UK Edible Insect Association

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Towards effective and sustainable regulation of edible insects in the UK: A White Paper from the UK Edible Insect Association

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University of Sheffield Institute for Sustainable Food

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We also acknowledge the support of the team at the FSA who have always been encouraging and realistic regarding the legal position, have sought to support our desire to provide a legal basis for our members to sell in the UK, within the legal constraints of which they are subject, and have initiated the review of the Novel Food Regulations – which we hope will now lead to a new and much improved environment for the sector to flourish.

About UKEIA:

The UK Edible Insect Association is the trade association for companies and farmers working with farmed insect protein in the UK.

https://www.ukeia.co.uk

About Unconventional Connections:

UC is a small consultancy run by Dr Nick Rousseau providing Executive services for UKEIA.

https://www.unconventionalconnections.co.uk

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Foreword

Our planet faces a climate crisis, and it is becoming increasingly clear that food production plays a huge part. The UK insect sector has strived to challenge perceptions and provide solutions to this problem, from sweet protein packed snacks, to meat-alternatives, restaurants and even pet or animal feed.

As the chair of the UK Edible Insect Association and Co-Founder of Yum Bug, I believe that insects have a critical role to play in creating a sustainable future food system, due to their efficiency in converting biproducts into nutritionally dense, sustainable protein, a belief shared by the edible insect community. Yum Bug's goal is to challenge unsustainable and unhealthy meats, by providing an alternative wherever meat is an option. Over the last few years, it has been fantastic to see start-ups emerging in the sector led by forward thinkers with diverse product ideas.

As this report sets out, the Novel Food regulations in the UK have provided a substantial challenge to our sector's innovation and growth, which we feel is disproportionate to the risks to consumers. Yum Bug has successfully introduced tens to hundreds of thousands of consumers to edible insects since we started on this journey, and, having alerted potential customers to the allergenicity issue, we have absolutely no reason to think any have come to harm.

On behalf of the other UKEIA board members, I'd like to thank Nick, Anna, Ben and the University of Sheffield, for doing excellent work in researching and setting out this analysis and the resulting recommendations. We feel the arguments are compelling and evidence-based and strongly endorse the suggestions set out for a more balanced approach to protecting consumers and supporting the growth of businesses offering consumers more sustainable food options.

Aaron Thomas, Co-Founder Yum Bug and chair of UKEIA board

Foreword

The food system currently contributes around one-third of greenhouse gas emissions. It is a major contributor to biodiversity loss and a cause of numerous diet-related diseases. Feeding a growing population with fixed or diminishing resources is a major challenge as recognised by the UN's Strategic Development Goals (where SDG 2 commits us to end hunger, achieve improved nutrition and promote sustainable agriculture).

As well as reducing meat consumption and promoting a higher intake of fruits, vegetables and pulses, other innovative approaches focus on the increased consumption of alternative sources of protein such as insects. Entomophagy (the human consumption of insects) is widespread in other parts of the world and is becoming increasingly popular in the UK and Western Europe. The practice raises issues of consumer acceptance and palatability as well as questions of governance and regulation. It is the latter issues that are the focus of the current report.

The Institute for Sustainable Food at the University of Sheffield has partnered with the UK Edible Insect Association to produce this independent review of the evidence surrounding the safety of insect consumption. It comes at a crucial time when the UK's exit from the EU presents a unique opportunity to review the current legislation on novel foods and to propose some alternatives that are consistent with the scientific evidence and proportionate to the foreseeable risks.

The research that led to this report was funded by a grant from the QR Policy Support Fund (QR-PSF) and we are very grateful for this support.

Professor Peter Jackson and Dr Mike Foden,

Institute for Sustainable Food, University of Sheffield

Executive Summary

The world needs alternative sources of protein for human consumption. There is considerable evidence that insects are a sustainable option, requiring much less land and water than conventional livestock farming, while also producing fewer greenhouse gas emissions. Developing insect products that Western consumers will enjoy requires considerable, creative innovation and companies in the sector are investing in a wide range of options.

The UK has a diverse and growing set of companies in the edible insect sector. Despite some challenging market conditions, demand from consumers continues to grow and we see a steady flow of new companies forming and developing exciting new product offerings. Post-Brexit, the UK has adopted the European Novel Food Regulations including the designation of edible insects as Novel Foods for Great Britain[1] and this places very substantial barriers to trading of edible insects here, with many companies closing.

This report raises the question: is this warranted?

Our review of the available evidence regarding sales from the edible insect sector and safety of consumers eating insects reveals:

- Extensive and widespread consumption of *harvested insects from the wild* across many species and countries but with the risk of unknown contaminants entering the food chain e.g. pesticides.
- Considerable published material showing a solid understanding of the risk factors associated with a small number of extensively farmed insects (crickets, mealworms and grasshoppers in particular) and, most importantly, a robust analysis of the mitigation measures that farmers should adopt to minimise risks to consumers - leading to comprehensive guidance for insect farmers.
- No reports of cases of consumers coming to harm from eating insects or products containing insects.
- A wide variety of other insects that could potentially be "farmed" in various ways but for which the research into how to mitigate risks to consumers is much less extensive.

Legislation regarding edible insects varies across different nations. Our review identifies several models, the most relevant, we feel, are those in place in Switzerland and Singapore. In addition, in most countries' legislation, "edible insects" are not treated as a single uniform category, as they currently are in the UK, with certain species identified as safe for consumers. Indeed, our analysis of the evidence suggests that it is not logical to treat all insect species uniformly. Further, our Rapid Evidence Review identified that the small

[1] GB - NI is still subject to EU legislation

number of insects that have been thoroughly investigated do not offer a disproportionately higher level of risk than commonly eaten foods such as chicken, pork, shellfish, etc.

Our direct experience, and the evidence of company closures, show how damaging the Novel Food Regulations demanding an extremely high level of proof of safety is on the sector.

We would argue that the insect species that we have reviewed should be treated as exposing consumers to a similar level of risk as any other consumed form of meat, with proportionate and well-promoted risk management and effective and safe farming and handling practices developed to protect consumers. The main concern is to ensure that all those setting up agrifood or product businesses with edible insects are fully aware of the risks and correct management.

The Swiss legislation for edible insects provides a model that could be built upon:

- Identify a set of insects for which farming practice and risk management are sufficiently well understood
- Work with the sector to develop standards for good farming practices
- Introduce a licensing or certification programme
- Legislate to allow for insects that meet criteria to be removed from the definition of Novel Foods with a requirement that organisations wishing to farm these should be approved and licensed by their Local Authority (following agreed standards with Environmental Health Officers training)
- Legislate to allow for insects approved for sale in the EU to be legally imported and sold in the UK

The vast majority of remaining, less well understood species should, reasonably, be subject to scrutiny regarding their safety, but we recommend several adjustments to the Novel Food approval procedure that would significantly assist businesses preparing applications. Ultimately, if the UK Government can use the opportunity resulting from Brexit to reduce the barriers to entry for companies in this sector, it offers the prospect of establishing a global hub of innovation and creating a growing number of “green jobs”.

1. Introduction

The UK Edible Insect Association (UKEIA) (legally the Woven Network Community Interest Company, incorporated in 2015[2]) has built a positive relationship with stakeholders in the industry, including, but not limited to, the Government, Food Standards Agency (FSA), regulators and consultants. We are very pleased to be able to carry out the research that led to this report, working in collaboration with the University of Sheffield Institute for Sustainable Food at this critical time for the sector. The work was funded by a grant through the QR Policy Support Fund.

The FSA informed UKEIA in 2022 that a review of the Novel Food Regulations will be taking place. This report builds on our case for a Transitional Arrangement (Appendix I). The Transitional Arrangement (introduced in late 2022) allows for the sale of edible insects while Novel Food applications are being assessed. We are working with the Belgian Insect Industry Federation (BiiF[3]) and have prepared and submitted an evidence dossier relating to *Acheta domesticus and* are working on another focused on *Tenebrio molitor*. Assuredly, we have first-hand experience of the work involved.

This report is intended to inform decisions made by the FSA regarding the most appropriate way to regulate edible insects for human consumption in the UK. Working with colleagues at the University of Sheffield has enabled us to follow a rigorous and evidence-based approach to developing an understanding of the situation regarding the safe management of edible insect farming, and to develop a set of policy options and recommendations that reflect the view of the UKEIA members.

The report starts by setting the scene. The factors behind the growth in the edible insect sector, subsequently the conditions placed in the UK market over the last decade are described. We review what we have seen in terms of enterprises in the sector and the extensive evidence of safe human consumption that this points to.

A key aim of this research was to investigate what is known about the management of risks to consumers in the production of farmed insects and products containing them. We summarise previous reports regarding the safety risks associated with consumption of edible insects, followed by reporting on results from three Rapid Evidence Reviews we have carried out using secondary data.

Our final sections focus on the policy options for safeguarding consumers. We describe the experience of our members working under the Novel Food Regulations imported from the EU and the substantial challenge they present to the sector, and review models in other countries. We conclude with our recommendations for how a better balance can be achieved between concern for consumers and enabling the sector to develop products that could support our global sustainability.

[2] Registered in England and Wales company number 09796593

[3] https://www.biif.org

2. Global Context

2.1. What is driving our sector?

The need for alternative proteins has never been more urgent. The global population is projected to reach 10 billion by 2050, consequently the demand for protein has reached the point it is exceeding the available supply. To quote the UN Food and Agriculture Organisation (FAO, 2018a):

> "Agricultural production is limited by the increasing scarcity and diminishing quality of land and water resources, as well as by insufficient investment in sustainable agriculture. Climate change is increasingly affecting yields and rural livelihoods, while agriculture continues to emit large amounts of greenhouse gases (GHGs)."

The FAO's 2050 projections offer a variety of scenarios: all scenarios representing major challenges for humanity. A population of 10 billion will result in an increase in food and feed demand and corresponding pressure on the environment. They expect growing scarcities of all the necessary inputs, such as land, water, and biodiversity resources. Continuing to farm livestock to produce meat to meet this demand is adding to our global carbon footprint.

As a result, a significant effort is being spent at exploring alternatives to farming livestock. Initially at identifying and addressing key research questions, subsequently in the development of new forms of food production, and finally in the exploration of what new sub-sectors could become viable within the food industry, leading to new market opportunities. This is a long-term endeavour and will require major shifts in consumer behaviour as well as innovation within the food industry - all of which are challenging for businesses in the sector as they experiment with new ideas and options.

While much of the focus on reducing the environmental impact of our food has been on increasing the proportion of plant-based protein in our diets, the FAO published a report in 2013 that has since become a milestone moment.

For all known civilization, insects have been a part of a regular diet in every part of the world – albeit primarily harvested from the wild. The FAO report notes that a small number can now be farmed and identifies farmed insects as potentially contributing a valuable role in the diets of humans as well as a source of feed for livestock (FAO, 2013). The FAO continues to argue that edible insects have the potential to make a positive difference to the sustainability of our global food system. In FAO published report (2020a):

> "Edible insects contain high quality protein, vitamins and amino acids for humans. Insects have a high food conversion rate, e.g. crickets need six times less feed than cattle, four times less than sheep, and twice less than pigs and broiler chickens to produce the same amount of protein. Besides, they emit less greenhouse gases and ammonia than conventional livestock."

The focus of our report is to explore the safety of insects for human consumption in the UK, where insects are not traditionally eaten.

2.2. Insect farming for human consumption

While we quote the FAO (2013) and others that claim over 1,900 species of insects can be safely eaten by humans, there are very few for which some form of agricultural production

is possible. In the case of most species, these insects are harvested from the wild in the regions where they are consumed.

Acheta domesticus (house crickets) are the most popular farmed insect due to their ease of rearing and versatile flavour profile. The initiator of cricket rearing for human consumption is Thailand (particularly in the northern and north-east regions). According to "Small-scale production of edible insects for enhanced food security and rural livelihoods: Experience from Thailand and Lao People's Democratic Republic" (Hanboonsong et al., 2013a), more than 20,000 insect farming enterprises are now registered there, primarily small-scale household operations. This production is entirely for human consumption. Local journalistic publications record a growing number of larger scale insect farming enterprises (Bangkok Post, 2022).

Unconventional Connections (the consultancy that delivers the executive functions of UKEIA) carried out a study for Spectrum – the Sustainable Development Knowledge Network of Myanmar[4] – to investigate the potential to grow an insect farming sector in Myanmar. This included identifying the species of insects that are currently consumed there and investigating how many can be "farmed". Consulting a range of sources, including leading experts in China, we were able to create a taxonomy of levels of practice and technology for stimulating and/or managing breeding and production and identify for which species different levels of production enhancement existed.

We learnt that the differences between insects and their natural mode of growing means that specific farming methods and technologies are required for each species. Hence insect farming is an extremely diverse domain with a great range from:

- arrangements that essentially seek to stimulate an otherwise entirely natural context with minimal technology; to
- fully automated and controlled semi-industrial systems.

In this context, we would highlight that the term "entomophagy" (the term many use to refer to the human consumption of insects) is widely debated. As mentioned by Hunter (2021) many cultures where certain insects are widely and traditionally consumed do not necessarily think of themselves as "insect eaters". Crickets, or silkworm pupae, may be consumed but in specific dishes or forms and these insects are selected for their nutrition, flavour and availability rather than insects being eaten indiscriminately. Hence, along with the key distinction between harvested and farmed insects, the argument that all edible insects should be grouped together as a food category is open to challenge.

Further, the initial idea behind much insect farming is to feed the insects on some form of organic matter that is usually a by-product from other activities, or else represent "waste" and the appeal of this as a basis for a business is because the process can be seen as valorisation of waste. As the insect production expands and there is a greater emphasis on achieving a consistent quality of the final product, this becomes less realistic and greater control over the substrate on which the insects are fed is required.

2.3. The market opportunity

As a result of these global challenges and the response from the food sector seeking solutions, investment in novel foods is growing rapidly. According to the Good Food

[4] https://www.spectrumsdkn.org/en/

Institute (2023a), since 2010 the alternative proteins sector has attracted $14.2 billion in private capital, with annual investments nearly doubling every year on average, with alternative protein companies raising $2.9 billion globally in 2022. The estimates for future growth in this industry vary; however, all recently published data demonstrates a substantial growth in the edible insect sector. Fortune Business Insights (2021) projects the edible insect market to grow from $189 million in 2022 to $856 million by 2029, while Barclays Research Highlights (2019) suggests an estimated value of $8bn by 2030. These figures suggest a growing market and therefore a major economic opportunity for countries with supportive food regulation and a track record of food product innovation, such as the UK (FDF, 2013).

3. UK context

3.1. Regulations

The development of the edible insect sector in the UK has been very limited, largely, we believe, because of inconsistent legislation and limited support for research and development. We have identified several phases - See **Table 1**.

Until 2018, the legal position of insects as human food was ambiguous in Europe with each Member State interpreting the Novel Food Regulations as they saw fit (Carbonnelle, 2015). For example, Italy did not allow insects to be sold for human consumption while the Netherlands, France and the UK presented no obstacles to trading whole and ground insects for human consumption. However, we witnessed a “Wild West” style business environment due to the few regulations or safeguards put in place for trading businesses. This enhanced the uncertainty for consumers and has therefore slowed positive consumer interest.

Table 1: Phases of evolving legislation relating to edible insects in the UK.

Time period	**Description of phase**
Pre 2018	No specific regulations relating to insects as food ingredient
2018- 2020	European Commission defines insects as Novel Food, requiring dossiers to show they are safe to be submitted
Jan 2020 to Nov 2022	Brexit leaves the UK in an unclear position regarding legality of edible insects
Nov 2022 to Dec 2023	Transitional arrangement in place allowing 7 different species to be sold in GB
Early 2024 onwards	Only insects for which Novel Food approval applications have been submitted to the FSA can be traded
Late 2024 onwards	FSA possibly granting approval of different insects and insect products, providing clearer basis for trading
2025 onwards	Potential for new legislation to be defined and taken through Parliament to change the legal status of edible insect material

Following the European Food Safety Authority (EFSA) Opinion (2013) on the safety of insects as an alternative source of protein, the European Commission extended the scope of Novel

Food Regulations to create a uniform legal position across the EU (including the UK). Regulation (EU) 2015/2283 (EU Monitor, 2018) created a requirement for companies to make a substantial investment in the creation and collection of the evidence for product safety of each individual insect species. These new Novel Food Regulations became law in 2018. Despite transitional measures, allowing existing companies to continue to trade pending submission of evidence of safety, which ended in January 2020, this led to significant challenges for companies and scaling back of the range of insects available. The process of preparing and submitting dossiers of evidence to secure Novel Food approval was substantial see Section 8 where we describe our direct experience of this) and we believed it favoured companies with strong financial backing and the ability to benefit from proprietary information that would restrict others coming into the market.

