Insect Industry Innovation Scan: Europe and Singapore

The Role of Insects in the Future of Food and Feed

Co-authored by:

Foodvalley®
Shaping the Future of Food Together

Enterprise Singapore

Contents

Picture Source: Ynsect

Preface

By 2050, the world population is projected to grow from 7.9 billion today to 9.7 billion[1]. In parallel, climate change effects and resource constraints are disrupting traditional ways of animal feed and food production. The pressing need to feed a growing population in an already delicate environment has prompted the search for sustainable alternative proteins such as insect-based proteins.

Insect protein production is touted as one of the most efficient and carbon-effective protein production systems given its circular approach combined with highly productive vertical farming systems. By 2050, it is anticipated that insects could provide 15% of the additional protein that will be needed by then.[2]

Globally, the insect industry has grown to more than 250 companies[3] – most of whom have emerged only in the last few years. Most of these firms helm from Europe with a handful of regional players headquartered in Singapore. Through private and public sector-driven regulatory and innovation initiatives, Europe and Singapore have made exemplary moves to grow their respective insect industries in a bid toward sustainable development.

It is thus opportune for these ecosystems to collaborate to launch the inaugural Insect Industry Innovation Scan: Europe and Singapore. This joint publication by Enterprise Singapore (EnterpriseSG) and Foodvalley Netherlands serves as a resource guide for current and aspiring insect industry players across the value chain, as well as investors to better understand developments of the insect industry in Singapore and Europe, including the regulatory environment, enterprise landscape, market opportunities and challenges.

Message from Authoring Organisations

“ The insect industry is barrelling toward scalability and in turn sustainability as breakthroughs in farming technology and novel regulations pave the way for insect protein to bridge the protein gap by 2050. As a Global-Asia hub for R&D innovation with a pro-business environment, Singapore is an ideal launchpad for Singapore and European insect players to collaborate and create insect-based diets of the future. Enterprise Singapore is honoured to have partnered Foodvalley NL to co-publish the first-ever Insect Innovation Scan: Europe and Singapore – a clear display of our commitment to drive thought leadership in this growing sector. ”

Eugene Toh
Director, Agritech, Enterprise Singapore

“ Insects are an important means to upcycle agrifood side streams into a valuable source for food. Hence, getting insects onto the plate of consumers can be a catalyser for more circular agrifood systems. International collaboration is a key step to accelerate growth faster and stronger together. It is our great pleasure to team up with Enterprise Singapore to highlight the rapidly occurring innovation in this exciting sector from an Asian and European perspective. The jointly developed Insect Innovation Scan brings together a shared vision on the development and opportunities of the insect sector internationally. With this scan, we are reaching out to all relevant international stakeholders who can contribute to the acceptance and further development of the insect sector as a valuable contribution to a sustainable, affordable and nutritious agrifood system. ”

Jolijn Zwart-van Kessel
Innovation lead, Foodvalley Netherlands

Picture source: Ergo Mediaproducties

About Us

About Enterprise Singapore

Enterprise Singapore is the Singapore government agency championing enterprise develpment. We also support the growth of Singapore as a hub for global trading and startups.

We attract global commodities traders to establish their global or Asian home base in Singapore. Today, Singapore is a leading global trading hub with a complete ecosystem for the energy, agri-commodities and metals & minerals trading clusters. We are also home to many global enterprises, startups and investors that operate in Singapore's robust pro-enterprise environment.

We build trust in Singapore's products and services through quality and standards. Renowned for our dedication to quality and innovation, Singapore companies make ideal business partners.

With our global network in over 35 locations spanning many developed and emerging markets, we connect businesses with relevant Singapore companies for their business expansion.

About Foodvalley Netherlands

Foodvalley NL is an independent international organisation working together with front runners to accelerate the global transition to a sustainable food system. Since 2004, Foodvalley NL has established itself as an innovation partner with a vibrant global network. From its roots in Wageningen, The Netherlands, Foodvalley NL built a strong network of Dutch agri-food SMEs contributing to the development of innovative solutions for sustainable agriculture practice and the production of healthier food. Foodvalley NL has up to 200 organisations connected as partners of our organisation.

The organisation acts as a catalyst for the transition of the global food system by addressing system and market failures. We guide parties through the transition, all in close cooperation with governments – international, national and regional – and renown educational and research institutions. Why? Because the food system has to change rapidly if we want to have tasty, affordable, healthy and sustainable food available for 10 billion people by 2050.

