuelling other aversions simultaneously. Such obstacles to consuming edible insects are food safety/health risk concerns,⁷⁰ low perceived sensory appeal, cultural inappropriateness (‘edibility’), or unwillingness to eat any animal-derived food—whether or not this is supplemented with concerns regarding the animal welfare of commercially farmed insects.⁷¹

The consumption of edible insects is particularly subjected to these negative associations because of its unfamiliarity. As indicated above, unfamiliarity with

⁶⁷ Ardoin and Prinyawiwatkul (2021), Dagevos (2021), de Carvalho et al. (2020), Kauppi et al. (2019), Kröger et al. (2022), Mancini et al. (2019), Sogari et al. (2019c) and Wendin and Nyberg (2021).

⁶⁸ For further details, see Mancini et al. (2019), pp. 663–669; Kröger et al. (2022), pp. 5–6; Sogari et al. (2019b), p. 172; Sogari et al. (2019c), pp. 32–33.

⁶⁹ Ardoin and Prinyawiwatkul (2021), de Carvalho et al. (2020), Kröger et al. (2022), Onwezen et al. (2021), Sogari et al. (2019c) and Wendin and Nyberg (2021).

⁷⁰ On this specific point, see *Why “New” Foods Are Safe and How They Can Be Assessed* by C. Dall’Asta and *The Safety Assessment of Insects and Products Thereof as Novel Foods in the European Union* by G. Precup, E. Ververis, D. Azzollini, F. Rivero-Pino, P. Zakidou, A. Germini, all in this volume.

⁷¹ Lambert et al. (2021).

entomophagy is considered a key barrier to achieving consumer acceptance for edible insects. Dagevos⁷² demonstrated how widely this point has been discussed in the literature. It does not seem a stretch to assume that many of the reasons for rejecting insects as food or food source are rooted in this lack of familiarity with edible insects in the Western diet. From this perspective, there is reason to believe that consumer reluctance or rejection eventually comes down to the fact that insects are not traditional foods and remain unfamiliar to date.

The opposite holds true, however, for the animal proteins (Western) consumers are used to eating abundantly: meat, dairy, eggs or fish. Contemporary food consumer attachment to meat is a particularly relevant issue in the context of entomophagy acceptance and adoption. Insect foods are often positioned as a non-conventional source of animal protein; as a meat alternative,⁷³ insect foods have to compete with the central position of meat on our plates and in our dominant eating regime. Since the early work of Verbeke,⁷⁴ the relationship between meat eating and eating insects has been given attention in several studies. Over time, findings have evolved somewhat.⁷⁵ Verbeke found that devoted meat lovers were very unlikely to belong to the early adopters of eating insects because they indicated little to no interest in consuming insects. This improbability still stands, and it has been corroborated that having strong attitudes towards meat may be associated with weak consumer willingness to try and buy insect food products.⁷⁶ More recently, complementary findings were reported by Sogari et al.⁷⁷ who did not find a specific link between meat consumption frequency and openness to insect-eating. In a similar vein, a study of Kornher et al.⁷⁸ showed that respondents who report infrequent and low consumption of meat products were more ready to adopt insect consumption. This suggests that entomophagy acceptance and adoption look more promising from the perspective of meat reducers (flexitarians) than that of convinced meat eaters whose meat attachment is high and inclination to substitute meat for insects correspondingly low. This aversive position may be supported by scepticism about the necessity for reducing meat intake and/or by beliefs that insect products will never resemble meat in taste, texture, and appearance.

On the other hand, in efforts to overcome widespread Western reluctance to adopting and accepting insects as food or a food source, the practice of entomophagy has some strong trumps. Consuming edible insects has environmental and human health benefits. The environmental footprint of ‘miniature livestock’ is significantly lower than conventional livestock farming. Farming edible insects is lower in greenhouse gas emissions, freshwater utilization, and land use. The efficient

⁷²Dagevos (2021).

⁷³de Carvalho et al. (2020), Guiné et al. (2022) and Sogari et al. (2019c).

⁷⁴Verbeke (2015).

⁷⁵See also Kröger et al. (2022), p. 12.

⁷⁶E.g. Van Thielen et al. (2019).

⁷⁷Sogari et al. (2019b).

⁷⁸Kornher et al. (2019).

conversion of feed into valuable proteins also make insects sustainable protein producers. Important nutritional properties of insects are beneficial to human health and food security as a rich source of protein, fibre, fatty acids, minerals and vitamins. Also, the aforementioned recent review studies pay close attention to the environmental, health and food security advantages of insects as food or food source.