In May 2018, the Woven Network attended the "The Future of Food Regulation in the UK post-Brexit: Standards, Delivery and the Supply Chain" workshop (Hancock, 2018). The FSA explained that trading edible insects in GB (Northern Ireland remained subject to EU Regulations) will require Novel Food approval, but no announcement was made in regard to transitional arrangements for this market. In January 2020, the UK left the European single market prior to the EFSA granting any Novel Food approvals for insects. The UK adopted the Novel Food Regulations, but no UK companies had the resources to individually finance Novel Food applications.

In 2021, the FSA wrote to local authorities stating that there is no legal cover for selling edible insects in GB. As a result, we witnessed a handful of companies continuing to trade and/or farm but they were increasingly finding it hard to secure investment, manufacturers, retail outlets, insurance. Three UKEIA members faced action from their respective local authority and an additional one who ironically had just been asked by InnovateUK to provide edible insect products at COP26 in Glasgow, were told to cease trading (personal communication, 2021).

In October 2021, Woven/UKEIA sent an open letter (Appendix I) with recommendations to the FSA for a transitional arrangement while, at the same time, submitting a full-length Novel Food dossier for *Acheta domesticus*. Following a formal consultation (FSA, 2022a), the FSA prepared legislation for a transitional arrangement. The transitional arrangement stated the species of edible insect that can be sold in GB until December 2023[5] or a Novel Food dossier is submitted and approved, whichever is later. The transitional arrangement was approved in Parliament in November 2022[6].

3.2. Media coverage and consumer perceptions

During the turbulent time of Brexit, there was a steady stream of media reports, articles and programmes that highlighted the environmental and nutritional value of edible insects. In

- [5]Alphitobius diaperinus (lesser mealworm)
- Acheta domesticus (house cricket)
- Tenebrio molitor (yellow mealworm)
- Gryllodes sigillatus (banded cricket)
- Schistocerca gregaria (desert locust)
- Locusta migratoria (migratory locust)
- Hermetia illucens (black soldier fly)

[6] https://www.ukeia.co.uk/post/parliament-agrees-to-transition-arrangement

parallel, several academics in different universities have chosen to personally promote edible insects with events, tastings, and campaigns to persuade students to sample them in different forms. We hope that exposure in education will create a domino effect as young people are the future consumers. Not only is there a significant market for edible insect companies supplying schools that want to give students direct experience; our experience, that when we mention to people our interest in edible insects is that many comment that "insects are the food of the future".

Media coverage is generally positive regarding the potential of edible insect products, however due to the lack of their availability in the shops the number of people trying insects first hand is minimal.

Our understanding of consumers' attitude towards eating products containing insects has largely come from the personal experiences of our membership network and quantitative survey data online. Anecdotal feedback was received from members' product development work, when offering samples across several different pop-up events, our own experience at Festivals (eg. Timber Festival[7]) and the shop at The Food Museum which is hosting an exhibition with tastings focused on edible insects selling out[8]! Regarding online surveys, we have collated the following statistics:

A survey commissioned in 2018 by Sainsbury's and EatGrub (ITV, 2018) found:

- 10% of British people have tried edible insects, of which more than half said they enjoyed them.
- About two in five (42%) shoppers were open to trying edible bugs, with 7% even prepared to add them to a weekly shop.

An online survey on alternative proteins commissioned by FSA in 2021 found (Ibrahimi et al., 2022):

- Half (50%) of respondents perceived edible insects as being safe to eat.
- Just over a quarter (26%) of respondents were willing to try edible insects.

A survey commissioned by Ÿnsect and conducted by OnePoll in April 2022 across the UK, US, Netherlands, and France found:

- Nearly three fifths of all respondents (57%) revealed a willingness to consume insects once the environmental and health benefits had been explained.
- 96% of the over 8,300 adults surveyed who had already eaten insects or insect protein said they liked them or would try them again.

This suggests that between 25% and 57% of the population are willing to try eating edible insects – between 16.75m and 38.18m. The reality may be midway between these – 27m – and if 7% of these were to incorporate them into their weekly shop, this would mean **980 million edible insect products being sold annually in the UK!**

[7] https://timberfestival.org.uk/2023-programme/edible-insects-2/#:~:text=Learn%20about%20the%20benefits%20of,precious%20planet%27s%20resources%20to%20farm.
[8] https://www.ukeia.co.uk/post/visiting-the-meat-the-future-exhibition

3.3. Research and innovation funding

We wanted to explore the support the Government has provided for innovation in this sector. We analysed the latest listing of InnovateUK funded projects, dating back to 2004, searching for entries with the following terms:

- Insect farming
- Entomophagy
- Edible insect
- Cricket
- Mealworm
- Black Soldier Fly/Black-Soldier Fly
- Insect protein

We then reviewed each to identify if they were relevant and then classified them – see **Table 2** and **Figure 1**. This showed that there has been a considerable investment in BSF farming for livestock feed since 2014, with only funding in other areas being provided since 2021.

Table 2: Analysis of InnovateUK grants to support farmed insect protein sector (Source: InnovateUK[9]).

	No of grants	Total value (£)	Average grant (£)	Period
BSF Livestock	38	9,225,841	242,785	2014-2023
Generic Livestock	7	963,860	137,694	2023
Pet Food	2	56,059	28,030	2022-2023
Human consumption	2	96,662	48,331	2021-2023
Frass	1	49,998	49,998	2023
Total	**50**	**10,392,420**		

BSF is the favoured insect to farm for livestock feed. Food products have yet to be developed for human consumption using BSF. Due to the potentially huge demand for more sustainable livestock feed options, the BSF farming sector has attracted considerable investment and has a strong focus on high-tech solutions. As a result, both Better Origin[10] and Entocycle[11] secured several funding series for their BSF farming technology and Beta Bugs[12] provide eggs that are selectively bred for optimal production rates. Recently a few companies have set up in the UK and secured funding. For example, OkO Protein[13] secured a grant from InnovateUK (included in our findings earlier).

[9] https://www.ukri.org/publications/innovate-uk-funded-projects-since-2004/

[10] https://betterorigin.co.uk

[11] https://entocycle.com/

[12] https://www.betabugs.uk

[13] https://www.okoprotein.com

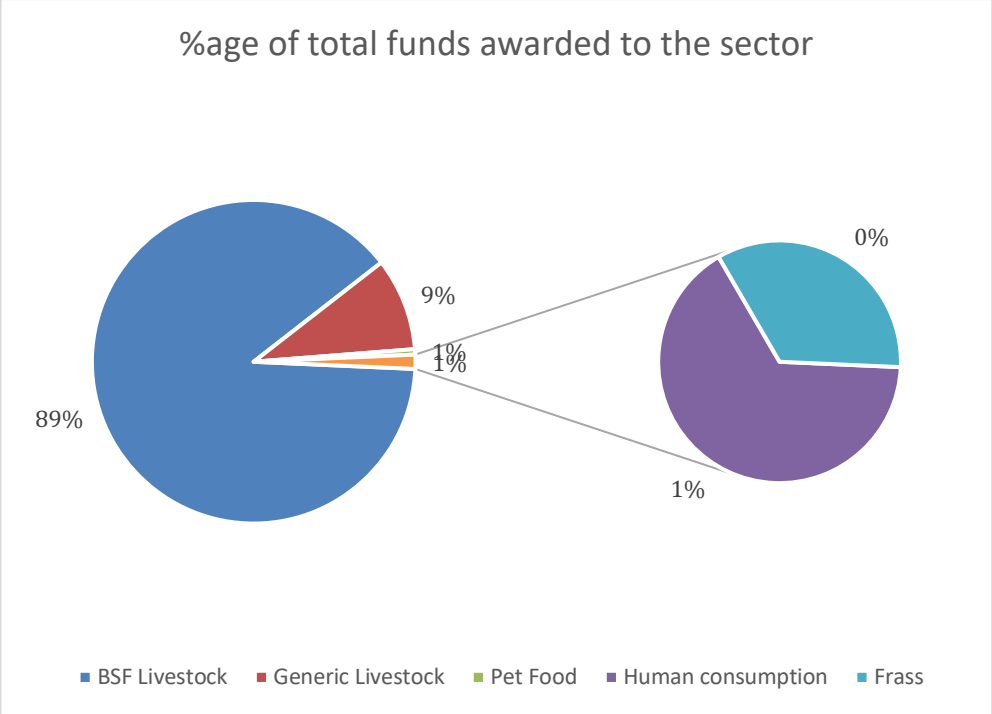

Figure 1: Pie chart showing how the grants to the sector were allocated between the main segments (Source: InnovateUK).

We also studied the Gateway to Research records of grants in the UK, using the same search terms as above and then filtering out those that appear, from the title, to relate to either general studies of insects (i.e. not relevant to farming) or cricket as a sport. Excluding those funded by InnovateUK, covered previously, that leaves 15 projects. **Table 3** and **Figure 2** show the results. The majority (9) were funded by the Biotechnology and Biological Sciences Research Council (BBSRC) with one from Engineering and Physical Science Research Council (EPSRC), one from Global Collaboration Research Fund (GCRF) and three Horizon Europe Guarantees. Given that Research Council research does not need to be tied to a particular market opportunity or commercial exploitation, most of these projects were exploring more fundamental questions regarding insect farming and feed for insects.

Table 3: Analysis of other research grants to support the farmed insect protein sector (source Gateway to Research[14]).

	Number of grants	Period	Total value (£)	Average grant (£)
Basic research into insect farming	9	2018-2026	1,240,610	137,846
Human consumption	2	2020-2026	913,286	456,643
BSF Livestock	4	2018-2025	209,754	52,439
Total	15		2,363,650	

[14] https://gtr.ukri.org

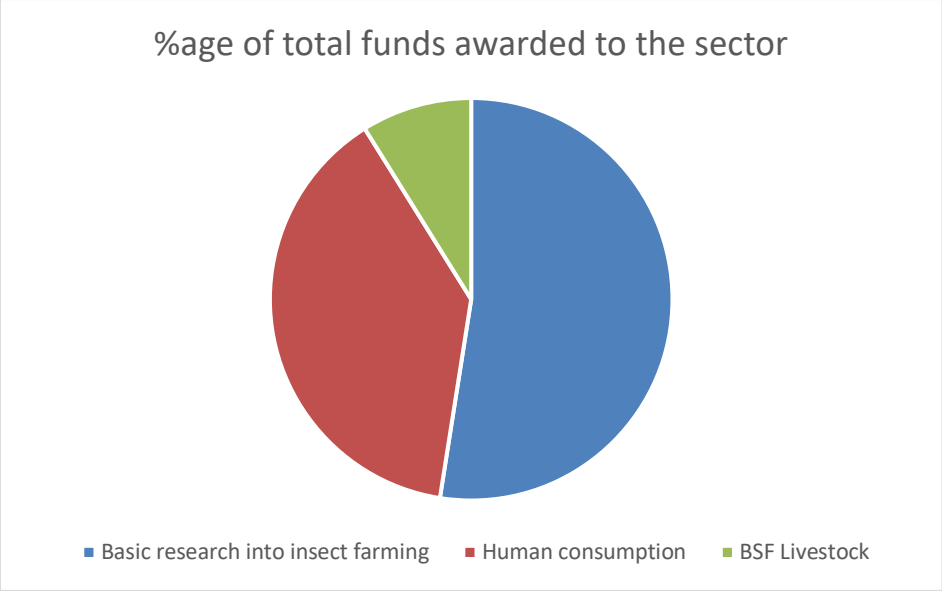

Figure 2: Pie chart showing how the grants to the sector were allocated between the main segments (source Gateway to Research).

Innovation in edible insects has been primarily funded by businesses themselves although we are aware of a small number of PhDs hosted by universities, such as James Hetherington investigating the effects of insect protein in sport and exercise settings at (Chester University, 2022).

Some new institutional investments to support research include:

- FERA Science's insect research facilities[15]
- Harper Adams University establishing a modular insect farm[16]
- University of Leeds Pig Centre implementing an insect bioreactor[17]

One significant private investment in edible insects has been in Wales with the development of insect and plant-based spaghetti sauce and piloting of this for inclusion in Welsh school dinners. Bug Farm Foods[18] collaborated with Cardiff Metropolitan University, Food Centre Wales, and the University of the West of England, to develop and pilot the sauce they called VEXo. Almost two hundred Welsh school pupils and three thousand children across the UK tried them. They found that 100% of children liked the VEXo bolognese, and, in fact, 71% of students preferred it to meat bolognese. As a result of eating VEXo, the percentage who would choose it for their school lunch rose from 27% to 56% (Jones, 2019).

UKEIA is actively seeking academic partners to strengthen the sector and continue establishing effective practice in edible insect production. Northumbria University has funding to enable it to collaborate with UKEIA to investigate risks associated with *Acheta domesticus* farming. This research will provide baseline information on the microbial landscape of *Acheta domesticus* rearing systems, and associated drivers of the community

[15] https://www.fera.co.uk/insect-bioconversion-reforming-the-food-system#packages

[16] https://www.harper-adams.ac.uk/news/209050/researchers-collaborate-with-industry-on-world-first-insect-farm-project

[17] https://biologicalsciences.leeds.ac.uk/biological-sciences/news/article/382/new-project-launched-to-boost-sustainable-farming

[18] https://www.bugfarmfoods.com

composition of the insects themselves. The research that resulted in the present report has been produced as part of a project funded by the University of Sheffield to support policy engagement relating to edible insects.

4. Farming of insects for human consumption

We know of 16 insect farming enterprises targeting human consumption established over the last 10 years in the UK with different levels of success. It is hard to get definite data on the timing of these starting and/or closing as they are often small-scale initially and based within some other agricultural enterprise. Others we know of are focused on the pet food sector (where there seems to be much more stability and several long-standing enterprises) and two that are essentially UK importers of insect material farmed in SE Asia.

The majority farm *Acheta domesticus* (house crickets), with only three working with *Tenebrio molitor*, the mealworm. Some such as Monkfield Nutrition and Instar Farming would be keen to expand into other species of insect. There is a particular need for another cricket species to be farmed in Europe as currently all the cricket farms work with *Acheta domesticus* which can be prone to *Acheta domesticus* densovirus (AdDNV) (Szelei et al., 2011) which, once it takes hold in a herd, can be extremely challenging to eradicate completely. Thus, if banded cricket (*Gryllodes sigillatus*) were also farmed, that could reduce risks to the sector, especially as this can prove to be more resistant to disease. However, the costs of seeking Novel Food approval for each species is a major barrier to this.

As well as the market uncertainty and difficulty building strong demand given the regulatory context, the challenge has been to develop a suitable scale of production that can expand as demand grows and that is financially viable. In many cases, the most successful models have been those that have been able to combine insect production for multiple markets. Thus, insects can be produced for both human consumption and as pet food, which helps to mitigate the risks of the human consumption market's current uncertainty.

The other challenges associated with insect farming in the UK are:

- Achieving the temperature and humidity conditions (eg see Cortez Ortiz et al, 2016) that are optimal for rapid growth while either powering it from renewable sources or minimising demand for grid electricity.
- Costs of the product tend to be higher than imports from SE Asia, requiring a strong focus on quality.