Overview of the Insect Industry

Global

Farmed insects are mainly used for animal feed, organic fertilisers, human consumption and other high value industries.

Animal Feed

With rising prices and sustainability concerns over soybean and fishmeal, insects are seen as an ideal alternative for high-protein feed given its similar nutrient profile and environmentally efficient way of production.[4]

Market for insects as feed was valued at US$688 million in 2018 and is expected to grow up to US$1.4 billion by 2024.[5]

Food

Insects can be consumed whole or processed into familiar products such as protein bars, chips, flour, and cookies.

The insect-based food & beverages segment is expected to grow rapidly from 2020 to 2030 driven by rising food shortage worldwide and increasing demand for high-quality alternative protein sources among end users.[7]

Organic Fertiliser

Frass, which includes the biological waste of insects and undigested food, is one of the main outputs of insect rearing.

Frass can be used as an organic fertiliser given its nutrient composition that is easily absorbed by plants, as well as addition of biomolecules and microorganisms that promote plant growth and increased resistance to pests.

Other Uses

Insects, specifically black soldier flies, can also produce biofuel, chitin, and chitosan which are used in cosmetics and pharmaceuticals.

For example, chitosan extracted from the discarded shells of black soldier fly (BSF) pupae can be used for the cosmetics industry given its antioxidant, antimicrobial and wound-healing properties.

The growth of the insect industry is driven by a growing global population and a rising need for sustainably-produced protein sources for food and feed.

A growing global polulation creates a protein gap

The global population will increase to 9.7 billion by 2050 from 7.9 billion today.[8] In developing countries, per capita meat consumption has doubled since 1980 and is expected to rise by 50% by 2050, according to UN FAO. This drives the need to source for sustainable alternative protein options, especially for animal feed applications.

Insects can be a viable alternative for food and feed, given its high nutritional value and environmental benefits.[9] By 2050, it is anticipated that insects could provide 15% of the additional protein that will be needed by then.[10]

Current ways of producing protein are not sustainable

Concerns over the environmental impact of soybean cultivation and fishmeal production have led to a search for alternative protein sources. The cost of fishmeal and soybean are also rising, and are susceptible to price volatility.

Insects on the upside, is both sustainable and efficient. They have high feed-conversion efficiency and can convert feed into protein at a higher rate than livestock.[9] Insect farming also has higher land-use efficiency than traditional protein sources, and it requires 2-10 times less agricultural land to produce 1kg of edible insect protein compared to 1kg of protein from pigs or cattle.[11]

