Insect Proteins Market

Market Scenario and Competitive Landscape

A CURA DI

Francesca Furlan

Ufficio Valorizzazione della Ricerca

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Disclaimer

Context

This report provides an overview of the **global market for insect proteins**, with reference to the main values, trends and dynamics in the period 2022 – 2027, to the regulatory landscape, to the market segmentations by insect type, application and region and to the competitive landscape of the sector.

1 Insect Proteins Market

According to the European Food Information Council (EUFIC), insects have the potential to produce less greenhouse gas (GHG) emissions and use fewer resources as compared to conventional sources such as plant and animal proteins. Proteins derived from insects, either through consumption of the whole of the insects or through extraction processes, are termed **insect proteins**. Insect-based protein is considered a viable alternative source for protein, majorly in food and feed applications. Like animal proteins, insects are rich in proteins and essential amino acids, which are easily digestible compared to plant-based proteins. They have been an integral part of traditional food across various countries, majorly concentrated in Southeast Asia. However, with the increasing awareness of the nutritional benefits of these insects, the acceptance of insect-based products in North America and Europe has increased drastically.

There are multiple advantages associated with insect protein, not only in terms of nutrition but also in terms of a sustainable environment, which have been driving the **growth potential** for this market. The land and water requirement for insect rearing is minimal in comparison to all other livestock rearing. For instance, one kg of insect requires only 40 m2 land for production along with 2 kg of feed and 2500 L of water, while beef production requires 250 m_2 land along with 10 kg of feed and 15,500 L of water. This can hugely affect the cost of insect protein since the production cost is reduced to a large extent. Also, the majority of the insect body is edible, while only 40%-50% of livestock is edible. **Opportunities** in insect rearing, such as redirecting food waste as a substrate for insect rearing, can drive the insect protein market to a large extent. Insect rearing is a zero-wastage process wherein in addition to whole edible insects, after the production of protein, chitin, and fats from insects, even their **frass** can be applied as a fertilizer for plants. These opportunities have been encouraging capital investments in the market.

The growth potential for insect protein has been projected to be high due to the increasing investments and ventures by the players in the industry. For instance, in 2020, Ynsect has extended series C funding to USD 352 million in 2020 to strengthen its product lines and increase its global presence. The company is utilizing these investments majorly to expand its production capacities by 5-10-fold to meet the increasing demand for insect protein products in food and feed applications. Cumulatively, the major players in insect protein have a production capacity of over 15 KT for feed application during the study period. This production capacity is estimated to grow by almost 80% in the coming years based on these companies' investments and expansion strategies.

1.1 Global Market and Market Dynamics

The **global market for insect protein** is estimated at USD 789.79 million in 2022; it is projected to grow at a Compound Annual Growth Rate (CAGR) of 33.38% to reach USD 3,334.29 million by 2027 (Figure 1). The market is driven by the **growing opportunities for alternative proteins** globally. However, the threat posed by the **vegan trend** among end-use consumers can affect the market growth to some extent in the coming years.

Figure 1. Global Insect Protein Market in the Period 2022 - 2027

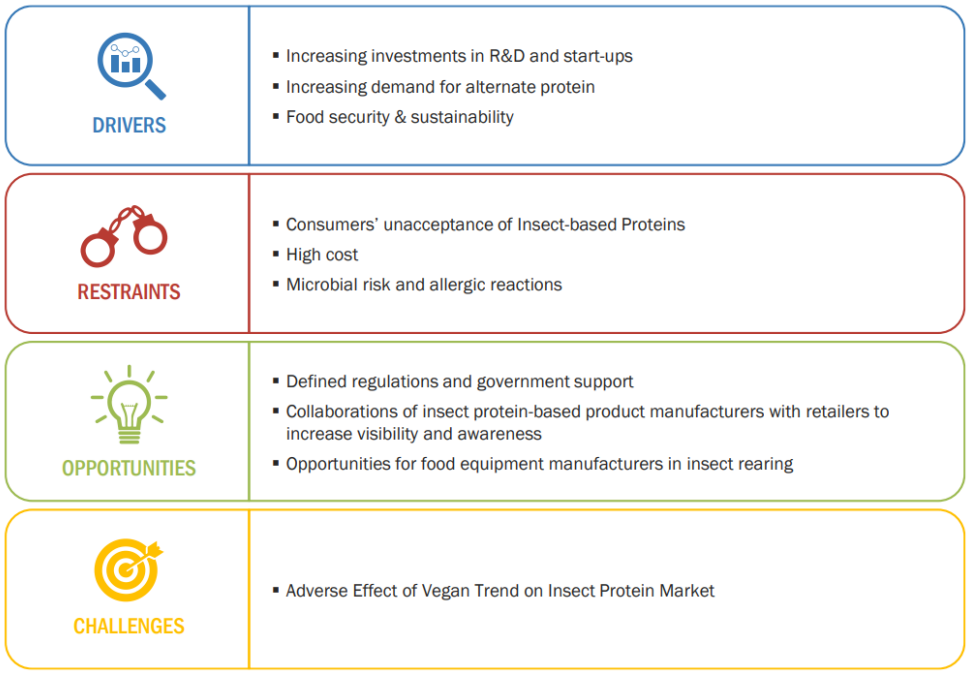
Though insects have been an inclusion in the diet across a few countries, consumers are reluctant the adoption of this protein form in other countries. However, manufacturers' development of palatable and appealing products, such as pasta and confectioneries, can help convince the consumers to accept the product. Since a majority of the insect characteristics replicate that of shrimp, there is a high possibility of minor allergies in association with this product, which can further **restrain** the growth potential of this market (Figure 2).

Edible insects have been a tradition across the Southeast Asian countries, owing to their high protein benefits. However, processed insect protein is a growing trend, which can serve as an alternative for animal-produced meat products, as it provides more nutritious value compared to other meat products such as pork, chicken, lamb, and beef. On the other hand, fluctuating prices of fishmeal owing to their low availability, especially encourage aquafeed and pet food manufacturers, to adopt alternate protein sources. Also, in comparison to animal rearing, **insect rearing is cost-effective** and environment-friendly due to lesser usage of water and land resources. Thus, due to these factors, food and feed manufacturing companies are highly attracted to this market.

Active participation of major players such as Ÿnsect (France), Hexafly (Ireland), InnovaFeed (France), Protix (Netherlands), and JIMINI'S (France) has helped boost the market awareness across the globe. Moreover, partnership by key feed and food companies such as Cargill (US) and ADM (US) has boosted the growth opportunities of this market. For instance, In December 2020 Innovafeed has collaborated with ADM for the construction of insect protein production site in Decatur, Illinois, to provide Innovative and sustainable solution to meet the growing demand for insect protein in animal feed. The variety of insect protein products introduced by these companies has helped garner the attention of consumers and helped companies widen their consumer base.

However, the cost of these products in comparison to conventional protein, and the reluctance of consumers toward products based on insects, can **narrow** the growth opportunities. However, the insect protein market is expected to witness potential **opportunities** in the future due to changing consumer preferences and rising acceptance of insects in regular meals among millennials.

Figure 2. Market Dynamics: Insect Protein Market



Drivers

Increasing Investments in R&D and start-ups: Insect protein has gained traction from various firms in the past five years, wherein multiple capital investors have been willing to invest in emerging insect protein manufacturers. Companies such as Cargill (US) and PepsiCo (US), directing their investment toward this market, has raised the credibility of insect protein products. Established companies have also been investing in start-ups to provide them monetary support for research & development, expansion of their production facilities, and implementation of marketing strategies regarding brand awareness. These investments are being directed mainly towards the expansion of production facilities.

Increasing demand for alternative proteins: The increasing population is a major reason for the requirement of an alternate source of protein. The focus in the past decade was to develop proteins from sources other than traditional crops and livestock. Conventional animal protein sources such as pork, beef, and chicken would be insufficient to meet this need in the future, thus providing opportunities for the insect protein market to expand. Besides fats and proteins, insects are also considered as an excellent source for minerals and vitamins. Insect proteins are now getting highly popular among the young population, especially for sports nutrition. For instance, start-ups such as Next Step Foods (UK), produce cricket protein bar "Yumpa" and offers it in three different flavors.

Another important factor affected by the adoption of alternative proteins would be greenhouse emissions. Switching from beef to alternative proteins can lead to a significant reduction in greenhouse gas emissions, especially for transitions to plant- or insect-based alternatives. It is also found that continued innovation in the development of alternative proteins, livestock production, and consumer behavior can lead to a sustainable food industry and healthier human life. Moreover, switching to alternative proteins has been observed to reduce diet-related concerns in developing countries. These factors translate to growth opportunities for the insect protein market.