To date, the largest domestic farms are Monkfield and Peregrine Live Foods. At present only Monkfield is delivering insects for human consumption at scale (Monkfield has 30,000sq ft of insect rearing space). Smaller commercial farms exist but there has been considerable turnover of farming enterprises because of the many challenges affecting the sector. New start-ups continue to be formed, though, with the hope that the conditions will improve. For example, The Bug Factory is setting up a medium scale *Hermetia illucens* (Black Soldier Fly or BSF) farming unit in Leicestershire and Horizon Edible Insects[19] and Ento U.P.[20] have small scale *Tenebrio molitor* farming operations. As a result of the limited domestic production, companies making food products largely rely on importing the insect material

[19] https://horizoninsects.co.uk

[20] https://entoup.co.uk

from Europe or SE Asia. However, the UK has followed the European model of only allowing the import of insects from a very small number of countries – currently Switzerland, Canada, and South Korea (Animal Plant Health Authority, 2020) and Thailand (Journal of the European Union, 2020).

At this point, the challenge is to balance the desire to be sustainable and harness the insects' potential as waste converters with that of quality and cost. To some extent this can be seen as a question of scale of production. Small, very local, insect farming may well be viable purely based on locally produced organic by-products. This is best illustrated by the kitchen top scale BeoBio system (now rebranded The Bug Factory[21]) for using household waste to feed mealworms that can be fed to pets. If expansion is modular, with a network of small-scale production units being put in place, each can be highly sustainable, but the tendency is to develop large scale farming operations that require a different approach.

There is also a growing market for training/consultancy to support those setting up insect farms as the sector grows:

- Next Generation Nutrition[22] in the NL (led by Marian Peters who set up the Dutch association of insect farmers – Venik),
- Wageningen Summer School[23] (led by Prof Arnold van Huis - the main author of the original FAO report on insect protein and continues to be a leading researcher in this area),
- ADAS[24] (UK agricultural consultancy, with Mark Ramsden),
- FERA Science[25] (UK food and farming quality and safety specialists)

5. From whole bugs to the insect as an ingredient

The development of edible insect products that have really shifted consumers eating patterns in the UK has been very limited. We attribute this lack of progress to the changing and challenging legislative position, which we will discuss later. We have seen four phases as shown in **Table 4** (below).

5.1. Novelty edible insect products

While representing only a small section of the supply range, the most commonly sold edible products containing insects essentially targeted the novelty/entertainment market with demand stimulated by the ITV series "I'm a Celebrity, Get Me Out of Here". From the start of the series, the "Bushtucker Trial" was the central element of the show. Bushtucker Trials included eating trials with contestants being expected to eat a wide variety of unconventional food items. These included "crickets (in a variety of forms, such as cooked into biscuits, blended into drinks or eaten dead), green ants, mealworms, witchetty grub" and other food items chosen for their disgust potential (Wikipedia, 2022). When the show

[21] https://bugfactory.co.uk

[22] https://ngn.co.nl/aboutus

[23] https://www.wur.nl/en/show/summer-school-insects-as-food-feed.htm

[24] https://adas.co.uk/news/roadmap-to-accelerating-insect-protein-in-uk-feeds-published/

[25] https://www.fera.co.uk/insect-bioconversion-reforming-the-food-system

started, in 2002, contestants were expected to eat dead insects but by 2015, live insects were selected for the challenges, as shown in **Figure 3**, below[26].

Table 4: Phases we have observed in the UK edible insect sector.

Pre 2018	Small number of companies operating in the UK with an estimated 18 different species available – primarily novelty food items.
2018 to 2020	Huge reduction in the range of insects available. No UK companies submit Novel Food applications. Some companies focus on mainstream products – snack bars primarily. Woven Network attempts to create a consortium for seeking approval but is unsuccessful.
Jan 2020 to Nov 2022	With the legal uncertainty and need for Novel Food dossiers to be submitted to the FSA, further company closures. Woven Network starts trading as the UK Edible Insect Association and works with the FSA to improve the situation.
Nov 2022 to Dec 2023	Companies grow in confidence we see new companies start up. Increasingly universal focus on identifying ways to introduce insect material into more mainstream food products with the potential to become regularly consumed and shifting diet choices away from meat. However, a number of companies that had been struggling for some time finally ceased trading.

Each series of I'm a Celebrity had on average over 9 million UK viewers. The UK show, in addition to several series broadcasted internationally, raised awareness amongst the public that many insect species are edible (and presumably safe to eat, otherwise they wouldn't have been given to celebrities). However, damaging to our argument was the visual representation of eating them alive. The act of eating the insects was made clear that they were not enjoyed by the contestants! Furthermore, they were clearly strongly associated with a wide range of other unpalatable dishes or items.

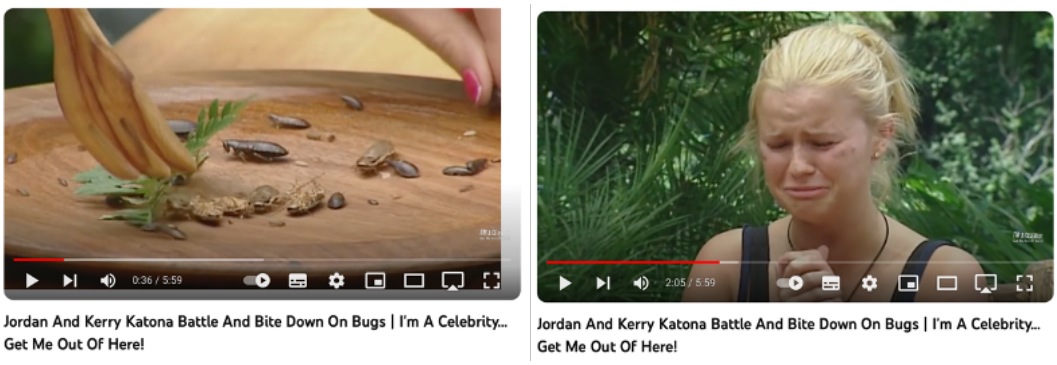

Figure 3: Screenshots from I'm a Celebrity in 2015 (YouTube, 2015)

At the first conference organised by the Woven Network there was a debate about whether that aspect of the sector was doing harm to the wider purpose of promoting insects as a serious food component.

[26] In 2019, ITV finally ended the practice of feeding celebrities live insects following criticism that it was inhumane (Walker, 2012).

Figure 4: Range of products available carrying the branding: Bush Tucker Challenge. (Source Gary Bartlett)

Food entrepreneur Gary Bartlett developed a range of novelty food items and sets with the branding "Bush Tucker Challenge" and, with the agreement of ITV, the connection to "I'm a Celebrity..." was very clear (**Figure 4**). Having successfully sold these for several years, in the UK and overseas, the team sold it to Tobar, so Gary transferred to become employed by them. In the first year that Tobar produced the Bush Tucker Challenge game (2012) it was their biggest selling item - selling to a range of stores including Tesco. Sales achieved in the first three years totalled 285,000 novelty items, sold in around 130 UK stores and exported to 27 countries (personal communication from Gary Bartlett, in 2020, who has since set up the Grub Consultancy[27]).

Insects forming part of the "Bush Tucker Trial" were very commercially successful, and after careful research, no reports of consumers with ill effects were found (see Section 7.6). We identified 18 species of insects that could be obtained in the UK during this time. Crunchy Critters[28] were offering a wide variety capitalising on the interest generated by I'm a Celebrity. They continue to offer a wide a range of insects.

5.2. Insects as food ingredient

In parallel, around the start of the 2010s, there was emerging interest in edible insect material as an ingredient in mainstream food products – primarily snacks at that time – with rapid expansion of early start-up companies here in the UK and in Europe. Early ventures set up insect farming to create insect material as a serious food ingredient, or the basis for more mainstream snacks and protein bars, such as Eat Grub which launched in 2014[29]. The more mainstream food product manufacturers worked with *Acheta domesticus* or *Tenebrio molitor* (house crickets or mealworms).

Throughout the 10-year period from 2013 to 2023, we have seen a series of enterprises being launched to offer edible insect products to UK consumers but with few being able to

[27] https://www.grubconsultancy.co.uk
[28] https://www.crunchycritters.com
[29] https://www.eatgrub.co.uk/about/

sustain viability – unless they had other sources of revenue it was very hard for any to keep trading during this period. **Figures 5 and 6** show how the number of businesses working with edible insects fluctuated and the number of companies that closed.

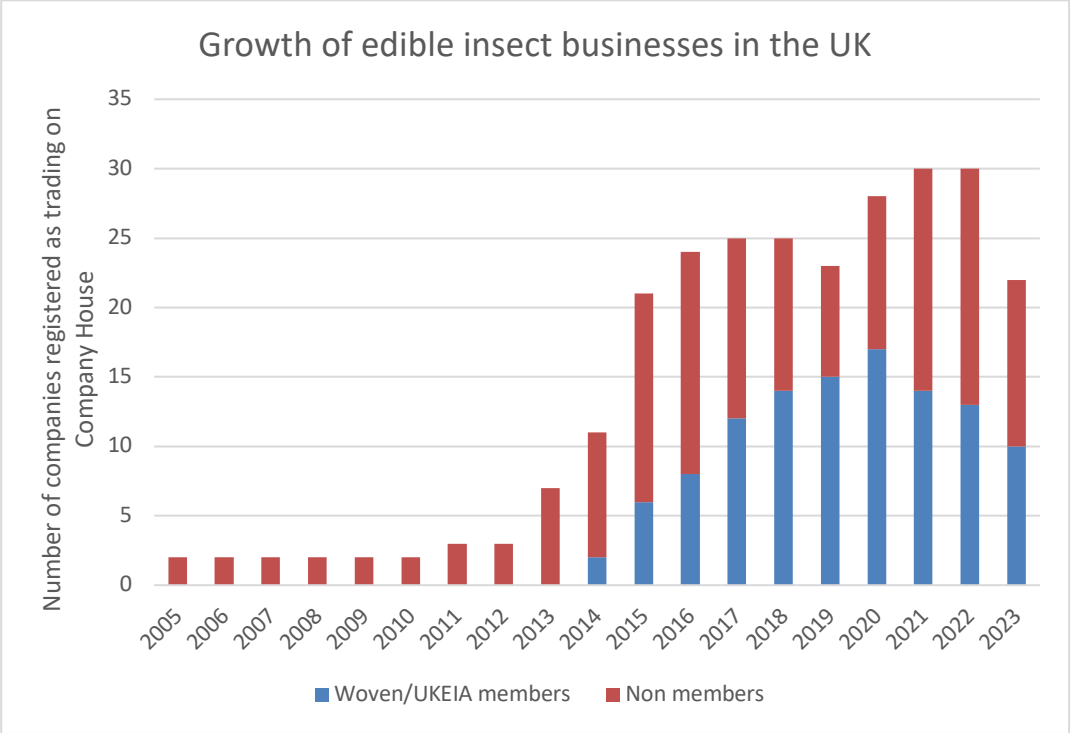

Figure 5: Based on data collected by UKEIA and Companies House records of periods when companies are trading, this table shows how many edible insect businesses have been trading since 2005.

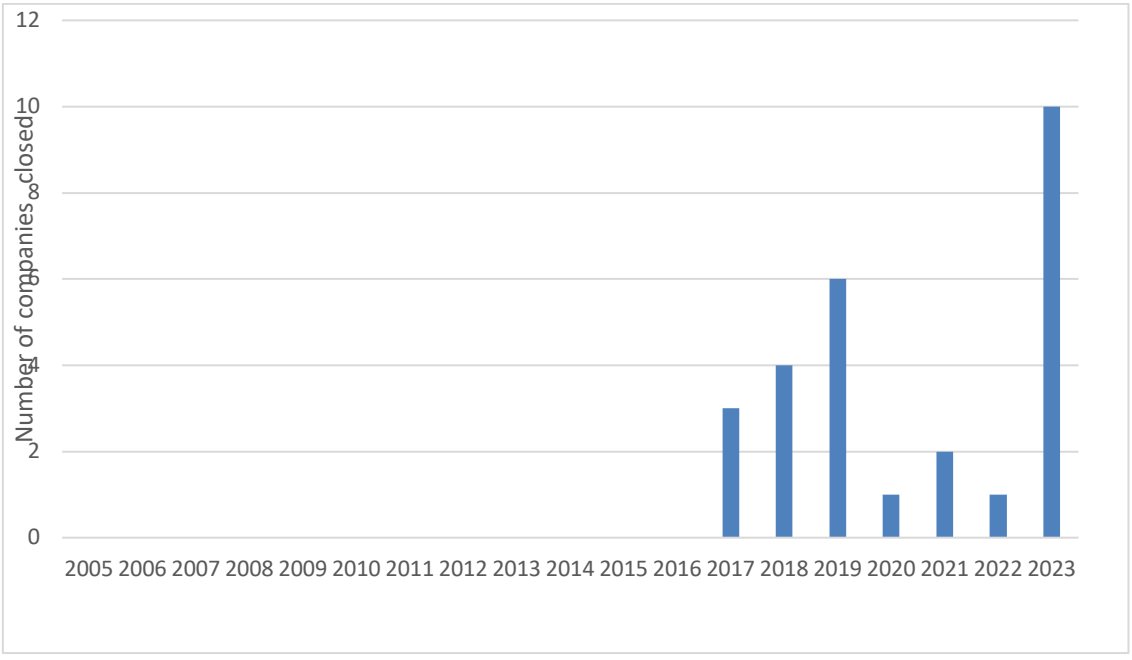

Figure 6: Using the same data, this graph highlights the number of companies that ceased trading in different years, according to their records on Company House.

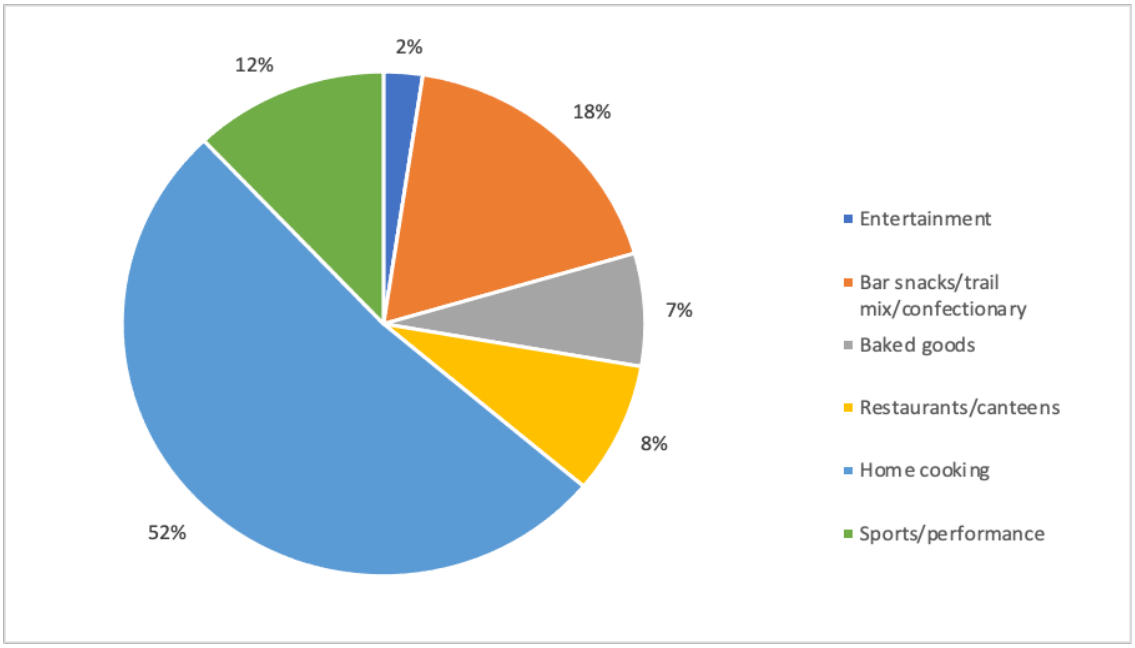

Figure 7: Using the same data, this pie chart shows the mix of companies on UKEIA's radar categorised by the type of products. NB if a business includes a number of different product categories in its current or past offering, these each count as a separate entry.