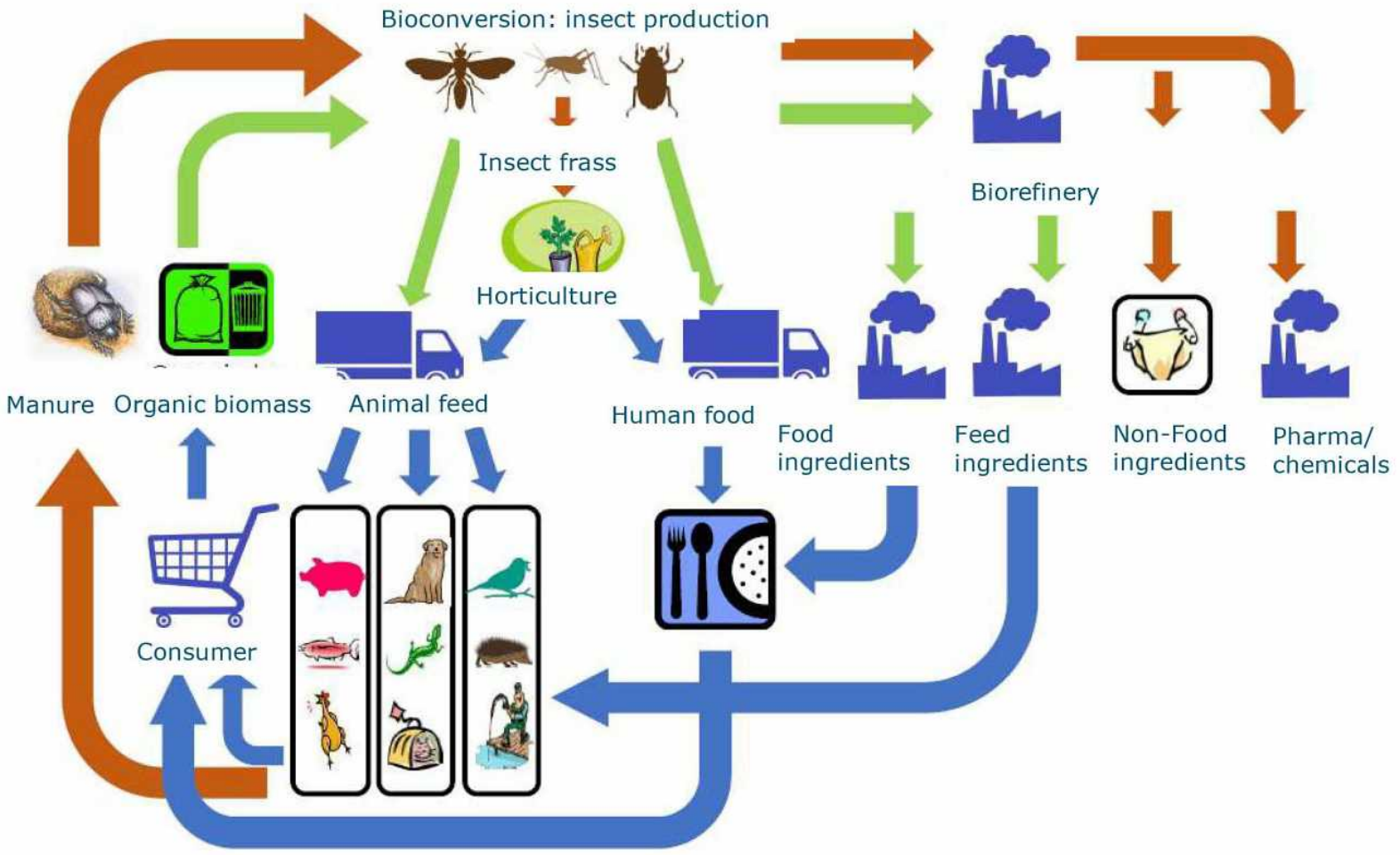
Large volumes of waste produced, with a need to valorise them

Around 931 million tonnes of food were wasted in 2019.[12]

Insects feed on food waste, agricultural residues, and agri-business processing byproducts to convert into insect-based products.

Valorisation of waste to produce food, feed, and high-value commodities such as frass and biofuels contributes to global efforts to support a circular economy.

Through a circular approach, insects have a great potential to create a more sustainable protein production chain, and yield other useful, high-value by-products for industrial use.



Overview of the Insect Industry

Europe

Overview of the European Insect Industry

At present, edible insects in Europe are mostly utilised as specialised pet food, livestock feed (aquafeed) and soil fertiliser.[13] The total output volume of edible insects in Europe was 194,000 tonnes in 2020.[16] In 2021, the European edible insect market value was estimated to be worth US$46.75 million with the demand for insect protein being higher than its supply.[22] This indicates a demand-supply mismatch between the various actors in the edible insect chain.[14]

The total output volume of edible insects in Europe is estimated to grow by 47% between 2019 and 2026 to 235,000 tonnes a year, making Europe the second largest growth region.[17] In addition, the European market value is estimated to reach US$828.76 million by 2029.[22] To allow for the edible insect industry to effectively exploit these favourable prospects, a diverse and stable company portfolio has to be established with a constant funding supply.[15]

As for investments, the capital flow into the European edible insect industry increased from US$20 million in 2015 to over US$400 million in 2020 and this increase is expected to continue over the next few years.[14] The European edible insect industry consists of insect feed business operators (iFeedBOs) and insect food business operators (iFoodBOs), where a few iFeedBOs also produce products for pharmaceutical applications.