Food security and sustainability: Catering to the increasing demand food is getting difficult due to less availability of land for livestock farming and water resources. Availability of limited land and water resources has been a major constraint for livestock rearing and also for plant-based meat ingredients, insect rearing is an alternate option, as it requires only a

fraction of these resources. Insects are significantly more efficient as compared to other livestock in terms of feed conversion. This is because they are cold-blooded and they control their metabolic processes such as body temperature, based on their outside environment. Insects are mostly considered to be 80%– 100% edible as compared with other livestock that are only 40%–50% edible. This new adoption will not only fulfil the global food requirement but would also help save water and feed resources for other applications. Insect rearing is also proving to be helpful for waste management. For instance, according to International Platform of Insects for Food and Feed (IPIFF), in the European Union alone, approximately 88 million tons of food is wasted per year, and this is anticipated to rise in the coming years. These waste products can be directed as feed to insects, which, in turn, would provide better-quality protein for human consumption. Thus, insect protein not only proves to be advantageous for consumers but also addresses the additional environmental wastage concerns.

Protein is considered to be a primary source of energy, Due to urbanization and rising incomes, the demand for animal protein is expanding quickly in emerging economies. By 2050, it is anticipated that the world's protein consumption would have roughly doubled, with an increasing market share for marine-based proteins. In 2022, according to UNICEF, Madagascar children are seriously threatened by the drought, storm, and global food security crises. Acute malnutrition, the most dangerous type of malnutrition for children's survival, affects 6% of children under the age of 5. These malnutrition-affected countries are usually weak in terms of economy, and hence, insect protein production would be more affordable as this would help people to consume protein at a similar level to that of animal protein but at an affordable price. Countries such as Madagascar and Zambia possess 22 to 33 species of edible insects which can be incorporated in regular meals. Also, protein ingredients are well-known for their emulsification, gelation/viscosity, water-binding/ hydration, foaming, and aeration properties, owing to which protein application across different industries has been growing. These functionalities, along with the nutritional aspects of proteins, are a major advantage to end-user industries, and are, thus, one of the major market drivers.

Restraints

Consumers' unacceptance of insect-based proteins: Edible insects are currently an integral part of numerous traditional diets found in over 113 countries, including those in Africa, Asia, and South America. It is yet to be accepted in countries such as the US and the UK. The creepy appearance of insects raises the difficulty for most consumers to adopt it. This factor has been the main barrier for all types of insect-based technologies. To overcome this aversion, scientists are focusing on developing palatable and scalable insect protein-made products to meet the rising demand for protein from the growing global population. Similarly, the introduction of insects as a source of food in Western societies has more possibilities of success if insect proteins are added to similar food items. This will reduce the fear, negative attitude, and neophobic reactions among consumers for insect-based food products.

High cost: Insect proteins are currently expensive, owing to being a new product in the market. Additionally, efficient mass rearing of insects requires hot and humid temperatures. In western countries, where the temperature is usually low, companies need to invest in technologies to maintain the required temperature, which, in turn, increases the production costs. Additionally, some of the companies also import insects from Southeast Asian countries, which also leads to additional transportation costs, which, in turn, increases the price of the final product. However, this scenario is projected to change during the forecast period. Increased demand and government support will encourage efficient production of insects and insect-based products. The involvement of local distributors and the establishment of new manufacturing facilities in nearby areas are also projected to reduce the overall costing of insect protein products.

Microbial risk and allergic reactions: Food allergies are common and have become even more widespread globally. Although insect consumption is healthy in terms of nutrition, it is also prone to various allergic risks among animals and humans. Since the introduction of insects in food and feed is a new concept, the allergies related to it are not completely known, and causes are not well understood; hence, they cannot be treated on an immediate basis. This ends up increasing

the risk factor for consumers. Risks associated with eating insects could be caused by probable chemical (e.g., heavy metal accumulation) and microbiological contaminations. Additionally, several insects have been known to trigger allergic reactions by eating, inhalation, direct contact, stings, and bites. Cross-reactivity with other taxonomically related food allergens, such as crustaceans, as well as inhalant allergens, such as home dust mites, can contribute to the adverse reactions recorded after ingesting insects (HDM).

Opportunities

Defined regulations and government support: For better acceptance of insect protein-based products, taste, texture, and looks are some of the major sensory factors. Apart from these, regulations defined by governments along with related edible insect associations help in gaining confidence of the consumers since such regulations give assurance of safety and hygiene. These regulations give guidelines on the production of insect protein-based products, the type of insects to be used, and the type of substrates to be used for rearing insects. Since it is a niche market, proper regulations were not defined. However, with the gaining popularity and demand for insect protein-based products, many new companies are emerging in each region. Thus, for proper standardization of the production process, governments and associations in various regions are introducing regulations.

Collaboration of insect protein-based product manufacturers with retailers: Higher costs and visibility of insect protein-based products have been some of the major problems for the companies. Many start-ups have been selling these products majorly through online channels. However, due to the increasing awareness regarding the benefits of insect protein and to increase the visibility of insect protein-based products, many companies have started collaborating with retail chains and other convenience stores. For instance, in the recent years, Eat Grub, a UK-based insect protein-based products manufacturer collaborated with SOK—one of Finland's largest supermarket groups. SOK will be selling Eat Grub's products in 400 of its stores. The French insect-based snacks start-up, JIMINI'S, secured a listing with Carrefour, a multinational retailer, to supply items to 300 of its stores. JIMINI'S intends to educate and increase awareness regarding insect protein as a future sustainable source for proteins by selling insect-based products in retail stores and considers it as one of the major steps for future growth of the insect industry.

Opportunities for food equipment manufacturers in insect rearing: Insect rearing is feasible in hot and humid regions in countries such as Malaysia and Thailand. However, in cold regions, efficient technology and automation are required for mass and continuous production of insect and insect-based food and feed production. This aspect will become more important in the coming years when the demand for protein will increase due to the rising population, and the need for sustainable protein production will be required. Additionally, the present insect rearing technologies are not efficient for mass rearing, which is also one of the major factors for high production costs.

The concept and applications of new strategies are now gearing up and moving toward the industrialization of insect products. Currently, a few industrial enterprises are in various stages of development for insect farming. For large-scale production, critical elements, including research on insect biology, suitable rearing conditions, and diet formulas are required. To achieve commercial mass production, current farming systems need automation of some key processes to make them economically competitive with the production of meat from livestock. Edible insect farming could produce in sufficient quantities at low enough cost per kilogram to compete with any other animal-derived commodity if the production procedures were at least 80% mechanized. An integrated rearing system with mechanization, information, and automation can be applied competitively and effectively for large-scale insect farming.

Challenges

Adverse effect of vegan trend on insect protein market: Excessive consumption of animal-based protein has been proven to result in various diet-related diseases such as obesity, type-2 diabetes, heart diseases, and certain cancers. Whereas,

on the other hand, the consumption of vegan products is observed not to accentuate such diseases; moreover, they help in building better immunity. The rising awareness of the nutritional benefits of vegan food products and their safety compared with conventional meat are also some of the important factors that have been contributing to grabbing the attention of consumers. Vegan products are replacing conventional processed meat products such as burgers, sausages, and nuggets. This is because vegetarian food contains lower levels of saturated fat, cholesterol, and calories than animal-based meat. It often contains higher levels of micronutrients such as zinc, iron, and calcium.

Considering this rapid growth of the vegan population, various meat product manufacturers are shifting toward producing plant-based meat and soy-based products, which are projected to impact the global insect protein market. Besides, the growth of the global insect protein industry is majorly being influenced by the rising flexitarian population. This section of the population substitutes some of the meat products in their daily or weekly diet for plant-based alternatives.

1.2 Regulatory Landscape

From a geographical point of view, there are **three legal trends** in the insect protein market:

- The UK, US, Canada, New Zealand, and Australia: These countries do not consider edible insects as a novel food, and hence, food agencies have authorized their import and sales.
- Non-English-speaking Western countries and the European Union: These countries have agreed to provide regulations and approvals for marketing insect-based products.
- Non-Western (majorly Southeast Asian) countries: Insects are part of traditional food but rarely packaged and exported or imported.

Owing to these different sets of dynamics across the globe, the regulatory framework for insect protein is not consistent. After 2018, the US and Europe initiated with regulations on edible insects and insect-based products.

1.2.1 Europe

In the context of insects for animal feed, one of the most critical changes in 2017 was introduced by Regulation (EU) No 2017/893. This act amended Regulations (EC) No 999/2001 and (EU) No 142/2011, allowing the feeding of seven insect species to aquaculture animals (black soldier fly (*H. illucens*), common housefly (*Musca domestica*), yellow mealworm (***T. molitor***), lesser mealworm (*A. diaperinus*), house cricket (*A. domesticus*), banded cricket (*G. sigillatus*) and field cricket (*Gryllus assimilis*)). Regulation (EU) No 2017/893 removed the requirement for reared insects that 'products of animal origin must be sourced from a registered slaughterhouse', because insect rearing facilities (where the insects are generally also 'slaughtered'), could not comply with the requirements specific to slaughterhouses.