Figure 7 looks at the question of where businesses have been focusing their efforts and exploring the most promising product categories:

- Home Cooking (52%) – recipe kits or products such as pasta or insects as ingredients (whole or in powder form) for home cooking
- Bar snacks/trail mix/confectionary (18%) – these seek to find a space that involves consumption of the whole insect in a visible form but with a flavouring that makes eating them more akin to eating crisps, or similar, or lollipops
- Sports/performance (12%) – bars or shakes that are sold on the basis of their protein contents and marketed to appeal to body-builders, athletes or sports enthusiasts.
- Restaurants/canteens (8%) – seeking to insert insects as ingredient into dishes available from restaurants or school meals, including chefs with their own restaurants and/or offering chefs to cater for events
- Baked goods (7%) – biscuits, bagels, granola and similar
- Entertainment (2%) – focusing on the Do you dare to eat them appeal

In summary, the UK has produced a string of early stage, highly innovative enterprises exploring a range of product types. With the right conditions, this has the potential to expand rapidly based on a combination of locally and internationally sourced insect material, a diverse and engaging set of food offerings for the public and a well-primed market of potential consumers.

The retail options for these companies have been limited to their own online platforms, Amazon and, in recent years, the health food outlets run by Sacoma Health Foods[30]. Previously, Sainsburys carried a small selection of Eat Grub's products, Tesco and many

[30] https://www.sacoma-healthfoods.com

other major retailers carried the Bush Tucker Challenge range, Harrods and Selfridges had a short period of selling luxury, but essentially novelty, products and while some of the companies in the sector were having productive conversations with other major outlets, the regulatory uncertainty essentially prevented these converting into products appearing on the shelves (personal communication, Monkfield).

During the year 2022 - 2023, two brands have been leading the way in getting their products into the marketplace:

- Saved Food[31]'s Lentil Puffs containing cricket flour have been accepted for sale by a growing number of independent retailers[32]
- Yum Bug[33], are targeting the restaurant sector with their cricket preparations and dish recommendations

Both of these have experimented extensively with a range of business models and product categories before arriving at these models.

6. Published reports on the safety of different farmed insect material

Having set out the situation of the edible insect sector in the UK, we now turn to the evidence we have collected regarding their safety, potential risks to consumers and the current understanding of how these risks can be effectively mitigated through professional farming and product manufacture practices.

There have been three main reviews of the safety of farmed edible insects. In 2015, the EFSA consulted experts and published their Opinion (EFSA, 2015) which concluded:

> "... the specific production methods, the substrate used, the stage of harvest, the insect species and developmental stage, as well as the methods for further processing will all have an impact on the occurrence and levels of biological and chemical contaminants in food and feed products derived from insects. Hazards related to the environment are expected to be comparable to other animal production systems. The opinion also identifies the uncertainties (lack of knowledge) related to possible hazards when insects are used as food and feed."

The FAO Guide: Looking at Edible Insects from a Food Safety Perspective (FAO, 2021) summarises the situation as follows:

> "Safe and successful insect production must include efforts to prevent, detect, identify, and mitigate such food safety concerns. Food safety risks can be higher when insects are harvested from the wild and consumed raw. Farming insects under controlled hygienic conditions and implementing sanitary processing techniques should reduce some hazards, such as microbiological contamination.
>
> An important area of food safety consideration is the quality and safety of the feed or substrates used for rearing insects - as the nutrient content and food

[31] https://savedfood.co.uk

[32] https://www.linkedin.com/company/saved-food-ltd/posts/?feedView=all

[33] https://www.yumbug.com

> safety aspects of reared insects depend on the substrate, further studies and monitoring will be needed to determine the quality and safety of such side streams as well as the insects that are produced.
>
> Insects and crustaceans (shrimp, prawns, etc.) belong to the arthropod family. While allergic reactions to shellfish are well-known, the potential allergenic risks associated with consuming edible insects needs further investigation."

Most recently, the FSA published a Technical Report setting out the Risk Profile on edible insects (FSA, 2022b). Key points from the Summary are:

> "Several hazards have been identified. Edible insect products can present high levels of microbial contamination if the animals are not reared in appropriate conditions or if the product is not processed by heating to high temperatures for several minutes. Insects also have the potential to accumulate toxic compounds, particularly heavy metals, when fed contaminated substrate. Ensuring hygienic rearing practices and minimising the levels of contamination of the substrate can help avoid accumulation of toxic compounds, but more research is necessary to inform the identified knowledge gaps in this area.
>
> This review has updated the evidence on the allergic cross-reactivity between shellfish and insects, therefore consideration may be given to informing consumers accordingly. De-novo sensitisations are likely to occur in the future, but estimates of the risk are likely to be highly uncertain based on the existing literature. Lastly, there is a high composition variability of insect larvae depending on the substrate. Standardisation of substrates can minimise composition variability."

In summary, these studies have all focused on the risks associated with edible insects and agree that the best way to manage these risks is through careful and professional farming practices with Good Manufacturing Practice applied, and following the principles set out in HACCP. IPIFF have issued guidance on hygiene for insect farming (IPIFF, 2022).

While these reviews set out the range of risks associated with edible insects for human consumption, they do not provide a comprehensive assessment of how adequately effective farming practices can mitigate these risks.

Based on our review of the available evidence, our contention is that the risks associated with the most well understood insects are comparable to other livestock production sectors and that proper management informed by on-going research is the route to enabling the growth of this potentially highly important new source of nutrition, rather than requiring onerous and costly laboratory studies.

7. Rapid Evidence Review of the mitigation measures for the microbiological hazards associated Insects for human consumption.

We have carried out a Rapid Evidence Review (RER) to identify evidence in the scientific literature regarding mitigation measures for the hazards associated with edible insects outlined in the FSA Risk Profile on Edible Insects Technical Report (FSA, 2022). The methodological approach of this review was largely based on the same methodology used in that report to remain consistent and build upon its findings. A RER is similar to a systematic literature review but uses a streamlined process to provide a more rapid review of the evidence. For further discussion, see Government guidance on RERs (Collins, et al., 2015).

7.1. Research methodology

Primary question: What mitigation methods are there for consumer safety risks associated with edible insects for human consumption?

Secondary questions:

- What are the empirically studied risk mitigation procedures or approaches for the insects referred to in the FSA technical report? (NB focus on *Acheta domesticus* (AD), *Tenebrio molitor* (TM), and *Locusta migratoria* (LM))
- What is the resulting level of confidence in the safety of each insect as a human food product/ingredient resulting from these risk mitigation procedures or approaches?
- What does the research identify as the outstanding risks that remain once these risk mitigation procedures or approaches are used?
- To what extent are these procedures already carried out by UK insect farmers?
- What evidence exists of consumer harm arising from eating insects/insect material produced using these risk mitigation procedures or approaches?

The databases used for the search were consistent with that of the FSA report, with the exception of 'Food Science Source' which we did not have access to. These were:

- PubMed
- Web of Science

The same key terms were used as those used in the FSA Risk Profile on Edible Insects report relating to species, food, and risk, with the addition of a mitigation terms column (**Appendix II**). Mitigation terms that were referred to in the body of the FSA report were included, alongside other terms identified to be associated with the safety controls of edible insects.

7.2. *Tenebrio molitor* (TM)/ Mealworm

A search was conducted using the species term *Tenebrio molitor* or mealworm, alongside key terms related to food, risk, and mitigation shown in Appendix II, through both Web of Science and PubMed (*adjustments were made to the key terms for PubMed due to character count limitations). 274 results were returned on Web Of Science, and 1,134 results were returned on PubMed which narrowed down to 161 results through applying a subject filter of "edible insects". The literature included in this review is a mix of primary and secondary studies.

7.2.1. Microbiological risks

As highlighted by Yan et al. (2023), edible insects contain complex associated microbiomes, characterised by high variations in microbial load and diversity. In raw TM Larvae, high levels of mesophilic aerobes, lactic acid bacteria, enterobacteriaceae, bacterial endospores, psychrotrophic aerobic counts, and yeasts and moulds have been observed (Kooh et al., 2020). There have been reports of bacterial pathogens capable of causing illness in humans detected in edible insects (as reviewed by Garofalo et al., 2019), either through culture-based or molecular detection methods. However, it was noted that despite these reports, no outbreaks of illness attributed to contaminated edible insects have been reported. Thus, understanding the effectiveness of mitigation measures in eliminating or minimising these microbial risks during processing pathways is critical to assessing the ultimate risk to the consumer.

Several studies were identified in this review which look at the effectiveness in reducing microbial loads in TM using a range of methods during processing. The majority of these studies focused on heat treatment for microbial inactivation. In a study assessing microbiological quality of mealworm powders obtained through four different processing pathways, Yan et al (2023) found that heat treatments (boiling and cooking) applied during processing were effective means of microbial inactivation. However, although the treatments were sufficient to kill vegetative cells, spore-forming bacteria remained viable. Similarly, in a study on the efficacy of various processing methods, Mohammadsalim et al (2021) found that boiling and drying for 24 hours eliminated most vegetative bacterial counts, and boiling and drying for 48 hours left no detectable counts, but neither were effective in eliminating all spore-forming bacteria. These observations remain consistent throughout the literature which analyses the efficacy of bacterial inactivation, citing most heat treatment methods as being effective, but not for spore-forming bacteria (Vandeweyer et al., 2017; Belleggia et al., 2020; Yan et al., 2023; Mohammadsalim et al., 2021; Kooh et al., 2020). Such resistance to heat treatment can also be seen within the processing of other common food products, such as dairy milk (Ledina et al., 2021)). A review of the risk profile of *Tm* by the EFSA concluded that, with adequate control measures in place for the insect feed, rearing, and edible insect product, the associated risk of exposure to harmful microorganisms is very low for current product on sale in the UK (Turck et al, 2021).

Studies also looked at the implementation of a stringent HACCP system during the processing stage of TM to monitor the effectiveness of heat treatment methods. Both Arévalo et al (2022) and Kooh at al (2020) conclude that following a HACCP procedure to test the efficacy of critical control points (heat treatment stages) is an effective way of ensuring associated consumer safety for TM. Verification for these steps include carrying out frequent laboratory analysis of pathogenic and spoilage microorganisms according to a sampling plan. The same alkaline phosphatase (ALP) heat treatment tests used for dairy were also observed to be effective in assessing heat treatment of TM (Grabawski et al., 2018). However, all studies which assessed the HACCP point out that its effectiveness is reliant on the quality of raw material input into that system. Therefore, in addition to this, good agricultural practices (GAP) must be implemented to ensure the safety of processed products (Yan et al., 2023; Arévalo et al., 2022). Furthermore, special attention should be paid to the prevalence of spore-forming bacteria at each stage.

Overall, studies show that processing TM in a controlled, traceable, strict HACCP system that employs heat treatment methods, sanitary techniques, Good Hygiene Practices (GHPs) and

Good Manufacturing Practices (GMPs) results in a product which is of comparable microbial standard to other foodstuff available on the market. Special attention and monitoring is needed to the microbial count of the product throughout processing, particularly to spore-forming bacteria (as with any food product). Additionally, good agricultural practice should be enforced on the rearing side of the supply chain to ensure high efficacy of the HACCP system. Further research is needed to identify criteria for acceptable levels of spore-forming bacteria in TM for consumers.

7.2.2. Risks from contaminants

This literature review explores various studies on mitigating contaminants in TM and highlights key findings and recommendations.

Environmental factors and processing can introduce contaminants into TM. Research by Cardoso et al. (2023) reveals that TM larvae can accumulate high levels of mercury (Hg) when fed contaminated substrates, such as olive pomace residues. However, the study also shows that TM can eliminate the accumulated Hg within a few days when transferred to a clean substrate, indicating their suitability for consumption. Similarly, Bordiean et al. (2020) found that TM reared on crops protected by biological or chemical agents could be contaminated with harmful compounds like pesticides. Nonetheless, their study demonstrated that TM had lower concentrations of these chemicals compared to widely consumed animal products, suggesting the potential for safe feeding substrates.

Arvalo et al. (2022) developed a Hazard Analysis and Critical Control Points (HACCP) system specifically for TM production. They identified physical contamination hazards, such as metal fragments from processing equipment, and emphasised the importance of visual inspection, maintenance, and calibration programs to prevent such hazards. Chemical hazards, including heavy metals, pesticides, and residues from cleaning agents, were considered relatively low risk and could be controlled through Good Manufacturing Practices (GMP) and strict adherence to cleaning and hygiene protocols. Similarly, Schrögel and Wätjen (2019) emphasised the importance of assessing potential hazards on a case-by-case basis, considering factors like insect species and developmental stages. They proposed regular monitoring of contaminants, including mycotoxins, heavy metals, pesticides, veterinary medicines, and allergens, in both the rearing substrates and final TM products.

Enriching essential elements during TM larval development has shown promising results in mitigating contaminants. Keil et al. (2020) discovered that enriching TM rearing substrates with zinc (Zn) reduced the levels of the toxic element cadmium (Cd) in TM larvae, ensuring consumer safety. This highlights the potential for fortification strategies to optimise nutrient quality and quantity, enhancing the suitability of TM for human consumption.

In conclusion, mitigating contaminant risks in TM for human consumption requires a multifaceted approach involving proper substrate selection, ongoing monitoring of contaminants, and adherence to appropriate mitigation strategies. By considering the findings of multiple studies, it becomes evident that transferring TM larvae to clean substrates, implementing HACCP systems, monitoring and managing contaminants, and exploring fortification strategies can contribute to ensuring the safety and quality of TM as a food source. Future research and collaboration are necessary to further refine these mitigation measures and establish comprehensive guidelines for the production and consumption of TM.

7.2.3. Allergenicity risks

The consumption of TM may pose allergenic risks for certain individuals. The risks arise from a combination of the potential for allergic reactions to the insect bodies or to the content of what they have recently eaten (eg. if it contains gluten). Several strategies and technologies have been proposed to mitigate these risks, but their effectiveness varies, and none can completely eliminate allergenicity (Pan et al., 2022).

Among the preventive measures identified, one highly sensitive and specific method is real-time PCR testing. This method is useful for quantifying TM in processed foods, aiding in effective allergen management for sensitised or allergic consumers (Villa et al, 2023). Despite the utility of this tool, allergenicity remains a notable risk, highlighting the need for additional mitigation strategies.

Processing technologies, such as heat treatment and enzymatic methods, have been explored for their potential to reduce allergenicity. However, heat treatments like blanching, baking, and frying do not completely remove allergenicity. More promisingly, fermentation and enzyme technologies, which expose allergen epitope regions to proteases and lower immunoreactivity, have been utilised to produce hypo-allergenic foods (Aguilar-Toalá et al., 2022). That said, other processing technologies, including high-pressure, microwave heating, ultrasonication, and more, need further exploration to evaluate their role in reducing allergic reactions from insect protein (Aguilar-Toalá et al., 2022).

Microwave-assisted enzymatic hydrolysis has been identified as another effective method to prepare bioactive peptides from insect proteins, thus reducing their immunoreactivity. However, this technique's effectiveness seems to vary by insect species, and while it can reduce allergenicity, it cannot eliminate it entirely (Pan et al., 2022).

Hazard analysis and critical control points (HACCP) systems applied to TM production processes reveal allergenicity as a hazard of high probability and critical severity.

In relation to reducing the risks associated with the substrate fed to the insects, Arevalo et al. (2022) suggest sufficient fasting and washing of larvae before processing. The verification of these measures may involve monthly testing of larvae samples for gluten levels.

The possible effects of unit operations like thermal and enzymatic treatments on insect allergenicity have been summarised by Meshulam-Pascoviche et al. (2022). They confirm that the use of enzymes and heating can reduce allergenicity. However, the use of fermentation, while promising, presents unique challenges due to insects' distinct microflora and high protein content, making them susceptible to wild fermentation and spoilage.

While research indicates that allergenicity cannot be fully controlled through external factors (Lee et al., 2021), specific processing methods like enzymatic hydrolysis or thermal treatment can reduce the IgE-binding, potentially reducing cross-reactivity and allergenicity in edible insects (Pali- Schö ll et al., 2019). However, the effect of these processes is often protein-, species-, and treatment-specific (Lamberti et al., 2021).

