Alternative Proteins

INTERNATIONAL MAGAZINE FOR
ALTERNATIVE PROTEINS TO ANIMAL FEED
by Feed Additive Magazine

www.feedandadditive.com

October 2025 - Issue 6

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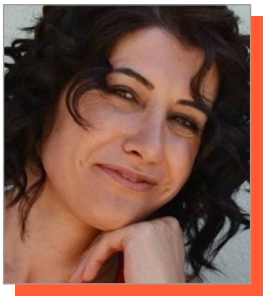
EDITOR **Derya Gulsoy Yildiz**

The Role of Alternative Proteins in the Circular Economy



The animal feed industry remains largely dependent on soy and fishmeal. However, these two sources present serious hurdles to sustainability due to environmental pressures, supply risks, and rising costs. The industry is no longer just looking for "more protein," but for "smarter protein sources."

Alternative proteins, especially insects and single-cell proteins (SCPs) produced by microorganisms, are at the heart of this transformation. Yet, the value of these sources is no longer determined solely by production efficiency, but by the extent to which they contribute to the circular economy. Insect farming, in particular, stands out for its potential to convert food waste into high-value feed protein. However, some experts argue that these wastes could also be utilized directly in feed formulations.

The sustainability of insect farming seems closely linked to material used for feeding. Some life cycle analyses show that environmental impacts can be significantly reduced if by-products that cannot be used as human food are utilized in insect feed. However, significant legal barriers still stand in the way of this. Expanding permits for by-product use and diversifying raw materials could accelerate the sector's transition to circularity.

Another important point is logistics. Insect farms fed with by-products need to be close to waste sources; otherwise, transport costs could overshadow the environmental benefits.

On the other hand, single-cell proteins also present a strong alternative for valorizing industrial side streams.

Ultimately, whether insect or microorganism- based, the true potential of alternative proteins lies not only in production technology but also in innovative resource management. The circular economy approach will minimize the environmental impact of these new proteins while also determining the future resilience of the feed sector.

In this issue, as we discuss the place of alternative proteins in the circular economy, we return once again to the question: What resources and approaches are we truly relying on to build a sustainable feed chain?

Hope to see you in the next issue…

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by Feed Additive Magazine

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Publication Type: Periodic
(Twice a year)

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New Study: Insect protein enhances skin barrier and antioxidant defences for dogs

The results of a study by the Federal University of Paraiba in Brazil show that the inclusion of ProteinX, Protix's black soldier fly protein, can improve the skin barrier of dogs and strengthen their antioxidant defences. The findings, published in Archives of Animal Nutrition, are particularly good news for dogs that suffer from skin diseases or allergies, Protix points out. Versatile ProteinX can be incorporated into a variety of end products, from wet food to kibble and (nutritional) treats, so the study opens up various opportunities for manufacturers to develop healthy pet products.

The skin barrier acts as an important defence mechanism in dogs. An effective skin barrier is essential for maintaining hydration. It protects against allergens, viruses, bacteria and environmental toxins, and ultimately helps to keep the overall skin healthy.

According to the announcement, there was a noted improvement in skin barrier function when the canines consumed the ProteinX-based diet. Transepidermal water loss decreased at both the pinna and belly, indicating improved water retention. There was also a significant increase in stratum corneum hydration at the belly (the outermost layer of the skin serving as the primary barrier between the body and the environment), suggesting enhanced skin hydration.

Protix explains that ProteinX contains relatively high concentrations of lauric acid and linoleic acid which may account for the improvements in skin barrier function and water retention.

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Ulf Meyer becomes new CDO of Big Dutchman

In a move to expand the company's Board of Management, the Supervisory Board of Big Dutchman appointed Ulf Meyer as Chief Development Officer (CDO), which took effect 1 October 2025. The 54-year-old business administration graduate is responsible for the group's investment companies. These currently include SKOV and Better Insect Solutions in Denmark, Inno+ in the Netherlands, Zucami in Spain, the local companies Högemann, Bosche Systembau, Hellmann and Willoh, the horticulture business, and more.

Meyer is also responsible for sales activities relating to digital solutions for farmers and innovative new developments.

Ulf Meyer was the Head of Region at the group's headquarters in Vechta-Calveslage and responsible for the markets in Europe, the Middle East and Africa (EMEA).

Bernd Meerpohl, Chairman of the Supervisory Board of Big Dutchman AG and member of the shareholder family, says, "With Ulf Meyer, we are adding an experienced colleague to the Board of Management. He knows our family business very well and has played a decisive role in shaping the company in various positions for decades."

Ulf Meyer

The Board of Management of Big Dutchman AG thus consists of CEO Steffen Bersch, CFO Erkul Basaran, COO Dr. Thomas Dalstein and CDO Ulf Meyer in future.

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Loopworm insect protein approved for India

Loopworm, one of India's leading insect biotechnology companies, secured approval from the Coastal Aquaculture Authority (CAA) of India, certifying the direct use of Loopworm's protein and fat products as additives, attractants, and palatants in aquaculture nutrition and health at the farm level. The company highlights this approval as showing a paradigm shift, allowing Loopworm's products to directly serve aqua feed supplement and additive manufacturers.

The CAA approval opens an entirely new domain for Loopworm, enabling the company to bridge the gap of palatability and attractability for aquaculture feed additives products, according to the announcement. It will support farmers in challenging weather conditions and early disease incidents, as well as improve feed consumption rates for farmed fish and crustaceans, providing direct nutritional supplementation at the farm level.

The brand has started with exports of its insect protein powder (i.e, insect meal) to one of the leading global salmon feed manufacturers, making a mark in sustainable aquaculture. Multiple commercial consignments have been shipped

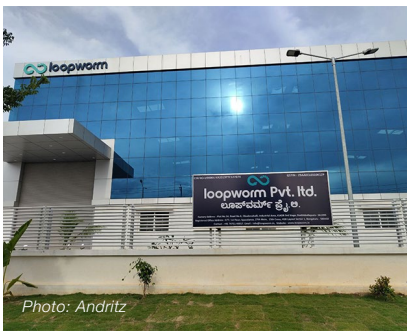

Photo: Andritz

to one of the largest clients in the salmon feed space. With this regulatory milestone, Loopworm will reportedly cater to both feed manufacturers and the broader aquaculture supplement ecosystem, expanding its addressable market in India's growing aquaculture sector.

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Nasekomo reports stable industrial BSF eggs production rate

The insect-biotech company Nasekomo, owned by French entrepreneurs and operating in Sofia, Bulgaria, says it consistently achieved ~25 grams of Black Soldier Fly (BSF) eggs per cubic meter per day across its reproduction enclosures in its industrial operation, positioning the system as deployment-ready for mid- to large-scale customers.

The sustained industrial operating result in BSF reproduction is measured on the effective volume of reproduction enclosures under routine production. The performance figure is expressed per effective reproduction-enclosure volume to provide a clear and comparable indicator of system efficiency without disclosing company intellectual property. The daily result is derived from routine production days and reflects the company's standard operating environment.

The company highlights that at the heart of this milestone stands its Multiplication center "Multi-Fly" - the genetics and breeding nucleus that multi-


Photo: Nasekomo

plies elite insect lines and ensures a reliable supply of high-performance neonates. "This is a daily operating level reflecting a mature, production-grade set-up operating at scale," said Marc Bolard, co-founder and CEO of Nasekomo and a recently joined member of Management Board of the reputable international organization of insect producers IPIFF. The company also operates its suspension technology to further improve its product delivery internally but also to send the genetic resources to its network of clients around the world.

Read more>>

Goterra unveils first large-scale insect protein rendering trial

Goterra announced the successful completion of its first large-scale rendering trial, marking a significant milestone in the commercialisation of insect protein in Australia. Conducted using larvae aggregated from all operational sites and processed with an external regional NSW rendering partner, Goterra explained that the trial produced insect meal containing >70% protein and ~12% fat, exceeding industry requirements, outperforming conventional benchmarks like soymeal and more in line with premium fish meals.

Photo: Goterra

"This trial validates a core part of our thesis," said Olympia Yarger, CEO of Goterra. "Aggregated food waste inputs don't compromise protein quality. It's a key step forward in demonstrating the consistency and scalability of our product."

This successful trial also marks a deliberate and strategic step in Goterra's evolution by externalising the rendering process and focusing on core competencies in organics waste processing technology and protein production, according to the announcement. Outsourcing the rendering of BSF meal, oil, and tallow creates better pathways to scale more efficiently and deliver on the current infrastructure gap for food waste processing in Australia.

The trial follows the announcement of a landmark partnership between Goterra and Skretting Australia in 2024 to integrate insect protein meal into aquaculture feed. As global demand for sustainable, traceable feedstocks increases, partnerships like this are critical to accelerating Australia's circular economy.

Read more>>

BSFL research shows promise for eco-friendly feed

Researchers from UK-based Kent University, working with a local farm, found promising results in the sustainable growth of black soldier fly larvae (BSFL) – which offer an innovative way of tackling food waste, environmental impact and cost.

Working with bio conversion hub producer Inspro, the researchers from Kent's School of Natural Sciences have tested a novel bio-conversion unit (BCU) based at Bank Farm in Aldington to assess its viability for extensive BSFL production at an industrial scale. This provides real-world analysis of how BSFL could be used to provide an eco-friendly approach to animal feed.

BSFL are recognised as a sustainable feed additive for livestock and can help create a more complete system for farms by recycling food waste into eco-friendly protein and fertiliser. The BCU's effectiveness in converting organic byproducts into valuable biomass through the production of BSFL was assessed to reduce the farm's reliance on environmentally taxing feed sources, such as soy and fishmeal.


Photo: TaraPatta | Shutterstock

The researchers analysed the gut microbiome of the larvae to understand how it behaves when reared on different waste diets at a large scale. They found that larvae reared on low-bioburden substrate (waste with very few germs) in the BCU demonstrated comparable or improved protein and fat content compared to those reared on animal feed.

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VERDILOX antioxidants are the solution for natural pet food diets with its distinct well balanced of blend of mixed tocopherols and vertically-integrated supply chain of botanically-sourced ingredients.

The VERDILOX line of products gives pet food manufacturers an innovative, more sustainable option for achieving their **shelf-life goals**. The unique antioxidant combinations of VERDILOX provide the ability for pet food manufacturers and ingredient suppliers to stabilize their novel ingredients and formulations with **natural antioxidants**.

A study on *dried black soldier fly larvae meal*, recently approved for adult dog food, assessed its oxidative stability and suitable antioxidant treatments. Oxidation in this meal can decrease palatability and nutrient quality. The study tested untreated and antioxidant-treated samples, measuring peroxide values and residual antioxidants over six months. VERDILOX GT Liquid, containing mixed-tocopherols and botanical extracts, was found to be the **most effective in preventing oxidation**. The larvae meal's fatty acid profile was similar to other animal-based meals, like chicken and pork, with comparable iodine and fatty acid levels.

VERDILOX enhancing *pet food stability*:

- Well balanced blend of mixed tocopherols and botanically sourced ingredients
- Assists in preventing the formation of free radicals that start the autoxidation process
- Improved chelation
- Improved sustainability
- Enhanced pet food and ingredient shelf-life performance
- Suitable for vegetarian-vegan diets

Sources: INF-22-20267

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New Study: Insect-based foods unlikely to replace meat in Western diets

A peer-reviewed analysis, published in the prestigious Nature journal npj Sustainable Agriculture, has found that efforts to incorporate edible insects into Western diets face a number of consumer acceptance barriers. These barriers, which are psychological, taste-, culture- and price-related in nature, challenge the long-standing assumption that farmed insects have the potential to replace traditionally farmed meat as a source of dietary protein.

Authored by an international team of academics from the UK, USA and Europe, "Beyond the Buzz: Insect-based Foods are Unlikely to Significantly Reduce Meat Consumption", evaluates the likelihood of insect-based foods in replacing meat from farmed animals, when compared to alternatives including plant-based proteins and lab-grown meat.

The study notes that the successful inclusion of any new food product in Western diets depends on a number of factors, but crucial is the willingness of consumers to try a product. Analysis of earlier research on consumer acceptance rates of alternative proteins indicates the highest acceptance is for plant-based meats, with a reported 'willingness to try' reaching as high as 91%. In contrast, farmed

insects show the lowest acceptance of any alternative proteins, with reported 'willingness to try' routinely scoring in the 20% region.

Beyond the Buzz notes that the main barrier to market acceptance of farmed insects is "the psychological rejection experienced by consumers, predominantly feelings of disgust".

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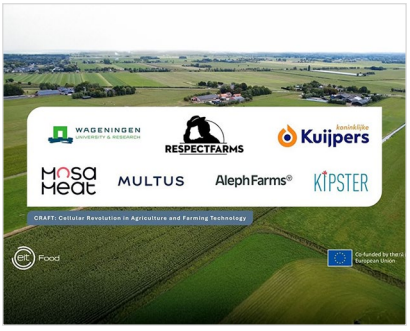
World's first cultivated meat farm receives €2m support

The CRAFT Consortium, consisting of RespectFarms, Wageningen University & Research, Mosa Meat, Aleph Farms, Multus, Kipster, and Royal Kuijpers, started designing and building the world's first cultivated meat farm, paving the way for commercialisation.

Co-funded by EIT Food, the project has been awarded the first €2 million of a €4 million grant request. This landmark initiative is expected to enable farmers to diversify their businesses with cultivated meat technology—reducing water consumption by 78%, land use by 95%, and societal cost by 56%.

"It is important for food innovations to stay as close as possible to primary food production, making use of local resources and waste streams," says René Wijffels, Professor at Wageningen University, Bioprocess Engineering.

"This represents the first effort globally to merge cellular and traditional farming and promises to deliver consumers the best of both worlds: the unrivalled experience of real meat, through products produced and sold locally. The project will deliver a business model that is fundamentally new on one hand and centuries old on the other, and will add new perspective, also for farmers, to agri-



culture as we know it. Mosa Meat has been part of this development from the get-go and we are more than happy to support the project with our knowledge and experience across the various steps of this revolutionary technology," remarks Peter Verstrate, Co-founder and COO at Mosa Meat BV.

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BeneMeat launches cultivated meat program for dogs

BeneMeat launched the Try & Share Program, inviting those who want to provide products based on cultivated meat to their four-legged friends and share their experiences.

The company points out that the program opens up the possibility for EU citizens to test dog treats rich in cultivated meat. Other cultivated products will reportedly follow in the EU soon, followed by other territories once the regulatory approvals are granted.

The program offers an opportunity for those who want to actively participate in the development of top-quality cultivated products that are unconditionally safe, cruelty-free, and environmentally friendly. Developed together with established pet food producers and overseen by veterinarians, BeneMeat Cultivated Dog Treats meet the highest safety standards while ensuring excellent digestibility, according to BeneMeat's statement. The dog treat trial builds on successful safety and digestibility testing of complete cat food conducted at a prestigious European university. The program's primary goal is to help producers collect long-term, meaningful feedback from real potential customers. The program's primary goal is explained as to provide producers with long-term, meaningful feedback from real potential customers. Its second goal is to build awareness and interest in cultivated meat as it moves from curiosity to a genuine new choice for consumers. BeneMeat invited dogs and their owners to take part in this pioneering journey by signing up online.

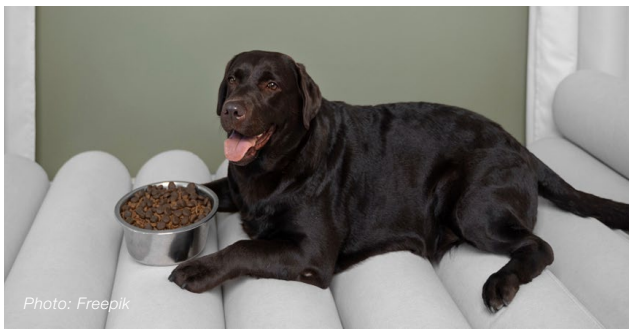
Photo: Freepik

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New Analysis: BioCraft ingredient emits 1/12 less CO_2 than beef byproducts

BioCraft Pet Nutrition™, a biotech company that develops animal cell-cultured ingredients for the pet food market, released the results of a new product carbon footprint analysis, conducted in collaboration with ClimatePartner, a solution provider supporting companies on their journey towards net zero. The analysis showed that its proprietary BioCrafted Meat™ emits one-twelfth of the carbon dioxide of conventional beef byproducts used in pet food.

According to the analysis, based on standard EU beef production processes, a hypothetical beef byproduct emits 21.28 kg CO_2 per kilogram—in comparison, BioCrafted Meat produces just 1.73 kg CO_2 per kilogram. The calculation was based on internationally recognized methodologies, including the Greenhouse Gas Protocol Corporate Accounting and Reporting Standard (GHG Protocol) and the Product Life Cycle Accounting and Reporting Standard (PDF), using emission factors from trusted databases such as ecoinvent, Agri-footprint, and DEFRA.

Photo: BioCraft

According to the company's statement, the comparison to byproducts not typically consumed by humans—like offal, bones, blood, and fat—rather than prime beef cuts is significant because the pet food industry, and consumers, often regard these byproducts as sustainable, low-impact alternatives.

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Croatia pilots closed-loop fish farming model with insect protein

Set on 1,300 hectares of historic fish farming land, the Končanica Project in Croatia marks a significant step forward in circular bioeconomy, combining aquaculture, renewable energy, and insect farming into one integrated, self-sufficient system. The initiative is expected to respond to growing climate and market pressures, including rising water temperatures, declining yields, and lack of value-added infrastructure, by introducing a multi-layered model that aims to revitalize the region while setting a blueprint for sustainable production in Europe.

At the heart of the project is a collaboration between three specialized partners: Flybox®, FreezeM, and Ribnjačarstvo Končanica, Croatia's oldest carp farming operation,

According to the announcement, Flybox® contributes its modular insect farming technology and operational expertise, enabling decentralized waste conversion and protein production close to the source. FreezeM supplies high-performance Black Soldier Fly (BSF) neonates using its PauseM® live-suspension technology, allowing rearing operations to be decoupled from breeding and seamlessly integrated into the aquaculture value chain. Ribnjačarstvo Končanica brings deep local knowledge and infrastructure, serving as the foundation for integrating modern H-RAS systems, fish processing, and energy capture from biogas and photovoltaics.

Photo: Faizal Afnan I Shutterstock

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Global Black Soldier Fly experts unite at BSFCON 2025

Following the success of its inaugural edition in 2023, BSFCON 2025 brought together the world's leading minds across science and industry to unlock the full potential of Hermetia illucens, also known as the Black Soldier Fly. The event took place on 8–10 September 2025 in Cambridge, UK. Organised jointly by the University of Cambridge, Better Origin, FreezeM, and Innovafeed, BSFCON remains the only international conference fully dedicated to the Black Soldier Fly. From cutting-edge research to industrial breakthroughs, this unique event offers a 360° view of one of the most promising species for sustainable transformation.

As global interest in insect-based solutions grows, BSFCON provideed a crucial platform to connect researchers, entrepreneurs, investors, buyers and policy-makers advancing the future of feed, food, fuel, and waste valorisation through Black Soldier Fly innovation.

According to the announcement, whether you're working on upscaling production systems or pioneering bio-conversion technologies, BSFCON is the place to learn, collaborate, and lead.

The 2025 edition of the event included:

- Expert-led sessions on physiology, genetics, nutrition, feedstocks, behaviour, and automation,
- Keynotes from global academic and industry pioneers,
- Poster sessions and interactive workshops,
- High-value networking opportunities with the global BSF ecosystem.

The new Industry Day, an exclusive addition to the 2025 program, put real-world application in the spotlight.