In 2015, the European Parliament decided that insects fall into the "novel foods" category, and consequently are subjected to approval processes. EU Law regulates the conditions for food and feed business operators, such as insect producers, to produce and commercialize their products in the European Union. In accordance with the General Food Law and Hygiene Package, "producers of insects – like any other food or feed business operator – are responsible for ensuring the safety of the marketed products, such as the registration or approval of their activities before national competent authorities – and establish hygiene standards to be applied at the different stages of production covered." Insects are currently listed as "Terrestrial invertebrates" in the EU-Catalogue of feed materials.

The **insect species reared in the EU** shall not be:

- pathogenic or have other adverse effects on plant, animal, or human health;
- recognized as vectors of human, animal, or plant pathogens;
- protected or defined as an invasive alien species.

Regulation (EC) No 767/2009 10 (the Feed Marketing Regulation) provides that "*animals in the EU may be only fed with safe feed. With respect to feed/substrate for insects, Annex III to the Feed Marketing Regulation prohibits the feeding of feces and separated digestive tract content. Finally, as insects reared in the EU are farmed animals, Regulation (EC) No 999/200112 (the TSE Regulation) prohibits to feed insects with any processed animal proteins (PAP), except fishmeal*."

In addition to the general feed hygiene requirements, "*insects intended for feed use have to be processed in establishments approved by the competent authority of the relevant Member State according to the Animal By-Product Regulation (ABP) Regulation, addressing mainly biological risks. When insects are rendered into PAP, operators currently producing insect meal with plant-based substrates must comply with processing methods 1-5 or processing method 7 provided for by the ABP implementing Regulation. The processing is based on parameters such as the combination of reduction of particle size, heat treatment, time, and pressure*."

The EU Catalogue of feed materials lists feed materials together with a product description and the respective product properties in a non-exhaustive manner. Terrestrial invertebrates (entry 9.16.1) are in the current Catalogue described as "*whole or parts of terrestrial invertebrates, in all their life stages, other than species pathogenic to humans and animals; with or without treatment such as fresh, frozen, dried*." Live insects complying with this description can be fed to animals in the EU without prejudice to specific legislation.

On top of the inclusion of the positive list of eligible insect species mentioned in chapter 1.1, a **revision of the Catalogue** should include the following aspects:

- "Processed animal protein" (9.4.1) would explicitly include insects;
- "Terrestrial invertebrates" (9.16.1) would consequently cover only insects not processed as referred to in the Animal By-products Regulation;
- The footnote referring to insect products would require a mandatory indication of the life stage of the insect.

Within the existing legal framework, the **import of insect PAP** is allowed based on the following requirements:

- The insect PAP must be produced in line with the requirements laid down for category 3 material and for processed animal protein (PAP).
- Only imports from the countries listed in Part I of Annex II to Regulation (EU) No 206/201023 are allowed.
- The processing plant in the third country must be listed in accordance with the ABP Regulation.
- The insect PAP consignment must be accompanied by a health certificate in line with the model health certificate laid down in Chapter I of Annex XV to Regulation (EC) No 142/2011 and must undergo the veterinary checks at a Border Inspection Post.
- Before release into free circulation in the EU, the importer must ensure that each consignment is tested by light microscopy and/or PCR test, in line with the Standard Operating Procedure of the EURL for Animal Protein, to verify the absence of constituents of animal origin prohibited by EU feed ban rules.
- In relation to the use of insects for animal feed EU parliament announced major changes in 2017 with the Regulation (EU) No 2017/893. This act amended Regulations of (EC) No 999/2001 and (EU) No 142/2011 and permitted seven insect species to be fed to the aquaculture animals. The seven insect species include yellow mealworm (T. molitor), common housefly (Musca domestica), (black soldier fly (H. illucens), lesser mealworm (A. diaperinus), house cricket (A. domesticus), field cricket (Gryllus assimilis), and banded cricket (G. sigillatus)
- The amended regulation in 2017 also withdrawn the requirement for insects reared that 'products of animal origin must be sourced from a registered slaughterhouse'.

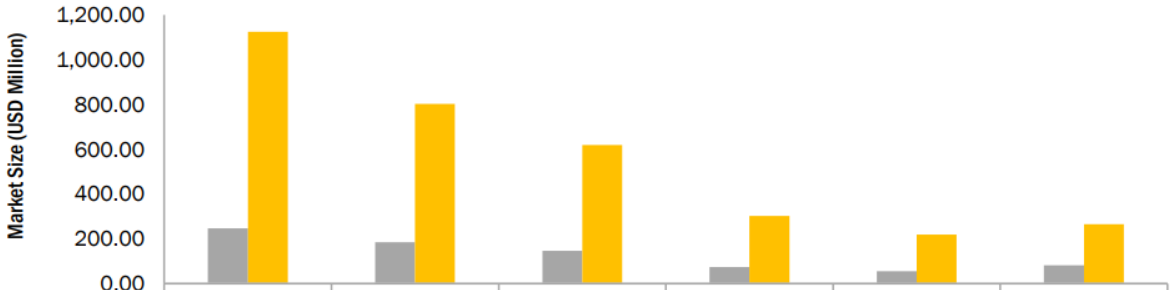
The import of treated, but not processed according to Regulation (EC) No 1069/2009, insects (e.g., dry frozen insects) for pet food is currently allowed; however, in the absence of health import requirements laid down in the ABP Regulation,

the import of treated but unprocessed insects for the manufacturing of processed animal protein in the EU territory for food-producing animals is currently not permitted.

1.3 Market Segmentation by Insect Type

The insect protein market by segment can be segmented into: **cricket, black soldier flies, mealworms, grasshoppers, ants and other insect** (silkworms, beetles, buffalo worms) (Figure 3). The **crickets** segment dominated the global insect protein market in 2022. The dominance is attributed to the increased prices of food products, where these insects are used. While black soldier fly larvae are majorly applied in feed industry, crickets are used in food products due to their nutritional properties.

Figure 3. Insect Protein Market, by Insect Type, 2022 - 2027 (USD Million)



	Cricket	Black Solider Flies	Mealworms	Grasshoppers	Ants	Other insects
2022	246.91	185.10	146.09	74.55	55.52	81.56
2027	1,125.24	803.12	618.95	302.81	219.05	265.13
CAGR(2022-2027)	35.44%	34.11%	33.48%	32.36%	31.59%	26.59%

Crickets

Due to the high availability and acceptability of **crickets**, their usage in products in the form of powder and protein bar is extremely high. Dried cricket powder contains 69% of protein, compared chicken (31%), dried beef (43%), and to sirloin beef (29%). It also contains nine essential amino acids, along with zinc, vitamin B12, iron, potassium, magnesium, sodium, and calcium. Cricket flour also act as an alternative for milk, as it contains a high amount of calcium. To produce 1 kg of meat, crickets usually require around 2 kg of feed, in which around 80% is edible, whereas cattle require 8 kg of feed to produce the same amount of meat, out of which only 40% is edible. Moreover, it only takes about a gallon of water to rear a pound of crickets, whereas 2,000 gallons of water is spent to rear a pound of cow. Researchers derive a similarity between crickets and shrimp since the digestibility of their protein is almost similar for humans. Also, crickets have been a part of the traditional diet in Thailand and Southeast Asian countries since ages, and hence, the chances of cricket allergy among humans have been observed to be least. Owing to these reasons, the application of crickets is majorly targeted towards human nutrition. According to the FAO, livestock rearing is accountable for 18% of GHG emissions (CO_2 equivalent), which is higher than the share of the transport sector. On the contrary, cricket production is estimated to produce around 80 times less methane than cattle, thus proving to be more environment friendly. Due to these factors, consumers widely accept crickets globally.

Black soldier flies

Black soldier fly, also known as *Hermetia illucens*, is a widespread fly of the family Stratiomyidae. Although it is used in food products, its application in the feed industry is more evident. This is due to black soldier fly larvae's essential role in breaking down organic substrates well, and its **frass** can be utilized as nutrients to the soil. The larvae are used in animal

feed, as they are a good source of protein and are easy to farm. A black soldier fly contains up to 43% of protein and is rich in calcium and various other nutrients. Additionally, for rearing one kg of Black soldier larvae, only about 1.5 kg of feed is required, which makes the process cost-effective as well. Also, these insects support zero-wastage processes, wherein even their by-products are put into application. For instance, **frass**, a by-product of black soldier flies, can be used as fertilizer while fat and chitin are applied in cosmetic products.