In conclusion, while various strategies have been proposed to mitigate the allergenicity of TM, their effectiveness varies. None can completely eradicate allergenicity, indicating that caution must be exercised, particularly for individuals with known allergies. Further research is needed to develop more effective mitigation strategies and fully understand the impacts

of different processing methods on allergenicity (de Gier et al., 2018; van der Fels-Klerx et al., 2018).

7.3. *Locusta migratoria* (LM) / Migratory Locust

A search was conducted using the species terms migratory locust, locust, and Locusta migratoria, alongside key terms related to food, microbial risks, and mitigation shown in Appendix II. Searches were conducted on the databases of PubMed and Web Of Science, from which a result count of 82 and 170 records were returned, respectively. Literature was selected or excluded based on the criteria outlined in the search process as specified in earlier. Following this process, 11 records were included in this review.

Locusta migratoria (LM), like other insects, carry microbial loads on both the inside and outside of their bodies, thus sufficient processing methods are needed to minimise the risk of microbial contamination in locusts intended for human consumption (Mudalungu et al., 2021). As with other insects, heat processing methods are a favoured approach to deactivating harmful microbial loads. Unlike TM, the search returned only a small number of primary studies which looked at the effectiveness of different processing methods on microbial deactivation. However, several studies tested microbial loads post-processing, which provides a valuable insight into how the risks might be influenced and controlled through the supply chain.

Osimani et al. (2017) tested the microbiota of marketed processed LM using high-throughput sequencing. The results showed that pathogens such as Salmonella spp. and L. monocytogenes were not detected, but human opportunistic pathogens and spoilage bacteria were detected. The low number of samples tested must be considered within the context of these results.

Gałęcki and Sokół (2019) carried out a parasitological evaluation of LM using samples from 75 household and pet shop farms from Czechia, Germany, Lithuania, Poland, Slovakia and Ukraine. The following parasites were identified: *Nosema* spp.—in 125 (16.67%) samples, *Cryptosporidium* spp.—in 13 (1.73%) samples, *Gregarine* spp.—in 180 (24.00%) samples, *Isospora* spp.—in 15 (2.00%) samples, *Entamoeba* spp. in 9 (1.20%) samples, *Balantidium* spp.—in 14 (1.87%) samples, cysticercoids—in 15 (2.00%) samples, *Physaloptera* spp.—in 17 (2.27%) samples, *Steinernema* spp.—in 31 (4.13%) samples, nematodes of the order Gordiidea—in 7 (0.93%) samples, and Acaridae—in 31 (4.13%) samples. The results of this study highlight the importance of maintaining high hygiene standards during the rearing of LM, and ensuring that rearing occurs in appropriate locations (i.e. not in households). Gałęcki and Sokół (2019) recommend that heat processing methods such as boiling or blanching should be used as an efficient way to eliminate or inactivate parasitic developmental forms, and state that insect welfare standards and real time PCR testing should be carried out to monitor and effectively eliminate pathogens from farms.

Upon testing samples of LM for the food borne parasite “Toxoplasma Gondii”, Percipalle et al. (2021) found no detectable counts of the parasite in both processed and raw samples. However, the risks around T. gondii and edible insects are still relatively unknown, thus as with any other susceptible food product, proper hygienic management of Locusta migratoria farms is crucial to prevent T. gondii from stepping into the food chain.

As with TM, ALP is detected in LM, thus the same ALP testing method used for milk can be used to test bacterial deactivation post-heat treatment (Grabowski et al., 2018).

7.4. *Acheta domesticus* (AD) / House Cricket

A search was conducted using the species terms house cricket, cricket, and Acheta domesticus, alongside key terms related to food, microbial risks, and mitigation shown in Appendix II. Searches were conducted on the databases of PubMed and Web Of Science, from which a result count of 53 and 170 records were returned, respectively. Literature was selected or excluded based on the criteria outlined in the search process described above. Following this process, 34 records were included in this review.

This literature review explores various studies on mitigating microbiological risks in Acheta domesticus and highlights key findings and recommendations.

The European Food Safety Authority (EFSA) carried out a review of the literature into risks associated with *Acheta domesticus* (AD) (Fernandez-Cassi et al, 2018). This drew on extensive research and, *where data was scarce, comparative evidence from close relatives of the orthoptera genus were used*[34]. They conclude that effective risk management requires a closed AD rearing system under HACCP and GFP. This contrasts with open cricket farms typical of Southeast Asian small scale farming practice.

They also highlight that even if HACCP-type systems are implemented the following concerns remain:

- high total **aerobic bacterial counts**;
- **survival of spore-forming bacteria following thermal processing**;
- **allergenicity** of insects and insect-derived products; and
- the **bioaccumulation of heavy metals** (e.g. cadmium, zinc, mercury) - where it is present in their feed or soil. Heavy metals can be bioaccumulated or bioconjugated. According to Bednarska et al. (2015), crickets are more efficient in regulating their dietary exposure to zinc than cadmium, suggesting that crickets tend to accumulate cadmium.

Subsequent research has investigated these points further. Garofolo C., et al. (2019) carried out their own state-of-the-art review on all edible insects intended for human consumption. They also recommend that microbial hazards should be limited through the implementation of good hygienic practices during rearing, handling, processing, and storage, as well as the implementation of an appropriate HACCP system for edible insect supply chains. As the EFSA, they conclude that raw insects generally contain high numbers of mesophilic aerobes, bacterial endospores or spore-forming bacteria, Enterobacteriaceae, lactic acid bacteria, psychotropic bacteria, and fungi and potentially harmful species (ie pathogenic, mycotoxigenic, and spoilage microbes). They argue that spore-forming bacteria presents the highest concern. They added, further, that there is research evidence pointing to the need for risk assessments of edible insects to include an evaluation of the incidence of antibiotic-resistance (AR) genes and AR microorganisms in the production chain. One point to note is that they emphasise (as others have done) the need for a specific legislative framework for edible insect production, commercialisation, and trading as well as the need for microbiological criteria specifically tailored for edible insects

[34] This is significant given our recommendation that similarities between insect species should be considered as broader approvals may be possible than purely on a species-by-species basis – See section 10.

7.5. Summary of risk mitigation

We have extracted the main points from the above review of studies to create a simplified risk register for each insect species. This makes it easier to see similarities and differences. **Tables 5, 6, and 7** for the insects focused on above.

Table 5: Tenebrio molitor

Mitigation	Remaining risk
<u>Microbiological risk mitigation</u> A controlled, traceable, strict HACCP system during the processing stage of Tenebrio molitor.	An effective means of microbial inactivation to ensure consumer safety for Tenebrio molitor.
Heat treatments (boiling and cooking) applied during processing.	
Drying for 24 or 48 hours	24 hours eliminates most vegetative counts, 48 hours leaves not detectable counts.
Frequent laboratory analysis of pathogenic and spoilage microorganisms according to a sampling plan.	Special attention should be paid to the prevalence of spore-forming bacteria at each stage as they can be resistant.
Employing heat treatment methods, sanitary techniques, Good Hygiene Practices (GHPs) and Good Manufacturing Practices (GMPs).	
Good agricultural practices (GAP) enforced on the rearing side of the supply chain.	A product which is of comparable microbial standard to other foodstuff available on the market
Alkaline phosphatase heat treatment tests as used for dairy	Effective in assessing heat treatment

Contaminant risk mitigation Transferring TM larvae to clean substrates prior to dispatch Implementing HACCP systems, Monitoring and managing contaminants Fortification through addition of appropriate minerals into the substrate.	Product that contains below thresholds for toxic contaminants.
Allergenicity risk mitigation Sufficient fasting and washing of larvae before processing. Monthly testing of larvae samples for gluten levels. Labelling of food products to alert consumers to the risk of allergic reactions, most notably where the consumer is allergic to molluscs and crustaceans or dust mites may have an allergic reaction to crickets..	Risks of allergic reactions are acceptable.

Table 6: Acheta domesticus

Mitigation	Risk post mitigation

An enclosed Acheta domesticus rearing system. Good hygienic practices during rearing, handling, processing, and storage. Appropriate HACCP system for edible insect supply chains. Risk assessments of edible insects to include an evaluation of the (AR) genes and AR microorganisms in the production chain	Microbial hazards should be limited. Spore-forming bacteria presents the highest concern. Allergenicity of insects and insect-derived products; Prevent these getting into the food chain

Table 7: Locusta migratoria

Mitigation	Results of mitigation
High hygiene standards during the rearing of Locusta migratoria, and ensuring that rearing occurs in appropriate locations (i.e. not in households). Sufficient processing methods are needed Heat processing methods such as boiling or blanching Testing for levels of human opportunistic pathogens and spoilage bacteria Insect welfare standards and real time PCR testing ALP testing method used for milk	To minimise the risk of microbial contamination in locusts intended for human consumption. Eg to prevent T. gondii from stepping into the food chain Deactivating harmful microbial loads. Efficient way to eliminate or inactivate parasitic developmental forms, Effectively eliminate pathogens from farms To test bacterial deactivation post-heat treatment

In summary, we would conclude that the safety risk mitigation measures for these three insects are remarkably similar. The main outstanding areas that require further investigation are to identify criteria for acceptable levels of spore-forming bacteria and contaminants in food products derived from insects.

We consulted our most experienced insect farmer in the UK - Monkfield Nutrition - who have farmed a wide range of insects for over 25 years, but only in the last X years for human consumption regarding their risk mitigation practices, and Ento UK who have relatively recently set up a TM farming operation. **Table 8** summarises their approach.

Table 8: Overview of risk mitigation practices in two UK insect farming companies.

Mitigation recommendation	Monkfield	Ento UP
Microbiological risk mitigation Monitoring and managing contaminants Transferring TM larvae to clean substrates prior to dispatch Heat treatments (boiling and cooking) applied during processing. Drying for 24 or 48 hours	All insects are bred and reared at the farm, so fully traceable and controllable. Prior to euthanising them (by freezing), they are separated from their food for a minimum of 24 hours. They are then sieved in the frozen state to ensure complete separation from any remaining substrate and samples tested in metal detecting machines. They are packed into food grade poly bags and transferred into the area for cooking They are then washed and placed in an industrial microwave to be cooked before being dried for 24 hours.	They source their substrate through a whole-saler who guarantees it as organic. Before euthanising by dry freezing, they are separated from their substrate and sieved three times to ensure complete separation from the substrate as well as any expired larvae, pupae and beetles and starved for 24 hours. They are kept frozen for at least 72 hours before being dispatched to customers – as raw frozen product. They sell the frass as fertiliser.
Frequent laboratory analysis of pathogenic and spoilage microorganisms according to a sampling plan.	Samples are sent to their laboratory and subject to three suites of testing: heavy metals. Full set of microbiological risks.	Samples are sent for testing for heavy metals and microbiological risks They run tests on the quality of their frass but do not currently

	full nutritional analysis	test the nutritional make-up of the mealworms. They will send a sample for shelf-life testing in different states. They are at an early stage and will do more testing when trading. Their current customers do not require nutritional analysis.
A controlled, traceable, strict HACCP system. Good Hygiene Practices (GHPs) Good Manufacturing Practices (GMPs). Good agricultural practices (GAP) Sanitary techniques	HACCP in place. They have controlled environments and staff wear different PPE for each of raw and cooked sections. Food grade cleaning products. They have a full Quality Management System in place with all elements documented and records kept of start up checks, cleaning records, metal detector results, etc..	HACCP in place. Their processing and growing facilities divided into sections with fly screens. The environment is monitored to ensure stable humidity and temperature. Daily cleaning of all areas. Use of UV light on substrate to detect mould – removal and disposal of any mould detected. They have followed all available guidance from the FSA for GHP, GMP. They have reviewed and implemented GAP guidance. Eg. They ensure there is no liquid waste or run off.
Alkaline phosphotase heat treatment tests as used for dairy. Fortification through addition of appropriate minerals into the substrate.	Not aware of these.	Not aware of these.

Allergenicity risk mitigation Sufficient fasting and washing of larvae before processing. Monthly testing of larvae samples for gluten levels.	Some companies want to declare as gluten free – aiming to provide this option in future. Intending to do a project on purging times to eradicate the gluten allergen risk.	Use of Rapid gluten detection testing kit for every new batch of mealworms. Tested from sample of frozen batch before distribution. Results must show 20 parts per million (ppm) or less to be despatched / sold as 'gluten free'.
Labelling of food products to alert consumers to the risk of allergic reactions.	We declare an allergen risk on our labels	If selling dried as food, have all labels.

7.6. Other Insects

We have also carried out the initial stages of Rapid Evidence Reviews for other insect species, using the same search terms and sources, to explore how the volume of research into the mitigation of risks associated with each differs – **Table 9**.

This shows clearly that the body of research varies substantially by insect species with many requiring substantially more before we can state confidently that we understand the risks and can mitigate these in any production system.

Table 9: For a set of edible insect species, the total number of articles that were identified in searches in PubMed and Web Of Science with no filtering.

Insect species	Total articles
Tenebrio molitor	252
Acheta domesticus	234
Locusta migratoria	252
Hermetia Illucens	253
Weaver Ant - Oecophylla	4
Palm Weevil - Rhynchophorus Ferrugineus	28
Cicada - Cicadoidea	44
Banded Cricket - Gryllodes Sigillatus	4

7.7. Search for food safety alerts / news stories regarding consumer harm from the consumption of insects

Our members' experience has been that no cases of people coming to harm have resulted from the consumption of edible insects in the UK, but this is not a robust basis on which to make any claims of safety. Our hypothesis is that, despite millions of instances of edible insect consumption, the number of people who have come to any harm has been minimal. In order to test our hypothesis further, we searched Food safety alert databases for different countries / regions for food alerts relating to *Tenebrio molitor* and *Locusta migratoria* (**Table 10**) using the key species terms. No results were found. Similarly, a database search for news articles relating to human harm from the consumption of *Tenebrio molitor* and *Locusta migratoria* was carried out on Nexis using the following search terms: (Harm or death or illness or sick*) and (Mealworm or Tenebrio or Locusta or locust) and (Human) and (ento*). 105 results were returned, but none related specifically to a case of human harm from the consumption of mealworms.

Table 10: Results from searching various alert databases for instances of health alerts related to consumption of Tenebrio molitor.

Alert database	Date range	Results
Canadian Recalls and safety alerts [35]	2011-2023	No current or archived results
FSA Alerts [36]	2015-2023	No current or archived results
Swiss Meic food safety recalls [37]	2013-2023	No current or archived results
RASFF European Food Commission [38]	2020-2023	No current or archived results

[35] https://recalls-rappels.canada.ca/en/

[36] https://www.food.gov.uk/search?keywords=&filter_type%5BFood%20alert%5D=Food%20alert/

[37] https://fsca.swissmedic.ch/mep/#/

[38] https://webgate.ec.europa.eu/rasff-window/screen/search/

8. Our experience of seeking Novel Food approval

UKEIA has made two main attempts to engage with the Novel Food process, both under EFSA pre-Brexit and under FSA subsequently.

When the regulations first changed to designate edible insects as Novel Foods, we saw the risk that it would only be well-financed companies that could gather the evidence and prepare the necessary dossiers. The issue is that the regulations allow for companies submitting dossiers to specify some of the contents as not for publication for 5 years based on their containing proprietary information. This would have the effect that only those companies (and any to which they grant the right) could benefit from the approval. This would create potential monopoly positions and lead to severe restrictions on what is available to consumers and the risk of prices being inflated.

In 2017, we attempted to bring together companies with a shared interest in each insect species so as to pool the resources needed to develop dossiers. We estimated these costs to be up to 100k Euros. However, with the substantial uncertainty associated with this undertaking regarding additional costs that might arise and no guarantee of a successful outcome, we were unable to build the necessary coalition.

We also looked at the option that the regulations set out for a dossier based on "history of consumption" outside of the EU[39] but understood that this was unlikely to be successful as any one EU member state could raise objections to this and the application would be rejected. If this were to happen, the applicant must revert to the conventional approach, effectively adding to the already lengthy delay before going to market. Also, the history of consumption approach would only result in the approval of products/ingredients that are equivalent to that consumed in the other locations and, as the evidence of history of consumption relates to *harvested* insect species, this may not directly apply to farmed insects.