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Singapore greenlights cultivated meat pet treats

Friends & Family Pet Food Company received regulatory approval to commercially sell cultivated meat-based pet food in Singapore. With this milestone, Friends & Family becomes the first-ever cultivated meat pet food approved for sale in Asia. The company joins only a handful of cultivated meat companies with regulatory approval across the world.

The approval was issued by Singapore's Animal & Veterinary Services (AVS) in June 2025. Friends & Family will begin production of cultivated meat-based treats for cats and dogs in Singapore in the fall.

"Part of the Friends & Family mission is not simply to replace the protein in the pet food supply chain, but to improve the underlying protein cats and dogs eat," says Joshua Errett, CEO and founder of Friends & Family Pet Food Company. "That's only possible with cultivated meat. We can optimize cultivated meat to have higher levels of nutrients, like taurine, and improve digestibility and nutrient absorption. And ultimately we believe we can make much better meat for our cats and dogs."


Photo: Freepik

The company's inaugural products are freeze-dried treats for cats and dogs, with human-grade cultivated poultry as the first ingredient.

"This is a big step for the cultivated meat industry, and for Singapore – which soon will be the only place in the world where you can buy your cat or dog a cultivated treat," comments Maurice Yeo, Friends & Family's COO.

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Insect meal commercialisation in aquaculture enters new stage

On the opening day of the 2025 Global Shrimp Forum, being held from 2-4 September, BioMar, Innovafeed, and Auchan announced a significant industry commitment: The large-scale integration of insect protein into commercial shrimp feed in Ecuador.

This milestone is viewed as a turning point for both the insect and aquaculture industries, demonstrating that insect protein is a viable part of the solution in responsible and resilient shrimp farming.

Insect meal is much more than a protein source, it contains functional nutrients like antimicrobial peptides. Recent research from BioMar showed a unique functional benefit in shrimp feeds, making it possible to substitute it with a similarly valued ingredient currently in use.

This discovery offers insect meal a viable market entry position in shrimp feeds at its current market value. From there, it's possible to scale insect meal and hopefully be market competitive in the protein ingredient segment in the future, but for now, it can play a vital role in the functional ingredient segment in aquafeeds, according to the partners' statement.

Photo: Innovafeed

As part of this industry-first initiative, Auchan, one of Europe's leading retailers, will support the rollout by integrating shrimp raised on this next-generation feed into its responsible sourcing strategy and product offering.

Read more>>

New study focuses on low environmental impact of BSF farming

A recent study conducted by Better Insect Solutions in collaboration with FarmInsect sheds light on the carbon and water footprints of BSF farming. The study analyzed three operational BSF farms each producing between 400 and 1,000 tons of live larvae annually. The study focused on the "fattening stage" of BSF larvae, where young individuals are grown into harvest-ready larvae – similar to broiler chicken production.

All three farms reported emissions below 1 ton of CO_2 equivalent per ton of fresh BSF larvae produced, the study found. In fact, when benchmarked against broiler farming, BSF production showed up to 40% lower emissions. This is considered a game-changer for the feed industry, which is under increasing pressure to reduce its environmental impact as well as remaining cost-effective.

In the study, feed for the larvae emerged as the most significant contributor to emissions, but also the area with the greatest potential for improvement. Farms using organic waste streams like potato pulp dramatically reduced their carbon and water footprints. According to the GHG protocol, true waste materials carry zero upstream carbon burden, making them ideal for sustainable feed.


Photo: Better Insect Solutions

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Marsapet unveils vegan wet dog food

Pet food manufacturer Marsapet GmbH has expanded the MicroBell product line with wet food and snacks. Following the launch of the world's first dry dog food based on microbial protein in early 2025, the Swisttal, Germany-based company is now presenting a complete range for future-oriented canine nutrition, including the world's first vegan wet dog food with microbial protein.

With the new MicroBell wet food and MicroBell snacks, Marsapet is reportedly offering dog owners for the first time a fully vegan product line consistently based on microbial proteins. Both products embody innovation, sustainability, and a forward-looking approach to canine nutrition – from daily meals to healthy treats in between.

"Tierisch gut, ganz ohne Tier!" ("All the goodness, none of the animals!") – Marsapet states that this claim is now brought to life in three product categories. MicroBell Snacks impress with their innovative recipe and delight dogs, while the wet food stands out with its creamy texture, offering a modern and complete form of vegan canine nutrition.


Photo: Freepik

"With the expansion of our MicroBell line, we are creating an entirely new category in pet nutrition," explains Marcel Hoffmann, Managing Director of Marsapet GmbH. "Dog owners can now feed their companions in a fully sustainable and wholesome way – without compromising on taste or nutritional quality. This is true innovation that makes a real difference."

Read more>>

New Report: Insect protein could be 13.5 times worse for climate than soy

Up to one fifth of the world's greenhouse gas emissions derive from meat production, the majority of which is from pig and poultry meat. With around 60% of emissions from pig and poultry meat linked to the production of animal feed, there has been much debate within the sector over the use of alternative animal feed sources with insect-based feed gaining interest as it may require less water, energy and land resource than plant-based products.

In July 2023, the UK government's Department for Environment, Food and Rural Affairs (DEFRA) commissioned Ricardo's sustainability team to provide an independent, scientifically robust Life Cycle Assessment (LCA) report exploring how, from an emissions reduction point of view, the production of insect protein might perform as pig and poultry feed compared to conventional soybean and fish stocks.

The research looked at the potential cradle-to-gate – ie. from raw material acquisition to manufacturing and distribution - impacts of using the larvae from Black Soldier Fly Larvae (BSFL) (Hermetia illucens) reared from both permitted sources (e.g wheat-based feed) and currently unpermitted sources (e.g food waste, chicken manure).

The associated potential impacts of the BSFL feed were assessed in terms of 16 environmental impact categories, including climate change, acidification, ecotoxicity, land, and water use. Comparative assessments were made for soybean meal grown in Brazil and transported to the UK, and fish meal made from blue whiting caught off the Scottish coast.

Read more>>

Volare secures €26M to build high-efficiency protein plant

Finnish biotech company Volare announced the closing of a €26 million funding round to build Volare 01 – a facility set to become the most efficient protein production plant in the world, and to advance its unique technology. Located in Pori, Finland, the facility will serve as a cornerstone in scaling Volare's proprietary insect protein technology. The company points out the milestone as strengthening protein self-sufficiency and accelerating the shift toward sustainable, circular food production in Europe. The round includes a mix of equity, mezzanine and senior loans, and public funding, with support from Maki.vc, Firstminute Capital, Springvest, The Finnish Climate Fund (to be merged with Finnish Industry Investment), Finnvera, Norion Bank, South Ostrobothnia ELY Centre and Business Finland.

The European Union is currently just 34% self-sufficient in protein concentrates (containing more than 30% protein), according to the European Commission, leaving the region heavily dependent on imports. This

reliance makes the food system increasingly vulnerable to supply chain disruptions, geopolitical tensions, and price fluctuations. Volare explains that its scalable, local production model addresses this challenge head-on by converting food industry byproducts into circular, insect-based protein. The approach reduces waste, supports regional agriculture, and strengthens the resilience and self-sufficiency of Europe's food system.

At the core of Volare's breakthrough is the black soldier fly (Hermetia illucens), nature's most efficient bioreactor.

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UK insect farming venture targets food waste reduction

MYGroup entered into a joint venture with Beta Bugs, an insect genetics company, to supply eggs for its Black Soldier Fly (BSF) bioconversion Insectology™ process for food waste management.

Under the joint venture, Beta Bugs will become MYGroup's exclusive supplier of BSF eggs, with a new breeding and hatching facility to be established at the waste management company's the Maltings site at South Milford, near Leeds, England.

The new in-house breeding and hatching facility will complete MYGroup's Insectology process end-to-end, ensuring a reliable and consistent supply of eggs and neonates.

MYGroup will draw on Beta Bugs' specialist expertise in establishing and up-scaling BSF hatchery operations and their superior genetics to optimise the Insectology process. Beta Bugs will leverage an oversized breeding site to enhance their supply of high-quality breeding stock to the UK market.

Photo: Courtesy of Beta Bugs

Steve Carrie, Group Director, MYGroup, said, "With the vertical integration of egg supply directly into our Insectology process, together with enhanced breeding and hatching capabilities, we're able to ensure optimal quality, reliability and transparency at every stage. Beta Bugs are the perfect partner – innovative, highly specialised and equally committed to scaling BSF bioconversion as a mainstream solution for food waste and the sustainable protein market."

Read more>>

Calysta's FeedKind Pet protein proven safe for dogs in long-term study

Calysta, a company focused on large-scale cultured protein, published a new peer-reviewed research confirming that FeedKind Pet protein is a safe, highly digestible ingredient for adult dogs with promising early signs of supporting gut health.

Published in the journal Animals, the eight-month target animal safety study was designed under FDA Center for Veterinary Medicine guidelines and supports Calysta's planned GRAS notification for the US market. Thirty-two healthy adult beagles were fed diets containing up to 8% FeedKind Pet protein for six months, followed by a two-month period on a control diet.

The results reportedly reaffirm that FeedKind Pet protein can be safely included in dog food, maintaining healthy weight and body condition scores throughout, with no impact on feed intake and high digestibility. Protein and energy digestibility exceeded 80%, and fat digestibility exceeded 90%. The study also revealed positive shifts in the dogs' fecal microbiome, increasing alpha diversity, an early sign of potential gut health benefits.

Key findings from the study have been highlighted as:

• Long-term safety confirmed: All dogs maintained normal health, weight, and body condition.

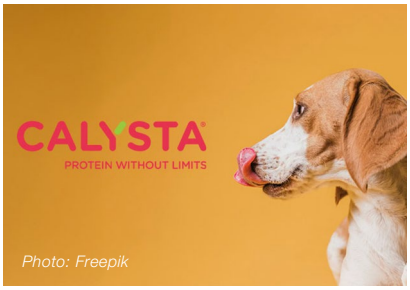


Photo: Freepik

• High digestibility: Protein and energy digestibility consistently above 80%, fat above 90%.

• No feed intake impact: Dogs readily accepted FeedKind Pet at all inclusion levels.

• Positive microbiome effect: Inclusion increased alpha diversity and promoted healthy bacteria, signs of gut health support.

Read more>>

Siemens and Entocycle open insect farming technology hub

Entocycle, a specialist manufacturer of insect farming technology which uses insects to turn food waste into sustainable protein for animal feed, worked alongside Siemens to create the UK's first digitalised insect farm showroom under four Victorian railway arches in the heart of London.

The company, which designs and builds insect farms that convert food waste into low-carbon protein, strategically picked its central London location to attract talent and investors to its concept. Using Siemens' digital twin technology, Entocycle explains it was able to virtually model the facility before physical construction began, optimising the challenging arch-shaped space and preventing costly mistakes during the build phase.

A full digital transformation was then undertaken, and the facility now leverages Siemens AI and automation to help scale operations while driving efficiencies. The advanced site features robotic arms, climate-controlled chambers and machine vision technology that counts and monitors 3,000 microscopic larvae a second with 96-100% accuracy.

Implementing digitalisation has reportedly reduced insect larval growth time and improved survival rates by 30%, demonstrating how the emerging insect bioconversion process can be accelerated and implemented at industrial scale in the future.

According to the announcement, after a year of successful operation at the site, the insect farm concept has proven how it can help address two critical sustainability challenges: Tackling the staggering 10.7 million tonnes of annual UK food waste (30% of which stems from supply chain inefficiencies) while simultaneously reducing dependency on the 3.3 million tonnes of imported soybean products that currently flood into the country each year for animal feed.

Read more>>

IPIFF Secretary General: Insect meal is key to sustainable EU aquaculture

The EU's ambitious policies—such as the Common Fisheries Policy, the Vision for Aquaculture, EU Bioeconomy Strategy or the Oceans Pact—are designed to boost innovation, resilience, competitiveness and sustainability. With global demand for farmed fish expected to reach nearly two-thirds of total fish consumption by 2032, securing sustainable and scalable feed ingredients is more critical than ever, the Secretary-General of International Platform of Insects for Food and Feed (IPIFF) Steven Barbosa stated.

Leading market reports, including the World Bank's "Harnessing the Waters" (2025), highlight that investment in alternative proteins—such as algae and insect meal—is set to grow exponentially, driven by the need to meet rising demand and reduce reliance on overfished wild stocks. The 2025 Global Aqua Feed Market Outlook emphasises that innovations in sustainable feeds, including insect-based ingredients, will be vital to supporting aquaculture industry growth while minimising environmental impact, Barbosa highlights.

Furthermore, the 2025 Market Report Feed Proteins stresses that with the increased focus on sustainability and efficiency — circular economy models, like insect-based feeds, are becoming an increased priority to livestock producers.

Read more>>

CONTRIBUTION OF ALTERNATIVE PROTEINS TO THE CIRCULAR ECONOMY

- The role of alternative proteins and industrial symbiosis in a circular bioeconomy
  Eleni Ntokou, Unibio
- Revolutionizing food systems by turning organic waste into high-value proteins
  Dr. Greg Wanger, Oberland Agriscience Inc.
- Insects: The missing link in feed circularity
  Salamahafifi Yusnaieny, Protenga
- Closing the Loop: The circular potential of novel ingredients
  Aashish Khimasia, Centre for Feed Innovation
- Black Soldier Fly: Environmental engineer for sustainable agri-food systems
  Dr. Solomie Gebrezgabher, IWMI
- Black Soldier Fly Farming: A greener future for sustainable feed
  Lars-Henrik Lau Heckmann, Better Insect Solutions
- Can insect protein be circular without compromising?
  Francis Maugère, Eurogroup for Animals

THE ROLE OF ALTERNATIVE PROTEINS AND INDUSTRIAL SYMBIOSIS IN A CIRCULAR BIOECONOMY

Eleni Ntokou
New Product Development, Sustainability, & Regulatory Affairs Director
Unibio

Across industries, vast amounts of valuable byproducts are discarded daily, despite their potential to become high-value resources. Biotechnology is revolutionizing this paradigm by converting waste gases like methane into nutritious protein for feed and food applications. As the biotech industry advances, integrating sustainable resource utilization will be critical for long-term success of building more resilient food systems.

Global demand for protein continues to rise, driven by population growth, rising incomes, and shifting diets. At the same time, conventional protein production, whether from livestock, soy cultivation, or fishmeal production, places significant pressure on ecosystems.

Livestock farming accounts for about 14.5% of global greenhouse gas emissions (FAO, 2013). Most emissions come from methane (CH_4) and nitrous oxide (N_2O), released through enteric fermentation, manure management, and fertilizer use for feed crops (IPCC, 2021). Soy expansion is a leading cause of deforestation in South America (WWF, 2021), while fishmeal production threatens marine ecosystems and food security for communities that rely on fish as a staple (FAO, 2020). Meanwhile, the use of land, water, and fertilizers in conventional protein production is already unsustainable in many regions, and climate change is making these challenges worse (World Bank, 2019).

In short, the world faces a protein paradox: We need to produce more, but we must do it with far fewer resources. This challenge has sparked growing interest in alternative proteins, from plant-based and cultivated meat to microbial proteins and algae. These innovations offer an opportunity to rethink the role of protein in food systems not only as a dietary requirement, but also as a driver of sustainability, resilience, and circular economy models.

SUPPORTING SUSTAINABLE GROWTH IN GLOBAL FOOD SYSTEMS

Unlike traditional linear models of "take-make-dispose", the circular bioeconomy aims to keep resources in use as long as possible, minimize waste, and regenerate natural systems through the "reduce-reuse-recycle" model (OECD, 2018). In food systems, this means finding ways to use byproducts, side streams, and even waste gases as valuable inputs for new production.

Alternative proteins are particularly well suited to this approach, as their production relies on non-traditional inputs, which allows companies to trans-

form low-value resources into high-quality protein. This creates multiple benefits:

• **Waste reduction:** By using byproducts like methane, agricultural residues, or industrial CO_2, alternative proteins prevent pollution while generating value.

• **Resource efficiency:** Many microbial and fermentation-based proteins require little to no land and far less water than conventional protein sources (FAO, 2021).

• **Climate impact**: By decoupling protein production from deforestation, overfishing, and intensive farming, alternative proteins reduce greenhouse gas emissions and preserve biodiversity (IPCC, 2021).

• **Resilient growth:** New protein sources diversify supply chains, reducing reliance on fragile global commodity markets (World Economic Forum, 2019).

In this way, alternative proteins support a resilient, circular bioeconomy where secure, diversified protein supplies meet growing demand with lower environmental impact. Several companies are already putting these principles into practice, demonstrating how alternative proteins can transform waste into high-value resources.

FROM METHANE TO PROTEIN TO FEED

A leader in this field is Unibio, a Danish biotechnology company with a pioneering method for converting methane into protein. The company's flagship product, Uniprotein®, is a single-cell protein produced through a proprietary Vertical Loop fermentation process, in which naturally occurring microbes are cultivated using methane as a carbon and energy source. Methane is a potent greenhouse gas, released from agriculture, landfills, and industrial processes, often wasted or flared, with a warming potential more than 25 times that of carbon dioxide over a century (IPCC, 2021). By capturing methane and turning it into protein for feed, Unibio provides a double benefit: Reducing emissions and producing a high-quality, safe, and scalable protein ingredient for animal feed.

Uniprotein® is a single-cell protein produced by feeding methane to a culture of methanotrophic bacteria along with water, oxygen, ammonia, and simple minerals using a patented process

This innovation is particularly important in the context of animal farming, which consumes vast quantities of protein in the form of feed, particularly soybean meal and fishmeal. These conventional feed ingredients are resource-intensive, contribute to deforestation, and create volatility in global feed markets. By converting industrial byproducts and side streams into alternative proteins, feed producers can reduce reliance on imported soy and wild-caught fish, while simultaneously improving feed security for farmers (FAO, 2020).

Looking at the bigger picture, this shows how biotechnology can turn waste into value and build more resilient food systems by applying circular economy principles. Methane-to-protein approaches provide a clear example of how innovation, sustainability, and efficient resource utilization can come together to strengthen food security.