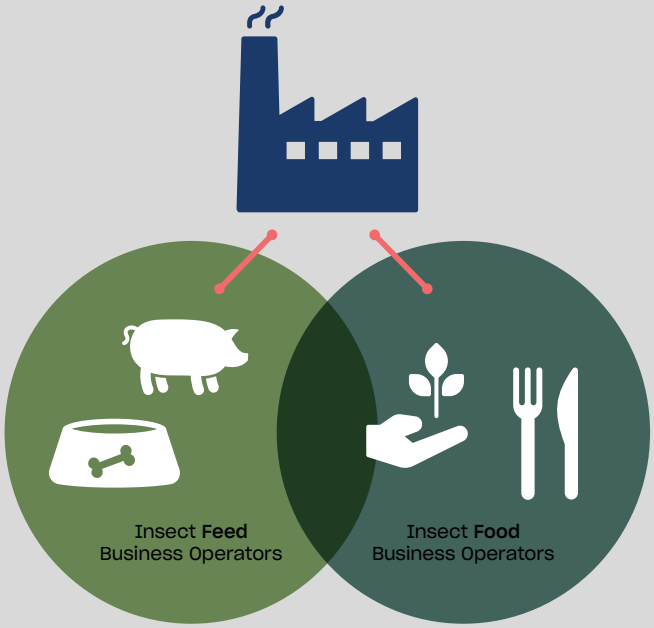
Application
Mostly in pet food, livestock feed (aquafeed) and fertiliser

Demand
As of 2021, demand is higher than supply

Investments
Reached US$1 billion in 2021 and just for feed

Output Volume
194,000 tonnes in 2020, expected to grow to 235,000 tonnes by 2026

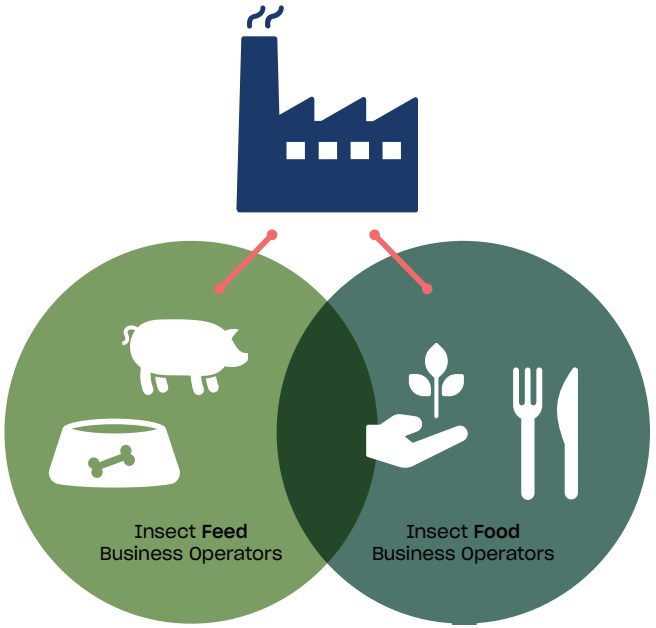
Company profiles



- 40% micro-sized companies[18]
- More medium-sized companies, few very large players
- 81% micro-sized companies[19]
- No large producers

Micro-sized company: <10 employees
Small-sized company: 10 – 50 employees
Medium-sized company: 50 – 250 employees
Large-sized company: 500+ employees

Investment Trends



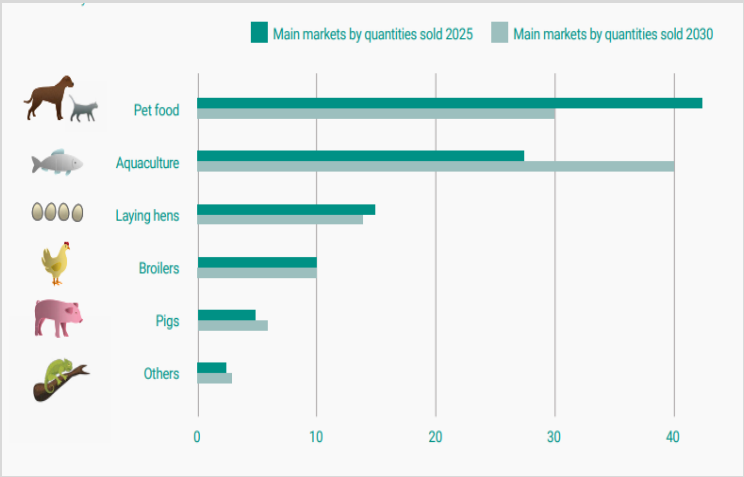
Niche market[20, 21]

- Total €1 billion as of 2021[18]
- Single investments up to €150 million[18]
- Majority micro-sized companies investments are < €500.000[19]
- 3% gets up to €25 million[19]