We were extremely pleased, therefore, when we learnt that the Belgian Insect Industry Federation (BiiF) had succeeded where we did not and had formed "clubs" of companies willing to share in the investment needed. The development of these clubs, the formation of the legal frameworks and the collation of funds, procurement of specialist and scientific laboratories, etc. all required considerable work and we give credit to the team, especially Bart Mertens for what they have achieved.

To protect UK companies, the Woven Network established a partnership with the BiiF in 2020 to develop evidence dossiers for both EFSA and FSA on a cost-sharing basis. Woven subsequently reconstituted itself to become the UK Edible Insect Association (UKEIA) to enable it to better represent the needs of companies working in this sector.

We have collated a summary of our collective experience of the Novel Food application process – Table 11.

We are at an earlier stage in our application to the FSA than BiiF is with its engagement with the EFSA, and we cannot rule out the possibility that our application will result in a similar

[39] https://efsa.onlinelibrary.wiley.com/doi/pdf/10.2903/j.efsa.2016.4590

number of requests for information. However, the experience to date is that the progress of the FSA dossier is much more manageable than that for the EFSA ones.

Table 11: overview of the BIIF and UKEIA experience of Novel Food applications

Dossier	Date of first application	Duration to date	Costs to date	Requests	Expect completion
Acheta domesticus – EFSA	Jan 2018	5.5 years	150k Euros	13	2024?
Tenebrio molitor – EFSA	April 2018	5 years	150k Euros	15	2024?
Locusta migratoria – EFSA	April 2018	5 years	TBD[40]	3	2024?
Acheta domesticus – FSA	Dec 2021	1.5 year	150k Euros[41] plus £10k for FSA	2	?
Tenebrio molitor - FSA	(Dec 2023)	-	-	-	-

The dossiers originally submitted by BiiF to the EFSA were substantially revised at a number of points in response to the Requests for Information received, leading to the dossier that BiiF shared with UKEIA (and on which we work together now) arguably being stronger and more convincing. It may be that both the team at EFSA and at BiiF have learnt a lot about what constitutes a strong evidence base for safety of edible insects and that UKEIA's ability to pick up from where BiiF got to with the *Acheta domesticus* application has meant that the FSA has not needed to ask for as much work to be done.

Feedback from the consultants who have worked on these dossiers is that:

- The approach seems very academic rather than pragmatic and has clearly been influenced by academic publications that have come out during the period since 2018.
- The heavy time requirement and cost of carrying out the research and producing the evidence dossiers puts small businesses at a disadvantage. Only big private companies can afford to allocate the required resources to construct such dossiers.
- Data requirements to meet the standard for approval are unclear – follow-on questions and requests for further information feel like a rabbit hole of enquiries potentially requiring additional work (admin and data) which increases cost and time. This means that applicants that apply are also taking on a risk of ongoing cost.

Suggestions to the FSA based on the above observations:

- Provide a dossier template to both speed up and harmonise the application process – this would benefit both applicants in preparing applications, and the FSA to review standardised dossiers
- Explicitly outline the data requirement e.g. "FSA require at least 5 lab datum for nutrient X in question" as there is currently an unclear threshold for supporting data to achieve authorisation

[40] Much less than others as not progressed as far.
[41] ie cost of the EFSA dossier

What has become clear from the process BiiF undertook, and that has been mirrored by our own experience with the FSA, is that the assessment of the evidence is extremely opaque as it relies on the judgement of a panel of scientific experts. It can seem that there is an almost endless potential for requests for clarification, for requiring additional laboratory work and for the costs involved to grow in an entirely unpredictable manner. For small companies at the early stage of their development this kind of uncertainty and risk has proven to be a very substantial challenge.

In practice, we have benefited enormously from the work done by BiiF and they generously allowed access to the dossiers they have developed for a fraction of the cost. However, they have, to date, only developed these for *Acheta domesticus*, *Tenebrio molitor* and *Locusta migratoria*. Some of our members are considering preparing dossiers for other insects but will have to cover the costs in full.

In summary, given the considerable evidence that farming these three insects can be managed with a high level of confidence, the requirement for Novel Food approval appears to be disproportionate as a means of protecting consumer's safety in relation to food products containing them.

9. Approaches to protecting consumer safety in relation to edible insects around the world

We are monitoring the regulations governing the sale of edible insects around the world - we can report findings in relation to *Acheta domesticus* in the following jurisdictions:

- In Australia and New-Zealand: *Ad* is considered as non-traditional, not novel foodstuff and no safety concerns were identified with the exception of potential risk of allergenicity in crustacean-allergic or other sensitive individuals when consuming crickets or foods derived from crickets (Payne et al., 2023).
- In Mexico: *Ad* is commonly consumed (Ramos-Elorduy, 2009).
- In Asia: Their consumption by humans has been reported mainly in Thailand (Hanboonsong *et al.,* 2013; Yen, 2015) and Laos PDR ((FAO and WHO, 2019 ; Hanboonsong and Durst, 2014), but also in Cambodia (FAO, 2013). In 2017, the Thai Agricultural Standards Committee established Good Agricultural Farming Practices for cricket farming including *Ad* (ACFS, 2017). *Ad* is also farmed in Laos PDR (Hanboonsong and Durst, 2014), as well as to a lesser extent in Cambodia (Halloran *et al.,* 2018).
- In North Amercia: In Canada, *Ad* is considered non-novel for use as a food or food ingredient (CFIA and Health Canada, 2021). *Ad* also appears to be marketed for human consumption in the USA as a whole insect or as a food ingredient in a number of food products (e.g., nutritional bars, lollipops, flour, chocolate etc.).
- In Africa: *Ad* is commonly consumed in Ghana (Anankware *et al.*, 2016), Democratic Republic of Congo and Kenya (Halloran *et al*., 2018).

The apparent lack of concern in many of these jurisdictions over the sale of crickets is very encouraging.

9.1. Swiss Regulation of edible insects

We investigated the Swiss situation which we feel has considerable merit in providing a means for the safe farming of selected insects intended for human consumption.

Since 1 May 2017, the insect species *Acheta domesticus*, *Locusta migratoria* and *Tenebrio molitor* can be legally sold in the Swiss market as food (whole, chopped or ground) (FSVO, 2017).

This legislation is underpinned by:

- A framework of good agricultural practice approved by the OSAV (Food Safety and Veterinary Federal Office).
- Guidance supplied to businesses supplying edible insects under the regulation of Article 21 (organic foodstuffs and unusual objects).
- Cantons (equivalents of Local Authorities) issue licences to the farm before legal production can begin. Cantonal enforcement authority examines each application and carries out an inspection on site.
- Agreement with the EU that such products can be exported into that market.

Three businesses are now producing edible insects in Switzerland under these regulations and are examples of safe production:

- Essento Food AG[42] - Zurich (Tm, Lm, Ad)
- Entomos AG[43] - LucerneEndingen (Tm, Lm, Ad)
- Lowimpact Food SA[44] - St-Aubin (Tm)

We have made enquiries to establish how well these Regulations and procedures are accepted in Switzerland. Christian Bärtsch, who leads Essento Food described as "Helpful and very constructive" (personal communication, Feb 2023).

Appendix III gives more detail on the evidence that needs to be covered in a request for authorisation.

9.2. Measures for protecting consumers in relation to imported insect products – The Singapore Food Agency model

In 2022, the Singapore Food Agency (SFA) issued a statement announcing that it had put in place a regulatory basis for insects to be acceptable in the Singapore market – based entirely on importing insect material[45].

> "To safeguard food safety, we will put in place requirements which companies intending to import or farm insects for human consumption or livestock feed have to meet.
> These include:
>
> - Providing documentary proof that the imported insects are farmed in regulated establishments with food safety controls and ensuring

[42] https://essento.ch/en/
[43] https://www.entomos.ch/en
[44] https://lowimpactfood.ch/
[45] https://www.sfa.gov.sg/docs/default-source/default-document-library/sfa-insect-regulatory-framework-factsheet.pdf

> that the substrate used for rearing or feeding insects is not contaminated with pathogens or harmful contaminants.
> - Insect species without a history of human consumption are considered novel food and companies would be required to conduct and submit safety assessments for SFA's review in line with our novel food regulatory framework before they can be allowed for sale.
> - As with other food available in our market, insect products would be subjected to food safety testing. Food that is found to be non-compliant with our food safety regulations will not be allowed for sale. "

This offers a useful basis for consideration of UK regulations in relation to import.

10. Potential policy for FSA

In this section, we offer our analysis and recommendations for the FSA regarding the most appropriate way to regulate and support the emerging edible insect sector in GB[46].

We understand that regulation is a key tool for the Government to balance:

- the needs of business to innovate and bring new products to the market; with
- protecting consumers and ensuring clarity regarding expectations.

The UK has a reputation for robust food safety legislation and enforcement but has become increasingly dominated by the European Commission's extremely cautious and risk averse model, while within the European Union. Brexit provides the opportunity to review how a better balance can be achieved. We also recognise that the resources at Local Authority level for scrutiny and enforcement are increasingly stretched and need to be supported to prioritise their activities and effectively assess risks.

We welcome the report of the review they commissioned from Deloitte (FSA, 2023). Their statement signals a willingness to balance these risks and, in addition, includes four observations that resonate with the experience of the UK edible insect sector:

> "Businesses making novel foods applications tend to be smaller firms that may not have dedicated regulatory teams nor prior food regulation experience. They may require more clarity and guidance from regulators than more established operators.
>
> There is a greater focus on sustainable and more environmentally friendly food options among consumers. This may contribute to greater demand for new food options and, consequently, more novel foods applications that consumers and producers want approved at a faster pace.
>
> The surge in investments in novel foods, with global alternative protein companies means the volume of novel foods applications could increase significantly.

[46] Under current Brexit arrangements, Northern Ireland remains subject to European trading legislation.

> Small and Medium Enterprises (SMEs) are increasingly recognised for their contributions to the economy and the UK Government published an action plan to support SMEs achieve sustainable growth. "

We also note the Terms of Reference[47] of the Vallance Review which states that:

> "Pro-innovation regulation focuses on ensuring that we can safely and ethically accelerate the development, testing, route to market and uptake of new technology products. It should give confidence to innovators. This is key to making the UK an attractive destination for R&D projects, manufacturing and investment, and ensuring we can realise the economic and social benefits of new technologies as quickly as possible.
>
> The UK should be on the front foot in shaping the evolution of regulation and standards in key growth sectors. This will help to encourage innovation and influence the evolution of international regulatory frameworks to give us economic and security advantages."

The report from the FSA review suggests three principles that seems really promising:

> Risk-benefit assessments as opposed to only risk assessments – While food safety is key, there are opportunities to consider wider societal benefits as well (e.g. sustainability, carbon footprint) when approving novel foods applications.
>
> Greater transparency and better communication from the FSA to applicants – The FSA has sometimes taken a more business-minded and transparent approach to keep businesses updated on the process. That said, more could be done to provide greater clarity and reduce compliance costs for businesses (e.g. detailed and up-to-date regulatory guidelines for novel foods applicants).
>
> Triaging applications based on the level of risk arising from the product/process, recognising novel foods is a broad category and a one-size-fits-all approach may not be appropriate.

We would add that the focus should be on shifting from securing Novel Food approval as the primary tool for protecting consumers to a model that shares responsibility between multiple stakeholders in the sector.

We recommend the FSA move away from the lengthy regulated products process currently applied to edible insects classified, universally, as novel foods. They should opt instead for a more streamlined and targeted process, more proportionate the scientific evidence of risk – see Table 12.

Our experience and knowledge of the sector indicates that this approach is science-led, would position the UK as an ideal location for inward investment by insect farming companies and could unlock significant investment and economic activity in the UK edible

[47] https://www.gov.uk/government/publications/terms-of-reference-for-the-review-of-regulation-for-emerging-technologies

insect sector. It builds on the regulatory process already adopted in Switzerland and Singapore.

We submit the following initial assessment of risk classification for the most widely farmed edible insect species:

- **Low risk**: *Acheta domestica*, *Gryllodes sigilatus*, *Gryllus assimilis* and *Gryllus bimaculatus* are all commercially bred crickets, reared in the same environments and fed the same diets, all with very similar nutritional profiles. In our opinion all would be low risk and should be categorised together for novel food purposes. Also, larvae of *Tenebrio molitor*, larvae of *Alphitobius diaperinus*, *Locusta migratoria* are established farmed insect species. Finally, we would add that Grasshoppers are also well understood and farmed by Hargol Foodtech[48] in Israel;

- **Medium risk**: *Hermetia illucens* (BSF) - as the bulk of the research we have found has been on livestock consumption and the impact of substrates, etc. on the nutritional value - much less on risk management in relation to human consumption

- **High risk**: All others

Further, we would argue, from our practical experience of insect farming and the results of our literature review above that there are considerable similarities in the risk mitigation requirements for insects in the same genus/family. Hence, the approach of having to assess and approve on a species-by-species basis, and to specify only limited stages of dispatch (adult, larvae, etc.) is unnecessarily burdensome on the sector and on the FSA. We would recommend a short review of the known similarities and differences between species in the genus *Gryllus*, *Caelifera*, *Tenebrio* and *Locusta* and of the impact of the stage at which the product is processed be undertaken.

[48] https://hargol.com

Table 12: Our recommendations for how different aspects of the current protection of consumers could be improved.

	Current situation	**Recommendation**
FSA	Novel Food approval required for each individual insect species and subsequently any variation to production methods, product range, etc.	Consultative and proportionate approach to regulating insect products (hopefully aligned with the approach taken for other regulated products to streamline Legislation and procedures). Triage insect species, working with the Industry Trade Association and academic experts, to allocate species into low, medium and high risk based on available science regarding evidence of safety. ● Low risk: Industry is invited to submit proposals for farming and food production standards, and licensing of production facilities. ● Medium risk: As for Low risk but with academic supervision and support. ● High risk: Full Novel Food approval is required on a species-by-species basis. Once approved, licensing standards are developed with the industry and academia. Further, given the EU's stringent safety controls, all new kinds of foodstuffs marketable in the EU according to the Union list can be placed on the market in GB without authorization (following the Swiss model).
Local Authorities EHO	Assess edible insect businesses to ensure fit within Novel Food definition and generic farming and food production good practice. No specialist training in the particular risks associated with edible insects.	EHOs are trained to understand the licensing requirements and inspect against these.

	Current situation	**Recommendation**
Import Regulation	Only insect material from a very small number of countries is allowed.	Companies intending to import insects for human consumption have to meet the following requirements: ● Providing documentary proof that the imported insects are farmed in regulated establishments with food safety controls and ensuring that the substrate used for rearing or feeding insects is not contaminated with pathogens or harmful contaminants. ● Depending on the risk category of the insect species, this would need to reflect the licensing requirements identified. ● As with other food available in our market, insect products would be subjected to food safety testing. Food that is found to be non-compliant with our food safety regulations will not be allowed for sale.
Industry Trade Association	No recognised role although, in practice, UKEIA has been vital to enabling the sector to prepare and submit Novel Food applications.	Works with the FSA and the academic community to develop and maintain industry standards and communicate these to consumers.
Businesses	Expected to fund preparation of Novel Food applications and comply with generic farming and food production good practice.	Individual production facilities are required to apply for a license and demonstrate compliance.

	Current situation	**Recommendation**
Academia	Minimal role in the Regulation. One expert in insect farming sits on the FSA Scientific Advisory Council. Limited, uncoordinated research into safety issues associated with production of edible insects.	BBSRC establish and fund a Network of academics working in this area, offering opportunities to apply for funding for key research as determined by the dialogue with Industry and the FSA. This network works with the FSA on risk assessment and the development of licensing requirements.

This is in line with our assessment that there is no evidence that edible insect ingredients, as a broad category, are intrinsically more hazardous than traditionally farmed livestock meat and is consistent with the widespread, and nutritionally and environmentally very beneficial consumption of edible insects around the world.