KALUNDBORG SYMBIOSIS: A LIVING EXAMPLE OF CIRCULARITY

Unibio's approach to protein production is further strengthened by its participation in Kalundborg Symbiosis, an industrial cluster located in the

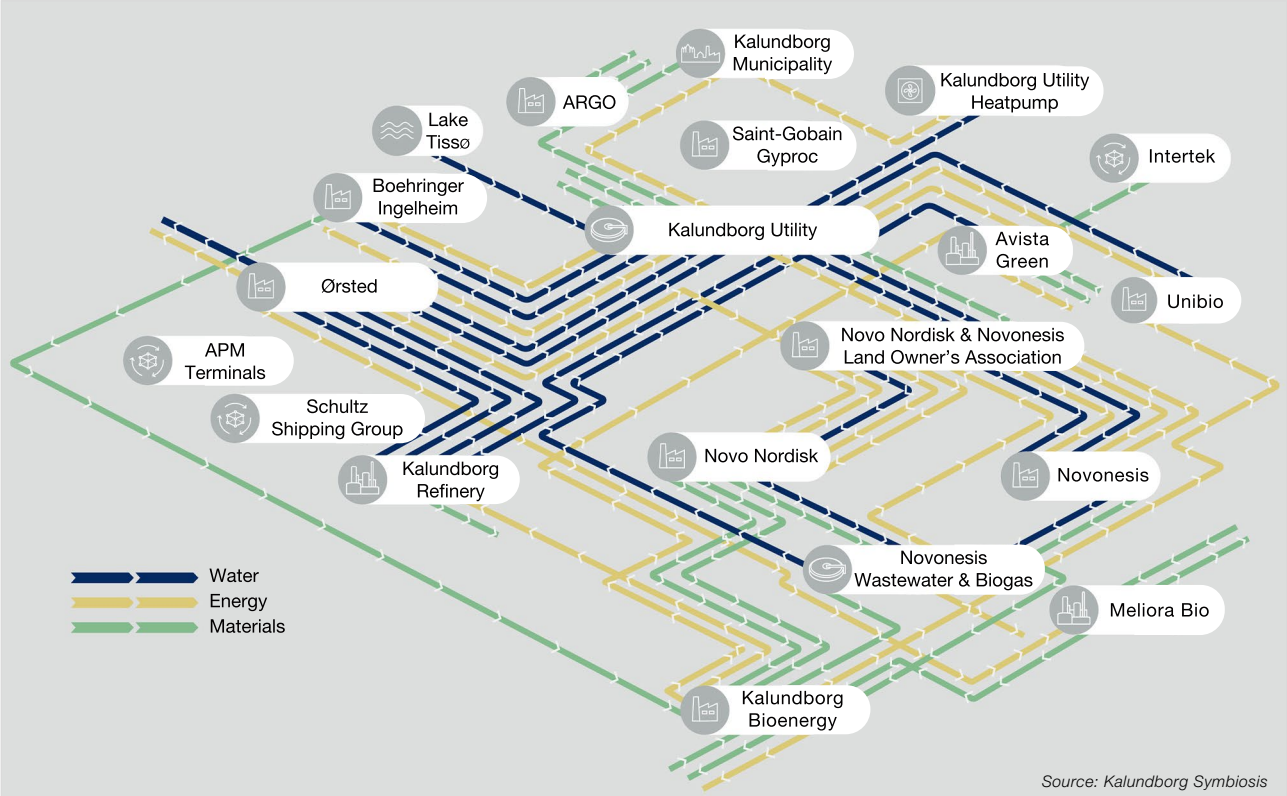


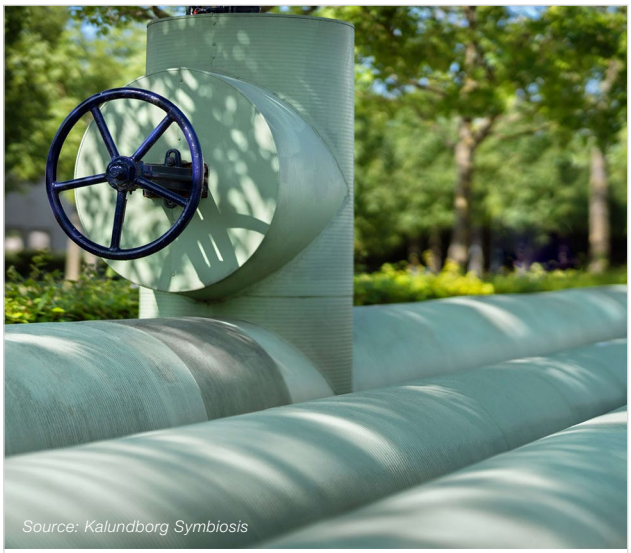
Figure 1. Symbiosis partners are diverse companies and organizations that collaborate by sharing resources, energy, and materials in a mutually beneficial network

city of Kalundborg, Denmark, which is recognized worldwide as a model of circular economy in action. Kalundborg Symbiosis operates on a simple but powerful principle: One company's byproduct can become another's resource. Since its establishment in the 1970s, the symbiosis has expanded into a network of more than a dozen companies that exchange energy, water, and materials to reduce costs, cut emissions, and generate new value (Kalundborg Symbiosis, 2022) (Figure 1).

The impact is significant. Each year, the symbiosis saves:

- 4 million m^3 of groundwater by substituting with surface water,
- 586,000 tonnes of CO_2 emissions,
- 62,000 tonnes of residual materials, which are recycled rather than wasted,
- Since 2015, CO_2 emissions within the industrial symbiosis have been reduced by 80%, and today the local energy supply is carbon neutral (Kalundborg Symbiosis, 2022).

By integrating methane fermentation into this ecosystem, Kalundborg Symbiosis demonstrates the real-world potential of circular bioeconomy models and serves as an inspiring example for other countries. It clearly demonstrates that methane and oth-



Symbiosis partners are connected by pipes supplying and exchanging resources

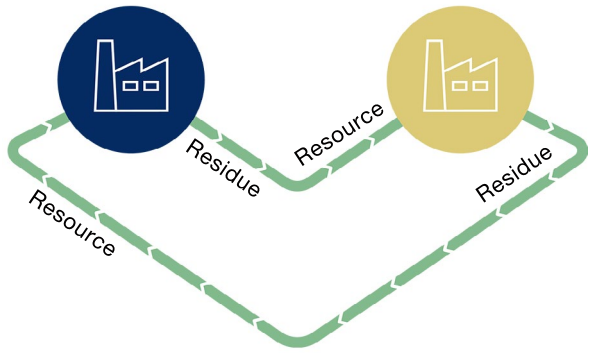


Figure 2. Illustration of the industrial symbiosis principle: Residues from one partner become valuable resources for another

Source: Kalundborg Symbiosis

er industrial side-streams can be effectively shared among partners and used as valuable inputs for protein production in global feed markets. In addition, collaboration between member companies reduces waste, prevents emissions, benefits the local community, and strengthens the competitiveness of the entire cluster. This synergy highlights an important point: The transition to circular systems cannot be achieved by one company alone. It requires collaboration across industries and sectors (Figure 2).

THE GLOBAL IMPACT OF INDUSTRIAL SYMBIOSIS ON FOOD SYSTEMS

The significance of the Kalundborg Symbiosis goes beyond Denmark or Europe. It speaks to a broader transformation underway in global food systems. The challenges with protein supply are global in scope, but so are the opportunities. Countries dependent on protein imports could benefit from local production of alternative proteins, reducing vulnerability to price swings and supply disruptions. Regions facing land or water scarcity could use methane fermentation to produce protein without competing with food crops, and industries seeking to decarbonize could derive new value from their emissions through circular bioeconomy applications (FAO, 2021; WEF, 2019).

LOOKING AHEAD: SCALING CIRCULAR PROTEIN SOLUTIONS

The potential of alternative proteins is vast, but realizing it requires scale, policy support, and continued innovation. Scaling production is essential: fermentation technologies need to be deployed at larger volumes and across more regions to make a meaningful impact on global protein supply. Policy and regulation also play a crucial role, as governments can accelerate adoption by supporting circular bioeconomy models, incentivizing methane capture, and creating clear regulatory pathways for novel proteins.

Simultaneously, market acceptance is key. Feed and food producers must be confident in the quality, safety, and cost-effectiveness of alternative proteins, and early partnerships will be critical in building trust. Beyond this, innovative ecosystems demonstrate how industrial collaboration can enhance efficiency and reduce emissions, and replicating these models in new contexts could unlock significant opportunities.

These approaches provide both inspiration and practical solutions as the global food system seeks sustainable growth.

CONCLUSION

The world needs to rethink protein production if it is to feed a growing population sustainably. Alternative proteins, grounded in circular bioeconomy principles, provide a powerful way forward. They reduce waste, improve resource efficiency, and create more resilient food systems.

One example is the integration of methane fermentation into industrial symbiosis networks, where emissions and byproducts from one industry become valuable resources for another. This approach demonstrates how collaboration and circular models can be brought to life in practice, turning challenges such as methane emissions into opportunities for sustainable food and feed production.

As demand for protein continues to grow and the world seeks climate-smart solutions, these innovations illustrate how technology, resource efficiency, and cross-sector partnerships can come together to deliver real impact. Alternative proteins are not a distant future. They are already here, reshaping global food systems for the better.

REVOLUTIONIZING FOOD SYSTEMS BY TURNING ORGANIC WASTE INTO HIGH-VALUE PROTEINS

Dr. Greg Wanger
Founder & CEO
Oberland Agriscience Inc.

"Commercial-scale black soldier fly larvae (BSFL) production transforms copious volumes of low-cost organic waste into high-value nutrition. In a short space of time, BSFL can flip a waste challenge into an economic opportunity. This waste-to-value method radically reduces feedstock input costs compared to conventional proteins, diminishing the risks associated with price volatility."

FROM WASTE TO VALUE

A quiet revolution is wriggling below the surface of our global food system, which is facing unprecedented challenges and significant economic pressure. Driven by a growing population and our increasing awareness of resource constraints, health, ethical, and environmental concerns, the demand for responsible, resilient protein sources is at the tipping point. Rising feed ingredient costs, regulatory complexities, and supply chain volatility threaten the stability of the animal feed, agriculture, aquaculture, and pet food industries. Traditional animal-derived protein sources are resource-intensive and financially unsteady. Health and environmentally conscious consumers are looking beyond traditional proteins, in search of solutions that align with their desire to address these concerns. This surge in demand is forcing livestock and pet food producers to seek out future-forward protein sources – such as insect-derived protein – as innovative solutions to the challenge of a crowded planet.

Black soldier fly larvae (BSFL) are widely recognised for their environmental benefits. However, it is the larvae's ability to valorize wastes and low-grade byproducts that deserve more recognition. Through low-cost feedstock, highly efficient nutrient conversion, and diversified product lines, the humble BSFL can have a lasting impact on local and global economic growth opportunities.

ECONOMIC PRESSURES ON TRADITIONAL PROTEIN PRODUCTION

The economic landscape for traditional protein sources has become ever more precarious. Conventional systems are failing to recognise the innovation and efficiency required to feed an increasing global population, which is expected to soar above nine billion by 2050. Agriculture faces considerable challenges when it comes to traditional protein production. Livestock farming is a significant contributor to greenhouse gas (GHG) emissions, with some peer reviewed studies estimating as high as 19.6% of global emissions annually. Land used for livestock farming requires massive amounts of water and energy, while contributing to deforestation. The overuse of antibiotics in animal feed is contributing to the rise of antibiotic-resistant microbes and patho-

gens which, when coupled with large headcount in confined spaces, leads to the swift spread of disease.

Aquaculture also faces economic and environmental pressure. Open-net pen fish farming leads to water pollution, disease, and parasite outbreaks. This pollution threatens already fragile aquatic ecosystems and fish farms are facing ever-growing pressures from local populations who want the farms removed. The aquaculture and agriculture feed industries rely heavily on wild forage fish stocks rendered into fishmeal and fish oil ingredients. Across our oceans these forage fisheries are reaching or have reached their sustainable limits, resulting in rapidly declining wild stocks. Governments around the world, including Canada, Norway, and the UK, have begun to recognize the problem and are setting strict limits on catch quotas for forage fish, such as mackerel, sardines, herring, anchovies, and menhaden. This scarcity creates economic insecurity, driving up ingredient prices and fueling uncertainty for feed producers.

The rise in consumer health awareness is not simply human-focused, it extends to our pets also. Historically, this sector has relied heavily on beef, lamb, chicken, and fish, all of which come at a high environmental cost, and exposure to fluctuating availability and price. Animal-based feed tends to be higher in saturated fat, which may contribute to pet obesity and other health problems, including allergies and intolerance to meat-based protein.

The search for an innovative, cost-effective solution is more than a fleeting trend. Collectively, these challenges are forcing the pet food, agriculture, and aquaculture feed industries to shift toward forward-thinking solutions to improve resource efficiency, reduce environmental impact, and drive economic prosperity.

BSFL: ECONOMIC AND NUTRITIONAL POWERHOUSE

By design, circular economies are more efficient, restorative systems. They seek to minimize environmental harm, while nurturing continued economic growth and resource resilience. For a circular economy to succeed, it needs to redirect wastes and by-products, revitalise natural ecosystems, and keep products and materials in use at their highest value for as long as possible.

There are several varieties of alternative protein sources available today:

- **Plant-based proteins**, such as pea or soy, are derived entirely from plant sources.
- **Cultivated proteins**, also known as cultivated meat, are real animal proteins produced by growing animal cells in a controlled, laboratory environment, independent of the living animal.
- **Fungi**, including yeasts, mushrooms, and molds, are organisms found on land, while microalgae are organisms found in freshwater and marine environments.
- **Insect protein** is derived from insects, such as black soldier fly larvae.

Alternative proteins, such as the BSFL, are uniquely equipped to reduce the environmental footprint of food production.

Photo: Courtesy of Oberland

BSFL have emerged as a compelling nutrient-rich protein source with wide-ranging uses in aquaculture, animal feed, and agriculture. This humble sub-tropical species lives only a few weeks, but during the larval stage, produces industrial scale efficiencies. The adult black soldier fly lives only a matter of days – to mate and start the next generation of larvae. A single female fly can lay up to 800 eggs. The larvae have an outstanding ability to convert low-value organic waste streams into high-quality nutrition for a wide variety of animals and fish.

BSFL also contain an abundance of essential amino acids, micronutrients, and rich fatty acids – properties that make them an obvious substitution to conventional proteins. Packed with a highly palatable and digestible protein, BSFL-derived nutrition can rival fish meal and outshine many plant-based proteins. The amino acid profile is well balanced, including impressive levels of lysine, valine, and leucine – all significant in supporting animal growth and immunity. The considerable fat content of BSFL not only provides a dense energy source, but also functional benefits. For example, lauric acid is recognized for its antimicrobial properties, supporting gut health. The presence of such beneficial medium-chain fatty acids helps make BSFL ideally suited to livestock, aquaculture, and pet nutrition.

SO, HOW DO BSFL FIT INTO A CIRCULAR ECONOMY?

Commercial-scale BSFL production transforms copious volumes of low-cost organic waste into high-value nutrition. In a short space of time, BSFL can flip a waste challenge into an economic opportunity. This waste-to-value method radically reduces feedstock input costs compared to conventional proteins, diminishing the risks associated with price volatility.

Located in Halifax, Nova Scotia, Canada, Oberland Agriscience collects organic food waste and by-products from local food and beverage production processes. The organic materials are fed to the larvae, who voraciously consume it in a matter of days. As the larvae feast and grow, they produce waste – known as frass – and heat. In the spirit of a truly circular economy, Oberland's closed loop approach captures the heat from the larvae to heat other parts of its facility, and the frass they produce

Photo: Courtesy of Oberland

is used as a valuable soil amendment from home gardens to large agricultural operations.

The fully grown larvae are harvested and processed into a wide variety of products – ranging from dried whole larvae used as pet and poultry treats to protein powder for incorporation into livestock and aquaculture feed, as well as frass used as a soil amendment. The versatility of BSFL-derived products creates multiple coexisting revenue streams.

Oberland uses energy efficient innovations to optimize BSFL nutrition, while also keeping our resource use and carbon outputs to a minimum, and reducing operating costs. Our facility leverages the heat generated by the larvae to provide domestic hot water and offset heating costs. The non-native fly demands a balmy 28°C to thrive, a challenge on Nova Scotia's coal-powered grid, especially during Nova Scotia's harsh winters. Over time, we will install solar arrays augmented with wind power to further reduce reliance on fossil energy consumption.

Oberland's 108,000-square-foot commercial facility can process 36,500 metric tonnes of waste per year. That's 100 metric tonnes of organic waste diverted from regional compost and landfill every day. The "waste" is transformed into 9,000 metric tonnes of wet protein and almost 10,000 metric tonnes of frass per year. We achieve this in a closed loop system that uses less land, water, and creates significantly fewer carbon emissions than traditional protein sources.

Once processed, our low-carbon footprint products are packaged and ready to ship to our customer base. This includes pet food manufacturers, poultry farms, aquaculture farms, as well as farmers and large-scale producers looking for chemical-free soil amendments for their arable land.

Transforming locally produced organic waste into high-value animal nutrition and soil amendments requires a dedicated, skilled team. Oberland's workforce benefits from specialized training, attracting nationwide talent and supporting local employment diversity.

A MODEL OF ECONOMIC AND ENVIRONMENTAL INTEGRATION

Oberland is a key connector in a network of innovative Nova Scotian companies collaborating to benefit the local economic and environmental backdrop. Our ecosystem is more than circular – it's a web economy, with byproducts from one process feeding the next. Each company mimics the natural order of things, where nothing goes to waste. We recycle, reuse, and valorize what would normally end up in landfill. One partner offers waste management services; they turn municipal solid waste, including difficult-to-recycle plastics, into new plastics and biomass pellets. While not currently approved for use as a feedstock, in the future this biomass could feed into Oberland's process supplementing the other organic wastes and byproducts from the food manufacturing industry. Oberland's animal nutrition and frass products then flow into local farms, including a land-based recirculating aquaculture farm producing Atlantic Salmon. Oberland's BSFL is combined with other ingredients to produce a pharmaceutical-free, nutrient-rich feed for the salmon in the tanks. The salmon farm recycles 100 percent of its water in a closed loop system, extracting the solid waste in the process. The fish waste, insect frass, and cellulose from the waste management company can be combined to create a rich fertiliser that returns organic matter to the soil, further reducing the regional reliance on chemical fertilizers.

Nova Scotia is a hub of innovation and collaboration. Other companies fit into the web at distinct stages of the process. This network builds resilience and trust into the food system by replacing outdated practices with a steady, sustainable source of food and economic growth. Each company is committed to transparency, measuring the total impact of production and collaboration, sharing the data internally and externally. Collectively, we believe there is a large opportunity for continued collective growth. The growth potential is enormous, from aquaculture and agriculture to the pet food industry.

Growth is not a straightforward path. There are challenges and opportunities to face along the way.


Photo: Courtesy of Oberland

Canadian food safety regulations allow the use of alternative proteins in animal feed. While BSFL-derived protein is recognised by the Canadian Food Inspection Agency (CFIA) the registration is slow, often taking years and inhibiting market entry and scaling potential in Canada. Oberland is committed to high-quality, transparent products that customers can trust. We believe that accelerated regulatory pathways are critical to leveraging capital and expanding market success, allowing Canada and other regions to benefit from the full economic benefits of BSFL.

ECONOMIC LEADERSHIP FOR OUR FUTURE FOOD SYSTEMS

The future of resilient proteins depends as much on economic viability as environmental sustainability. Highlighting the cost efficiencies, market opportunities, revenue diversification, and local job creation strengthens the business case, addressing criticism of a purely green narrative.

The food waste problem isn't going away and the cry for resilient food systems will continue to get louder. The team at Oberland is working to change the way our food systems work, building economic and environmental stability back into those systems. To maximise the benefits of circular economies, a coordinated effort across multiple sectors is needed sooner than later. Oberland's approach, and that of our Nova Scotian web economy, is vastly scalable and well-suited to many locations across North America. The economic impact of our model is exciting and achievable. To truly make such initiatives the norm, we need real commitment, investment, and leadership from local, regional, and federal governments in research and technology to forge a food system that is better for the planet, and economically viable and prosperous. Linking waste producers, protein manufacturers, farmers, policymakers, and researchers helps to ensure that circular economies function effectively and scale over time.

No country is immune to economic pitfalls of the looming protein crisis. Innovative collaborations in Canada's Maritimes demonstrate that a circular or web economy approach is a viable and scalable economic solution, marking a significant milestone on the road to regenerating our planet's food systems.

About Dr. Greg Wanger

With a Ph.D. in Geology and Environmental Microbiology, Dr. Greg Wanger is an experienced research scientist whose career milestones include five years at the NASA Jet Propulsion Lab, culminating in their optical organics mapper, SHERLOC, landing on Mars in February 2021 with the Perseverance Rover. In 2016, Greg and his family relocated to Halifax, Nova Scotia in Atlantic Canada. Shortly after, Dr. Wanger founded Oberland Agriscience Inc. out of his desire to address the escalating global protein shortage.