Mealworms

Mealworm consumption, as part of the tradition, is highly practiced in Southeast Asian countries. Mealworms can be cooked through roasting, hot air drying, steaming, oven broiling, deep-frying, boiling, pan-frying, and microwaving. Among these methods, oven broiling provides a desirable aroma of steamed corn to cooked mealworms. These insects can be easily reared on fresh oats, with sliced potatoes, wheat bran or grain, carrots, or apples as a moisture source. However, the requirement of small space to rearing mealworms has made them more popular in many parts of Southeast Asia. Mealworm larvae contain nutrients, which has increased their use for food and feed applications. For instance, every 100 grams of raw mealworm larvae contain 206 calories and 14 to 25 grams of protein. Further, mealworm larvae contain selenium, potassium, copper, iron, sodium, and zinc, along with essential linoleic acids and vitamin. Insect protein isolates extracted from mealworms are equivalent to soy protein and helps in increasing the levels of essential amino acids as well as branched-chain amino acids. Due to this, they are universally used as sport nutrition supplements. Mealworms are also used as pet food for captive fish, reptiles, fish, and birds. They are also fed to wild birds in bird feeders, particularly during the nesting season. They are also used as fishing baits.

Grasshoppers

According to the Food and Agriculture Organization of the United Nations, **grasshoppers** are considered a good source of unsaturated fats that lowers the risk of heart disease. These insects are also a good source of iron. They are consumed in Asia, Africa, and Central America. In Mexico, they are famously known as Chapulines and are found in the states of Oaxaca, Guerrero, and Morelos. Grasshoppers are frozen, dried in ovens, and then milled into a fine powder. Whole grasshoppers are sold to the foodservice industry, whereas milled grasshopper powder is sold to food manufacturers. Grasshoppers are not very delectable but have high nutritional value. According to the Biology Institute of the National Autonomous University of Mexico (UNAM), these bugs also have medicinal properties. Hence, they can be used in the pharma industry for producing cost-effective medicines.

Ants

There are around 313 types of edible **ants**, with extremely high calcium content, across the globe. Some of these ants are immensely popular in South America and are used in various applications. For example, fire ants are consumed as evening snacks in South America. Also, black ants are another species that have a stronghold in the market, due to its high nutritious value. Black ants contain vitamins B12, B1, B2, D, and E, and calcium, iron, phosphorous, manganese, and selenium. Due to this, they are available for commercial usage in the powder form. The black ants have medicinal properties and can be used to cure chronic diseases. However, this study is at the preliminary stage and will take time to attract decent acceptance among consumers.

Other insects

Other insects include silkworms, beetles, buffalo worms. Edible silkworms are known for their nutritional quality. 100 g of silkworms contains 80 g of carbohydrate, protein, and 8 g of lipid, 389 kcal of energy. Beetles are consumed as food in the form of larvae. There are about 344 species of beetles that used as food. Among them, rhinoceros beetles and mealworms, which are the larvae of darkling beetles, are consumed most commonly. Moreover, a wide range of species

is also used in folk medicine to treat patients suffering from various disorders and illnesses. However, this is performed without clinical studies supporting the efficiency of such treatments. Nevertheless, the increase in research & development in the various uses of these species would prove beneficial. Another species in this category are buffalo worms, which come from the species of darkling beetles. The larvae of darkling beetles are commonly marketed under the term “buffalo worms.”

1.4 Market Segmentation by Application

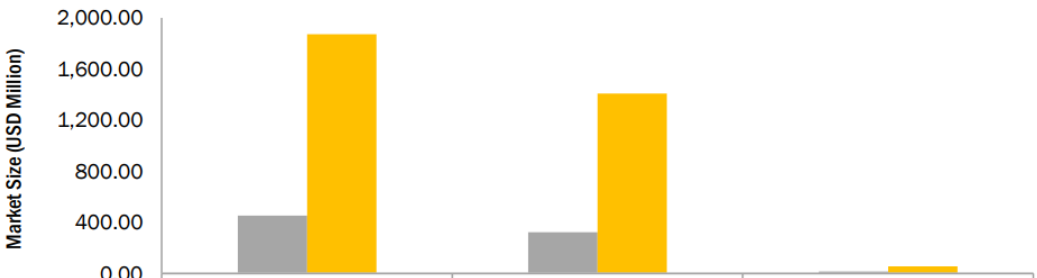
Insect protein is a used in various application such as: **food, feed, pharmaceutical & cosmetics** (Figure 4). The **nutritional benefits** of insects, in comparison to animal-based and plant-based protein, is a major driver for its wide adoption in the North American and European markets. High protein content in crickets has been explored in **food** application, while the application of varied insects has been tried for major **feed** application. The declining production of fishmeal, its fluctuating prices, and the pressure on food security have led to an increasing need for a protein substitute, which could be fulfilled by insects. These factors are projected to drive the market growth during the forecast period. According to the UN Food and Agriculture Organization, the use of insects for feed and food products has a lower environmental impact compared to conventional sources. However, despite various regulatory hurdles in North America and Europe, several insect protein products have already been launched in the market. Products such as insect protein-based pasta, cookies, croquettes, and snacks are accepted and available in supermarkets, which are made of insect protein powder or flour.

There have been research activities focused on the development of insect technology for **pharmaceutical and cosmetic applications**, wherein by-products such as chitin and insect fat are finding applications in these industries. Moreover, protein from insects such as grasshoppers and beetles are also used as medicines to treat animal diseases as well as human diseases. They are also used to make skincare products, although this acceptance is extremely low, and currently, companies are investing more in research & development rather than new product launches.

The **animal nutrition segment** dominated the market in 2022. Due to its rising popularity as a substitute for fish meals, the demand for insect protein is projected to remain high during the forecast period. The **food & beverages segment** was the second-largest segment in 2022. It is projected to grow at a CAGR of 34.32%% from 2022 to 2027. This is due to consumers' growing demand for insect protein as a protein substitute to supplement their healthy life.

Slow and gradual acceptance of insect protein products in food and feed sectors is projected to drive the growth in **pharmaceutical and cosmetics industries** during the forecast period.

Figure 4. Insect Protein Market, by Application, in the Period 2022 - 2027



	Animal nutrition	Food & beverages	Pharmaceuticals & cosmetics
2022	452.56	321.90	15.28
2027	1,870.72	1,407.16	56.41
CAGR(2022-2027)	32.82%	34.32%	29.85%

1.4.1 Food & beverage

Due to the rising necessity of protein alternatives among food & beverage manufacturers to fulfil the increasing demand of consumers, the adoption of insect protein has been growing in the **food & beverage** segment. High global population growth is witnessed, as the UN estimates that the global population will reach 9 billion by 2050. Moreover, the consumption of animal products such as meat, egg, and milk continue to rise, which puts a lot of pressure on environment sustainability. However, around 2,000 insect species are already consumed by humans and domestic animals across the globe as part of their regular diet. Insects contain high protein content, favorable fats, minerals, and vitamins.

Nutritional values are considered of high importance when consumed, which is a key factor that provides leverage to food manufacturers. Due to this factor, the companies are currently focusing on increasing insect protein awareness, as the acceptability of insect protein in regular diets is uncommon in western culture, although extremely common in the Southeast Asian and African countries. Edible insects are consumed with beverages across the Southeast Asian countries. For instance, mealworms are used in tequila-flavored novelty candies. Furthermore, in Mexico, mealworms are used in certain mezcals (Mexican Drink), which are usually the larva of the moth *Hypopta agavis*. This widens the opportunities for the beverage manufacturers to experiment in insect protein and provide more innovative products to consumers.

The **food & beverage market segment by region** is reported in the following Table.

Table 1. Food & Beverages: Insect Protein Market, by Region, 2022–2027 (USD Million)

Region	2022	2023	2024	2025	2026	2027	CAGR (2022–2027)
North America	79.23	107.15	144.98	196.25	265.80	360.10	35.37%
Europe	141.60	189.93	254.83	342.04	459.32	616.93	34.22%
Asia Pacific	62.00	82.60	110.10	146.80	195.82	261.27	33.34%
RoW	39.07	52.33	70.10	93.94	125.94	168.86	34.01%
Total	**321.90**	**432.01**	**580.01**	**779.02**	**1,046.87**	**1,407.16**	**34.32%**

1.4.2 Animal Nutrition

Insect protein manufacturers are focusing on catering to the dietary needs of animals used for agriculture and wildlife management. Zoo and pet animals along with fishes are provided with these insect protein products. The key nutrients included in animal nutrition are fiber, vitamins, carbohydrates, proteins, fats, minerals, and water. According to the United Nations Food and Agriculture Organization (FAO), the production of animal proteins between 2010 and 2050 is expected to grow by around 1.7% annually. This is due to the growing demand for nutritious, healthy, and safe pet foods, as well as a ban on antibiotics. These factors are projected to drive the market growth. Moreover, growing concerns about pet health and willingness to spend more on pet food products and medicines among pet owners is further projected to drive the market growth.