Feed : iFeedBOs

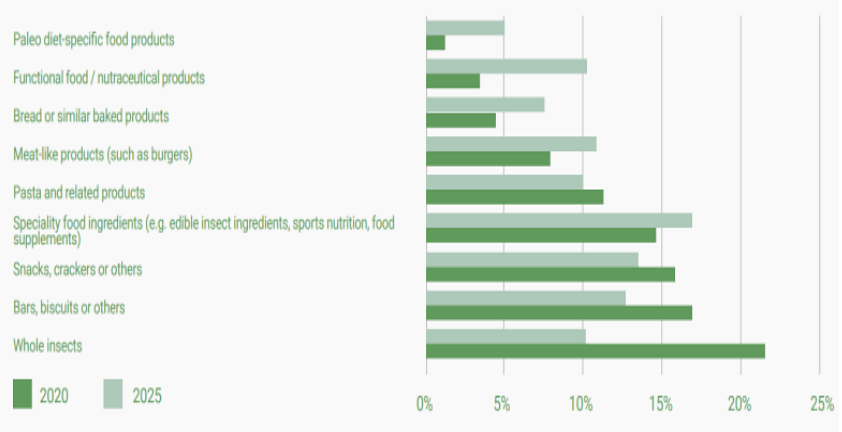
The iFeedBO industry is larger and more stable than the iFoodBO industry as it is formed by a relatively large share of medium- and large-sized companies.[18] Together with recent EU legislation amendments that allowed the usage of insect-based feed for pig and poultry production, the iFeedBO market is especially appealing to investors. Until 2021, a total of €$1 billion was invested in iFeedBOs, which is expected to increase to €$3 billion in 2023.[13] The iFeedBO market is expected to see a €2 billion turnover by 2030 and 1 million tonnes of insect meal produced.

According to a report by the International Platform of Insects for Food and Feed (IPIFF), by the middle of the decade, most of the demand for insect meal will lie in the pet food sector. However, the share of insect meal used in aquaculture is likely to surpass the pet food market, reaching 30-40% by 2030. Given the recent authorisation of insect Processed Animal Proteins (PAPs) in poultry and pig feed, the next relevant market for insects as feed operators will be poultry (20-30%) and pig markets (5-15%).



Food : iFoodBOs

The iFoodBOs industry, on the other hand, consists mostly of micro-sized companies (83%) and is thus heavily dependent on external investors to allow them to grow. The largest application sectors are speciality food ingredients and snacks.[19] For 63% of these micro-sized companies, investment numbers are below €500,000 per investment and for only 3% of these micro-sized companies, investment numbers reach up to €25 million.[19] Furthermore, these iFoodBOs are involved in different stages of edible insect utilisation. 20.3% are involved in production, processing, and retailing; 64.4% are involved in processing and retailing; and 15.3% are only involved in retailing.[36] Most of the iFoodBOs are located in northern European countries due to the favourable national legislation that is currently in force in these countries. Furthermore, northern European consumers generally have a more positive attitude towards edible insect food products.



Key Facts and Figures[19]

- 500* tonnes produced in 2019
- 260,000 tonnes by 2030
- 9 million consumed insects in 2019
- 390 million by 2030

* Relatively low number was due to regulation limits and could have been higher (i.e. causing companies to deliberately put productions on hold)

Overview of the Insect Industry

Singapore

The insect industry has a role to play in Singapore's nation-wide sustainable development agenda

Singapore Green Plan 2030

Considered the umbrella policy to advance Singapore's sustainable development agenda, 'The Singapore Green Plan 2030' outlines Singapore's targets to halve its 2030 peak greenhouse gas emissions and achieve net zero emissions by around 2050. It also targets to build the capability and capacity to increase domestic food production to provide 30% of Singapore's nutritional needs by 2030 and reduce the amount of waste to landfill per capita per day by 30%.[24] These targets unveiled by the Ministry of Sustainability and the Environment in February 2021 offer tremendous opportunities for the nascent but steadily growing local insect industry to contribute toward Singapore's transition toward climate neutrality and bolster food resilience.

Feed and Food Security

As a nation which imports >90% of its food, there is a strong push to strengthen Singapore's food security. One way is to ramp up domestic food production amidst increasing global supply chain volatility. However, local food production activities are still heavily dependent on imported agricultural inputs such as mineral fertiliser and corn or soy-based animal feed, which are susceptible to price shocks and whose prolonged use may be damaging to the environment. In contrast, insects are able to convert waste into frass, which can be used to substitute or supplement fertilisers, as well as protein and fat-rich larvae which can be used in animal feed for poultry or aquaculture diets. Insects offer a sustainable source of agricultural inputs whilst mitigating our reliance on input imports.