Combining a life-long passion for science and innovation with environmental activism, Dr. Wanger and his team are optimizing the black soldier fly to produce a premium, nutrient-rich, reliable protein for inclusion in aquafeed, pet food, and livestock feed.

INSECTS: THE MISSING LINK IN FEED CIRCULARITY

Salamahafifi Yusnaieny
Director
Protenga

"Tapping into wisdom from nature, we see the self-sustaining cycle of flora and fauna operating on a fundamentally circular blueprint. In any ecosystem, decaying organic matter is the starting point for new life. Nutrients are efficiently recaptured and redeployed to the soil by a system of microorganisms and animals, with insects playing a crucial role as master bioconverters."

HOW NATURE'S BIOCONVERTERS BRIDGE THE GAP, INDUSTRIALLY

Food waste is more than just a lost resource; it reflects the shortfalls of our food system. By learning from nature's circular blueprint, insects show us how nutrients can be recovered and turned into feed. The idea of insect farming takes this principle to deliver circular ingredients at commercial scale, consistently and profitably, for the feed industry.

PRESSURES ON THE MODERN FEED INDUSTRY

For every tonne of food eaten, another is wasted. This isn't just the statistics on food loss; it's the inevitable outcome of a linear supply chain by design. The water, land, energy, and complex feed formulations invested in our food are all discarded along with it.

Traditionally, the industry has treated these organic side-streams as a financial burden, a waste disposal problem to be managed. This reliance on a linear model creates mounting pressures. Ingredients like fishmeal and soy face volatile prices and growing scrutiny over their environmental footprint, exposing supply chain fragility. Simultaneously, consumers and regulators are demanding more sustainable and functional ingredients. This creates a critical need for a new generation of raw materials that are not only sustainable but also cost-efficient, consistent, and reliable at scale. The industry needs a solution that can bridge the gap between the rising demand for high-performance feed and the limitations of the current supply chain.

What if this "waste" wasn't an endpoint, but a new beginning waiting for the right technology? What if it could become the very fuel for the next generation of feed?

NATURE'S BLUEPRINT: INSECTS AS MASTER BIOCONVERTERS

Tapping into wisdom from nature, we see the self-sustaining cycle of flora and fauna operating on a fundamentally circular blueprint. In any ecosystem, decaying organic matter is the starting point for new life. Nutrients are efficiently recaptured and redeployed to the soil by a system of microorganisms and animals, with insects playing a crucial role as master bioconverters.

While many companies have gained insights from this observation and have tried to mimic the forests, current technologies fall short at industrial scales. Composting is slow and produces lower-value output. Anaerobic digestion can recover energy, but only at high cost. And unfortunately, the most 'practical' option remains still too often the least sustainable: landfill and incineration. Neither delivers the high-quality protein the feed industry needs.

The challenge is therefore not theoretical but practical: How do we take the nutrient recapture role of insects and turn it into an industrial process that is reliable, economical, and scalable?

DECENTRALISATION: BRINGING THE FARM TO THE WASTE

To industrialise this natural process, we must begin with the logic of the raw material itself. Unlike consolidated commodities like grain or soy, organic side-streams are wet, heavy, geographically scattered, and often spoil quickly. Transporting this low-value, high-volume material over long distances creates enormous costs in fuel, labour, and carbon, eroding the value we aim to create. The most effective strategy, therefore, is not to fight the distributed nature of this resource, but to embrace it.

This is why decentralisation has become a central idea in insect industrialisation. Medium-scale, modular systems allow insect conversion to happen closer to the source. What is transported is no longer low-value waste but stable, higher-value ingredients.

This approach also shifts the role of industry actors. Instead of a few central processors managing logistics, decentralised models invite orchestrators who coordinate many smaller nodes of farms and processors into a functioning network. Waste is valorised locally, ingredients are standardised through protocols and technology, and trade platforms connect supply with demand. In this way, insect farming resembles not just biology scaled up, but also an infrastructure for distributed nutrient recovery (Figure 1).

INGREDIENTS WITH A CIRCULAR STORY

The products that emerge from insect conversion are familiar to the feed sector: Protein, oil, fertiliser, but they carry with them a different story. They are not only functional ingredients, but embodiments of a system where waste is recaptured and revalued.

At Protenga, we've been working since 2016 to industrialise the Black Soldier Fly (BSF), one of nature's most efficient recyclers of organic matter through the Smart Insect Farm (SIF). We are leaders

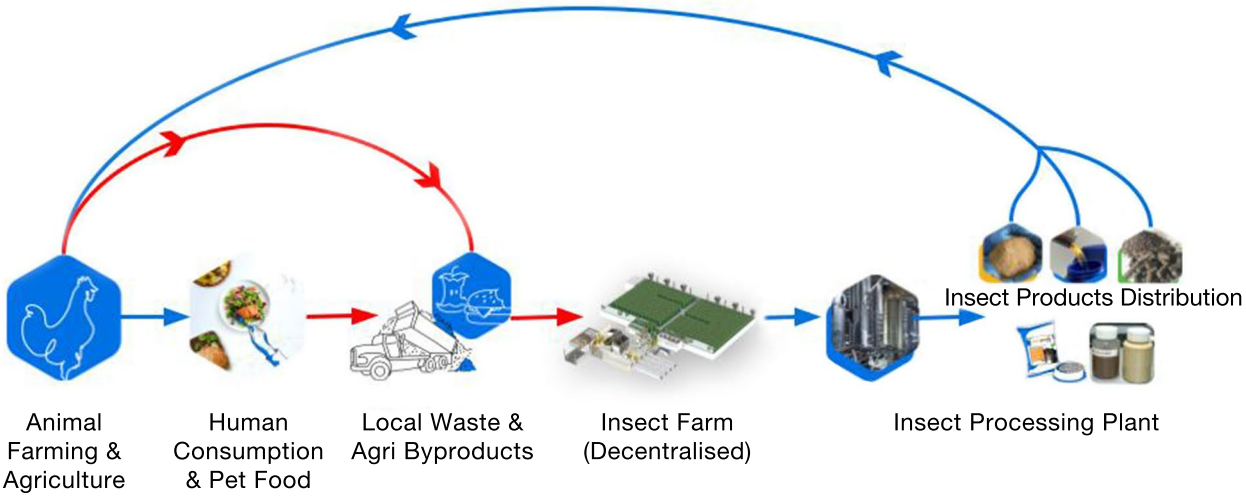


Figure 1. A decentralised approach: Local insect farms turn agricultural byproducts into valuable ingredients, feeding back into the food system

Source: Protenga

in upcycling waste streams from palm oil mills into valuable insect-based products:

• **Hermet Protein:** A high-quality protein that de-risks feed supply chains from reliance on volatile fishmeal. With stable amino acid profiles and digestibility, it offers a consistent and sustainable alternative for aquafeed and livestock formulations.

• **Cens+ Palatant:** A natural flavour enhancer derived from the BSF larvae, offering an alternative to chicken liver hydrolysates or synthetic additives. Its clean-label profile makes it particularly valuable in hypoallergenic and premium formulations, where conventional animal-based palatants may not be suitable.

• **Hermet Oil:** A functional lipid source rich in lauric acid that enhances palatability and energy in feed formulations.

• **Hermet Frass:** A nutrient-rich organic fertiliser that restores soil health, completing the circular economy loop and providing a sustainable alternative to chemical fertilisers and synthetic agri-inputs.

Through years of industrialisation, automation, and data-driven farming, we have built processes that move the biology from backyard compost bins to a predictable, scalable industrial platform. Our SIF is a modular, turnkey system that transforms 10 to 40 metric tonnes per day of organic byproducts into high-value insect protein, oil, and frass, close to the source.

This model creates dual value for feedstock suppliers and for animal feed producers. For palm oil mills, farms, and processors, side-streams like fruit sludges are bulky, wet, and costly to manage. For feed companies, the same model delivers a steady, predictable flow of insect ingredients. Because BSF larvae thrive on palm oil byproducts, the products offer stable and favourable amino acid profile, lipid quality, health-promoting effects and functional benefits. This consistency is critical for dependable, scalable inclusion in high-performing compound feed.

Operating on as little as 1500m² and only four operators, the SIF allows mills, farms, and processors to valorise their side-streams without needing large land footprints or specialised expertise. At its heart is InsectOS, our proprietary farm management software that de-risks insect farming. It enables remote monitoring, automation, and predictive health checks, turning a complex natural system into a stable, manageable process. This isn't just hardware; it's a whole Farming-as-a-Service model. We supply the BSF seedlings and data-driven protocols, and we guarantee buyback of the outputs. For our partners, their waste liability becomes a reliable new revenue stream.

TOWARDS A CIRCULAR FEED ECONOMY

The feed industry doesn't just need more raw materials; it needs smarter ones, ingredients with both sustainability and performance. With the Smart Insect Farm, agrifood waste is no longer a burden but the foundational building block for a new generation of nutrition.

Across Southeast Asia, this new paradigm is already unlocking value from agricultural byproducts, with palm oil standing out as the most scalable example. Palm oil is often framed as an environmental challenge, yet some of its side-streams are abundant and nutritionally suitable for BSF. We are already embedding these solutions into the mainstream. In collaboration with forward-looking industry partners, we have developed a steadily growing presence in commercial animal and aquafeed, bringing the value of insect ingredients in their regular production.

About Salamahafifi Yusnaieny

As a Director at Protenga (Malaysia), Salamahafifi Yusnaieny leads business development and drives new market opportunities. Her work focuses on opening pathways to deliver insect-based products and the Smart Insect Farm across the region to the wider feed and agriculture industry. She has been active in the sector since 2018 and served as Vice-President of the Asian Food and Feed Insect Association (AFFIA) from 2022 to 2023.

CLOSING THE LOOP: THE CIRCULAR POTENTIAL OF NOVEL INGREDIENTS

Aashish Khimasia
Director of Research
Centre for Feed Innovation

"Circular feed ingredients represent one of the most practical tools for improving the sustainability of animal feed. By valorising industrial by-products into nutritious inputs for livestock and aquaculture, they can help diversify supply chains and reduce over-reliance on conventional ingredients such as soy and fishmeal. Substantive progress will depend on supportive regulation, investment in infrastructure, and stronger collaboration between feed producers, innovators, and policymakers."

Feed supply chains in both livestock and aquaculture rely heavily on a small number of conventional ingredients, including soy and fishmeal. Whilst ingredients such as soy and fishmeal have delivered efficient and highly nutritious sources of protein for decades, reliance on a narrow set of inputs exposes feed supply chains to environmental and market risks. For example, climate change is altering weather patterns, with droughts and shifts in ocean conditions reducing crop yields and fish stocks. Meanwhile, cyclical events, such as El Niño, are intensifying these challenges by simultaneously disrupting both agriculture and fisheries. Overfishing is leading to resource depletion, and large-scale soy production has been linked to biodiversity loss. Furthermore, trade disputes, tariffs, and transportation bottlenecks are contributing to volatility in global markets.

In response, the feed sector is increasingly exploring the adoption of novel ingredients to diversify inputs and enhance the circularity of feed production. These novel ingredients, many of which can be produced using industrial by-products, including agricultural waste, processing effluents or landfill biogas, offer a promising solution to reduce dependency on environmentally intensive or volatile inputs, while helping producers improve their climate and biodiversity performance.

WHAT ARE CIRCULAR FEED INGREDIENTS?

The utilisation of waste is already a well-established practice within feed production. Brewers' spent grains, a major by-product of beer production, are commonly repurposed as a nutrient-rich ingredient in livestock feed. In addition, swill feeding is a practised approach in East Asia, where regulated frameworks support the large-scale conversion of post-consumer food waste into pig feed.

Novel feed technologies are emerging ingredients that offer the potential to further expand the range of sidestreams valorised for animal feed, using more heavily underutilised waste streams, including industrial by-products, emissions, and processing res-

idues. Through fermentation, enzymatic hydrolysis, pyrolysis and other bioprocessing methods, industrial side-streams can be converted into high-value nutrition for livestock production and aquaculture. Rather than drawing on new land or ocean resources, they close the loop by transforming existing outputs into proteins, oils, and functional additives that can be incorporated into animal feed.

WHAT ARE THE POTENTIAL CIRCULAR FEED SOLUTIONS?

Single-cell proteins (SCPs)

Single-cell proteins are ingredients produced by cultivating microbes, including bacteria, yeasts, or microalgae, on carbon-rich feedstocks. They can be processed to generate concentrated protein meals with balanced amino acids, or oils rich in omega-3 fatty acids, and are positioned as partial replacements for fishmeal and fish oil in diets for salmon and shrimp. Use cases are also emerging in piglet feeds and in pet food. In principle, SCPs can be cultivated on a wide range of side-streams, including waste gases such as biogenic methane, nutrient-rich wastewaters such as aquaculture effluents, lignocellulosic biomass such as woody agricultural residues, and food industry by-products like whey permeate.

Circularity is already being demonstrated through several established pathways. Yeast SCPs produced on whey from cheese manufacturing and on molasses from sugar refining are already widely incorporated into animal feeds, demonstrating well-established circular pathways. Distillery residues are also being commercialised as substrates for cultivating microalgae rich in omega-3s, showing how nutrient-dense side streams can be upgraded into high-value ingredients, though adoption remains at an earlier stage. In parallel, bacterial SCPs produced on natural gas are entering commercial markets, where natural gas could eventually be replaced by biogenic methane as the feedstock. Research is also exploring additional lower-value substrates with greater circularity potential, including lignocellulosic residues, aquaculture effluents, and other nutrient-rich wastewaters. These approaches remain experimental but illustrate the scope for SCPs to redirect heavily underutilised outputs back into the food system.

Regulatory frameworks are adapting, with approvals in the EU, US, and Japan showing that microbial proteins can be authorised when substrates are clearly defined and demonstrably safe. However, commercial production is concentrated on relatively clean co-products such as whey and molasses, or on defined inputs such as natural gas. Expanding the use of underutilised waste streams such as industrial effluents and wastewaters will require regulatory adaptation, new infrastructure to link residues with fermentation plants, and further cost reductions in large-scale bioprocessing.

Photo: Freepik


Photo: TaraPatta | Shutterstock

As a circular solution, SCPs are among the most advanced options available today. They already demonstrate how industrial by-products can be redirected into high-value ingredients, while offering clear scope for expansion as new substrates are approved and technologies mature. With supportive regulation, improved logistics, and ongoing cost reductions, SCPs are well placed to make a significant contribution to a more circular feed system.

Protein hydrolysates

Protein hydrolysates are produced by using enzymes to break down animal and plant by-products into functional feed ingredients. Protein hydrolysates help valorise trimmings from fish processing, poultry offcuts, and cereal processing residues. This process extends the utility of existing nutrient resources within the food system by improving the digestibility of by-products while increasing the bioavailability of peptides and amino acids.

The circular production of hydrolysates is well established. Hydrolysates derived from fish trimmings are widely incorporated into salmon aquafeeds and early-life diets, where they improve palatability and growth. Poultry and fish by-products are also widely processed into protein hydrolysates for use in piglet and pet diets, while cereal residues can be converted into soluble proteins or functional protein extracts for livestock feed. The market for hydrolysates is concentrated in early-life and high-value feeds, where the nutritional and functional benefits justify their price premium. Although production is relatively small on a global scale, it is commercially stable and widely incorporated into aquafeeds. Constraints are mainly linked to feedstock availability and logistics, as suitable inputs for hydrolysis are finite and have other commercial uses.

As a circular solution, protein hydrolysates illustrate how existing side streams can be upgraded into higher-value ingredients in a technically mature and commercially proven way. Their overall contribution remains limited by the finite availability of suitable feedstocks, but within these constraints, they remain a dependable pathway for making animal feed more sustainable.

Insect proteins

Insect proteins are mainly produced from the black soldier fly larvae or mealworms. They are reared on organic substrates and then processed into protein meals and oils for use in animal diets. By converting organic residues into protein and lipids, this process has the potential to revalue waste products into feed ingredients.

The circularity potential of insect ingredients remains constrained by regulatory limits on approved feedstocks. In key markets such as the EU and US, the use of post-consumer waste and animal by-products is prohibited in insect farming due to food safety concerns. As a result, producers rely on cleaner inputs such as bakery waste, fruit and vegetable trimmings, and cereal by-products, as well as crops and feed materials that compete with other uses in livestock feed, pet food, and bioenergy. Despite these restrictions, several early commercial production facilities have been established, demonstrating some progress beyond the pilot stage. However, high capital costs and reliance on relatively expensive substrates continue to limit profitability and restrict the volume of commercially available product.

The promise of insect proteins as a circular solution is based on strong principles, but continues to face challenges in implementing circularity and reaching commercial scale. The insect farming industry is still in its early stages, with companies actively testing various production scales and refining indoor farming technologies to identify viable and efficient business models. The industry will have to overcome its challenges in sourcing circular feedstocks and achieving regulatory acceptance of underutilised waste streams in key markets before production volumes can increase.

Biochar feed additive

Biochar is a carbon-rich material produced by pyrolysing (i.e., heating without oxygen) biomass such as crop residues, forestry by-products, or food waste. When included in small amounts in animal diets, early studies suggest it may influence gut function, reduce methane emissions in ruminants, and alter nutrient cycling. These effects can also improve manure quality, lowering ammonia emissions and enhancing soil fertility when the manure is applied as fertiliser. Biochar's circularity potential lies in converting waste biomass into a feed additive while creating co-benefits for both livestock systems and soils.

The commercial adoption of biochar remains in its early stages and is currently limited to trials and niche markets. In experimental settings, the use of biochar has yielded inconsistent results for both animal performance and environmental outcomes. Regulatory approval is also still evolving. For biochar to be deployed more widely in feed, updated safety and efficacy standards are needed.

As a circular solution, biochar illustrates an intriguing pathway to link waste management, livestock production, and soil health. Its role in feed remains experimental, with inconsistent evidence and evolving regulation limiting broader uptake. Realising its potential will require a stronger evidence base and a clear demonstration of benefits at a commercial scale.

NOVEL INGREDIENTS CAN HELP CLOSE THE LOOP IN FEED

Circular feed ingredients represent one of the most practical tools for improving the sustainability of animal feed. By valorising industrial by-products into nutritious inputs for livestock and aquaculture, they can help diversify supply chains and reduce over-reliance on conventional ingredients such as soy and fishmeal. Substantive progress will depend on supportive regulation, investment in infrastructure, and stronger collaboration between feed producers, innovators, and policymakers.

At the Centre for Feed Innovation, we believe the sector's priority should be to advance feed solutions that combine circularity with commercial viability. By directing support toward approaches that can scale safely and sustainably, the feed industry can strengthen resilience, reduce environmental impact, and deliver on the promise of closing the loop in livestock and aquaculture nutrition.

The Centre for Feed Innovation is a think tank dedicated to advancing novel feed ingredients. We work with companies, policymakers, and investors to identify commercially viable pathways, de-risk innovation, and accelerate adoption. We will continue to provide analysis and insights on how circular feed ingredients can contribute to more resilient and sustainable food supply chains.

About Aashish Khimasia

Aashish Khimasia is Director of Research at the Centre for Feed Innovation (CFI), a think tank dedicated to accelerating the transition toward sustainable, scalable and safe animal feed. Khimasia leads CFI's research agenda on novel feed ingredients, in collaboration with academics & industry, bridging technical, regulatory, and investment perspectives to help support the scaling of new solutions from pilot to market.