The **animal nutrition market segment by region** is reported in the following Table.

Table 2. Animal Nutrition: Insect Protein Market, by Region, 2022–2027 (USD Million)

Region	2022	2023	2024	2025	2026	2027	CAGR (2022–2027)
North America	160.60	212.72	281.81	373.42	494.97	656.11	32.51%
Europe	147.43	196.22	261.24	347.94	463.63	617.93	33.19%
Asia Pacific	52.07	69.42	92.59	123.54	164.92	220.22	33.43%
RoW	92.47	122.35	161.95	214.45	284.11	376.47	32.42%
Total	**452.56**	**600.71**	**797.60**	**1,059.34**	**1,407.63**	**1,870.72**	**32.82%**

The **market segmentation by livestock for insect protein in animal nutrition** is reported in the following Table and further described in the following paragraphs.

Table 3. Animal Nutrition Insect Protein Market, by Livestock, 2022–2027 (USD Million)

Livestock	2022	2023	2024	2025	2026	2027	CAGR (2022-2027)
Aquafeed	240.00	318.35	422.40	560.63	744.44	988.68	32.73%
Poultry feed	92.63	123.17	163.83	217.98	290.16	386.30	33.06%
Pet food	80.01	105.98	140.43	186.14	246.84	327.38	32.55%
Others animal nutrition	39.92	53.21	70.93	94.58	126.18	168.36	33.35%
Total	**452.56**	**600.71**	**797.60**	**1,059.34**	**1,407.63**	**1,870.72**	**32.82%**

Aquafeed

According to the Food and Agriculture Organization (FAO) estimates, by 2050 the demand for **aquaculture** will grow by 90%, and its production will increase from 59.9 million (MT) in 2010 to 113.7 million (MT) in 2050. According to the same resource, the aquaculture industry is one of the fastest-growing industries across the globe, wherein about 600 species are grown via aquaculture; the production volume of which amounts to more than 100 million tons, and the global value of production is about USD 170 billion. The sustainability of aquaculture depends highly on the nature and quality of the feed used in aquafarms, and this has been a major concern. Due to insufficient existing oceanic resources, the huge amount of fish meal (FM), fish oil, and other marine protein sources in fish feed is a major problem.

The main proposed **alternative to fish meal** is soybean meal, which has been introduced into fish farms. However, due to various food security issues such as GM and organic sourcing, an alternate source of protein is required. Hence, insect protein is increasingly gaining traction in the aquafeed industry. **Insect meal** has great potential to overcome the problems in the aquaculture sector. Insects are part of the natural diet of freshwater and marine fishes, particularly in the juvenile stage. Insects are also an excellent source of protein, with an average dry matter (DM) basis that varies between 45% and 75% and a well-balanced essential amino acid profile, as well as a source of several other high-quality components, including appropriate levels of minerals (such as potassium, calcium, iron, magnesium, and selenium) and several vitamins. The insect business is a fast-growing sector for aquafeed application, and several such companies or start-ups are founded in Europe such as Ÿnsect (France) and Protix (Netherlands).

Poultry Feed

Due to the increasing poultry production and changing preferences of consumers for chicken as compared to pork have led to high demand for protein-rich feed products. According to the FAO, **poultry production** is going to increase from 98.9 million (MT) in 2010 to 201.9 million (MT) in 2050, registering an increase of 104%. This high production will lead to an increase in demand for poultry feed, which creates opportunities for manufacturers in the insect protein market to grow. Although insect protein products are available for poultry feed, approval for the same has not been granted by the European Union.

Pet Food

Acceptance of insects as premium products in the **pet food** category is increasing due to the rising concerns among pet owners to provide a healthy diet. Increasing spending power of pet owners has also attracted the focus of pet food manufacturers in this market. Companies such as AgriProtein Holdings Ltd. (South Africa) offers products such as MagMeal for pets, which include insect protein. Innovafeed (France) provides products such as Protinno to cater to the health requirements of pet animals, whereas Ÿnsect (France) provides products such as Ynmeal, which is made of mealworms for pets. Companies are also introducing various flavors in this category and have also expanded their offerings in the market.

Other animal nutrition

Exotic bird and animals belong to the premier category, and hence, the expenditure on them by their owners are high. The premium pet owners do prefer spending a high amount of money on their pets as a part of their status symbol and luxury lifestyle. Due to these factors, animals are provided with premium food products in their regular diet. Thus, insect protein being a premium product is more acceptable in this application. Companies such as Enviroflight LLC (US) provide products such as EnviroMeal for exotic birds, animals, and swine. The introduction of new products is projected to drive the market growth of insect proteins.

1.5 Market Segmentation by Region

The insect protein market by region has been segmented into: **Europe, North America, Asia Pacific and Rest of the World** (Table 4). **North America** was the largest market share in the insect protein market in 2022, followed by Europe, Asia Pacific and RoW. The presence of key insect protein manufacturing companies in developed regions such as North America and Europe contributes to these regions' high market share. Moreover, various companies are investing and expanding their footprint in the Asia Pacific region to gain a larger global market share. For instance, in March 2021, Nutrition Technologies, an insect protein manufacturer, raised USD five million in a fundraising round and opened a new industrial-scale insect protein production facility in Malaysia. In African regions, the conductive climate and huge demand for new sources of animal feed protein coupled with a supportive regulatory environment are poised to drive the market growth.

Insect protein is anticipated to witness significant growth in the **European** region during the forecast period. This is primarily driven by the European Union’s decision to introduce the first novel insect protein, a yellow mealworm, in the European market in July 2021.

Moreover, the **Asia Pacific** region is anticipated to be positioned as one of the leading consumers and producers of insect protein. The lucrative opportunity offered by the region has encouraged multinational companies to start their operations in the region.

Table 4. Insect Protein Market, by Region, 2022–2027 (USD Million)

Region	2022	2023	2024	2025	2026	2027	CAGR (2022–2027)
Europe	294.85	393.68	525.84	702.61	939.31	1,256.03	33.62%
North America	245.41	327.24	436.52	582.52	777.74	1,038.63	33.45%
Asia Pacific	117.71	156.69	208.64	277.93	370.42	493.81	33.21%
RoW	131.77	174.96	232.39	308.78	410.49	545.82	32.88%
Total	**789.74**	**1,052.57**	**1,403.39**	**1,871.84**	**2,497.97**	**3,334.29**	**33.38%**

1.5.1 North America

Since the UN FAO published the benefit of eating insects as an alternate ingredient source, consumers are increasingly interested in trying edible insects and insect protein-based products. Many **start-ups** have been established in the region that provide both edible insects and insect protein-based products for food and feed applications. Enterra Feed Corporation (Canada), Entomo Farms (Canada), EnviroFlight LLC (US), and Aspire Food Group (US) are some of the leading companies providing insect protein-based products.

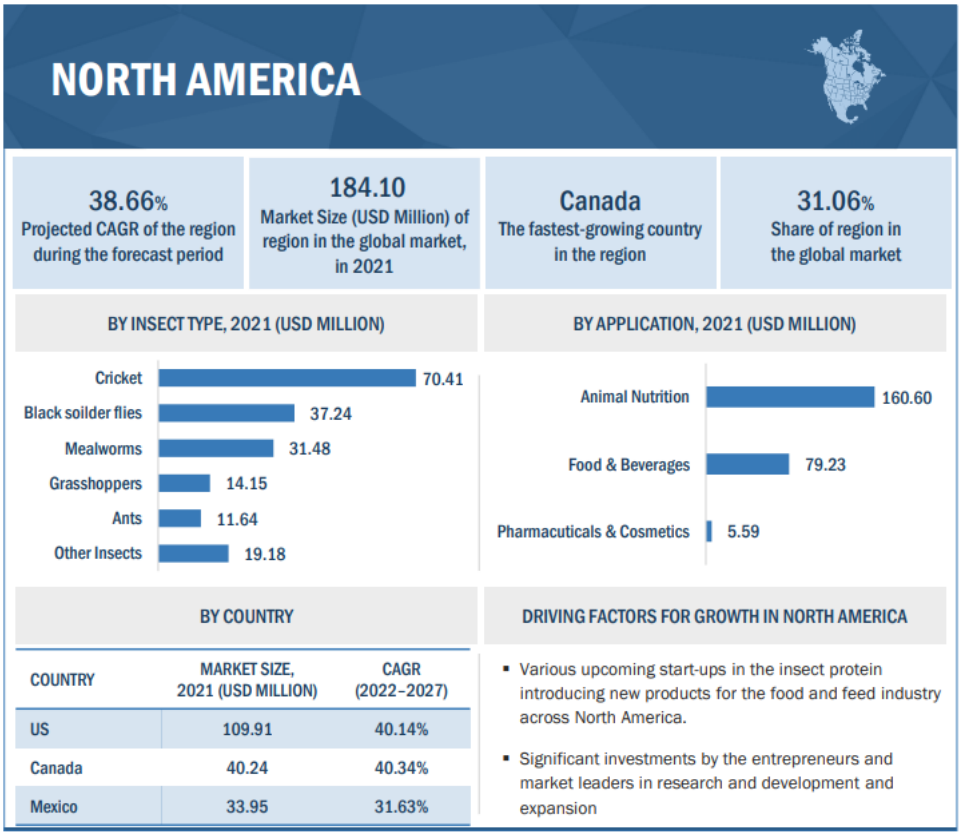
Although insect protein is majorly used in **feed** applications, the market for insect **protein-based food products** is projected to record the fastest growth during the forecast period due to the increasing awareness among people (Figure 5).

