Flagship demonstration of industrial scale production of nutrient resources from mealworms to develop a bioeconomy new generation

The use of insect-derived products in the food, feed, and chemical industries

Policy Brief

This policy brief was prepared by the Cluster Industrial Biotechnology (CLIB) as part of the FARMŸNG project. This project has received funding from the Bio Based Industries Joint Undertaking (JU) under grant agreement No 837750. The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Bio Based Industries Consortium. The views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or BBI JU. Neither the European Union nor the BBI JU can be held responsible for them.

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1 Executive Summary

This policy brief is intended to give an overview of the potential of insect farming, providing intermediates and products for the feed, food, and chemicals industry.

Insect farming is emerging as a sustainable and resource-efficient alternative to conventional animal production, with promising applications across food, feed, and chemical industries. Insects such as *Tenebrio molitor* (mealworms) and Black Soldier Fly (*Hermetia illucens*) can be cultivated on agri-food by-products, transforming low-value inputs into high-quality protein, fats, and co-products like frass (fertiliser) and chitin. Compared to traditional livestock, insects require less land, water, and energy, and emit significantly fewer greenhouse gases. Their ability to grow on non-arable land makes insect farming viable even in urban environments, contributing to local circular economies.

Insect-derived ingredients are gaining interest, particularly in aquaculture, poultry feed, pet food, and health-oriented snack products as an entry point to the food industry. Their high protein content, favourable amino acid profile, and potential health benefits offer a compelling nutritional case. Insect oils also show promise in cosmetics, coatings, and potentially as bio-based alternatives to palm oil. However, cost competitiveness remains a challenge, with insect protein currently priced significantly above soy or fish meal.

Widespread adoption of insect farming faces regulatory, technical, and consumer acceptance hurdles. Current EU legislation restricts the types of feedstock allowed for insect rearing, limiting the sector's circular economy potential. Consumer unfamiliarity and food safety concerns further hinder market growth. To scale the industry, automation, targeted high-value applications, technical improvement to insect farming, and clear regulatory pathways are critical. Strategic investment and continued research will be essential to unlock the full potential of insect farming in a bio-based, resilient, and sustainable economy.

2 Introduction

Insect farming includes the breeding, rearing and harvesting of a range of insect species for a range of purposes. Most commonly known to European consumers would be the keeping of honeybees for honey or wax, silkworms for their silk thread, or cochineals for red carmine colourant. However, in many areas around the world, a wide range of insect species are being farmed for food and feed ingredients. These include for example crickets[1], caterpillars[2], or even cockroaches[3].

In a circular bioeconomy, insects are of special interest, since they effectively transform agri-food side-streams into more valuable products. Dedicated insect farms, or biorefineries are being developed and implemented. Their products can be used in a variety of industries – not only food or feed, but also the chemical or materials industry. The main ingredients which can be obtained are insect protein and insect fat/oil. In addition, side products such as the insect skin (chitin) and insect excrement (frass) accrue in notable quantities. The farming of insects has the potential to contribute to a more sustainable agriculture. It has a reduced dependency on land- and water-based resources, and comes with a significantly lower carbon footprint than traditional livestock like cattle, pork, or poultry[4]. In addition, insects can be farmed on non-

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arable land and can locally convert side- and waste streams. This means that insect farms can be implemented in small areas, potentially even an urban environment, and create value for local communities.

The use of insect protein and insect oil has gained traction over the past years as ingredient for human food and animal feed[a], with several companies pioneering insect farming. In the FARMŸNG project, the focus lies on the farming of *Tenebrio molitor* larvae to produce insect protein and insect oil, while using the side stream of insect frass for fertiliser. This is mainly driven by the French SME Ÿnsect. Other stakeholders active in *T. molitor* farming are Tebrio and IberInsect (Spain). Other companies are pioneering the farming of Black Soldier Fly (*Hermetia illucens*), these include a.o. Hermetia Baruth GmbH, Illucens, FarmInsect (Germany), Innovafeed, Agronutris (France), Volare (Finland), Enorm Biofactory (Denmark), and Protix (the Netherlands).

Insects, being an important source of protein and lipid, have been a source of human nutrition for ages, with scientists positing that even early hominids included termites in their diet[5]. Insects are often part of the natural diet of animals kept as livestock, such as poultry, pigs, or fish. Insect protein from seven different species had first been approved for the use in aquafeed (2017[b]), and then also for the inclusion in pig and poultry feed (2021). This applies to eight specific insect species, with silkworm being the latest addition[c]. The first insect-derived products have also been approved for human consumption[d].