Black Soldier Fly: **ENVIRONMENTAL ENGINEER FOR SUSTAINABLE AGRI-FOOD SYSTEMS**

Dr. Solomie Gebrezgabher
Senior Researcher
International Water Management Institute (IWMI)

"Soybeans demand vast amounts of land and water, and their cultivation often relies on intensive monoculture farming that depletes soils and reduces biodiversity. Prices of soybeans and fishmeal have also soared, leaving farmers paying far more to raise animals to market size. For farmers in developing countries in particular, this volatility makes traditional feed sources increasingly unaffordable and unsustainable."

In a village in Kisumu County, Kenya, chicken farmers have found an unlikely ally: Flies and their squirmy larvae. At first, one farmer wouldn't dare touch the wriggling critters as they devoured piles of organic waste. She was frightened by their appearance. But that fear quickly faded once she discovered how useful they were—not only harmless, but a healthy, affordable feed for her chickens. "Even the chickens love them," she says with a smile. "They eat them at a high speed."

A FOOD SYSTEM UNDER STRAIN

Her experience speaks to a much bigger story. Food systems around the world are under strain. Farmers face rising costs for fertilizer and animal feed. Land and water are becoming scarcer. At the same time, unsustainable farming practices and heavy use of chemicals are degrading soils, harming biodiversity, and polluting water. Food loss and waste occur across the entire value chain, with some estimates suggesting that almost 30% of food produced never reaches consumers. This waste generates billions of tonnes of greenhouse gas emissions each year. Meanwhile, the global population is growing, and demand for meat, milk, and fish is expected to rise by up to 70% by 2050—with much of this heightened demand expected to be in developing countries. This places even greater pressure on feed supplies and makes finding sustainable, affordable solutions more urgent than ever. The humble black soldier fly is emerging as an innovative, circular solution that can help solve many of these challenges by turning waste into food security.

Soybeans and fishmeal are major protein sources for animal feed production. Around 85% of the world's soybeans are processed into animal feed, while more than 20% of all fish caught globally are processed into fishmeal for pigs, poultry, cattle, and farmed fish. This is becoming increasingly unsustainable. Soybeans demand vast amounts of land and water, and their cultivation often relies on intensive monoculture farming that depletes soils and reduces biodiversity. Prices of soybeans and fishmeal have also soared, leaving farmers paying far more to

raise animals to market size. For farmers in developing countries in particular, this volatility makes traditional feed sources increasingly unaffordable and unsustainable.

TURNING WASTE INTO FEED

Black soldier fly (BSF) farming is a promising alternative. It's a low-cost, environmentally friendly source of protein at a time when farmers are confronted with rising feed and agricultural input prices. The larvae's protein content rivals or even surpasses the traditional sources like fishmeal and soybeans. The BSF larvae can cope with a wide range of environmental conditions and the adult fly does not spread disease.

What makes BSF especially powerful is its ability to turn waste into value using low-cost technologies, which can be produced on-farm or near farming communities. The larvae can feed on a wide variety of organic materials, including food scraps and market waste which are produced in huge volumes in urban and peri-urban areas. As they consume this waste, the larvae grow into protein-rich biomass while leaving behind a nutrient-rich residue. The larvae can then be processed into feed for poultry, fish, and pigs, while the residue serves as a valuable soil conditioner.

This adaptability and dual benefit—reducing waste while producing affordable animal feed—makes BSF one of the most promising circular solutions for developing countries. It tackles two urgent challenges at once: the rising cost of animal feed and the mounting problem of organic waste.

CAN BSF FARMING PAY OFF?

Insights from Kenya's BSF Enterprises

Across Kenya, a quiet insect revolution is taking shape. From Kirinyaga to Nakuru, 14 BSF enterprises are proving that BSF farming can be both profitable and sustainable. These insights come from a financial feasibility study conducted by the International Water Management Institute (IWMI) under CGIAR's Multifunctional Landscape (MFL) Science Program, which analyzed BSF operations across five counties in central, eastern, and Rift Valley Kenya.

The enterprises vary in scale—small and medium producers process under 15 tonnes of waste a year, while large-scale farms handle up to 700 tonnes. Yet all share a common goal: transforming organic waste into high-value animal feed and fertilizer.

From Waste to Value

Most enterprises rely on locally available organic waste—market waste, kitchen leftovers, and vegetable farm residues—used by nearly two-thirds of the surveyed farms. Others source from slaughterhouses and hotels. The BSF larvae feed on this waste, reducing its volume while producing nutrient-rich protein and frass (Figure 1).

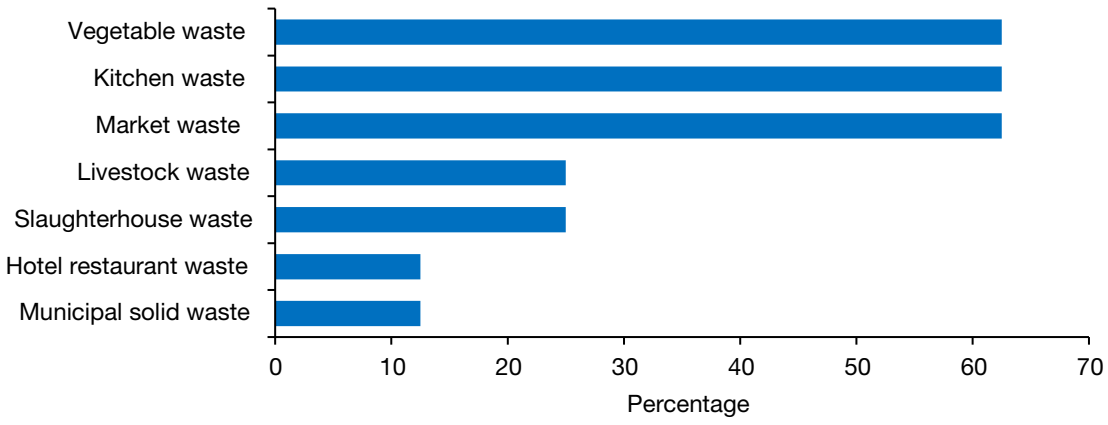


Figure 1. Feedstock used for feeding BSF larvae

Larger farms benefit from economies of scale. The IWMI study found that while small and medium enterprises invested about 17 Kenyan shillings (Ksh), or US$ 0.16 per kilogram of waste treated, large-scale ones managed at Ksh 9.76 (US$ 0.09) per kilogram. Most rely on simple, low-tech setups—manual sorting, basic tools, and often family-owned land. This keeps start-up costs relatively low.

Profits in the Process

Despite modest infrastructure, BSF farms in Kenya are turning solid profits. Labor makes up the bulk of operational costs (63–96%) due to the manual nature of processing, but gross margins often exceed 70%, regardless of scale.

Enterprises generate income from several BSF products:

- **Eggs** – sold at up to Ksh 200,000 (US$ 1,625) per kilogram to new BSF producers.
- **Larvae** – a protein-rich animal feed ingredient sold for Ksh 150–250 (US$ 1.2–2) per kilogram.
- **Frass** – the nutrient-rich residue used as fertilizer, sold for Ksh 50–60 (US$ 0.40 - 0.49) per kilogram.

Many enterprises also diversify by offering training and starter kits to aspiring BSF farmers, creating both additional income and local capacity. Training sessions cost between Ksh 1,000 and 2,500 (US$ 8–20) per person, attracting up to 200 participants each year.

A YOUTH STORY: FROM CHURCH WALLS TO CIRCULAR ECONOMY

One such enterprise is AderoFarms Karateng' Ltd., a youth-led agribusiness in Kisumu County. Founder Christopher Adero Okeyo said, "We began inside an incomplete church building, not because it was ideal—but because it was all we had. At the time, we couldn't afford the expensive BSF infrastructure. What we did have was a dream: to build a circular economy model that turns waste into value and empowers communities."

Today, AderoFarms processes over 4 tonnes of food waste weekly, collected from local markets and hotels. Since 2024, the enterprise trained more than 1,300 farmers—with a strong focus on youth, women, and persons with disabilities—on

Photo: AderoFarms Karateng' Ltd.

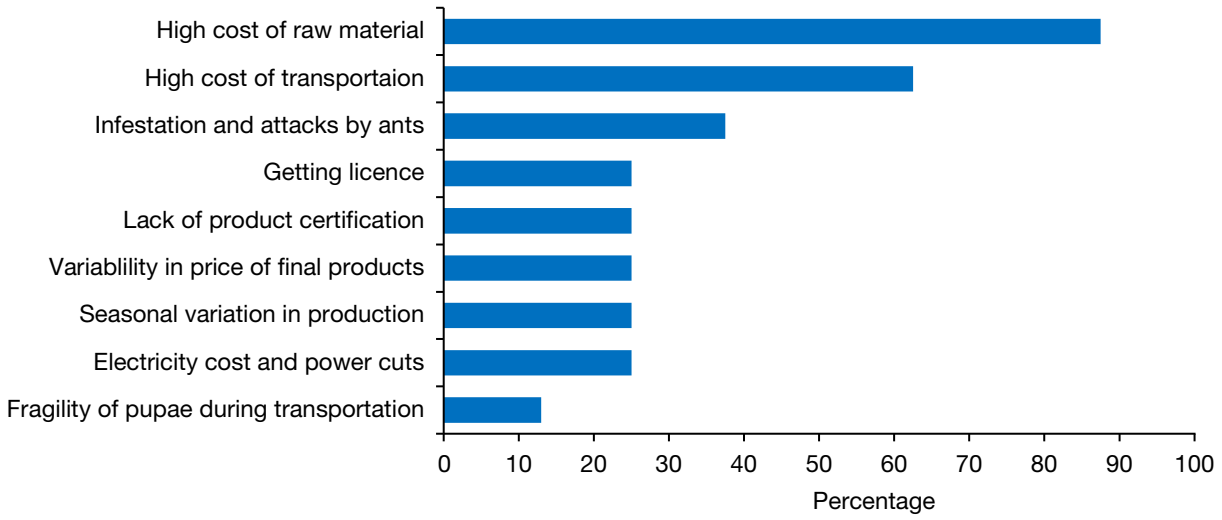


Figure 2. Percentage of BSF enterprises reporting risk factors in Kenya

BSF farming and entrepreneurship. Their products include BSF eggs (US$ 0.32) per gram for companies managing waste in hotels and parks, larvae (US$ 2.8) per pack for community farmers, pupae (US$ 7.2) per kilogram for startup BSF farms, and frass (US$ 0.4) per kilogram for vegetable growers and nurseries.

RISKS FACED BY BSF ENTERPRISES

The IWMI study also highlighted key risks. Rising competition for organic waste was cited by 88% of enterprises, while transportation costs—especially for fragile pupae—were a concern for over 60%. Infestations by houseflies and ants, limited product certification, and market monopolization by a few large players pose additional challenges. Some farmers also hesitate to adopt BSF products, confusing the larvae with housefly maggots or underestimating the value of frass as fertilizer (Figure 2).

FROM FEASIBILITY TO COMMUNITY INNOVATION

Building on the feasibility study findings, IWMI, in collaboration with Kisumu community, established a community-run BSF plant that processes up to 40 tons of organic waste annually. Operating since 2024, the plant doubles as a training hub for over 100 farmers, turning organic waste into high-quality feed and fertilizer. The initiative exemplifies how science-based insights can evolve into community-driven circular economy solutions. Dr. Noah Adamtey, Senior Researcher and Resource Recovery Expert at IWMI, describes BSF as "*environmental engineers*" whose benefits span food, nutrition, and even pharmaceutical applications.

BUILDING A CIRCULAR FUTURE

From small youth-led startups to community-scale models, BSF farming in Kenya is proving both financially viable and socially transformative. With continued investment, knowledge sharing, and supportive policies, the humble BSF could become a cornerstone of sustainable, circular agri-food systems across Africa.

About Dr. Solomie Gebrezgabher

With over ten years of experience in research and project implementation focused on advancing circular bioeconomy solutions for economic, social, and environmental sustainability in developing countries, Dr. Solomie Gebrezgabher's work focuses on the economics of resource recovery, business model innovation, and entrepreneurship in circular systems. She has led and contributed to numerous projects across multiple countries, driving research, capacity building, and the scaling of circular bioeconomy solutions in diverse contexts.

BLACK SOLDIER FLY FARMING: **A GREENER FUTURE FOR SUSTAINABLE FEED**

Lars-Henrik Lau Heckmann
Head Of Business Development
Better Insect Solutions

"Feed for the larvae emerged as the most significant contributor to emissions, but also the area with the greatest potential for improvement. Farms using organic waste streams like potato pulp dramatically reduced their carbon and water footprints. According to the GHG protocol, true waste materials carry zero upstream carbon burden, making them ideal for sustainable feed."

In the heart of Central Europe, a quiet revolution is taking place in the world of sustainable agriculture. Black Soldier Fly (BSF) farming, once a niche concept, is now emerging as a powerful solution to the environmental challenges of traditional livestock feed production. A recent study conducted by Better Insect Solutions in collaboration with FarmInsect sheds light on the carbon and water footprints of BSF farming - and the results are promising.

FARMING INSECTS, NOT EMISSIONS

The study analyzed three operational BSF farms each producing between 400 and 1,000 tons of live larvae annually. These larvae are used in livestock and pet food, offering a protein-rich alternative to conventional feed sources. The study focused on the "fattening stage" of BSF larvae, where young individuals are grown into harvest-ready larvae – similar to broiler chicken production.

What makes BSF farming stand out is its low carbon footprint. All three farms reported emissions below 1 ton of CO_2 equivalent per ton of fresh BSF larvae produced. In fact, when benchmarked against broiler farming, BSF production showed up to 40% lower emissions. This is a game-changer for the feed industry, which is under increasing pressure to reduce its environmental impact as well as remaining cost-effective.

FEED AND FRASS: THE TWIN PILLARS OF SUSTAINABILITY

Feed for the larvae emerged as the most significant contributor to emissions, but also the area with the greatest potential for improvement. Farms using organic waste streams like potato pulp dramatically reduced their carbon and water footprints. According to the GHG protocol, true waste materials carry zero upstream carbon burden, making them ideal for sustainable feed.

Then there's frass, the nutrient-rich by-product of BSF farming that can be valorized as a fertilizer and used in biogas facilities. One farm uses 25% of its frass to generate energy, while another farm is experimenting with natural drying methods to hygienize frass for agricultural use. These innova-

tions not only add economic value but also shift emissions away from the primary product, further improving the sustainability profile of BSF farming.

WATER USE: LESS IS MORE

Water consumption is another area where BSF farming shines. The study tracked blue (surface/groundwater), green (rainwater), and grey (polluted) water usage. Two farms consumed around 10,000 liters of blue water per batch, while the farm using potato pulp, relied heavily on green water which is considered more sustainable. Compared to traditional livestock, BSF larvae require approximately 2,700 m^3 per ton which is significantly less water than required for other livestock. This is roughly 1.5-5 times higher than the water consumption required for producing a ton of fresh soybeans or industrial fish for fishmeal; however, the water used for BSF farming can predominantly (70-90%) be provided as green water.

HEATING SMARTER

Heating is the second-largest source of emissions in BSF farming. Farms using fossil fuels like LNG recorded higher emissions, while those using biomass or wood chips fared better. For instance, one of the farms could reduce its heating emissions by 43% through the installation of a heat recovery system saving 187 MWh of energy annually.

A BLUEPRINT FOR THE FUTURE

As the insect farming sector continues to grow, data-driven insights like these will be crucial for guiding policy, investment, and innovation. A recent life cycle assessment study commissioned by Department for Environmental Food & Rural Affairs (DEFRA) in the UK, raised concerns that insect protein meal could be up to 13.5 times worse for the climate than soy and up to 4.2 times worse than fishmeal (reference: Life Cycle Assessment of UK Insect Protein Production Processes for Pig and Poultry Feed - SCF0235). Our farm-level assessment presents a more grounded and optimistic view. The UK report relied heavily on cradle-to-gate modeling and included scenarios using high-impact feedstocks like traditional feed, which may not reflect best practices in commercial insect farming. In contrast, this study draws on real-world production data from three operational BSF farms in Germany, each employing practical sustainability strategies such as biomass heating, frass valorization, and organic waste feed integration. These farms demon-

Photo: Better Insect Solutions

Photo: Better Insect Solutions

strated carbon footprints below 1 ton CO_2e per ton of fresh BSF larvae, which is at the low end of the scale for an animal-based product used for feed and petfood. By focusing on actual production conditions and scalable waste management solutions, the findings offer a more nuanced and actionable blueprint for sustainable insect farming, bridging the gap between theoretical modeling and industrial reality.

WASTE MANAGEMENT AS PART OF THE SOLUTION

This study offers more than just numbers—it provides a roadmap for making insect farming a cornerstone of sustainable agriculture. But beyond feed optimization and energy efficiency, one of the most transformative opportunities lies in waste management. By upcycling food waste and agricultural residues into high-value protein and fertilizer, these insects act as natural decomposers reducing landfill volumes and preventing methane emissions. This isn't just sustainability; it's circular economy in action. Furthermore, when applying waste streams as main feedstock for insect farming this will also enable compliance with the EU Deforestation Regulation (EUDR).

To support the continued growth of the insect farming sector, it is pivotal to integrate waste valorization into its core operations. At present EU legislation is holding back on fully leveraging this potential. Whether it's through frass-to-fertilizer innovations or full-scale organic waste conversion, BSF farming is poised to become a dual-purpose solution: providing nutrition for animal and plant production through upcycling waste streams in our food system.

About Lars-Henrik Lau Heckmann

As a business development leader, Lars-Henrik Lau Heckmann has a strong focus on innovation, strategic partnerships, and portfolio growth. At Better Insect Solutions, he drives initiatives across product development, R&D, marketing, and stakeholder engagement. With a background in biology and insect farming, he combines scientific expertise with commercial insight, shaped by leadership roles in biotech and applied research. His business acumen is supported by executive education from institutions like Harvard Business School. He has helped shape the insect-based feed and food industry over the last 10 years and contributed to regulatory progress through active involvement in international platforms such as IPIFF.

CAN INSECT PROTEIN BE CIRCULAR WITHOUT COMPROMISING?

Francis Maugère
Insects Political Adviser
Eurogroup for Animals

"Circularity may be the latest buzzword to find purpose in an insect farming industry that has given up on having a transformative effect on food systems, yet, under scrutiny, the use of food waste appears more counterproductive than anything. Any sustainability or economic gain made by feeding insects on food waste fails to make insect protein a competitive and environmentally beneficial alternative to animal feed or pet food. Besides, the food safety and animal welfare risks surrounding insect farming are exacerbated when relying on true waste streams."

As the European Union is striving to develop its circular economy, insect farming is often presented as an innovative solution that can reconcile food waste management and protein production. Beyond the buzz, can insect farming really deliver on circularity without compromising on quality, safety, competitiveness, and welfare?

CIRCULARITY AS A LAST RESORT

Industrial insect farming is starting to soar in Europe. Initially touted as a 'sustainable' form of agriculture by comparison with other livestock systems, it is now clear that insect farming is essentially about insects being used as feed for animals. This growing industry is predominantly driven by a need to feed other farm animals reared in intensive systems or, as long as this remains unprofitable, to enter premium pet food formulas.

The claim that farming insects pollutes less than producing cow meat fails to consider the bigger picture. What is the true cost of using insects to replace soymeal, fishmeal, or pet food ingredients?

Insect farming is an additional step in the food chain, feeding on crops, vegetables or feed-grade by-products and taking their place in the diet of farmed and companion animals. Essentially, it upholds an already unsustainable status quo.