This last point brings us to another potential driver of consumer willingness to eat insects. In addition to the introduction of insects into the food system through insects as feed (indirect entomophagy), consuming edible insects can be seen in two forms of direct entomophagy. Eating insects directly can take place not only through the consumption of whole insects, but also by consuming food products in which insects are indistinguishable. Such foods contain no visually identifiable insect ingredients, for instance in the form of insect flour or insect-based proteins. Based on several consumer studies demonstrating that consumer willingness to engage with insect consumption increases when insects are processed ‘in disguise’ in food products, it has been suggested that disguising insects in such familiar products as bread and biscuits, or sauces and soups, is a crucial facilitator to improving consumer receptiveness towards edible insects. This form of direct entomophagy has recently been termed ‘entomophagy by stealth’,⁷⁹ and is believed to help raise familiarity and willingness to engage with eating insects.⁸⁰

4.2 New Instruments to Measure Consumer Perceptions and Acceptance

To assess consumer responses to insects as food and feed, a few new instruments have been recently introduced: Moruzzo et al.⁸¹ developed the Insect Phobia Scale (IPS), La Barbera et al.⁸² composed the Entomophagy Attitude Questionnaire (EAQ), and Guiné et al.⁸³ compiled a questionnaire containing seven subscales including a variety of items.

These recently developed scales to measure consumer perceptions, awareness, and acceptance represent a next step into consumer-oriented entomophagy studies and are, therefore, worth mentioning with respect to current and future research. By briefly introducing these three different scales and the items included we can see which factors are taken into account and which of the issues mentioned in the previous subsection are conspicuous by their absence.

⁷⁹Dagevos (2021), p. 253.

⁸⁰Ardoin and Prinyawiwatkul (2021), Dagevos (2021), de Carvalho et al. (2020), Kröger et al. (2022), Onwezen et al. (2021), Sogari et al. (2019c) and Wendin and Nyberg (2021).

⁸¹Moruzzo et al. (2021a).

⁸²La Barbera et al. (2020, 2021).

⁸³Guiné et al. (2022).

Table 1 Insect Phobia Scale (IPS)

Items
1. The idea of eating insects causes me disgust/repulsion
2. Insect consumption is not socially acceptable
3. I'm afraid insect-based foods have an unpleasant taste
4. I'm afraid insect-based foods have an unpleasant consistency
5. I think insect-based foods have poor hygiene
6. I think that eating insects is not suitable for our diet

The IPS by Moruzzo et al.⁸⁴ is the scale with the smallest scope. To come to a more specific scale than the traditional and more general Food Neophobia Scale,⁸⁵ the IPS focused on a variety of factors that obstruct the consumption of edible insects. A total of six statements referring to the acceptance/rejection of consuming insect-based foods were collected (Table 1).

The IPS clearly outlines common negative associations with eating insects. As such, the IPS-statements belong to the body of entomophagy literature that concentrates on addressing obstacles regarding consumer acceptance of including edible insects in the diet.

A broader perspective is obtained in the EAQ by La Barbera et al.⁸⁶ Next to statements about consumer hesitation due to disgust and perceived risks (negative associations) of eating insects, this instrument also includes items about intentions and readiness to eat insects (positive associations). The wording of the items in the EAQ remain more indefinite about how (un)processed insect foods and dishes are found to be in comparison to the IPS-items, which refer more explicitly to insects 'in disguise' (3–5), whereas items in the EAQ, in turn, refer more explicitly to insects as feed (indirect entomophagy) next to insects as food. Also, statements are included referring to practical situations of availability (12–14) and setting (4–5, 7). An impression of the EAQ is given in the following Table 2.

The perspective is further broadened by Guiné et al.⁸⁷ In their objective to develop and validate a questionnaire designed to assess consumer perceptions and knowledge regarding the consumption of edible insects, Guiné et al. include a wide variety of items ranging from sustainability and economic dimensions, and nutrition and health aspects to cultural and gastronomic perspectives. This has resulted in one of the most comprehensive questionnaires in the entomophagy research domain generated so far. This questionnaire is composed of no less than 64 items, grouped into seven subscales. A selection of its constituting items is presented in Table 3.

Even this selection of about a third of the items included clearly shows that the questionnaire by Guiné et al. addresses many of the issues raised in the literature as

⁸⁴Moruzzo et al. (2021a).

⁸⁵Pliner and Hobden (1992).

⁸⁶La Barbera et al. (2020, 2021).

⁸⁷Guiné et al. (2022).