The authority responsible for controlling feed safety in the US is the **Federal Food and Drug Administration** (FDA), which collaborates with the **Association of American Feed Control Officers** (AAFCO) in the area of feed regulation, particularly in addressing new feed ingredients. Products containing insects must follow the FDA's standards, including bacteriological tests and good manufacturing practice (GMP) certification. The **North American Coalition for Insect Agriculture** (NACIA), an organization for growing the insects for food & feed industry, has a mission to improve collaborations for stakeholders in the insect industry. NACIA plans to help the insect and insect-related product manufacturers by educating clients, consumers, and guiding potential producers.

Crickets are the major insects used for insect protein, followed by the **black soldier fly** (BSF) across North America. For instance, Chirps manufactures chips containing cricket flour, while Chapul Cricket Protein (US) manufactures cricket protein bars and cricket protein powder. BSF is used by companies such as Enterra Feed Corporation (Canada) and EnviroFlight LLC (US) to produce feed. Online retail channels are majorly used for selling products by these companies. However, the growing popularity of insect proteins and increasing focus on improving the visibility of these products have encouraged companies to sell their products in various retail stores and expand their product portfolio.

Various **private investors**, including entrepreneurs and companies such as Arielle Zuckerberg (US), John Chambers (US), Buhler Group (Switzerland), Wilbur-Ellis (US), and Mark Cuban (US), have invested in edible insect and insect protein companies for R&D and expansion. In the field. Aspire Food Group raised a fund of USD 8.5 million to produce cricket protein, producing a nutrient-rich protein for premium health food and pet markets. Thus, with the support of both private and government agencies, the growth of the insect protein market is projected to be high during the forecast period.

Figure 5. North America: Market Snapshot



Edible insects are not a preferred choice among consumers in the **US**. However, insect protein is gaining popularity among consumers due to increasing awareness about the growing need for sustainable and alternative protein sources. Additionally, various research studies have been conducted by scientists in the country on insect protein and its benefits. Seek Foods, Aspire Food Group, Tiny farms, Enviroflight, Chirps, All Things Bugs, and Beta Hatch are some players providing insect protein products for food and feed applications. Many of these start-ups are funded by both public players as well as governments.

Canada accommodates the largest cricket farm Entomo Farms, in North America. The company has developed "cricket condos," which allow the crickets to live as close as possible and is similar to their natural habitat. Additionally, these insects are fed with locally sourced organic food. Thus, this makes it one of the few companies worldwide to be certified as organic. The company processes the crickets to make it into cricket powder. Besides selling the powders online, the company has expanded its channel by collaborating with Loblaws, one of the largest grocery chains in Canada. With Canada's largest retail store selling insect protein-based products, visibility, awareness, and demand for such products are projected to increase in the coming years.

1.5.2 Europe

The **European Union** is highly dependent on the import of protein-rich feed, which accounts for around 70%, particularly soybeans and soy meal. Due to the increasing global population and rising per capita meat consumption, there is a growing demand for protein sources, raising concerns about future feed protein sources and food security. Moreover, Europe occupies a huge share in the global food ingredients industry. Animal protein occupies a dominant share in the European diet, but with the growing demand for sustainable protein sources in the region, the **demand for alternative protein** sources remains high.

Currently, the European Commission is promoting the adoption of plant-based and insect-based protein and planning strategies to incorporate these sources as an alternative to animal protein. Trends toward healthy eating and hybrid meat products are among the key drivers increasing its traction in the European insect protein market. Increasing research and development in insect technology, regulatory advancements supported by positive media coverage, and greater availability of insect products have further widened the growth opportunities for this market.

The majority of the **companies** in the insect protein market are headquartered in the region, with some of the key players such as Ÿnsect (France) and Protix (Netherlands) in the feed industry, and JIMINI'S (France) in the food industry. Also, consumer acceptance of insect products has been the highest in Europe compared to other regions. Hence, Europe is projected to dominate the global insect protein market during the forecast period.

The **European insect protein market segmentation by country** is reported in the following Table.

Table 5. Europe: Insect Protein Market, by Country, 2022–2027 (USD Million)

Country	2022	2023	2024	2025	2026	2027	CAGR (2022-2027)
Netherlands	41.99	55.70	73.91	98.11	130.30	173.08	32.75%
Germany	54.72	73.81	99.57	134.37	181.40	244.93	34.95%
France	79.03	105.56	141.06	188.56	252.19	337.37	33.68%
UK	51.40	69.17	93.11	125.38	168.91	227.59	34.66%
Italy	36.88	48.86	64.76	85.87	113.90	151.10	32.59%
Rest of Europe	30.84	40.58	53.42	70.33	92.61	121.96	31.65%
Total	**294.85**	**393.68**	**525.84**	**702.61**	**939.31**	**1,256.03**	**33.62%**

**Rest of Europe include Ireland, Norway, Sweden and Switzerland*

The **European insect protein market segmentations by insect type** and **by application** are reported in the following Tables.

Table 6. Europe: Insect Protein Market, by Insect Type, 2022–2027 (USD Million)

Insect type	2022	2023	2024	2025	2026	2027	CAGR (2022-2027)
Cricket	72.71	98.46	133.34	180.60	244.71	331.59	35.46%
Mealworms	55.46	74.84	101.03	136.42	184.27	248.94	35.03%
Grasshoppers	31.33	41.84	55.88	74.68	99.84	133.52	33.63%
Black soldier flies	81.98	110.40	148.72	200.40	270.16	364.25	34.75%
Ants	23.42	30.81	40.52	53.31	70.16	92.32	31.56%
Other insects	29.94	37.33	46.34	57.20	70.17	85.41	23.33%
Total	**294.85**	**393.68**	**525.84**	**702.61**	**939.31**	**1,256.03**	**33.62%**

Table 7. Europe: Insect Protein Market, by Application, 2022–2027 (USD Million)

Application	2022	2023	2024	2025	2026	2027	CAGR (2022-2027)
Animal nutrition	147.43	196.22	261.24	347.94	463.63	617.93	33.19%
Food & beverages	141.60	189.93	254.83	342.04	459.32	616.93	34.22%
Pharmaceutical & cosmetics	5.81	7.54	9.76	12.64	16.36	21.17	29.49%
Total	**294.85**	**393.68**	**525.84**	**702.61**	**939.31**	**1,256.03**	**33.62%**

France is one of the world leaders in the agriculture industry, and many investors are attracted to its insect production segment, influencing them to invest in this market. In 2019, FARMŸNG, a project coordinated by Ÿnsect (France) and co-funded by the European Commission and the Bio-Based Industries Joint Undertaking (BBI JU), developed farming methods and transformation of mealworms for automated and industrial production with the participation of 20 major players in the value chain. They have invested USD 20.3 million in this project. The project aimed at producing ***Tenebrio Molitor*** on an industrial scale for animal feed and fertilizer. These investments show that companies based in France are focused on leading the insect protein market in the coming years. French-based companies that sell edible insect products under their brands include Houhou, Insectes Comestibles, Gryo Bars, JIMINI'S, Micronutis, Minus Farm, and InPulse protein.

Italy is a major market for the aquafeed industry, and according to the FAO, it is one of the largest aquafeed producers. Aquaculture's contribution to total fishery production in Italy increased slightly from 41.6 % in 2000 to 43.6 % in 2019, with some fluctuations over the period. Thus, increasing aquafeed production is projected to increase the consumption of insect protein in the country. Though it is customary for Italian children to eat the sweet ingluvies of brightly colored moths from the genus Zygaena, the insect-based products were officially served for the first time in 2015 during Expo Milano by Belgium Pavilion. Additionally, lower prices of insect protein for feed are another major factor driving insect protein consumption in the animal nutrition segment.