In its current form, insect farming makes food systems lengthier, and is not circular at all. It comes as no surprise that its environmental impact is higher than most pet food ingredients (including animal by-products), and up to 13.5 times higher than soybean (4.2 times higher than fishmeal) (Ricardo Ltd., 2024, see Figure 2).

This reality, combined with the industry's economic difficulties, has led many to question the purpose of the sector. Some insect businesses and representatives have come up with propositions that

Figure 1

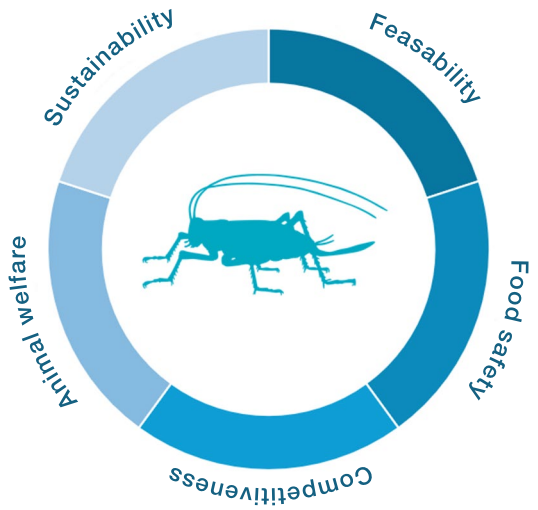


Chart by Eurogroup for Animals

claim to make insect farming *really circular*: Allowing "true" waste streams to be fed to insects, and better valorising a by-product of insect protein production, "frass", as a fertiliser (Figure 1).

CAN INSECTS AS ANIMAL FEED BRING SUSTAINABILITY BENEFITS?

It is unquestionable that food waste is a key concern of our food systems, with one quarter of the food produced for human consumption being wasted. It would however be foolish to think that all of it can be upcycled through insect farming, without compromising on food safety, costs, and animal welfare.

It would make little sense for insects to be fed the meat and fish co-products that are already used directly as pet food, given to farm animals, or utilised for composting or in other economic sectors. Incidentally, the properties that make a substrate useful or desirable for insect production are often the same that make them useful or desirable for other industries (Roffeis et al., 2020). A 2025 study of waste-to-nutrition pathways in France highlighted the limits of feeding waste to insects and concluded that feeding livestock with suitable organic waste was actually much more efficient to reduce the environmental impact of food systems (Javourez et al., 2025).

The most comprehensive life cycle analysis of insect protein production, commissioned by the UK government, compared insect meal from grain-fed, manure-fed, and waste-fed insects against soybean and fishmeal (see Figure 2). It found the climate impact of waste-fed insects to still be 1.8 times higher than fishmeal, and 5.7 times higher than soybean (and performing worse than soybean on 15 environmental metrics out of 16). Even fed with waste, insect feed would still be worse for the environment than what the industry seeks to replace at the moment.

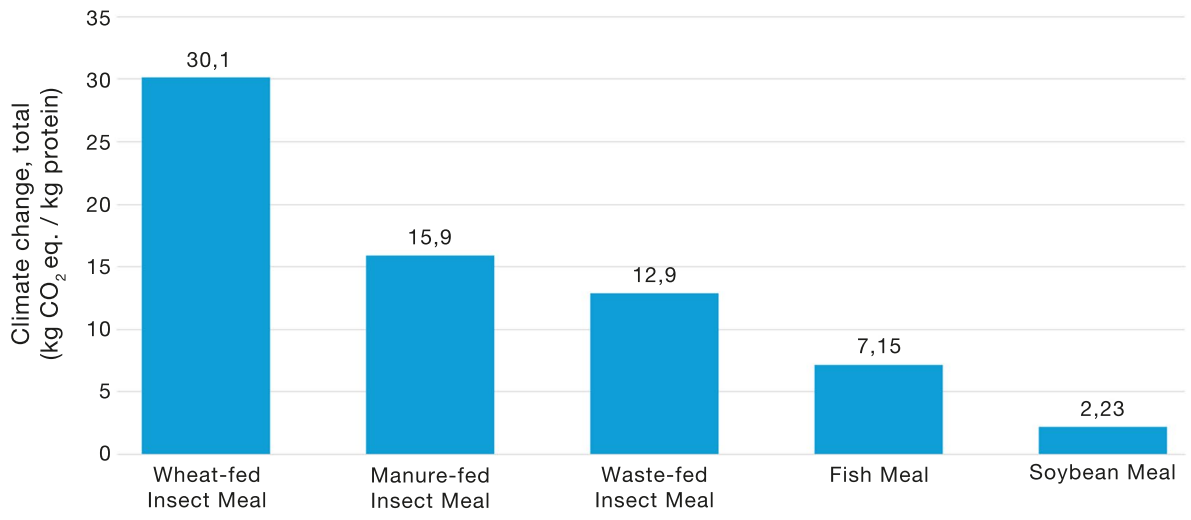


Figure 2. Climate change impact of insect meal, fish meal and soybean meal
Data from Ricardo Ltd., "Life Cycle Assessment of UK Insect Protein Production Processes for Pig and Poultry Feed" (2024)

Looking towards insect frass, a co-product of insect farming, also praised for its circularity potential, its environmental profile is unclear. The same UK government-commissioned study concluded that *"further research needs to be conducted to assess both efficacy and environmental risk"* due to a general paucity of data on this recently developed product. Some studies also suggest that frass from Black Soldier Fly larvae grown on food waste can hinder the growth of maize, contribute to excessive nitrite accumulation, and thus present little environmental benefits (Alattar et al., 2016; Watson et al., 2021).

FOOD SAFETY IN CIRCULAR ANIMAL FARMING

Intensive forms of animal farming are notoriously a leading cause of food safety problems, and there is no reason to believe that insect farming is an exception. With thousands, if not tens of thousands, of highly selected and homogenous individuals crammed in a limited space, insect farms are health liabilities. A 2019 study of insect farms in Germany and Central European countries detected parasites in 81% of examined facilities, with 35% of them infectious for animals and 30% for humans (Gałęcki and Sokoł, 2019).

Channeling waste streams (particularly meat waste streams) in animal farming has led to some of the worst animal diseases in history, like the BSE (Bovine spongiform encephalopathy). While early research suggests insects may be at lower risk of transmitting BSE-causing prions, they can still accumulate and transmit pathogenic elements from the feed they are given. Even the Black Soldier Fly, reputed for its ability to process some waste, can accumulate heavy metals present in the substrate at high level (Diener et al. 2015).

Currently, nine species of insects are allowed to be farmed at EU level, and insects reared in the same farm may be destined for human, farm animal, or pet consumption. While one insect species might be able to safely process one type of food waste, another may not, and the utmost care needs to be applied to safely trace the origin and content of waste streams, and the end use of the insects that will be fed upon them. There is no one size fits all.

Insects being natural vectors of pathogens, the highest level of caution needs to be taken before considering feeding them food waste, and only a careful evaluation of the safety of each waste stream for each species could prevent insect farming to replicate the animal diseases that regularly plague animal farming.

DO INSECT PRODUCERS CARE ABOUT WASTE AT ALL?

Using food waste would lead to several trade-offs when it comes to the consistency of insect farming end products. While a regular stream of feed-grade by-products is quite easy to channel to an insect farm, waste streams will differ in form, quality, and availability throughout the year, threatening the reliability of the insect supply chain. In addition, the ability of an insect to survive on food waste is not equivalent to its ability to deliver high-quality and cost-effective products. The nutritional quality of the substrate given will not only impact the nutritional profile of the end product, but also the life cycle of the animal.

If it takes a Black Soldier Fly 10 days to reach the appropriate larva stage when fed high-quality feed, it can take 35 days if it is fed potato peel, and even longer on inconsistent waste streams. This extra time induces energy and labor costs that can offset any production gains made elsewhere. It comes as no surprise that most major producers have been careful not to embrace inconsistent waste streams, even those that are authorised at the moment. It has also been admitted by industry players that it is extremely difficult to harness waste streams due to their high variability, referring to the example of AgriProtein, the former market leader having gone bankrupt after its failed attempt to scale up using waste (Biteau et al. 2024).

ECONOMICS OF USING FOOD WASTE

The idea of utilising food waste comes in a context of great uncertainty regarding the viability of the insect farming industry. Plagued with high energy


Photo: Šárka Krňávková

and labor costs, the sector has seen several market leaders filing for bankruptcy despite investments that numbered in the hundreds of millions of euros, while other companies across France, Denmark and the Netherlands have faced economic difficulties. This suggests that the problem may not be limited to just one company, one choice of insect, or one business model, but extends to the whole sector.

Insect meal currently retails at around 3800-6000 USD, and might go as low as 1600–2700 USD by 2030 according to some projections (de Jong & Nikolik, 2021). That would still put insect meal at a much higher price than the projected price of fishmeal, and that of soymeal.

While the use of low-cost food waste, combined with high retail prices for insect co-products, may be profitable, it has been deemed unrealistic for mass production in the largest study on the economics of industrial insect production in the Netherlands (Leipertz et al., 2024). As evoked earlier, relying on food waste would induce other costs that can offset any gains.

IS CIRCULAR INSECT PRODUCTION GOOD FOR THE ANIMALS?

From an animal welfare perspective, incorporating food waste in insects' diets, and waste-fed insects in other animals' diets might not be the best solution. While some studies suggest insect protein may be beneficial for some farm animals, the effect of waste-fed insects in farm animals' diets has been understudied and a precautionary approach is needed.

On insect welfare, a growing body of evidence suggests that insects, like many other invertebrates, may be sentient and feel pain (Gibbons et al., 2022). The question of insect welfare, recognised by industry representatives (IPIFF, 2019), extends to insect diets and their effect on their well-being. Just like improper feed may be detrimental to a farmed cow, improper feed may be detrimental to farmed insects.

While some insects may be able to digest several forms of waste streams, others, such as the yellow mealworm and the house cricket, two of the most farmed insects in Europe, need high quality ingredients to grow and remain healthy (Billen et al., 2020). Crickets were shown to experience a 99% mortality rate when fed on municipal-grade waste (Lundy and Parrella, 2015). Waste streams may also lack essential properties for insect farming, such as having a sufficient solidity for yellow mealworms. Even Black Soldier Flies are not immune to these challenges, as rearing them on manure was shown to hinder their survival (Miranda et al., 2020).

In general, the inconsistency and variability of food waste make using it as insect substrate hazardous in terms of welfare. Eurogroup for Animals recently published a report on insect diets and welfare, showing "a need for further research on insects'

dietary preferences" to enhance their welfare (Eurogroup for Animals, 2023).

CONCLUSION

Circularity may be the latest buzzword to find purpose in an insect farming industry that has given up on having a transformative effect on food systems, yet, under scrutiny, the use of food waste appears more counterproductive than anything. Any sustainability or economic gain made by feeding insects on food waste fails to make insect protein a competitive and environmentally beneficial alternative to animal feed or pet food. Besides, the food safety and animal welfare risks surrounding insect farming are exacerbated when relying on true waste streams, shedding doubts on the overall viability of the model. We can doubt whether, even with new waste streams being authorised, insect producers will choose this path forward.

The insect farming sector needs to be clear on its goals if it seeks to achieve policy change and develop at scale. The constant backpedaling of the sector in the last few years - from diet revolution to feed additive and from waste upcycling to lengthier food chain - make its latest claims of circularity hard to believe.

About Francis Maugère

Currently leading Eurogroup for Animals' work on insect farming, Francis Maugère has worked on several groundbreaking publications, pulling together the latest research, scientific evidence and expert opinions on insect farming, and has intervened at several insect farming conferences to explore the sector's significant implications for animal welfare and the environment.

As Europe accelerates its transition toward a more resilient and sustainable food system, insect protein has emerged as a strategic pillar in the continent's Protein Strategy. Following the European Parliament's endorsement of the European Protein Strategy in late 2023, the spotlight is now on how this recognition translates into action. The International Platform of Insects for Food and Feed (IPIFF) plays a central role in shaping this transition—bridging science, policy, and industry to unlock the full potential of the insect sector. In this interview, **Steven Barbosa, Secretary-General of IPIFF**, discusses the policy shifts driving the sector, the opportunities created by global market dynamics, and the regulatory reforms needed to position Europe as a global leader in sustainable protein production.

INSTITUTIONS UNITE BEHIND INSECTS FOR A COMPETITIVE AND SUSTAINABLE EUROPE

The European Parliament accepted the European Protein Strategy in late 2023, highlighting the importance of domestic protein production. How has the insect protein sector developed since then, and what role has IPIFF played in aligning the sector with this strategy?

The Parliament's Motion is a pivotal validation, formally recognising that Europe's food security depends on a diversified protein supply. Now, the EU must act. To position Europe as a leader in circular and sustainable feed, immediate action is essential.

This momentum is the result of years of strategic effort. IPIFF has successfully positioned the insect sector at the heart of key EU frameworks—from the Farm to Fork Strategy to the Circular Economy Action Plan. The upcoming Bioeconomy Strategy and the renewal of the Common Agricultural and Fisheries Policies are critical opportunities to convert this recognition into tangible support.

IPIFF serves as the essential bridge between policy and action. We are engaging directly with Commissioners and policymakers, providing the data and expertise needed to turn these strategic commitments into reality.

On July 14 2025, at the Council on Agriculture and Food meeting, Dutch representatives urged the European Commission to revise current legislation to unlock the full potential of insect farming. How do you think this initiative will shape investor confidence and the regulatory future of the sector in Europe?

The recent Agriculture and Fisheries Council deliv-

ered a powerful correction to the European Commission's vision for protein. EU Member States rejected a strategy disproportionately focused on plants, demanding a truly inclusive approach that embraces all sustainable solutions—including insect farming.

This political consensus is a game-changer for investors and innovators. It confirms that Europe is finally ready to back its ambitions with a regulatory environment fit for the 21st century. The Council didn't just voice criticism; it laid out a clear action plan:

1. Cut the Red Tape: With countries like Sweden and Finland leading the call, the Council demanded faster novel food authorisations to get innovative proteins to market.

2. Prioritise European Production: Member States called for binding targets and CAP support to build a sovereign protein supply chain.

3. Embrace Circularity: The Netherlands highlighted the absurdity of current regulations that stifle insect farming—a sector that uniquely upcycles food waste into valuable feed.

This shift aligns perfectly with IPIFF's advocacy. We welcome Commissioner Hansen's commitment to address these points, recognising our sector's immense potential.

The message from the Council was unequivocal: The future of EU protein is diverse, circular, and innovative. It's now time for the Commission to act on this mandate and deliver a strategy that harnesses the full power of European innovation.

A recent LCA commissioned by DEFRA suggested that insect proteins could have a much greater impact on the climate than soybeans. Some stakeholders argue that the study has methodological limitations. How do you assess these findings, and what is IPIFF's stance on providing reliable sustainability assessments for insect protein?

We welcome scientific scrutiny but share the UK Insect Bioconversion Association's significant concerns about the DEFRA study's methodology. Its conclusions are unrepresentative of the modern insect sector because they rely on outdated, small-scale data; ignore the core circularity of our waste-valorisation model; and were developed without industry input.

In conclusion, the DEFRA study is a snapshot of a past that no longer reflects the reality of a rapidly innovating industry. The true picture of insect protein is one of a circular, low-impact solution, and we are committed to providing the robust data to substantiate this. We stand ready to engage in an informed, science-driven dialogue on building a sustainable food future. Beyond critiquing flawed studies, we are proactively building the foundation for better ones.

China aims to reduce the share of soybean meal in animal feed to 10% by 2030 for greater self-sufficiency. The country is also promoting new sources, such as insect protein, as alternatives during this transition. How do you interpret this development in terms of global protein markets?

China's new policy to reduce soybean imports is a pivotal signal of a strategic reordering in the global

Photo: MDV Edwards | Shutterstock

protein market. The EU should view this as a catalyst to enhance its own protein diversification and food sovereignty.

We see three key implications:

• **A More Resilient Feed System**: This marks a decisive shift away from a monolithic, soy-centric model. The future will be diversified and regional, with blocs like the EU leveraging local resources to bolster food security.

• **A Global Catalyst for Alternatives**: The scale of Chinese demand will accelerate innovation and investment in alternative proteins. Insect farming is uniquely positioned to benefit, as its efficient, decentralised production aligns with self-sufficiency goals.

• **Validation of Strategic Autonomy**: China's move confirms that "protein self-sufficiency" is a top-tier geopolitical priority, a concern that resonates deeply with the ambitions of the EU Protein Strategy.

In this new context, a coordinated global effort is essential. IPIFF is proactively building a unified voice for the insect sector by collaborating with partner organisations worldwide, including in North America (NACIA), Asia (AFFIA), and China.

By aligning our scientific, regulatory, and market efforts across continents, we are ensuring the global insect community works in concert to promote sustainable growth and secure a resilient food future.

What role will insect protein play in Europe's sustainable and self-sufficient food and feed systems by 2030? How do you foresee regulations and industry practices evolving?

By 2030, insect protein must evolve from a promising alternative into a strategic pillar of Europe's sustainable food system. Its transformative potential lies in advancing three core EU objectives:

• **A Driver of Circularity**: Insects will be a primary solution for valorising millions of tonnes of agri-food waste into high-quality nutrients, creating a true circular bioeconomy.

• **A Cornerstone of Food Security**: As a homegrown, scalable protein, it will be a standard ingredient in animal feed, directly reducing Europe's dependency on imported sources like soy.

• **A Climate Solution**: With a low environmental footprint, insect production requires less land and water, directly contributing to the EU's climate and biodiversity goals.

To realise this vision, we must accelerate beyond current, slow authorisation processes. We need a streamlined, science-based framework that:

• **Expands Substrate Approvals** to include a broader list of safe, pre-approved agri-food by-products,

• **Creates Efficient Novel Food Pathways** for faster approval of new insect species and food applications,

• **Defines Holistic End-Points** to recognise the value of all insect-derived products, such as frass as a certified organic fertiliser.

The pace of Europe's regulatory action will determine its leadership in the global bioeconomy. With the right support, insect protein can be a cornerstone of a more resilient and self-sufficient Europe by 2030.

Despite growing interest in alternative proteins, consumer concerns persist. What do you think are the main reasons for these concerns? Is it safety concerns, lack of awareness, or cultural barriers? What different steps can the industry take to improve consumer perception and trust?

This question allows me to highlight the distinct benefits of various insect-derived products, addressing the unique opportunities and consumer perspectives within each market segment.

INSECTS AS FOOD

Consumer hesitation in Western markets stems from a cultural and familiarity gap, not a lack of viability. To build acceptance, the industry is focused on:

• **Transparent Communication**: Demystifying production through open access to state-of-the-art, hygienic facilities and clarifying that insects are farmed under strict EU food safety standards, not wild-harvested.

• **Strategic Integration**: Introducing insect protein in familiar formats like pasta and protein bars, allowing consumers to benefit from its sustainability and nutrition without a cultural barrier.

The narrative is not about replacing meat but about diversifying our protein sources with a sustainable option that is already consumed by billions globally.

INSECTS FOR ANIMAL AND AQUAFEED

Insects are the ancestral diet for poultry, fish, and swine. There is nothing new in seeing a worm serving as bait to catch a fish or about seeing a chicken eating a worm. Their integration into feed provides a sustainable, home-grown protein that improves animal health and reduces the environmental footprint of livestock production, all while strengthening EU feed sovereignty.