The potential of insect-derived products for the chemical industry is also of interest for stakeholders aiming to increase their share of bio-based feedstock use and products. Among other applications, they could be a substitute for palm oil, and thereby help to establish an additional, regional supply.

Several hurdles remain before the use of insects for the conversion of waste biomass to valuable products becomes industrial practice and products robustly enter the market. These include the solid showcase of suitable applications, improvements to insect biorefineries and the value chain, regulatory aspects, market development, and consumer acceptance.

3 Applications

Insects are rich in protein and oils, as well as vitamins and minerals, making them valuable sources for food and feed applications[6]. Their feed conversion rates are close to those of poultry. The fatty acid profiles of insect oils vary by species and feeding substrate and can be valuable products in a range of applications as well. In the following, examples for applications in the food, feed, and chemical industries will be briefly introduced.

[a] https://www.efsa.europa.eu/en/press/news/151008a (2015)
[b] Regulation 2017/983, Annex X
[c] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R1925
[d] https://www.efsa.europa.eu/en/news/edible-insects-science-novel-food-evaluations (2021)

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3.1 Food industry

Insect protein and oil can be a valuable addition to human food, not only by providing an alternative protein, but also via additional health benefits. These include e.g. improvement in gut health or the reduction of systemic inflammation[4,7]. Insect oils, depending on the species can have a polyunsaturated/saturated fatty acid ratio similar to plants rather than animals, making them a healthier addition to human diets.

Compared to commonly farmed animals, insects have a favourable nutritional composition, with a higher protein content and a full spectrum of essential amino acids. Digestibility is also good[8,9], with insect protein having been shown to support muscle growth as well as animal protein[10].

Entire insects can be added to a meal, as recipes from cultures where insect-eating is common show. This might not be palatable to European consumers, not used to having insects on their plates (see 4.4). In practice, processed insect ingredients could be introduced in familiar foods, adding extra functionality or sustainability benefits. They could be used to replace, or partially replace meat in processed foods, be added to baked goods at a small percentage, or to create insect snack bars. These bars are available in several countries and marketed mainly as either healthy/nutritious or sustainable[11].

From a competitiveness perspective, there is still a 2.5-5 times price difference between insect protein and the next cheapest animal meat, chicken. With the rising interest in alternative protein and potential price decreases, this might be overcome, especially when external factors such as problems associated with mega-farms and animal welfare concerns are factored into the price. Compared to lab-grown meat, insect protein is currently significantly cheaper[e].

3.2 Feed industry

Insects are often a natural part of a range of species' diets. It therefore seems logical evaluate if insect protein could help improve protein supply in the livestock industry or aquaculture. It could provide an alternative to soy meal (plant-based, but usually imported, connected to land use issues), or fish meal (which contributes to overfishing). One major challenge is the cost difference, where soybean meal is approximately 350 – 500 USD/ton, fishmeal 1,600 – 1,800 USD/ton and insect protein 2,700 – 6,000 USD/ton. This price difference of factor 5 – 10 will be challenging to overcome[12] and more high value applications in the food or even chemical industries might be more promising.

However, as part of a circular economy, farmers could grow insects regionally, on side- and waste-streams, to produce feed for regional rearing of livestock – potentially even on the same farm. This very regional value chain could be sustainable both ecologically and economically, especially if paired with local end consumers being supplied directly[f],[g].

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[e] Chicken meat : 1-2 USD/kg, insect protein (BSF meal) 2-5.5 USD/kg, soy meal 0.35 – 0.6 USD/kg, lab-grown meat 7 – 67 USD/kg.

[f] https://eu-cap-network.ec.europa.eu/projects/reg-insekt-tierwohl-regional-production-sustainable-pig-feed-using-insect-larvae-and-study_en

[g] https://www.farminsect.eu/en/

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The inclusion of insect protein and insect oil in pet food[13] is an example of a higher-value product, targeting a market where margins are higher and the insect-based products can claim to have additional benefits. Insect-based ingredients can increase the nutritional value of pet food and are considered hypo-allergenic.

3.3 Chemical Industry

Few applications of insect oil in the chemical industry exist so far. However, the specific and changeable fatty acid compositions of insect oils makes them interesting ingredients to produce coatings, lubricants, or biosurfactants, with less requirement on arable land for sunflower, rapeseed, or palm oil.

> In a model project funded by the INTERREG project RealiseBio, a Dutch SME tested the use of insect oils to realise a PFAS-free, bio-based coating for paper cups. First results were promising, with further research into purification of the oils carried out in 2025.