We look forward to a debate on this important topic and to the FSA finding a new, and hopefully more proportionate, position on how consumers' safety can be protected while opening up opportunities for new, more sustainable sources of protein that can contribute to solving the much wider threat of Climate Change.

11. Summary and Next Steps

In summary, we agree that the bulk of edible insect species are unproven and untested as far as the risks to consumers is concerned, however, these are not generally farmed to any significant extent. However, there is a growing number of insect species for which farming systems have been developed and extensively researched in terms of their potential for human consumption.

The UK has the potential to build a substantial hub of insect farmers and food product innovators but will require a significant change in the regulation of the sector.

Our Rapid Evidence Review has shown that there is a robust understanding of the measures required to mitigate the risks associated with farming *Acheta domesticus*, *Tenebrio molitor* and *Locusta migratoria* – and that these measures are actually very similar.

The Novel Food regulations, imported from the European Commission imposes an extremely high barrier to entry for any company looking to introduce any edible insect products into the market, seemingly starting with the assumption that they are all equally risky, and seemingly taking no account of the sector's potential to make a difference to the global sustainable food challenges.

We have proposed what we feel is a more proportionate model for finding the balance of risks to consumers and the risks to the planet. We believe that effective and science-led standards developed with the sector and a licensing requirement for farmers will provide thorough protection for consumers and offer the sector a route to much more rapid growth and support the innovation that will deliver products for both our domestic and overseas markets.

12. Bibliography

Section 2

FDF (2013) Delivering sustainable growth through innovation, report by the Food and Drink Federation. Accessed here: https://www.fdf.org.uk/fdf/resources/publications/reports/delivering-sustainable-growth-through-innovation/

Section 3

Barclays Research Highlights (2019) *Sustainable & Thematic Investing: Food Revolution.* Accessed here:https://www.cib.barclays/content/dam/barclaysmicrosites/ibpublic/documents/our-insights/FoodWaste/Leaflet%20Food%20Revolution.pdf

Chester University (2022) The effects of insect protein in sport and exercise settings. PhD author: James Hutherington. Supervisors: Sam Moss, Prof Jamie Highton. [accessed 13 November 2023] Accessed here:https://www1.chester.ac.uk/sport-and-exercise-sciences/research/current-phd-projects

EU MONITOR (2018) *Summary of EU 2015/2283 Legislation*. [accessed 12 November 2023] Accessed here:https://www.eumonitor.eu/9353000/1/j4nvk6yhcbpeywk_j9vvik7m1c3gyxp/vjzsag4e0num#:~:text=It%20lays%20down%20rules%20for,human%20health%20and%20consumers%27%20interest

FAO (2013) Edible insects: future prospects for food and feed security. 1st ed: Wageningen University. Food and Agriculture Organisation of the United Nations. Rome. [accessed 12 June 2023] Accessed here: https://www.fao.org/3/i3253e/i3253e.pdf

FAO (2018) The future of food and agriculture – Alternative pathways to 2050. Rome. [last accessed 12 November 2022] Accessed here:https://www.fao.org/global-perspectives-studies/food-agriculture-projections-to-2050/en/

FAO (2020) 'Insects for Food and Feed' [last accessed 11 November 2023] Accessed here: https://www.fao.org/edible-insects/en/

Fortune Business Insights (2021). "Insect Protein Market Size, Share and Covid-19 Impact Analysis". *Food Additives & Ingredients Research Report*.

FSA (2022a) Consultation on transitional arrangement for edible insects in GB [accessed 11 November 2023] Accessed here: https://www.food.gov.uk/news-alerts/consultations/consultation-on-transitional-arrangements-for-edible-insects-in-great-britain

Good Food Institute (2023). "A deeper dive into alternative protein investments in 2022: The case for optimism" [accessed 11th November 2023] Accessed here: https://gfi.org/blog/alternative-protein-investments-update-and-outlook/

Hancock, H. (2018). The future of food regulation in the UK post-Brexit: standards, delivery and the supply chain. Regulating our Future the view from the FSA. Westminster Food and Nutrition Forum.

Hunter, G (2021) Edible Insects - A Global History. 1st Ed: Raektion Books. 9781789144468

Ibrahimi, A and King, L., (2022) Alternative Proteins: Consumer Survey: Food Standards Agency [accessed 12 June 2023] Accessed here: https://doi.org/10.46756/sci.fsa.ncn554

Jones, V., (2019) Adapting our diets for global climate change. *Teaching Geography.* Geographical Association. **44** (2) pp. 72 – 74

Lesnik, J., (2018) *Edible Insects and Human Evolution*: University Press of Florida. Available at: 9780813056999

Carbonnelle (2015) Novel Food's Brave New World? Two Birds information brochure attributed to Nicolas Carbonnelle. Accessed 1 December 2016.

UKRI 2022, Innovate UK funded projects since 2004. [last accessed 13 November 2023] Accessed here: https://www.ukri.org/publications/innovate-uk-funded-projects-since-2004/

Ynsect (2022) Ynsect Ready to Ramp up Lesser Mealworm Production Across Europe Thanks to EFSA Positive Assessment for Human Consumption [accessed 13 November 2023] Accessed here: https://www.ynsect.com/2022/07/04/ynsect-ready-to-ramp-up-lesser-mealworm-production-across-europe-thanks-to-efsa-positive-assessment-for-human-consumption/

Section 4

Animal Plant Health Agency (2022) "Changes to Import Authorisations for Insects into the European Union". Food Standards Agency [accessed 12 October 2023] Accessed here: http://apha.defra.gov.uk/documents/bip/ovs-notes/2020-18.pdf

Bangkok Post (2022) "A growing hunger for bugs: Thai farms are capitalising on the booming market for green, protein-rich edible insects" [accessed 11 November 2023] https://www.bangkokpost.com/business/general/2453167

FAO (2013) "Edible insects: future prospects for food and feed security" 1st ed: Wageningen University. Food and Agriculture Organisation of the United Nations. Rome.

Hanboonsong, Y., Jamjanya, T., Durst, P.B. (2013) Six-legged Livestock: Edible Insect Farming, Collecting and Marketing in Thailand. Food and Agriculture Organization of the United Nations Regional Office Asia and the Pacific. Bangkok.

Hanboonsong, Y and Durst, P.B. (2015) Small-scale production of edible insects for enhanced food security and rural livelihoods: Experience from Thailand and Lao People's Democratic Republic. Journal of Insects as Food and Feed. DOI:10.3920/JIFF2014.0019

ITV, 2018. 'Sainsbury's becomes first UK supermarket to sell edible insects' ITVX [accessed 11 November 2023] Accessed here:https://www.itv.com/news/2018-11-17/sainburys-becomes-first-uk-supermarket-to-sell-edible-insects

Journal of the European Union (2020) Official Journal of the European Union, 29.10.2020, L 359/5, *COMMISSION IMPLEMENTING REGULATION (EU) 2020/1572 of 28 October 2020 amending Implementing Regulation (EU) 2019/626 as regards lists of third countries and regions thereof authorised for the entry into the European Union of dairy products and insects* Accessed here**: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020R1572&rid=1**

Cortes Ortiz et al (2016) Insect Mass Production Technologies, J.A. Cortes Ortiz, A.T. Ruiz, J.A. Morales-Ramos, M. Thomas, M.G. Rojas, J.K. Tomberlin, L. Yi†, R. Han, L. Giroud, R.L. Jullien in *Insects as Sustainable Food Ingredients - Production, Processing and Food Applications* 1st Edition Editors: Aaron T. Dossey, Juan A. Morales-Ramos , M. Guadalupe Rojas

Szelei, J., Woodring, J., Goettel, M., Duke, G., Joussett, F.X., Liu, K., Zadori, Z., Li, Y., Styer, E., Boucias, D.G, Kleespies, R. G; Bergoin, M. and Tijessen, P. (2011) "Susceptibility of North-American and European crickets to Acheta domesticus densovirus (AdDNV) and associated epizootics" *Journal of Invertebrate Pathology*, **106** (3), pp. 394-399 https://doi.org/10.1016/j.jip.2010.12.009

Unconventional Connections 2021, Farming Insects for Food and Feed Around the World - Trends and Current Practices: Unconventional Connections. [last accessed 14 Nov 2023] https://www.unconventionalconnections.co.uk/_files/ugd/14857d_5a58505a4e2c45e0b1aa09ba10569594.pdf

Section 5

FAO (2021) Looking at edible insects from a food safety perspective. Challenges and opportunities for the sector. Rome. [accessed 12 June 2023] Accessed here: https://doi.org/10.4060/cb4094en

IPIFF (2022) Guide on Good Hygiene Practices for European Union (EU) producers of insects as food and feed. International Platform for Industry for Insects for Food and Feed. https://ipiff.org/wp-content/uploads/2019/12/IPIFF-Guide-on-Good-Hygiene-Practices.pdf

Walker, T. (2012) 'Former I'm a Celebrity...Get Me Out Of Here! winner Tony Blackburn criticises 'cruel' Bushtucker trials'. *The Telegraph* [last accessed 20 October 2023] Accessed here: https://www.telegraph.co.uk/news/celebritynews/9681130/Former-Im-a-Celebrity...Get-Me-Out-Of-Here-winner-Tony-Blackburn-criticises-cruel-Bushtucker-trials.html

Wikipedia (2022) *I'm a celebrity … get me out of here! (British TV series)* [accessed 12 November 2023] Accessed here:https://en.wikipedia.org/wiki/I%27m_a_Celebrity...Get_Me_Out_of_Here!_(British_TV_series)

YouTube, 2015 "Jordan And Kerry Katona Battle And Bite Down On Bugs" *I'm A Celebrity... Get Me Out Of Here!* YouTube link: https://www.youtube.com/watch?v=zaC-3ZTWEZs [uploaded 19 October 2015] [accessed 12 November 2023]

Section 6

EFSA (2015) Risk profile related to production and consumption of insects as food and feed. *EFSA Journal* [accessed 12 June 2023] Accessed here: https://www.efsa.europa.eu/en/efsajournal/pub/4257

FSA (2022b) Technical Report: Risk Profile on Edible Insects. Science, Research and Evidence Dictorate [accessed 2 November 2023] Accessed here:

https://www.food.gov.uk/sites/default/files/media/document/Technical%20Report%20Risk%20Profile%20on%20Edible%20Insects%20V.3%20SM%20comments%20%2B%20FM.pdf

Section 7

Arévalo, H.; Rojas E., Barragán Fonseca, K.;Vásquez Mejía, S. (2022) "Implementation of the HACCP system for production of *Tenebrio molitor* larvae meal" *Food Control* **138**

Baiano, A. (2020) Edible insects: An overview on nutritional characteristics, safety, farming, burden production technologies, regulatory framework, and socio-economic and ethical implications *Trends in Food Science & Technology* **100** pp. 35 - 50

Bednarska, AJ., Opyd, M., Żurawicz, E. and Laskowski, R., (2015) Regulation of body metal concentrations: Toxicokinetics of cadmium and zinc in crickets. *Ecotoxicology and Environmental Safety*, **119** pp: 9–14

Belleggia, L., Milanovic, V., Cardinali, F., Garofalo, C., Pasquini, M., Tavoletti, S., Riolo, P., Ruschioni, S., Isidoro, N., Clementi, F., Ntoumos, A., Aquilanti, L. and Osimani, A. (2020) Listeria dynamics in a laboratory-scale food chain of mealworm larvae (*Tenebrio molitor*) intended for human consumption. *Food Control* **114**

Bordiean, A.; Krzyżaniak, M.; Stolarski, M.J. (2022) "Bioconversion Potential of Agro-Industrial Byproducts by *Tenebrio molitor*—Long-Term Results". *Insects*, **13,** 810

Cardoso, D.; Silva, A.; Morgado, R. ; Mostafaie, A.; Pereira, A.; Pinto, J.; Lopes, I.; Murta D.; Soares, A.; Brooks, B. and Loureiro, S.; (2023) "Improving Product Safety for Edible Insects: Toxicokinetics of Hg in *Tenebrio molitor* and *Hermetia illucens" ACS Food Science & Technology 2023* **3** (4), pp: 790-798

Collins, A. M., Coughlin, D., Mille, J. and Kirk, S. (2015) *The Production of Quick Scoping Reviews and Rapid Evidence Assessments: A How To Guide*. Department for Environment Food and Rural Affairs. London.

Dreyer, M., Hörtenhuber, S., Zollitsch, W., Jäger, H., Schaden, LM., Gronauer, A. and Kral, I. (2021) Environmental life cycle assessment of yellow mealworm (Tenebrio molitor) production for human consumption in Austria – a comparison of mealworm and broiler as protein source. The International Journal of Life Cycle Assessment, **26** (11), pp: 2232–2247

Fernandez-Cassi et al (2018) *Novel foods: a risk profile for the house cricket (Acheta domesticus)* X Fernandez-Cassi, A Supeanu, A Jansson, S Boqvist and I Vagsholm Volume 16, Issue 1 Special Issue: EU-FORA: Series 1 August 2018Accessed at: https://efsa.onlinelibrary.wiley.com/doi/10.2903/j.efsa.2018.e16082

Garofalo, C., Milanović, V., Cardinali, F., Aquilanti, L., Clementi, F. and Osimani, A (2019) Current knowledge on the microbiota of edible insects intended for human consumption: A state-of-the-art review. *Food Research International* **125**

Gałęcki, R and Sokół, R. (2019) A parasitological evaluation of edible insects and their role in the transmission of parasitic diseases to humans and animals. *PLoS ONE* **14**(7)

Grabowski, NT., Olivas, J., Lozano, D., Kehrenberg, C. and Aguilar D. (2018) Assessment of pasteurisation of edible insects using enzymatic tests (activity of alkaline phosphatase and lactoperoxidase) applied in dairy products. *Food Science and Technology International*. **24**(8) pp: 699-704

Keil, C., Maares, M., Kroncke, N., Benning, R. and Haase, H., (2020) Dietary zinc enrichment reduces the cadmium of mealworm beetle (*Tenebrio molitor*) larvae. *Scientific Reports* **10**

Kooh, P., Jury, V., Laurent S., Audiat-Perrin, F., Sanaa, M., Tesson, V., Federighi, M. and Boué, G. (2020) Control of Biological Hazards in Insect Processing: Application of HACCP Method for Yellow Mealworm (*Tenebrio molitor)* Powders. *Foods* **9**(11)

Ledina, T., Djordjevic, J. and Bulajic, S. (2021) Spore-forming bacteria in the dairy chain. *IOP Conference Series: Earth and Environmental Science* **854**

Mohammadsalim, S., Imani, S., Abdigoudarzi, M. and Hasanzadeh, N. (2021) Microbiological quality of dried larvae of *Tenebrio molitor* under various processing methods as food and feed in Iran. *Journal of Food and Nutrition Research* **60**(4) pp: 335 - 343

Mudalungu, C., Tanga, C., Kelemu, S. and Torto, B. (2021) An overview of Antimicrobial Compounds from African Edible Insects and Their Associated Microbiota. *Antibiotics* **10** (6)

Osimani, A., Garofalo, C., Aquilanti, L., Milanović, V., Cardinali, F., Taccari, M., Pasquini, M., Tavoletti, S. and Clementi, F. (2017) Transferable Antibiotic Resistances in Marketed Edible Grasshoppers (*Locusta migratoria* migratorioides). *Journal Food Science* **82**(5) pp: 1184 - 1192

Percipalle, M., Salvaggio, A., Pitari, G., Guinta, R., Alessandra, A., Tiziana, A. and Marino, A. (2020) Edible Insects and Toxoplasma gondii: Is It Something We Need To Be Concerned About? *Journal of Food Protection* **84**