Table 2 Entomophagy attitude questionnaire

Items
1. I would be disgusted to eat any dish with insects ^a
2. Thinking about the flavour that a bug might have sickens me ^a
3. If I ate a dish and then came to know that there were insects among the ingredients, I would be disgusted ^a
4. I would avoid eating a dish with insects among the ingredients, even if it was cooked by a famous chef ^a
5. I would be bothered by finding dishes cooked with insects on a restaurant menu ^a
6. I'd be curious to taste a dish with insects, if cooked well ^a
7. In special circumstances, I might try to eat a dish of insects ^a
8. At a dinner with friends I would try new foods prepared with insect flour ^a
9. I think it is fine to give insect-based feed to fish that are farmed for human consumption
10. In your opinion, does eating insects pose a risk to human health?
11. How serious do you think the risks of eating insects could be for human health?
12. Using insects as feed is a good way of producing meat ^a
13. I am ready to eat meat [beef, chicken, pork, fish] from animals raised on insect feed as soon as it is available on the market
14. I am ready to try edible insect foods as soon as they are available on the market
15. I think it is fine to give insect-based feed to fish that are farmed for human consumption ^a

^aItems that constitute the final version of EAQ

described in the previous Subsection. Strikingly, and in contrast to EAQ and particularly IPS, the questionnaire by Guiné et al. paid very little attention to negative perceptions: responses of disgust or food neophobia to ‘creeping and crawling creatures’ as food are entirely absent. Only the statement about obstacles to consumer acceptance of edible insects in Western countries refers—though in an unspecified way—to negative attitudes. However important it is to bring the benefits of the inclusion of insects in the Western diet to the fore, it is unrealistic to ignore consumer responses of reluctance and rejection to putting insects in their mouths. As Dagevos⁸⁸ aptly stated: insects are hard to swallow for many present-day Westerners. Consequently, widespread consumer acceptance and adoption of insect foods in Western diets may be expected to be a slow, difficult, and challenging process.

5 Discussion and Conclusions

5.1 Legislation, Information, and Temptation

In this chapter, we sought to outline the state of the art regarding legislation, consumer perceptions, and attitudes towards both insects as feed (indirect

⁸⁸Dagevos (2021), p. 258.

Table 3 Knowledge and perceptions about edible insects

<i>Culture and Tradition</i>
1. Entomophagy is a dietary practice that consists in the consumption of insects by humans
2. Consuming insects is characteristic of developing countries
3. There are obstacles to consumers' acceptance of edible insects in Western countries
<i>Gastronomic Innovation and Gourmet Kitchen</i>
4. Some gourmet restaurants use edible insects in their culinary preparations
5. Chefs contribute to the popularization of insects into gastronomy in Western countries
6. Culinary education favours overall liking for innovative insect-based products
<i>Environment and Sustainability</i>
7. Insects are a more sustainable alternative when compared with other sources of animal protein
8. Insects efficiently convert organic matter into protein
9. Insects are a possibility for responding to the growing world demand for protein
<i>Economic and Social Aspects</i>
10. Insect production can contribute to increase the income of families in low-income areas
11. Insects provide protein foods at cheap prices
12. In some countries insect farming is becoming a key factor in the fight against rural poverty
<i>Commercialization and Marketing</i>
13. The level of knowledge influences the willingness to purchase insect food
14. Price is among the motivations to consume insect foods
15. The consumption of insects and derived foods depends on availability
<i>Nutritional Aspects</i>
16. Insects are a good source of energy
17. Insects have high protein content
18. Insects contain group B vitamins
<i>Health Effects</i>
19. There are appropriate regulations to guarantee the food safety of edible insects
20. Industrially processed insect products are hygienic and safe
21. Insects contain bioactive compounds beneficial to human health

These 21 items have been selected by the authors to provide an overview of the scale. For the full version of the questionnaire (64 items) see the study by Guiné et al. (2022)

entomophagy) and insects as food (direct entomophagy). In addition to the necessary condition of legal approved introduction to the European food market—as discussed in Sect. 2 and more extensively in the second, third, and sixth chapters of this volume—at least two problems should be solved to tackle the unfamiliarity towards these products. First, increasing the amount of information provided to consumers about these foods. and second, offering more appealing products. Both these conditions are both important if we are to create a more enabling environment for (in)direct entomophagy.

Limited information about insects as food, food source, or feed is the first main issue. Secondly, an actual lack of appealing and readily available insect foods perpetuates unfamiliarity. From behavioural theory it is known that consumer choice is influenced by motivation, opportunity, and capability. The availability of information impacts the first factor, motivation. The availability of appropriate and

convenient products facilitates the latter factors, opportunity and capability. Lack of familiarity as a main cause of Westerners' non-acceptance of eating insects can be confronted by increasing information from a trusted source about the nutritional and environmental benefits and food safety guarantees of consuming edible insects and insect-based foods.⁸⁹ A higher awareness of the benefits of eating insects may be associated with an increased likelihood of food consumers beginning and continuing to eat insects and becoming—slowly but gradually—more convinced entomophagists.