The **Italian insect protein market by application** is reported in the following Table.

Table 8. Italy: Insect Protein Market, by Application, 2022–2027 (USD Million)

Application	2022	2023	2024	2025	2026	2027	CAGR (2022-2027)
Animal nutrition	24.74	32.70	43.23	57.17	75.64	100.10	32.26%
Food & beverages	11.86	15.80	21.07	28.10	37.48	50.01	33.36%
Pharmaceutical & cosmetics	0.29	0.37	0.47	0.60	0.77	0.98	28.00%
Total	**36.88**	**48.86**	**64.76**	**85.87**	**113.90**	**151.10**	**32.59%**

1.6 Competitive Landscape

Insect protein finds major applications in the food and feed industries, and hence, profiling of major manufacturers of insect protein products for both food and feed applications has been covered in this report. **Key companies** in the insect protein market include: Aspire Food Group (US), Entomo Farms (Canada), JIMINI'S (France), Chapul Cricket Protein (US), and Swarm Nutrition GmbH (Germany), while key companies in the feed application include AgriProtein Holdings Ltd. (South Africa), EnviroFlight LLC (US), Innovafeed (France), Ÿnsect (France), Hexafly (Ireland) and Protix (Netherlands).

The **main players active globally** are further described in the following Table.

Table 9. Global Players in the Insect Protein Market

Company	Geography	Description	Website
All Things Bugs LLC	USA	The company manufactures insect-based protein powder for the food industry. Its products have applications in protein bars, shakes, snacks, pastas, tortillas and baked goods with technology and scale, the company produces insect protein at lower cost than other animal protein with lower environmental footprint	https://allthingsbugs.com/
Aspire Food Group	USA	Innovative company in the food industry that develops food ingredients and end-products based on insect technology. The company applies precision farming technology for its insect breeding through complex modelling simulations and analytic approaches	https://aspirefg.com/
Beta Bugs	UK	Biotechnology company that produces black soldier fly breeds for insect farming that can be used in aquaculture, pork, and poultry feed. The company's flagship product (Hiper Fly) has an industrial unit that transforms food waste into high-value, low-impact protein and soil conditioner (**frass**) using black soldier fly larvae	https://www.betabugs.uk/
Bioflytech	Spain	Bioflytech is a leading company in Europe in the industrial production of insect protein for animal feed. The company has developed patents in insect protein for animal feed and feeding breeding, self-harvesting of larvae and other auxiliary systems. The application of its products includes fish, pets, and farm animals	https://bioflytech.com/
Chapul	USA	The company was the first to introduce insect protein products for food in the US market. The company has been producing cricket protein bars and protein flours, offering multiple flavored bars	https://www.chapulfarms.com/
Entomo Farms	Canada	One of the leading insect technology companies operating in the food and feed industries for their products. The company believes in a zero-waste approach and thereby produces **frass** for fertilizer application. For food application, Entomo Farms develops protein powder from crickets	https://entomofarms.com/
EnviroFlight	USA	EnviroFlight is an insect-based technology company that offers potential to recover the abundant food surpluses with much-improved protein yield potential compared to traditional protein sources, given their proficiency at transforming organic resources into valuable proteins oils and **frass**. The company develops animal and plant nutrition products from Black Soldier Flies (BSF) as whole insects or by-products. In animal nutrition, the company caters to a wide range of applications, covering poultry, aquaculture, pets, exotic animals and fertilizer	https://www.enviroflight.net/
Global bugs	Thailand	Leading player in the production of sustainable protein based on crickets. The business focuses on using crickets in place of animal protein as a sustainable solution to reduce the effects of global warming	https://globalbugs.asia/
Goterra	Australia	Goterra offers complete food waste management infrastructure. The company uses waste as a resource to feed insects instead of throwing it away, adding nutrients back into the food chain	https://goterra.au/
Hexafly	Ireland	Hexafly converts low-value garbage and waste streams to feed black soldier flies which would be processed and used as high-value feeds, fertilizers, and bioplastics, through insect farming. One of the main products is **HexaFrass**	https://hexafly.com/
HiProMine S.A.	Poland	Produces insect based raw materials for pets and livestock. The company offers, insect dried larvae, insect pulp (fresh meat), and insect meal (dry form produced from Black Soldier Fly - *Hermetia illucens*	https://hipromine.com/?lang=en

Company	Geography	Description	Website
Innovafeed	France	Biotechnology company producing insect-based protein for feed, especially in the aquafeed application. The company focuses on an innovative and sustainable agricultural value chain to implement zero-waste, as all parts of the insects is valorized, insect oil for poultry and swine nutrition, insect protein for aquaculture nutrition, and **frass** as an organic fertilizer. InnovaFeed has developed deep expertise in breeding *Hermetia Illucens*, an insect with an exceptional ability to extract proteins from low-value plant co-products	https://innovafeed.com/en/
Jimini's	France	The company produces edible insects in different products, as snacks, protein bars, granolas, crackers and pasta	https://www.jiminis.com/en/
JR Unique Foods	Thailand	The company offers insect protein powders which are shipped directly to food manufacturers worldwide for further processing into pasta, rackers, protein shakes, textured meat in ready meals, cbars. The core product of company is cricket powder	https://jrunique.com/
NextProtein	France	Manufactures insect-based protein and oil from black soldier fly. These fly larvae are raised, harvested and then processed into valuable components of animal feed for an insect-based protein for livestock, aquaculture, and pets by the company	https://nextprotein.co/
Nutrition Technologies	Singapore	Manufactures and supplies insect proteins, oils for agriculture, aquaculture, and animal feed. The company's products are derived from proprietary decomposition process with combination of yeasts, fungi, bacteria and insects to recover nutrients from agricultural and industrial food waste	https://www.nutrition-technologies.com/
Protenga	Singapore	Protenga has developed a Smart Insect Farm™ system. This system makes innovations in insect-based foods which are easy to use in various food manufacturing and agricultural by-products into fully traceable insect protein. Protenga produces reliable, sustainable, and high-quality protein, oil and **frass** products for feed under Hermet brand	https://www.protenga.com/
Protix	The Netherlands	Protix is one of the leading insect ingredient companies, with a broad range of offerings based on black soldier flies. The company not only markets edible insects for animal nutrition, but also processes by-products from the insects to provide premium protein-rich products in the market	https://protix.eu/
Tebrio	Spain	Biotechnological company, which is the leading industrial breeding of insects. The company products are: proteins for Pet Food, Fishmeal, Animal Feed and Human Food. **Frass**: organic fertilizers 3 and Tosan: for all types of industrial uses, agronomics, and health market among others	https://tebrio.com/en/
Ynsect	France	One of the leading producers of protein and natural insect fertilizers. The company processes insects into high-value ingredients for plants, fish, farmed animals, pets, and people to eat. One of the main products is **Ynfrass** as a natural fertilizer	https://www.ynsect.com/

2 Conclusions

Proteins derived from insects, either through consumption of the whole of the insects or through extraction processes, are termed **insect proteins**. Insect-based protein is considered a viable alternative source for protein, majorly in food and feed applications. Like animal proteins, insects are rich in proteins and essential amino acids, which are easily digestible compared to plant-based proteins.

As per the nutritional analysis by multiple researchers, in a comparison of beef and cricket protein, crickets are 69% protein while beef is only 29%. **Crickets** contain nine essential amino acids, along with Vit B12, iron, zinc, magnesium, sodium, potassium, and calcium. Similarly, the nutritional fact of other insects such as **black soldier flies, grasshoppers, and mealworms** are being explored for various applications.

These insects are used as a substitute for various meat products to fulfil the growing demand for nutritious food. They are consumed in various food products and are also used as a substitute for fish meals. These factors are expected to propel market growth in the near future. However, the lack of infrastructure to farm and process these insects at a large scale is hampering their growth as edible insects.

Insects, as a potential source of protein, are being explored in **North America** and **Europe**. Although the acceptance of the use of grasshoppers in the pharmaceutical application is at a preliminary stage, an increase in research and appropriate funding from the pharmaceutical industry could provide a wider pace for this market to grow. This would facilitate the production of cost-effective medicines in underdeveloped countries due to the easy availability and low cost of raw materials.