Insect oil can be used in cosmetics, where its characteristics are similar to palm or coconut oil. It can potentially also have antimicrobial properties or contain antioxidants. Insect oil can also be used for coatings and adhesives, with a patent having been granted [h], and research projects underway (see box).

Insect oil has been shown to be a feedstock for biodiesel[14], however, the amounts that can be obtained via insect farming might not be of large enough quantities to make this an accessible market, even if scaled to larger production volumes. It remains an alternative though, should no higher-value valorisation of the fat co-produced in an insect biorefinery be possible. Regulation and subsidies for renewable biofuels can also inform a biorefinery's economic decisions in this regard.

4 Challenges

Although insect farming has seen a lot of interest, research, and investment in the last years, it has not yet reached market readiness. Several challenges remain, including research of insect farming, regulations, market development, and consumer acceptance.

4.1 Insect Farming

While insects have been farmed around the world for food purposes, their farming in Europe and in industrial scale has not yet been established. There are different approaches, either in more centralised, large-scale facilities, or smaller scale operations, which can be set up on individual farms. Major challenges are the supply of breeding stock and feed, hygiene conditions, and energy requirements for temperature control.

[h] Use of an insect oil in resins for coating and adhesive compositions (patent EP3543323A1)

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An optimisation of the insect feed, adding essential amino acids or minerals to increase the growth of the farmed insects, was carried out in the FARMYNG project. Another legacy of the project is the *T. molitor* genome sequence, paving the way for a better genetic understanding and breeding populations. This can provide valuable information also for other insect growers.

Insects farmed for the production of processed animal protein are considered farmed animals by EU Regulation (1069/2009). This limits the materials eligible as feed to those of vegetable origin, and some animal-derived feeds. Material including meat or fish, such as catering wastes, or manure or animal faeces are not allowed as feed. This limits the use of insects to convert for example the organic fraction of municipal solid waste, hotel/restaurant/catering (horeca) food wastes, or certain former foodstuffs (unsold products).

A re-evaluation of the application of this regulation to insect farming, leading to evidence-based legislation potentially broadening the scope of allowed feed for farmed insects is highly important to realise the potential of insect farming. A very important benefit of insect biorefineries is their potential to convert waste streams into valuable products. Insects, depending on the species, are by their nature able to grow on a range of substrates, including those not suitable for other animals. Harnessing this power will be a great benefit in a circular bioeconomy – one not permitted under present regulations. Looking to future developments, plastic (or bioplastic) degradation by insect larvae is a promising field where research is currently concentrating on understanding the mechanisms (which seem to involve a combination of physical degradation by the larvae chewing on plastic followed by their gut microbiome, in which bacteria produce plastic-degrading enzymes)[15].

Farmed animals, including insects, are covered by regulations concerning animal health (2016/429 EC). However, insects are exempted from animal welfare legislation (Council Directive (98/58/EC)), creating some discrepancies.

Automation of insect farms is being optimised by all industrial stakeholders in the field, with most aiming for low floorspace vertical farms – which is a unique characteristic of insect farming. The breeding of insects, to develop specific, useful, traits, similar to the development of livestock races achieved already for chickens or cattle, is a relatively new field, but could help increase productivity.

4.2 Regulation

Frass is an interesting alternative to fossil-based fertiliser, or agrochemicals in general, since it not only adds minerals to the soil, but can also protect plants against stress[16,17]. Its use as fertiliser was authorised in November 2021[i]. It is an important side-stream for any insect biorefinery and its valorisation adds to the overall economic sustainability of the farm. Frass is composed mainly of insect excrement but also contains some remaining substrate and insect parts. The regulation limits the amount of insect body parts or eggs that may be present in the fertiliser, and heat treatment (similar as for other animal manure) is required. This makes the processing of frass into fertiliser more costly.

[i] COMMISSION REGULATION (EU) 2021/1925 of 5 November 2021 (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R1925&from=EN)

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More research is needed to determine the effectiveness of frass as fertiliser and plant protection agent in large-scale cultures. The current requirement for heat treatment should be reviewed, since it effectiveness is not yet sufficiently proven, while it may decrease the value of the fertiliser by inhibiting beneficial microbial activity[18].

> In the FARMŸNG project, quality control protocols based on real-time PCR technology have been developed by project partners[23–25]. These publications inform the sector and can be applied in farming a range of other insect species.