INSECTS AS SOIL FERTILIZER

Insect frass is a powerful, organic soil amendment that completes the circular economy model. It enriches soil health, promotes plant growth, and provides a sustainable alternative to conventional fertilizers.

Insect farmers already work along with other livestock farmers, locally supplying to their own needs for animal feed and soil fertilizer.

INSECTS IN PET FOOD

Insect protein has rapidly emerged as a premium ingredient in pet food, valued for its high nutritional val-

Photo: Freepik

ue, since it is a highly digestible, hypoallergenic source of protein and lipids. It is also valued for its inherent sustainability as it meets growing consumer demand for environmentally responsible pet care products.

Overall, by focusing on education and strategic market development, insect protein can deliver tangible benefits across the entire food system.

Outside of Europe, where do you see the greatest opportunities for insect protein? In Asia, Africa, or the Americas? How can IPIFF encourage international collaboration in this sector?

We see significant opportunities in all three regions, but for different reasons:

• **Asia**: Offers massive market scale, strong government support (e.g., China, Singapore, Thailand), and in many areas, a cultural precedent for eating insects.

• **North America**: Has a dynamic tech and investment ecosystem, a strong pet food industry, and consumers who are early adopters of novel food trends.

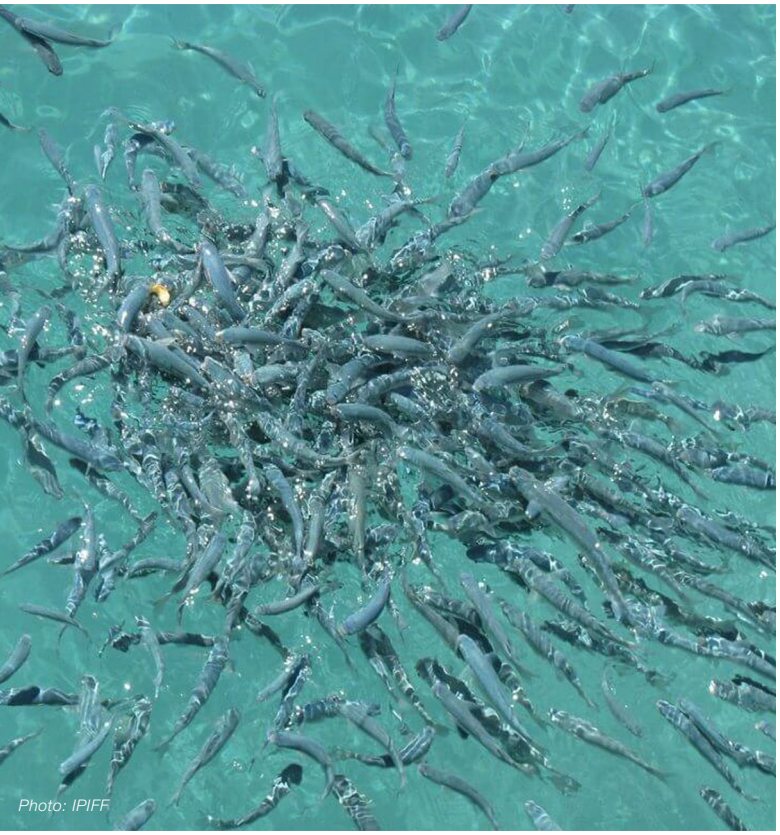


Photo: IPIFF

• **Africa**: Presents an opportunity for local, low-tech insect farming to address malnutrition and create circular economies at the community level, using local organic waste.

As mentioned above, IPIFF is working closely with its counterpart organizations representing different continents to encourage international collaboration. We value knowledge exchange via facilitating dialogues between EU and international regulators to harmonise standards and share best practices and global advocacy, representing the global insect sector in international forums like FAO and CODEX to promote the role of insects in global food security.

In your opinion, what will be the biggest opportunities and challenges facing the insect protein industry over the next five years, and what advice would you give to the alternative proteins sector in general?

Our sector is poised for transformative growth, driven by three powerful opportunities:

• **Regulatory Tailwinds**: The EU Protein Strategy and a global push for protein self-sufficiency are creating an unprecedented policy environment for sustainable solutions.

• **Market Expansion**: We are on the verge of unlocking massive new markets. Key developments include authorising a wider range of feeding substrates, approving insect frass as a certified organic fertilizer across the EU, and exploring its potential in biogas production and for export.

• **Technological Leap**: Next-generation production systems are emerging, focusing on greater automation and energy efficiency to dramatically improve scalability and reduce costs.

The Central Challenge is achieving Cost-Parity but with the right policies, can be easily and swiftly achieved. While the momentum is strong, achieving cost-competitiveness with conventional proteins remains our primary obstacle.

We view recent EU initiatives to promote sustain-

able feed in aquaculture as a critical and promising step in the right direction. Once again, the positioning of China in this regard, teaches a valuable lesson to Europe.

My advice to the entire alternative protein ecosystem is built on two core principles: The first is to collaborate, not compete. Our shared goal is to displace unsustainable conventional proteins, not each other. There is more than enough room for plant-based, fermented, and insect proteins to co-exist and complement one another.

At IPIFF, we embody this through our work in the InnovProtein EU Alliance with partners from the yeast and algae sectors, and by aligning with key industries like animal and pet food production. Together, we build a more resilient and sustainable future.

The second is to champion transparency and science. Trust is our most valuable currency, and we must build it through rigorous, independent science and honest communication—openly discussing both the profound benefits and the existing challenges of our solutions.

Finally, looking at IPIFF's own agenda, what will be your top priorities in dialogue with EU policymakers in the coming years?

IPIFF is engaging with EU policymakers to ensure the upcoming financial and policy frameworks unlock the full potential of the insect sector. Our focus is on three strategic priorities for 2028-2032:

Champion a Smart Regulatory Framework: We are leading the call to authorise a wider range of organic side-streams for insect feed. This is the single most important step to unlock the sector's circular potential and global competitiveness.

While our academic members generate the necessary science, we must urgently address the regulatory bottlenecks that currently hinder progress.

Set Sustainable Standards for the Agri-Food Sector: The EU must apply its sustainability ambition to food systems as it has for energy and transport. The future Common Agricultural Policy (CAP) and Fisheries Policy must incorporate mandatory sustainability criteria for feed and fertiliser, creating a guaranteed market for EU-made, sustainable ingredients like ours.

Promote Our Circular Products: We are ensuring that insect frass is recognised as a high-quality, circular fertiliser. The upcoming revision of the EU Fertilising Products Regulation is a direct opportunity to create an EU-wide market for this bio-solution, boosting both farmers and our producers.

Securing Strategic Status for the Insect Sector: The Net-Zero Industry Act and Clean Industrial Deal already prioritise the very circular, bio-based solutions that insect production delivers. Granting our sector strategic status is the essential next step to unlock the public and private investment needed to scale up and meet shared EU policy goals.

The foundation is laid; now is the time to build. We advocate for concrete measures to translate policy alignment into action:

Create Binding Market Demand: Introduce minimum incorporation rates for insect protein in animal feed. This market-driven mechanism is crucial for de-risking investments and scaling production.

Ensure Direct Support for Insect Farmers: The upcoming Protein Strategy must follow the precedent of the 2018 Plant Protein Report, ensuring our producers are explicitly recognised and supported under the CAP post-2027.

Modernise Regulation for Competitiveness: Expand Substrate Authorisations: Fast-track the approval of a broader range of safe, validated agri-food side-streams.

Streamline the Novel Food Process: Reform the current opaque and inefficient system to prevent delays that put European companies and jobs at risk.

Insect production is entering a new era of industrial scale and sustainability. Tebrio, a pioneer in mealworm (Tenebrio molitor) production, is taking a major step forward with the construction of oFarm—the world's largest insect production facility. Set to become a benchmark in green biotechnology, circular economy, and automation, oFarm embodies Tebrio's ambition to redefine sustainable protein production. In this interview, **José Ángel Sanz, Head of Communications at Tebrio**, discusses how this groundbreaking project will build on the company's expertise, advance the insect protein industry, and set new global standards for efficiency, scalability, and environmental responsibility.

Photo: Tebrio

INSIDE TEBRIO'S oFARM:
World's Largest Mealworm Production Facility

Tebrio has long been a prominent player in mealworm (*Tenebrio molitor*) production, and in early 2025, you broke ground for the world's largest insect production farm. How does the construction of this new plant transform the company's expertise?

The construction of our new plant, which will be the largest insect production farm in the world, represents a transformative step in our expertise. Currently, the civil works for the first modular building—an exact replica of future units—are nearing completion, with production having started in March 2025. This initial phase is crucial for identifying improvements that will optimize operations as the rest of the farm is built. The project allows Tebrio to scale up its technology and processes, reinforcing its position as a global leader in sustainable *Tenebrio molitor* production with an annual capacity exceeding 100,000 tons.

What will be the production capacity of this farm when it is fully operational? Compared to other insect production facilities around the world, what is the significance of this scale in the industry?

The new plant, called oFarm, will be constructed in six phases over a total area of 90,000 square meters. It will generate 150 direct jobs and 1,350 indirect jobs, and is designed with a strong focus on sustainability, including being powered by 100% renewable solar energy. Compared to the current production scale of small insect farms worldwide, oFarm represents a clear before-and-after moment in the industry, significantly advancing production capacity, process optimization, and environmental

standards. The full project completion is expected by 2028.

It is stated that approximately 60% of the mealworm production from the farm will be used in aquafeed. In this context, how do you ensure the quality and suitability of your products for aquafeed? If available, could you share examples of tests or studies conducted?

Modern aquaculture faces a problem of sustainability due to its reliance on ingredients like fishmeal and fish oil (sourced from fishing) and certain vegetable sources. These ingredients not only deplete resources and contribute to deforestation, but often fail to meet the full nutritional requirements of fish and crustaceans. The ingredients we produce, based on mealworm protein and oil, offer a genuinely sustainable alternative.

Our approach is modular: We optimize every stage of the value chain—from the feeding and rearing conditions of the larvae to the transformation processes—to ensure the final ingredients precisely meet the nutritional needs of our clients' animals. All this is done while guaranteeing total traceability of the process and maximum quality.

Beyond production, we conduct exhaustive characterization of our ingredients and validate their application through laboratory and field trials in collaboration with clients, universities, and leading technological centers.

We have participated in key initiatives like the ACUISOST research project (funded by NextGeneration EU Funds), where we formulated feeds with our ingredients that were successfully validated in trials with trout and gilthead sea bream, showing excellent results across different growth stages and in situations of biotic and abiotic stress.

Currently, we are part of the European SAFE project (funded by Horizon Europe), which aims to develop circular aquaculture production systems. In this project, aquaculture production waste is used to feed the mealworm, which is then used to produce fish feed that re-enters the cycle. We are specifically validating the use of our ingredients in freshwater species such as trout, salmon, carp, and perch.

One of the most ambitious aspects of the new facility is the goal of achieving a negative carbon footprint. What technologies and processes are you implementing to this end? What solutions are you envisioning in terms of renewable energy, circular economy, or waste management?

During the construction of oFarm, an advanced resource utilization strategy has been incorporated that reinforces the company's commitment to a negative carbon footprint. Instead of discarding the materials extracted during the construction work, we have reused the gravel and soil waste as construction material, reducing external transport and the use of new resources. In addition, all the energy used will come from 100% renewable and self-consumed sources, thanks to a photovoltaic installation that will triple energy self-sufficiency. oFarm will be located in the Puerto Seco of Salamanca (Spain), an intermodal logistics platform connected to the railway network and the main communication routes of the Atlantic Corridor. This location will optimize the transport of raw materials and final products, reducing logistics-related emissions by 30%. This model is complemented by a circular economy that generates zero waste, saves up to 98% of water, and reduces emissions by more than 90% compared to traditional livestock farming, positioning Tebrio as a global leader in green biotechnology and industrial sustainability.

This facility will be one of the pioneering projects applying large-scale automation to insect production. How will automation increase production efficiency, and what technical or logistical challenges did you encounter when designing the process?

Our facility will be one of the pioneering projects applying large-scale automation to insect production. This automation will significantly increase production efficiency through several factors: It will allow for higher working frequency, contribute to cost optimization, and result in more regular and therefore more controllable processes, which will optimize all


Photo: Tebrio

our production variables. Additionally, by achieving higher productivity with the same consumption of resources and energy, automation contributes to a significant reduction in environmental impact.

In designing this process, we encountered both technical and logistical challenges. The first was the actual definition of the automatizable process. Our prior experience in insect rearing, inherited from the exotic pet food sector, was highly artisanal. In that context, the production cost and large volumes were not relevant factors. To industrialize the rearing process at Tebrio's scale, it was fundamental to define a completely new production model and to precisely determine which tasks to automate and the methodology for doing so.

The second challenge was strategic: The choice of the automation strategy. Although the simplest automation solution is often the direct substitution of a worker with a robot or an AI (which can operate without rest), this was not the most suitable solution for our needs. Therefore, we had to discard this approach and commit to designing a totally new production process that specifically integrated the technology into our activity.

Finally, this transition specialized staff training. The employee role evolves from manual labor to supervising an automated production process that utilizes special equipment and automata. This demands that our staff possess a higher level of education and training. As a company, we must guarantee this training, either by continuously upskilling existing employees or by hiring personnel who already have the required qualifications.

We have heard that many ventures in the insect protein sector are struggling with financial difficulties. What strategies is Tebrio adopting to make this new facility economically sustainable in the long term? How do you plan to balance investment, operational costs, and market demand?

We have designed a unique technology that has been tested and validated in pilot facilities, proving that the industrial model is viable and highly competitive in terms of costs. In addition, the first module of this large factory is sufficient in metric terms to demonstrate these three variables: Sufficient production to enter target markets, low operating costs for the sale of products in specific niches, and return for investors or to continue building the rest of the modules with own funds depending on the company's financial decisions.

Finally, what is this farm's place in Tebrio's long-term strategy? How does the company see the future of insect production, and how would you describe the impact this facility will have on the industry?

The oFarm plays a key role in our long-term strategy, representing a qualitative leap in capacity and technology for industrial insect production. With a surface area of 90,000 m², this facility will enable us to provide a sustainable solution to the growing global demand for protein.

We see the future of insect production as a key opportunity to complement traditional sources of animal feed and raw materials, contributing to food security and environmental sustainability. In addition, oFarm will set a new standard in circular economy, energy efficiency, and environmental impact reduction, with a negative carbon footprint. The facility will not only drive technological development and innovation in green biotechnology, but will also have a significant socioeconomic impact, generating more than 1,500 direct and indirect jobs and positioning Spanish industry as a global benchmark in the emerging sector of sustainable insect production.

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USING DATA AND AI TO DEFINE THE FUTURE OF INSECT FARMING

David Fluker
Founder & CEO
Soldier Fly Technologies

Artificial intelligence is transforming insect farming from an emerging sustainability solution into a precision-controlled production powerhouse. Soldier Fly Technologies is pioneering this shift—merging data science, automation, and decades of farming expertise to redefine how the Black Soldier Fly is farmed at scale.

HARNESSING AI TO FEED THE FUTURE

When my family started Fluker Farms in 1956, the world of insect farming was driven by hands-on experience, intuition, and a deep respect for biology. Today, nearly seven decades later, we're seeing a remarkable evolution in this field—one fueled by automation, analytics, and artificial intelligence.

At Soldier Fly Technologies (SFT), we are bringing data-driven precision and scalable automation to one of agriculture's most promising frontiers: insect-based protein. Our focus on AI-powered production monitoring and process optimization is enabling us to unlock levels of efficiency and consistency once thought impossible in insect rearing.

WHY AI MATTERS TO THE INSECT INDUSTRY

The global insect industry is scaling rapidly to meet a pressing challenge—feeding a growing world population with finite resources. According to the United Nations Food and Agriculture Organization (FAO), the world's population is projected to reach nearly 10 billion by 2050. Yet two-thirds of agricultural land is already dedicated to feeding livestock, and studies by the United Nations and the World Wide Fund for Nature (WWF) warn that as much as 95% of the world's soil could be degraded or unfit for farming within the same timeframe.

Insect farming, particularly Black Soldier Fly (BSF) production, offers a sustainable solution: converting agricultural by-products and waste streams into valuable protein and soil nutrients using minimal land and water. However, reaching industrial scale demands precision, traceability, and reliability—areas where AI excels.

Unlike traditional livestock farming, insect production involves countless micro-environments that can shift rapidly—temperature, humidity, feed composition, and biological variation all play roles in performance outcomes. Human operators simply cannot monitor or respond to all of these fluctuations in real time. That's where AI-enabled production intelligence becomes indispensable.

THE SOLDIER FLY TECHNOLOGIES APPROACH

At Soldier Fly Technologies, we see insect farming

not just as a biological process, but as a data-rich manufacturing system. We've built our entire model around measurable performance indicators—yield per tray, feed conversion efficiency, reproductive success, and nutritional quality.

To manage this complexity, we developed Entoware—our proprietary software designed specifically for insect farming operations. Entoware provides advanced data collection, workforce management, and traceability across every stage of production, from egg to harvest. It offers real-time visibility into colony performance, resource utilization, and process efficiency.

Entoware is a rule-based platform, meaning it operates on structured logic and predefined parameters rather than self-learning algorithms. However, it's designed to connect seamlessly with cloud-based AI databases, allowing production data to be exported for external AI analysis and for results to be reintegrated into the operational framework. This ensures that farms of any size can benefit from advanced analytics without requiring fully autonomous systems.

DATA-DRIVEN NUTRITION: WHERE AI MEETS BIOLOGY

At Soldier Fly Technologies, the integration of artificial intelligence goes far beyond automation—it shapes how we design and adapt rearing conditions. By analyzing years of data from multiple production cycles, Entoware enables our team to correlate feed performance, environmental conditions, and colony outcomes.

This data-driven approach creates a powerful feedback loop between biology and engineering, giving us the tools to make measurable, science-based adjustments that directly enhance quality, consistency, and efficiency across every phase of production.

In practical terms, this means greater production reliability, faster decision-making, and better use of agricultural by-products and waste streams as feedstock for larvae growth—all key to a more circular and sustainable food system.

A PLATFORM FOR EVERY FACILITY

Our Entoware system stands as one of the most comprehensive data platforms in the insect production industry. Developed by our in-house team of engineers—drawing on deep professional experience in Research and Development (R&D), Production and Manufacturing, Advanced Programming, Food Safety, and Quality Management—Entoware integrates:

- **Lifecycle tracking**: Every egg, larvae batch, and production cycle is logged with full lineage data.

- **Workforce optimization**: Intelligent task scheduling, performance tracking, and productivity metrics.

- **Predictive resource management**: Data models that forecast feed, material needs, and labor requirements to prevent bottlenecks.

What makes Entoware particularly valuable is its adaptability. It can be deployed in both automated and non-automated facilities, scaling intelligently to match the level of mechanization, workforce, and production capacity. Whether a facility uses robotic tray systems or manual feeding operations, Entoware's advanced data collection and control tools provide the same level of precision and traceability.

This high-density accumulation of plump Black Soldier Fly Larvae (BSFL) is at its peak protein and lipid yield, signaling readiness for efficient, large-scale harvesting and subsequent processing

This versatility makes it an ideal solution for insect producers at any stage of growth—from small startups to full-scale industrial operations.

Entoware is already being used by facilities across the world—not only for BSF but also for crickets and mealworms. This scalability helps standardize best practices globally, allowing insect producers to leapfrog early-stage challenges and operate with industrial precision.

SCALABLE, MODULAR, AND BUILT FOR ANY FACILITY MODEL

Soldier Fly Technologies' approach to insect farming is inherently scalable and modular. Our facility designs are built around repeatable process modules—each containing the necessary systems for rearing, breeding, and processing Black Soldier Flies.