3 Additional Technology Information[1]

Insects are a lean source of protein and have an amino acid profile that makes them highly nutritional for feeding farmed animals and show promising results in terms of animal growth and performance. It also represents a promising alternative due to the possible environmental benefits, as production technologies leverage insect biomass conversion and are frequently touted as contributing to food waste reduction. Developers rear insects in enclosed and controlled environments, typically feeding larvae with food waste sourced from nearby food distributors. The end products are offered as wet or dried whole insects or powders. The most commonly favored insect species for feed applications are black solider fly (BSF) and mealworm larvae because of their high protein content and a short growth cycle. However, crickets and other insect types like fruit fly larvae are also exceptionally high in protein (reaching 70% protein content) and being explored.

The BSF remains the dominant insect targeting aquaculture feed, as they can consume catering waste that contains animal byproducts and solids from municipal waste streams. Mealworms are pickier about the selection of waste as feedstock, limiting their feedstock to spent grains and pre-consumer vegetable matter. However, ground-based insects offer ease of management; given mealworm beetles' inability to fly, their production management is considered an advantage for scalability compared to BSF. This advantage enables the production process to be more easily automated, promoting increased efficiency and large-scale production.

Promoters & Inhibitors

Insect protein is making headway as an alternative ingredient to replace fish meal, spurring significant investment in research and development of production methods. Today, most developers remain at an early-stage and face technical hurdles and regulatory challenges. A few key drivers and barriers are outlined below.

Promoters

- **Changes in legislation**. Regulations promoting sustainability and decarbonization enable the use of insect protein within livestock feed, pet food, and human diets. In 2017, the EU authorized the use of processed animal proteins

[1] *The following information have been provided by Lux Research in the framework of the Interreg ADRION Project Blueair developed by Area Science Park*

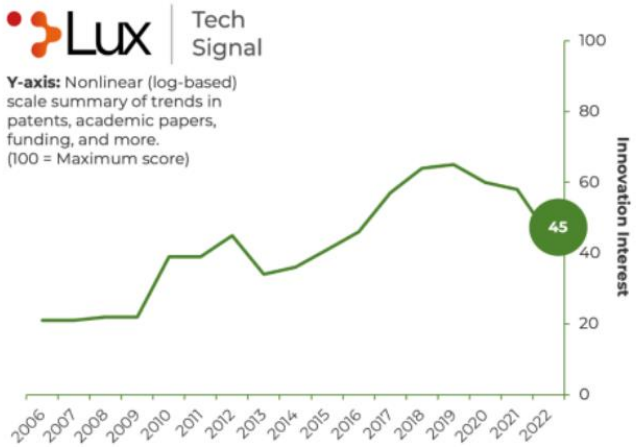
from insects in feed for aquaculture animals; support continues for food waste prevention and authorization for human consumption, promoting regional industry growth and opening the door for insect protein players.

- **Species development**. Advanced breeding techniques are leveraged to modify and improve traits for increased production efficiency and product quality. Many developers have significantly decreased the breeding cycle for greater productivity.
- **Product validation**. Insect protein for aquaculture applications requires strong feed trials data (e.g., increased or maintained biomass and quality, increased growth rate, or simplified valuedriving certifications) for adoption to reach critical mass. Developers that test their insect-derived ingredients in feeding trials are most likely to secure partnerships that will drive growth.

Inhibitors

- **Low production scale**. Global production capacity is currently unable to match demand for insect proteins. While some Southeast Asian nations consume insects regularly as part of the human diet, production for use in animal feeds is still in its infancy and markets often require improvements in quality control. Most insect producers report production for feed meals in single-digit-tons-per-week ranges.
- **Production efficiency**. Technical hurdles for insect production include formulating high-efficiency diets and controlling the growth environment to maintain optimal insect health and growth. Moreover, securing a predictable, cheap, and effective insect feedstock is paramount to the success of an insect protein company. While global food waste is abundant, insect production is not strongly restricted by its waste stream.
- **Animal diversity**. Dietary requirements of livestock vary by animal species. The nutrient content of insects is affected by the food source more than the insect species, but chitin content differs by insect species. Therefore, there is room within the production process to manipulate production for specific applications; however, in most cases insect meal cannot be the only ingredient source to satisfy livestock dietary needs without impacting production performance.

Innovation Trends



*The **Lux Tech Signal** is a composite score, combining data in patents, papers, and funding, plus Lux Research's proprietary data. It quantifies the progress of each technology, against a maximum innovation interest score of 100. Changes over time indicate growing (or shrinking) innovation interest, while inflection points may point to commercial opportunities or challenges ahead.*

The **Lux Tech Signal** indicates that innovation interest in insect protein has decreased over the last five years. Prior to this decrease, interest in insect production was escalating across the globe as a promising strategy to capitalize on trends to

minimize and valorize food waste and to support increasing protein demands for food and animal feed markets. Accordingly, up until 2020 insect protein experienced significant investment and rapid growth. It became crowded with players looking to test insect-derived ingredients in feeding trials and scale up production. Moving into the innovation downturn phase, leading insect producers are focused on improving adoption. Those capable of demonstrating strong business execution capabilities are experiencing scale up success. The largest insect production facility constructed to date produces about 15,000 MT of insect protein per year (InnovaFeed). Those operating at smaller scales or regional early-stage entrants, will need to secure capital to apply innovation to production efficiency, whether through automation, insect genetics, or production feedstock. Therefore, growth in insect protein production will be driven by the leaders rather than new entrants over the next five years. These players will continue to validate their products within a range of target industries, but insect protein will continue to generate the most interest for applications in aquaculture feed and pet food.

Key Players

Recent Developments

- **InnovaFeed (France)**. InnovaFeed's USD 250 Series D reaffirms BSF as a leading insect protein alternative. InnovaFeed will use the funds to further expand existing capacity in France, accelerate international expansion in the U.S., and support ingredient R&D. The announcement is particularly notable for the ample size of funding that exceeds rounds raised by other black soldier fly larvae (BSF) producers.
- **Nutrition Technologies (Singapore)**. Nutrition Technologies secured a USD 20 million to fuel its expansion plans for insect protein production. The funding will go towards Nutrition Technologies' expansion in Southeast Asia, including its site in Malaysia and a planned joint venture as well as support the company's product development and commercial launch in the European market.
- **Ynsect (France)**. Ynsect is expanding its mealworm production footprint with two planned facilities in North America. Ynsect has partnered with Ardent Mills to build a 50,000-Mtonne facility in the U.S. by the end of 2023 and with Corporativo Kosmos to build a similar plant in Mexico that will export to the U.S. market. Neither location was disclosed. The move follows the commissioning of Ynsect's flagship farm in Amiens, France, that is claimed to be the world's largest insect production site with a capacity of 200,000 Mtonne/y of insect-based ingredients. Ynsect has already established a presence in the U.S. through its acquisition of Jord Producers in March 2022.
- **Entocycle (United Kingdom)**. Entocycle raised USD 5 million for solutions to optimize black solider fly (BSF) farming. The investment will fund Entocycle's commercial rollout of its climate-controlled fly rooms and its computer vision platform (Entocycle Neo) for counting, handling, and weighing BSF larvae. Entocycle's market focus is Europe, eastern and southern Africa, and Japan, Singapore, and Korea for Asian markets.

Future Prospects

Feed formulators are increasing the inclusion percentage of insect protein. However, production scaleup, slow regulatory approval, and the need to reach cost parity with conventional ingredients impede widespread commercial adoption. To overcome these challenges insect protein developers are exploring the use of different production techniques including gene editing and varying levels of system automation as well as processing techniques like enzymatic hydrolysis to improve the nutritional value of ingredients. With the continued advancement of feeding trials and the resurgence of national and regional food and agriculture waste valorization initiatives, insect-derived ingredients warrant attention. Creating and identifying differentiation among competitors remains a challenge. There is not one insect species that has emerged as the clear winner evidenced by the fact that corporate players are hedging bets by investing in companies across multiple insect species. As a result, expect three correlated company attributes – industry partnerships, industry trials, and validated sustainability certifications – to be the key differentiators to monitor in the short-term as opposed to key innovations. Expect continued investment in insect protein production in the Adriatic-Ionian region, particularly for more advanced or early-stage regional developers focusing on stringent validation and operational scale-up including production automation.

4 Sources

MarketsandMarkets Knowledge Store - Multisectoral database that collects market research reports in various technological fields and designed to process some information interactively. More than 1,200 market reports are published each year (https://www.mnmks.com/). The information presented are contained in the report "*Insect Protein Market – Global Forecast to 2027*", published in August 2022.

Lux Research is a leading provider of sustainable innovation research and advisory services, helping clients drive growth through emerging technology innovation. Lux Research combines technical expertise and business insights with a proprietary intelligence platform, using advanced analytics and data science to surface true leading indicators. With quality data derived from primary research, fact-based analysis, and opinions that challenge traditional thinking, Lux empowers clients to make more informed decisions today to ensure future success (https://www.luxresearchinc.com/).