While several insects and insect-derived ingredients have been approved under the Novel Food Regulation for food and or feed in the EU, this process could be more streamlined and faster. Especially start-ups face great difficulty to wait for regulatory approval.

New processes or feedstock, as well as insect biorefinery concepts need quality control. Proper testing can ensure that insect meal placed on the market consist of the insect declared on the label and ensure authenticity. It can qualify microbial safety and ensure a healthy product[19]. Modern real-time PCR technology helps develop protocols which are less time-consuming than current techniques and allow for faster process control and mitigation measures in case of impurities.

4.3 Market development

Several challenges need to be overcome, in order to develop the market for insect products in the feed and food industries, or the chemical sector.

To become cost competitive, economy of scale will be important, meaning production needs to be scaled up – also an important prerequisite to develop and implement applications. At the same time processing technologies and new applications need to be developed.

An insect farming supply chain will need to be set up and monitored. This ranges from breeding the populations, to their rearing and processing, as well as the storage and transportation of the products and side-streams. Robust supply chains and traceability will be desired by customers adopting the insect products in their applications.

Insect protein meal for use in fish or poultry feed is in direct competition with an existing solution (soy or fish meal), while not offering significant benefits beyond sustainability claims. It will be crucial to develop applications where insect products outperform existing products or offer novel characteristics (see also 3).

One such example could be high value applications in cosmetics[20]. The special fatty acid composition of insect oils, which can even be changed via their diet, makes them an interesting alternative to palm (kernel) oil. Since such lipid profiles can usually not be extracted from plants grown in temperate regions like Europe, possible alternatives are either fossil-based, or for from microbial sources. Insect species can yield specific, desired fatty acid profiles depending on their diet, which makes them a flexible feedstock for these oils. Such a local and sustainably source of lipids would be a strong selling point for the industry and consumers.

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While insects as a source for pharmaceutically active ingredients has been mentioned or revisited[21], this might be restricted to certain insect species, which are not the most optimal for food production. More likely is the development of functional foods based on insects[7].

> When presented with insect-based food at a CLIB International Conference (CIC), visitors were intrigued by the samples offered. These had been prepared by a catering service specialising in adapting traditional Japanese food to European tastes. While some participants refused to try them, those who did were pleasantly surprised.

4.4 Consumer acceptance

Consumer acceptance remains challenging across Europe, since citizens are not used to considering insects as foodstuffs, or part of the products they use. Consumers might be averse to consuming insects for a range of reasons: they might find them disgusting, be not used to eating them, or have food safety concerns[22]. Other concerns have been raised including the potential for allergic reactions to insect ingredients, especially in individuals allergic to shellfish, or whether a meatless or vegetarian diet could include insects.

To pave the way towards consumer acceptance of insect-derived ingredients in food, preparations where the insects cannot be seen, such as insect flours, can be helpful. This means that a clear labelling system will be important to ensure that consumers know what they will eat. Customers can then choose insect ingredients to add health benefits, taste, or sustainability to their diet. It will be important to highlight these functionalities in marketing the new products – for example a high protein content. Showcasing the traditional uses of insects in other cultures, together with scientific research into safety, can also help to normalise the use of insects. To overcome a concern about safety, standards and evidence-based regulation will be important, as well as clear communication about the controlled farming conditions and traceability.

5 Conclusion

Insect farming presents a promising, resource-efficient addition to conventional animal production, with significant potential for improving global food security and advancing circular economy goals. However, its success depends on addressing economic and regulatory challenges.

One key barrier is cost: consumers are generally unwilling to pay a "green premium" for sustainable products, yet insect protein, or other insect-derived products remain relatively expensive. To overcome this, the sector must scale production and identify high-value market niches. Increased automation and decentralised, location-independent production models—ranging from rural areas to urban environments—offer flexibility and cost-saving potential. Insects require no arable land and minimal space, making them suitable for production even in regions with limited agricultural resources.

From a sustainability perspective, insect farming can valorise local waste streams, including organic residues and in future maybe even (bio-)plastics, turning low-value inputs into high-quality products. Insects demonstrate high feed conversion efficiency, and their integration into existing agricultural systems can support feed optimisation and reduce feed competition with

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humans and livestock. For example, insects can complement local, on-farm feed sources for poultry.

Globally, insect farming offers opportunities for countries facing protein shortages or land constraints. To fully unlock these benefits, evidence-based regulation is needed—particularly around the use of non-food grade feedstocks for insect rearing. Continued research is essential to support safe, effective, and economically viable insect farming systems that contribute to resilient and sustainable food production.

6 Disclaimer, Acknowledgement

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