Information also has an important role to play with respect to insects as feed. Considering that the market for new insect-fed meat products is set to emerge rapidly in Europe, policymakers, manufacturers and distributors will face new challenges related to label regulation and ingredient declaration.⁹⁰ As confirmed by most consumer studies, the success of such insect-fed products depends on providing adequate information to consumers through marketing campaigns at the point of sale and public communication.⁹¹ It has been suggested that Western consumers are likely to welcome insects as a feed, even if they are unlikely to notice the change.⁹² However, currently consumer interest in insects as feedstuff has not received broad media attention, with the result that awareness of the potential benefits of this alternative protein source is still low.⁹³

At a more practice-oriented level, increased availability and accessibility of desirable insect-based food products may also be associated with opposing unfamiliarity and negative consumer associations with eating insects. More and more positive exposure is vital to encouraging consumer willingness to try and buy insect foods, and eventually, to achieve a persistent consumer acceptance. In line with this is the finding that previous experience with eating insects appeared as a primary facilitator of consumer receptiveness to edible insects and insect-based food products.⁹⁴ In other words, increased exposure to insect-based foods and repeated insect-eating experiences increases familiarity that, in turn, increases entomophagy acceptance and decreases reluctance towards insects as food. Providing information on the merits of eating insects as well as putting palatable and desirable insect-based products on the supermarket shelves and on the menus of restaurants are key factors likely to overpower the disgust and fear of edible insects that prevail in current food consumer perceptions, as Sect. 3.1 clearly addressed, and tempt consumers to entomophagy. In the words of Ardoin and Prinyawiwatkul,⁹⁵ “as [insect-based] products become more appealing, existing negative emotions may diminish over time.”

⁸⁹Kröger et al. (2022) and Menozzi et al. (2017).

⁹⁰Sogari et al. (2022).

⁹¹Menozzi et al. (2021) and Spartano and Grasso (2021).

⁹²Altmann et al. (2022).

⁹³Sogari et al. (2022).

⁹⁴Dagevos (2021), Kauppi et al. (2019), Kröger et al. (2022) and Mancini et al. (2019).

⁹⁵Ardoin and Prinyawiwatkul (2021), p. 4954.

Future research should continue to examine both drivers and inhibitors of consumer acceptance of insects as food or food source separately, as well as the interrelationship between consumer readiness and reluctance to consume edible insects. The same holds for possible relationships between the use of insects as feed and its influence on consumer acceptance of insects as food—and possibly also vice versa. In this respect, future studies should also further apply the recently developed instruments in consumer-oriented research in both indirect and direct entomophagy. Finally, future studies should investigate psycho-attitudinal, behavioural, and experiential variables that will depend, at least in part, on future feed declaration regulations and expected label information.

5.2 *Final Considerations*

The pioneering industry of insects as feed and food could offer promising solutions to address major challenges to our global food system, including a growing population, limited natural resources and food waste mitigation. In this respect, this sector may be considered ‘strategic’ by national and international authorities from both SDG and CE perspectives as well as from the point of view of the current European policy reform (e.g., F2F) targeted at more sustainable and circular food supply chains.

Today the insect sector is still at an early stage, and its effect on the frequency and volume of consumption is almost negligible.⁹⁶ However, it is likely that in the coming years, the current legislative framework on Novel Foods and recent authorization approvals from the European Commission will play a constructive role in shaping the market⁹⁷ and facilitating access to such products. As a result, we might witness an increase in consumption, especially of products containing hidden insects: entomophagy by stealth seems the most promising way to move forward when it comes to direct entomophagy.⁹⁸

In addition, and turning to indirect entomophagy, safety laws related to animals farming and feeds are also a very central issue for the development of the insect sector.⁹⁹ The recent EU authorizations for using insects as feed in the poultry and pig sector are expected to open new avenues for insect producers, and to significantly impact the food supply chain for meat and animal-based products. According to recent studies, European consumers seem to be more open to accepting the use of insects as feed to produce meat and animal-based products (e.g., eggs) rather than embarking upon direct entomophagy.¹⁰⁰

⁹⁶Montanari et al. (2021b), Pippinato et al. (2020) and van Huis et al. (2022).

⁹⁷Mancini et al. (2022).

⁹⁸Dagevos (2021) and Pippinato et al. (2020).

⁹⁹Lähteenmäki-Uutela et al. (2021).

¹⁰⁰Mancini et al. (2022) and Spartano and Grasso (2021).

Acknowledgements All the authors would like to thank that the School of Advanced Studies on Food and Nutrition of the University of Parma and the Editors for providing the opportunity to share the latest advancements on this topic in this Volume.

With respect to the contribution to this chapter by Dagevos and Taufik, funding was provided by the Dutch Ministry of Agriculture, Nature, and Food Quality through the Knowledgebase Program 34: Circular and Climate Neutral [KB-34-006-001], Project ‘The Role of Insects in New Production Cycles’.

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