Each module functions independently but integrates seamlessly into larger systems as capacity grows. This modular architecture allows our clients and partners to start small and expand without re-engineering their entire operation. It also provides built-in redundancy, ensuring that even in the event of a system disruption, production continuity is maintained.

Because our systems are designed using off-the-shelf components, they can be rapidly deployed, easily maintained, and cost-efficient. Combined with Entoware's adaptable software backbone, these physical and digital systems provide unmatched control and insight at any scale.

This design philosophy—scalable, modular, and data-driven—allows Soldier Fly Technologies to bring the benefits of intelligent insect production to a wide range of facility models, from local upcycling plants to full-scale protein manufacturing hubs.

PRECISION COUNTING WITH SCIOTEX TECHNOLOGY

To ensure accuracy and consistency in early-stage production, Soldier Fly Technologies employs the Perfect Count Counter / Packager, powered by Sciotex. This high-speed counting system automates the process of counting and batching live neonates (newly hatched larvae) into desired quantities for rearing bins as well as for live insect sales—an essential step in maintaining uniform density and traceable production data.

FROM WASTE TO VALUE: CLOSING THE LOOP

The environmental implications of BSF farming are profound. Each ton of organic waste upcycled through our process has the potential to generate high-value outputs:

- **Protein meal** for aquaculture, livestock, and pet food.
- **Natural oils** rich in lauric acid with antimicrobial benefits.

Entoware provides real-time data collection, workforce tracking, and production analytics across every stage of the Black Soldier Fly lifecycle.

Soldier Fly Technologies vertically integrated Breeding Modules ensure a continuous, controlled, and efficient lifecycle for our Black Soldier Fly colony

• **Frass**, a nutrient-dense soil amendment that supports regenerative agriculture.

Through automation and precise data tracking, we're able to ensure that each of these outputs meets strict quality standards. Our traceability systems verify that every batch can be tracked back through its full lifecycle—an essential feature as the global feed and food sectors move toward transparency and sustainability.

LEAN SIX SIGMA AND CONTINUOUS IMPROVEMENT IN ACTION

Our engineering team operates with a Lean Six Sigma mindset—constantly analyzing data to identify inefficiencies and opportunities for improvement. The combination of structured process control and continuous improvement methodologies means that our systems don't just get more consistent; they get more efficient with every cycle.

Where traditional agricultural systems often plateau in performance, our integrated model continues to evolve. This ensures that as we expand production capacity, we're not simply scaling up—we're scaling *smarter*.

BUILDING A SMARTER INSECT INDUSTRY

Soldier Fly Technologies doesn't exist in isolation. We actively collaborate with academic institutions, including Louisiana State University, and industry organizations like the North American Coalition for Insect Agriculture (NACIA) and the Center for Insect Biomanufacturing and Innovation (CIBI).

Through these partnerships, we contribute to collective innovation and share insights that strengthen the entire insect industry. Data frameworks like those in Entoware are helping to create standardization—an essential step for scaling insect agriculture globally.

We view data as the connective tissue that links research, production, and market development. As datasets grow, so too will our ability to forecast yields, optimize breeding cycles, and model economic performance across multiple facility types using our proprietary Business Modeling Tool.

The Sciotex Counter counting BSF neonates (newly hatched larvae), providing the essential data for scientifically precise colony management

LOOKING AHEAD: AI AND THE NEXT FRONTIER OF INSECT FARMING

The next stage of our journey is about expansion—deploying our proven technology in new markets, building partnerships, and continuing to refine our models. The integration of AI, robotics, and biological innovation will enable us to transform how the world produces protein and manages waste.

For the insect industry at large, the shift toward intelligent automation is inevitable. As systems like Entoware mature, we'll see a move from artisanal production toward a truly industrial, data-centric sector—capable of providing consistent, traceable, and sustainable protein at global scale.

At Soldier Fly Technologies, we're proud to be leading this transformation. What began as a joint venture between Louisiana-based Fluker Farms and California-based HermetiaPro in 2020 has evolved into a cutting-edge agricultural technology company with a clear mission: to harness the power of the Black Soldier Fly through the precision of data.

Reference

1. *United Nations Food and Agriculture Organization (FAO); United Nations Environment Programme (UNEP); World Wide Fund for Nature (WWF)*

Photo: Freepik

Understanding Feed Proteins in Animal Nutrition

Animal feed proteins are essential feed ingredients for improving growth performance, supporting the immune system, and ensuring efficient production in animals. The global animal feed proteins market is witnessing significant growth due to increasing population and demand for animal protein, sustainability concerns, and a shift toward alternative sources. The market size, which stood at approximately 247 billion US dollars in 2024, is expected to grow at an estimated CAGR of 6.2% by 2034. This growth is primarily driven by the rise of plant-based, single-cell, and insect-based proteins.

By Derya Gulsoy Yildiz

Feed proteins are essential nutrients included in animal rations to support growth, health, and productivity. Plants (e.g., soybean meal, canola) and animal by-products (e.g., fish meal, meat and bone meal) are commonly used protein sources today. However, alternative protein sources such as insects, algae, or microbial proteins have gained popularity in recent years, particularly due to sustainability concerns. All these protein ingredients provide the essential amino acids required for the vital biological functions of livestock, poultry, and aquatic species.

There are many reasons for adding protein to animal feed. The primary reason, as mentioned above, is to provide amino acids, which are the building blocks of body tissues such as muscles, organs, and enzymes. Certain amino acids play a critical role in maintaining a healthy immune system and help animals build resistance to diseases. Additionally, sufficient protein intake increases weight gain, milk yield, egg

production, and feed conversion efficiency, and supports fertility and embryonic development. Young and growing animals, as well as lactating or laying animals, require higher protein levels to sustain their growth and production. In ruminants, protein also helps maintain microbial activity in the rumen, which is essential for efficient digestion.

In summary, proteins are vital ingredients of nutrition in animals, just as they are in humans, and contribute to animals' health, productivity, and sustainable food production.

GLOBAL MARKET STATUS: GROWTH AND EXPECTATIONS

The global animal feed proteins market is witnessing rapid growth due to factors such as increasing demand for animal feed, pressure for sustainable practices, rapid innovation in alternative proteins, and modernization of feed technologies. Several recent market reports support this growth.

For example, according to a report prepared by **Research and Markets**, the global animal feed protein market size was US$299.02 billion in 2024. The research firm projects that the market will reach 312.29 billion US dollars in 2025, with a compound annual growth rate (CAGR) of 5.8% during the 2025-2029 forecast period. According to this, the total market size will reach 391.19 billion US dollars by 2029.

Global Market Insights, meanwhile, puts the size of the animal feed protein market at US$309 billion for 2023. The company expects the market to grow at a CAGR of 4.9% during the 2024-2032 forecast period, with the total size reaching US$450 billion by 2032.

Expert Market Research (EMR) lags significantly behind other research companies in its forecasts for the global animal feed proteins market size. The company estimates the market size for 2024 at 66.64 billion US dollars, with an 8.4% CAGR from 2025 to 2034 and a projected size of 149.29 billion US dollars by 2034.

The Business Research Company estimates the market size of proteins used in animal feed at 299 billion US dollars for 2024 and 312 billion US dollars for 2025, with a CAGR of 5.8% for the 2025-2029 forecast period. Based on this, the total market size will reach US$391 billion in 2029.

The steady growth in these reports points to the remarkable role of proteins in animal feed. It should be noted that differences between reports may stem from differences in market segmentation, data collection methods, and scope of analysis. However, based on the average of the five reports, it is possible to project that the market size, which was 247 billion US dollars in 2024, will grow at a CAGR of 6.2% during the 2024-2034 period and reach 452 billion US dollars by 2034.

FACTORS DRIVING MARKET GROWTH

The global animal feed proteins market is expected to expand significantly over the next decade. According to analysts, this growth will be driven by a combination of economic, environmental, and

technological factors. The main contributing factors are listed below:

1. Increase in Demand for Animal Protein

The growing global population and rising middle-class income levels are increasing the demand for meat, dairy, and eggs, especially in developing regions such as Asia-Pacific, Latin America, and Africa. According to FAO projections, global meat production is expected to increase by more than 70% by 2050. This will keep the need for high-quality feed proteins high in order to support the productivity of animal production, especially feed efficiency.

2. Developments in Alternative Protein Sources

Environmental concerns and growing sensitivity toward the efficient and appropriate use of resources needed to feed the world's growing population are at the heart of research into new alternative and sustainable protein sources. Insect- and algae-based proteins, single-cell proteins (microbial, fungal, and yeast), and fermentation-derived proteins are among these new alternative protein sources.

These sources promise high digestibility, balanced amino acid profiles, and lower environmental footprints. Increasing investments and regulatory support in this area are driving growth in the feed protein market from a different angle.

3. Greater Focus on Sustainable Agriculture

Today, sustainability has become a key priority for producers in the livestock and feed sectors. As a result, protein sources that reduce greenhouse gas emissions, require less land and water, and contribute to circular economy models (e.g., feed production from waste) are gaining popularity.

4. Advances in Feed Formulations

Feed formulations continue to evolve to enhance the efficiency of protein utilization in animal nutrition. Precision nutrition tools and innovative feed additives enable protein levels to be tailored to an animal's life stage and production goals, while enzyme supplementation improves protein digestibility. Advances in digital technologies enable real-time monitoring of protein intake and performance in animals. All these developments contribute to improved animal health and performance, supporting market growth.

5. Government Policies and Regulatory Support

Many governments and international organizations are promoting the use of new feed ingredients that are sustainable and increase productivity through research funding (e.g., Horizon Europe, USDA grants), fast-track approval procedures, and sustainable feed certification schemes. Innovative protein sources are at the forefront of these efforts.

6. Growth of the Aquaculture and Pet Food Sectors

Aquaculture is the fastest-growing animal food sector globally, and its demand for high-quality, protein-rich rations is increasing. The transition from fish meal to sustainable alternatives is supporting demand for new protein sources.

Pet food manufacturers are also adopting high-protein, functional feed ingredients in response to consumer preferences for health-focused and environmentally conscious products.

7. Increased Awareness of Animal Health and Productivity

Protein is not only a growth driver but also essential for immunity, reproduction, milk and egg production, and carcass quality. Farmers are increasingly recognizing that balanced protein use in feed can reduce veterinary costs and increase profit margins by improving product quality.

8. Expansion of Livestock Farming

The rapid growth of industrial livestock farming, particularly in emerging markets in Asia-Pacific and Latin America, is driving demand for efficient protein solutions that will increase productivity and profitability.

FACTORS LIMITING MARKET GROWTH

Although the market is poised for growth, there are many factors that could limit market growth, such as


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fluctuating raw material prices, increasing competition for resources, and the high cost of developing new alternative proteins. Analysts list these factors as follows:

1. Fluctuations in Raw Material Prices

The cost of traditional protein-rich feed ingredients such as soybean meal and fish meal can vary significantly due to factors such as climate conditions, supply chain disruptions, geopolitical tensions, and concerns about overfishing. This volatility can lead to uncertain profit margins for feed producers and unpredictable pricing for end-users.

2. Sustainability Concerns

While some protein sources (e.g., insects, algae) are considered sustainable, traditional sources such as soy and fish meal are often associated with deforestation, disruption of marine ecosystems, high water use, and carbon emissions. Increased environmental scrutiny and sustainability regulations, the adoption of more sustainable sourcing practices, and consumer demand for sustainable alternatives may limit the use of conventional protein sources.

3. High Production Costs of New Protein Sources

One of the main barriers to growth is the production costs of alternative proteins. Although these protein sources are considered sustainable, their production costs are still high compared to traditional sources. Scaling up these alternatives, which require advanced infrastructure, strict hygiene controls, and costly R&D, necessitates significant investments and technological advancements. This makes them significantly more expensive than traditional sources such as soybean meal or fish meal. Until production costs are reduced through scale or innovation, the adoption of these proteins may remain limited.

4. Limited Consumer and Industry Awareness

In many regions, there is limited awareness of the benefits and nutritional value of new feed proteins. This lack of information may lead to resistance from traditional livestock producers toward new protein sources, skepticism from veterinarians and animal nutritionists, and slow adoption of new proteins in conservative markets.

5. Stringent Regulatory Constraints

The feed protein sector faces a complex regulatory environment, particularly when introducing new and non-traditional sources to the market. For example, while the use of insect proteins in poultry and pig feed was only recently approved in the European Union, some countries even lack clear frameworks for algae or microbial proteins. Overcoming these regulatory barriers could delay commercialization and increase compliance costs.

6. Supply Chain and Infrastructure Constraints

Producers of alternative protein sources for feed, such as insects and algae, may face various challeng-

es, including the lack of cold-chain or drying infrastructure, insufficient distribution networks, and limited integration with mainstream feed production systems. These supply chain gaps may restrict market access, particularly in developing regions.

7. Competition from Alternative Inputs

Alternative protein sources must compete with other performance-enhancing feed inputs such as feed proteins, amino acid supplementation, enzyme technologies, and plant extract-based functional additives. These can limit the share of protein in certain formulations by offering cheaper or more targeted solutions for animal growth.

Despite promising growth projections, the global animal feed protein market faces numerous structural and operational challenges that could limit or delay progress. Overcoming these challenges will be critical to unlocking the full potential of new and sustainable protein sources and ensuring the long-term resilience of global livestock systems.

MARKET STATUS BY ANIMAL TYPE

The global animal feed proteins market is shaped by the nutritional needs of different animal types, which in turn determine the market's current structure and future opportunities. Each segment—poultry, ruminants, swine, aquaculture, and pet animals—has its own unique production systems and protein requirements.

The **poultry** feed segment holds the largest share of the global animal feed proteins market. This is due to the increasing consumption of chicken meat and eggs worldwide. The most commonly used protein sources in poultry nutrition include soybean meal, corn gluten meal, fish meal, and synthetic amino acids (especially lysine and methionine). In recent years, innovative solutions have emerged with the inclusion of insect meal and fermentation-derived proteins in feed formulations. The high feed conversion ratio of poultry has increased the demand for protein-rich and cost-effective feeds. Both the broiler and layer sectors are increasingly focusing on optimized protein mixtures to enhance growth and egg production. Asia-Pacific (especially China and India), Latin America (especially Brazil), the US, and Europe are the main production and consumption regions in this segment.

Ruminant feed is a major consumer of protein sources derived from crops and by-products. Ruminants are able to efficiently utilize lower quality

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proteins thanks to rumen microbial fermentation. The most commonly used protein sources in this segment include canola meal, cottonseed meal, and distillers dried grains (DDGS). Milk production, reduction of methane emissions, and sustainable feed formulations are the key factors driving the growth of this segment.

The **swine** feed segment is also one of the areas where feed proteins are widely used. The fact that pork is the main source of protein in East Asia and Europe is one of the main factors supporting demand in this segment. Protein sources such as soybean meal, blood meal, fish meal, and rapeseed meal are prominent in swine feeds, while amino acids are also commonly used as additives. Fermented soybean meal and plant protein concentrates are used to support gut health, particularly in young animals. Additionally, insect and algae proteins are being evaluated as alternatives to reduce antibiotic use in piglets. However, diseases such as African Swine Fever (ASF) can cause fluctuations in regional protein demand in this segment.

The **aquaculture** segment is the fastest-growing area of use for alternative proteins. This growth is parallel to sustainability pressures and the rapid expansion of the sector. While fish meal and fish oil have traditionally been widely used, environmental concerns and cost increases are accelerating the shift toward land-based alternative protein sources. Insect proteins, algae proteins, and single-cell proteins (such as those derived from methane-oxidizing bacteria) are among the leading alternatives. The use of pea and soy protein isolates, as well as microbial proteins, is also on the rise. Vietnam, Indonesia, Norway, Chile, India, and China are among the leading regions in this segment.

The **pet food** segment, although smaller in volume, is a high-value market. This segment uses high-quality animal proteins such as chicken and fish, plant-based proteins such as peas and lentils, and innovative sources such as insect meal and hydrolyzed proteins. The increasing awareness of pet owners has led to the importance of criteria such as digestibility, hypoallergenic properties, and functional benefits. In this segment, where there is growing demand for grain-free, sustainable, and human-grade quality proteins, North America, Western Europe, and Japan are among the leading markets.

REGIONAL MARKET OVERVIEW

The global animal feed protein market exhibits significant regional differences. These differences are shaped by livestock production trends, consumer demands, feed regulations, and sustainability goals.

The **Asia-Pacific** region leads the global animal feed protein market in terms of both volume and growth. A large population and increasing consumption of animal-based foods are driving demand for poultry, pork, and aquatic feed. Countries such as China, India, Vietnam, Indonesia, Thailand, Japan, and South Korea are at the center of this growth. Rising demand for meat, eggs, and dairy products, driven by urbanization and income growth, is intensifying animal production, which in turn is creating a high demand for protein in the feed sector. Countries like China and India strongly support self-sufficiency policies for feed raw materials. While soybean meal remains the primary protein source, the region is actively researching and investing in alternative proteins such as insect meal and various plant-based isolates to enhance sustainability and reduce dependence on traditionally imported sources. However, diseases such as African Swine Fever in pigs and avian influenza in poultry, along with import dependency in some countries, remain significant challenges.

The **Americas** have a mature but innovation-driven market structure in animal feed proteins. The United States and Brazil are global leaders in soybean meal and animal protein production. High-density poultry and pig production systems, large-scale feed production infrastructure, and strong R&D investments in biotechnology are the key factors determining this region's competitive strength. Demand for sustainable proteins for pet food and aquaculture feed is growing steadily. However, fluctuations in trade policies and envi-


Photo: Luis Echeverri Urrea | AdobeStock

ronmental concerns such as the link between soybean cultivation in South America and deforestation pose some challenges.

Europe is a mature but dynamic market characterized by stringent regulations, a strong sustainability approach, and growing interest in the discovery of new protein sources. Countries such as Germany, France, the Netherlands, Spain, the United Kingdom, and Italy are leading the way in alternative proteins sector. The European Union's strict regulations on feed safety, traceability, and environmental impact are driving producers to develop more responsible and sustainable solutions. Circular economy investments and green feed technologies are also part of this transformation. However, limited agricultural land, complex and constantly evolving regulatory frameworks for new protein sources, and high production costs present some challenges for the sector.

The **Africa and Middle East** region has high growth potential for animal feed proteins but faces some structural constraints due to infrastructure and climate conditions. Urbanization and population growth in countries such as South Africa, Egypt, Saudi Arabia, the UAE, Nigeria, and Kenya are increasing animal food consumption and, in turn, feed demand. The expansion of the poultry and aquaculture sectors is revitalizing the feed industry. The lack of local feed protein production has led to a significant reliance on imported soybean meal and processed animal proteins. However, there is growing interest in insect farming and local alternative protein sources in countries like Kenya and Nigeria. Demand for halal-certified feed is also influencing the region's market structure. However, climate conditions limiting agricultural protein production, deficiencies in feed processing and logistics infrastructure, and political instability and currency fluctuations in some countries are the main obstacles that the market faces.

CONCLUSION

Animal feed proteins play an essential role in animal health, productivity, and sustainable food production. The growing global population, changing consumer expectations, and environmental pressures are increasing the importance of both traditional and alternative protein sources. The market continues to grow thanks to technological developments, new protein innovations, and sustainability-focused policies. However, overcoming structural barriers such as cost, regulations, and supply chain challenges will be critical for the sustainability of this growth. Differing nutritional needs across species will also continue to shape market dynamics.

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