Turck et al (2021) Safety of dried yellow mealworm (Tenebrio molitor larva) as a novel food pursuant to Regulation (EU) 2015/2283, EFSA Panel on Nutrition, *Novel Foods and Food Allergens (NDA),* D. Turck, J, Castenmiller, S. De Henauw, K. I. Hirsch-Ernst, J. Kearney, A. Maciuk, I. Mangelsdorf, H. J McArdle, A. Naska, C. Pelaez, K. Pentieva, A. Siani, F. Thies, S. Tsabouri, M. Vinceti, F. Cubadda, T. Frenzel, M. Heinonen, R. Marchelli, Accessed at: https://www.efsa.europa.eu/en/efsajournal/pub/6343

Vandeweyer, D., Crauwels, S., Lievens, B. and Van Campenhout, L., (2017) Microbial counts of mealworm larvae (*Tenebrio molitor*) and crickets (*Acheta domesticus and Gryllodes sigillatus*) from different rearing companies and different production batches. *International Journal Food Microbiology*. **2**(242) pp: 13-18

Yan, X., Laurent, S., Hue, I., Cabon, S, Grua-Priol, J., Jury, V., Federighi, M. and Boué G. (2023) Quality of *Tenebrio molitor* Powders: Effects of Four Processes on Microbiological Quality and Physicochemical Factors. *Foods* **12**(3)

Section 9

ACFS (2017) 'Good Agricultural Practices for Cricket Farm' Thai National Bureau of Agricultural Commodity and Food Standards. [accessed 2 November 2023] Accessed here (in Thai): https://www.acfs.go.th/standard/download/GUIDANCE_GAP_CRICKET_FARM.pdf An unofficial English translation of the document was made by Bugsolutely, a cricket pasta producer, and it can be found at: https://www.bugsolutely.com/good-agricultural-practices-gap-cricket-farming/ [accessed 2 November 2023]

Anankware, JP., Osekre, E., Obeng-Ofori, D. and Khamala, C. (2016) Identification and classification of common edible insects in Ghana. *International Journal of Entomology Research* **1**(5) pp: 33 - 39

CFIA and Health Canada (2021) 'Edible insects: what to know before biting into bugs' *Canadian Food Inspection Agency* [accessed 12 november 2023] Accessed here: https://inspection.canada.ca/inspect-and-protect/food-safety/edible-insects/eng/1632237657892/1632245370544

Durst, PB. and Hanboonsong, Y. (2015) Small-scale production of edible insects for enhanced food security and rural livelihoods: experience from Thailand and Lao People's Democratic Republic. *Journal of Insects as Food and Feed* **1**(1) pp: 25 - 31

FAO (2013) Edible insects: future prospects for food and feed security. 1st ed: Wageningen University. Food and Agriculture Organisation of the United Nations. Rome. [accessed 12 June 2023] Accessed here: https://www.fao.org/3/i3253e/i3253e.pdf

FAO and WHO (2019) Codex Alimentarius Commission – Procedural Manual twenty-seventh edition. Rome. [accessed 12 July 2023] Accessed here: https://www.fao.org/3/ca2329en/CA2329EN.pdf

FSA (2023) Novel Foods Regulatory Framework Review Executive Summary: Report commissioned by the FSA from Deloitte LLP. Date of Publication: 7th June 2023. Accessed at https://www.food.gov.uk/research/novel-and-non-traditional-foods-additives-and-processes/novel-foods-regulatory-framework-review-executive-summary

FSVO, 2017 'Authorisation for new types of foodstuffs': Food Safety and Veterinary Office. Bern. [accessed 12 March 2023] Accessed here: https://www.blv.admin.ch/blv/fr/home/lebensmittel-und-ernaehrung/rechts-und-vollzugsgrundlagen/bewilligung-und-meldung/bewilligung.html

Halloran, A., (2018) Marketing Insects Superfood [accessed 12 July 2023] Accessed here: https://www.researchgate.net/profile/Kristjan-Jespersen/publication/325133475_Marketing_Insects_Superfood_or_Solution-Food/links/5f736be2458515b7cf5857ee/Marketing-Insects-Superfood-or-Solution-Food.pdf

Hanboonsong, Y., Jamjanya, T., Durst, P.B. (2013) Six-legged Livestock: Edible Insect Farming, Collecting and Marketing in Thailand. Food and Agriculture Organization of the United Nations Regional Office Asia and the Pacific. Bangkok. [accessed 12 November 2023] Accessed here: https://www.fao.org/3/i3246e/i3246e.pdf

Hanboonsong, Y and Durst, P.B. (2015) Small-scale production of edible insects for enhanced food security and rural livelihoods: Experience from Thailand and Lao People's Democratic Republic. Journal of Insects as Food and Feed. DOI:10.3920/JIFF2014.0019

Payne, P., Ryan, A., & Finlay-Smits, S. (2023) Insects as mini-livestock: New Zealand's public attitudes toward consuming insects, Kōtuitui: New Zealand Journal of Social Sciences Online, 18(3) pp: 310-326

Ramos-Elorduy, J. (2009) Anthropo-entomophagy: Cultures, evolution and sustainability. *Entomological Research* **39**(5) pp: 271 - 288

Yen, A. (2015) Insects as food and feed in the Asia Pacific region: current perspectives and future directions. *Journal of Insects as Food and Feed* **1**(1) pp: 33 - 55

Appendix I: Open letter sent from Woven to the FSA Board

The Case for a GB Novel Foods Transitional Agreement for Edible Insects

Dear FSA Board,

Following Brexit there has been a lack of clarity around the legal status of edible insects in Great Britain. The absence of GB-specific Transitional Measures, transparency on the decision process and its potential outcomes is now causing unnecessary damage to the emerging UK sector. As a consequence, Local Authorities throughout GB are now unclear on the legality of edible insects and their approach to businesses are inconsistent across authorities. For example, since the week commencing 15th August, several Local Authorities have declined to approve edible insect business operations, despite edible insects being sold nationwide.

The impact of the FSA's actions have been poorly understood, with no industry analysis prior to implementation of the regulations. Initial discussions with the FSA, for instance, revealed they were unaware that the **UK is considered the leading country in Europe for edible insect innovation** (over ⅓ of all European edible insect companies reside here). In addition, UK companies have been legally operating for over 10 years, contributing to society and the UK's sustainability targets, such as net-zero carbon emissions by 2050.

On the week commencing the 23rd August, Woven Network CiC requested letters received by Local Authorities stating that "FBOs currently placing insects (excluding the German cheese mite) on the GB market are not in compliance with novel food regulations (Retained Reg 2015/2283)" and "that the FSA is currently reflecting on its policy regarding the marketing of insects in GB, including whether to introduce new GB-specific transitional measures". There has been no indication whether these blanket measures apply to businesses currently trading in the UK.

What is the Woven Network?

Woven is the UK's platform for insects as food. The Woven Network's mission is to directly benefit UK society by supporting entrepreneurs and researchers working to develop the insect industry in the UK food supply chain. Woven's mission also benefits the UK's food security through capacity building by prioritising home-grown insects. This strongly aligns with consumer trends towards more sustainable, alternative sources of protein. Insect-based foods are widely recognised as a key future alternative source to deliver locally-grown, high quality, sustainable and ethically produced food ("*Insect Protein: Bitten by the bug*", Sustainable & Thematic Investing, Barclays Equity Research, 2019).

The Woven Network includes over 25 companies operating in Great Britain, and it's connections span across the globe, including to political leaders, research institutes, organisations such as the International Platform for Insects as Food and Feed and various journalists.

Interpretation of the Retained Regulations

Woven recognises the inconsistent landscape for Novel Foods interpretation across Europe. Multiple EU countries have fully approved transitional measures whilst others do so to a lesser extent ("*IPIFF Contribution Paper: Application of the novel food transitional measure*", IPIFF, 2020). This presents confusion to businesses and hurdles to consumers. However, it also presents a timely opportunity for the UK to take initiative and implement a pro-insect GB policy to retain our world-leading status.

To share Woven's perspective on the situation, the UK's pre-Brexit interpretation of EU law **allowed edible insects to be legally sold in the UK** under the Belgian Insect Industry Federation's (BiiF) 'public-use' Novel Foods applications submitted to the EFSA or through collaboration with other existing EU applicants:

Acheta domesticus, submitted *03-07-2018*, BiiF

Tenebrio molitor, submitted *28-09-2018*, BiiF

Locusta migratoria, submitted *20-06-2018,* BiiF

Alphitobius diaperinus, submitted 10-04-2018, Proti-Farm Holding NV

As made clear by previous communications from the FSA – please see a notice published by the FSA regarding the Changes to Import Authorisations for Insects into the European Union, dated 11 March 2020, stating:

"*In the UK, any species of whole insect marketed in the EU before the end of 2017 can continue to be sold subject to a novel food application having been submitted by 1 January 2019. Transition measures in Regulation (EU) 2015/2285 on novel foods, allow foods that have been legally on sale in the EU prior to the regulations to continue to be sold. The transition measures were intended to give businesses time to comply with the new requirements.*

These Transitional arrangements, under the Novel Food Regulations (EU) 2015/2283, ended on 31 December 2019. ***For the 7 listed species of insects currently going through the authorisation process, the transition period is still in place.*** *This is to give additional time for these applications to reach a conclusion. Once these have been concluded, the outcome will determine if they can continue to be sold or not.*"

Woven hopes the FSA recognises the industry has only continued to trade within the regulations outlined for the UK. However, it has become clear that the transposing of EU regulations onto the UK may have catastrophic implications for the emerging industry, due to a lack of UK-based Novel Foods applications and therefore any Transitional Measures. Woven does not believe this is the fault of the industry as **the FSA did not communicate or explicitly require the industry to submit applications prior to Brexit,** considering UK insect trade was operating under the EFSA's 'public use' applications. Therefore, a decision by the FSA to discontinue the EU transitional measure or fail to implement a new GB measure, would cause a sudden change in legality and unnecessary damage to the industry.

Failure to implement a transitional measure, thereby creating a sudden change in legality to an established UK market is likely to fall under the scope of the Small Business Enterprise and Employment Act (2015). This Act aims to protect small and micro businesses (SMB's) from disproportionate burdens of regulatory change. Considering the majority, if not all, companies selling insect based products into the UK fall within this category, the

government may be required to give special consideration to these businesses and review the implemented regulations to mitigate damage to the sector.

Food Safety

Woven understands and fully supports that the health and safety of the public is the primary objective of the sector's success. The FSA pre-Brexit did not view insects as a risk to public health. UK businesses have been regularly inspected and approved by their respective EHO's and Trading Standards, with some becoming SALSA accredited and selling into major supermarkets, with an estimated 6 million insect products sold – all with no safety issues.

Critically, the FSA did not consider insects to be a serious risk pre-Brexit, and **there is no material change in food safety risk pre and post-Brexit**, it is purely a legislative change.

UK Sustainability Goals

In 2015, the UK committed to the 2030 Agenda for Sustainable Development, as agreed by the United Nations (UN). Within this development plan there are a number of goals including: ending poverty, enhancing food security, combating climate change, local sector development and ensuring sustainable production and consumption patterns. It is clear that alongside these societal goals, there is a public drive for healthy, sustainable, and local food production here in the UK, as was found in the FSA's COVID-19 consumer research report (July 2021).

Edible insect farming and consumption aligns with many of these goals, providing benefits to UK agriculture through reductions in water, feed, land-use and start-up costs required for production compared to traditional meats. The potential for insects to revolutionize our food systems is internationally recognised, for example, they were listed within the EU's recent Farm-to-Fork strategy and members of Woven have been asked to attend and speak at events such as COP26 in Glasgow. These events bring international industry and thought leaders together to accelerate action towards our global sustainable development goals.

GB Specific Transitional Measure

Woven fully intends to comply with the current UK Novel Foods process and is actively preparing NF applications for submission by the **31st December 2021**. However, in light of the increasing negative pressure on the industry and the potential collapse of the GB market, Woven urges the FSA to announce a 'GB Transitional Measure' allowing the sale of specific edible insects and their derived products in GB up until approval of the applications submitted before this deadline.

This GB Transitional Measure mirrors that implemented for the CBD market and Woven proposes that the requested agreement is limited to the companies, products and NF use-levels intended for UK dossiers and already traded or imminently intended for the UK market. The companies and products that are currently included on UK dossiers as of the date of this agreement are outlined in the attached table below.

Woven hopes to receive clarity on the above before the **28th September**, so that we can constructively work together and minimize damage to the industry.

If you need to set-up a call to discuss this in more detail, please do not hesitate to get in contact.

Sincerely,

Nick Rousseau
Managing Director, Woven Network C I C

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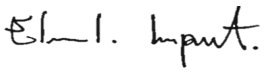
Company name	**Signature of support on behalf of company**
The Woven Network	
Better Universal Grub ltd	
New Foods Ltd t/a HOP®	
Saved Food Ltd.	
Poseative Ltd t/a Small Giants	
Monkfield Nutrition Ltd	
CF Banks Ltd	
Nutribug Ltd	
Prosects Ltd	
Protein Rebel Ltd	
Bug Farm Foods Ltd	
MiniFeasts Ltd	

Appendix II: Search terms used in the Rapid Evidence Reviews

We organised search terms into three categories:

Food

- Food
- Consumption
- Edible
- Market
- Human*
- Eat*
- Entomophag*
- Ate

Risk

- Bacter*
- Allerg*
- Microbiol*
- Substrate
- Vir*
- Accumulat*
- Contamin*
- Chemical
- Parasit*
- Toxi*
- Antibiotic*
- Risk
- Safety
- Hazard
- Intake
- Expos*
- endospore-forming
- metal*

Mitigation

- Mitigation measures
- Control strategies
- HACCP*
- Critical Control Point*
- CCP*
- Boiling
- Blanching
- Irradiation
- Heating
- Hygienic rearing practices
- Enzymatic digestion
- Processing
- Education
- Monitoring
- Pasteuri*
- starv*
- freez*

Literature was selected on the basis that either the abstract or title included a term from both the species name and the mitigation column. Literature which is in reference to mitigation measures applied to other insects (but mention the species term in the body) was excluded, as was literature focused solely on the impact of mitigation measures on the nutritional quality of the insect.

Appendix III: Requirements for authorisation under the Swiss system

They relate to ensure the following: (i) safety of insect species for human consumption, (ii) prevention of the introduction of diseases and contaminants; (iii) the substrate used to not impart contaminants to insects, (iv) safety of final product for consumption.

The following criteria is regulated before business is approved:

3. 1 Request for authorisation

Establishments subject to authorization must submit the following documents with their application:

a) Description of the establishment, with the name of the person in charge according to art. 2 ODAIOUs, as well as an organization chart;
b) Overall plans showing the flow of personnel and goods, the name of the premises, the machines and, where appropriate, the areas of hygiene;
c) Data on the plant and its production activity (e.g., age of buildings, dimensions, types and quantities of products, personnel involved in production);
d) Traceability data (batch identification, specification number defined in the factory, art. 83 ODAIOUs);
e) Evidence of good practices according to art. 76 to 80 ODAIOUs, either by a procedure in accordance with the HACCP method, or by a good practice guide approved by the by the OSAV;
f) Data concerning sampling and analysis (e.g. sampling plan)

3.2 Inspection of buildings requesting authorisation

A. Authority inspections

- Procedures that conform to HACCP procedures or good practices approved by OSAV (food safety and veterinary federal office)
- Traceability
- Procedure in case of recall
- Autocontrol documents
- Sample information and analysis
- Analysis detecting zoonotic pathogens

B. Organic food

- Naming (identification), presentation, wrapping, materials used, disposal of waste
- State and quality of primary ingredients and organic foodstuffs
- Results of analysis, specific criteria of applicable orders
- Criteria specific to references of orders

C. Process and activity

- Hygiene of production line
- Delivery of primary materials
- Storage
- Treatment
- Thermal procedures and hygiene of transformation
- Delivery, vehicles
- Separation of what is clean / dirty
- Temperature control
- Cleanliness and disinfection
- Waste removal
- Personal hygiene, safety, work clothing

- Staff training
- Drinking water
- Deworming

D. Level of requirement in trading

- Demands concerning the building and nearby area
- Materials of building, including state and well keptness of floors, walls and ceilings
- Access to building
- State of installations
- Staff room, changing rooms, toilets
- Hand sanitation
- Flow of staff and goods
- Ventilation