Case Study: Blue Aqua Food Tech

Founded in 2009, Blue Aqua International (BAI) is a Singapore-based solution provider for the aquaculture industry. The company farms and distributes antibiotic-free fish and shrimp for local restaurants and grocery chains through their retail brand, Nature's Hug.

To boost food security locally, BAI founded Blue Aqua Food Tech, an alternative protein company that upcycles local pre-consumer food waste to produce insect protein meal as an alternative to traditional fishmeal. The subsidiary aims to build a sustainable, circular, and resilient aquaculture ecosystem to feed Singapore and the world.

In 2021, BAI signed an MoU with Dnata to upcycle organic waste from Dnata's catering and ground handling operations into quality insect proteins for aquacultural use.[27] Dnata will also add BAI to its list of suppliers to purchase locally farmed seafood for catering operations.

However, while the use of insect protein as animal feed has received much industry support and is permitted in Singapore, the potential of insect protein for human consumption remains unrealised . There has been no application to the Singapore Food Agency (SFA) – Singapore's regulatory body for food safety, for the use of insect protein in food for human consumption.

Progressively, this is likely to change in the near-future as the Singapore Food Agency has established an Insect Regulatory framework to guide the nation's approach to insects for human consumption and insect feed. The regulatory framework is currently opened for public consultation, slated to close by December 2022. The framework will allow for the commercial sale and consumption of edible insects in Singapore – a major milestone in Singapore's edible insect industry. Details of the framework are elaborated on page 27.

Picture source: Altimate Nutrition

Altimate Nutrition

Altimate Nutrition is founded in 2020 by 2 biotechnology students from Republic Polytechnic. It currently has 5 Stock Keeping Units (SKUs) ready for production. The flavours of their protein bar include peanut butter cinanamon, double chocolate, almond nutella, matcha green tea and mixed berries. Each bar (80g) contains 12g of protein. While Altimate Nutrition is working closely with the Singapore Food Agency (SFA) to authorise the sale of their products, interested consumers can indicate interest by pre-ordering on their website.

Circularity and Waste Valorisation

Food waste is one of the biggest waste streams in Singapore and has grown by ~20% over the last 10 years.[28] Nearly 700,000 tonnes of food waste are incinerated annually, which has prompted Singapore's search for innovative ways to reduce waste generation and upcycle food waste. Singapore's inaugural Zero Waste Master Plan charts Singapore's path towards a zero waste nation.[29] The plan includes adopting a circular economy approach to waste and resource management practices, shifting towards more sustainable production and consumption.

In 2021, the National Environment Agency (NEA) launched the Food Resource Valorisation Awards to encourage more organisations to adopt and develop food waste valorisation solutions. The award recognises companies that engage in the conversion of food waste, such as homogenous by-products, rejects and mixed food waste, into products that contribute to a sustainable economy. Singapore-based insect companies such as Insectta, Ento Industries and Insect Feed Technologies were award recipients, recognised as trailblazers leading Singapore towards efficient, zero-waste circular food systems which can enhance our national food security.

Insectta at Food Resources Valorisation Awards

Case Study: Ento Industries

Incorporated in 1994, Tiong Lam Supplies (TLS) is a traditional food waste management firm that works with local food producers like Sunshine bakery and Meiji to manage, process and upcycle food waste into animal feed and by-products for the agricultural industry.

To transform the waste industry to valorise a greater volume and multiple streams of food waste, the second generation team of TLS founded Ento Industries, a biotech black soldier fly (BSF) company to tackle Singapore's food waste problem. Ento Industries aims to reduce additional capital outlay and turn large amounts of unchecked disposal of food waste into resources in the agricultural industry. Most recently, Ento industries partnered DBS Foundation and Pawfoo, a local sustainable pet snack manufacturer, to launch Good Dog Cookies – responsibly crafted nutritious dog treats made from insect meal, salmon fish skin and eggs.

Picture source: Ento Industries

Game-Changing Yellow Biotechnology Research

Beyond food, feed and waste valorisation applications, insects have a much larger potential for higher value industries. The use of whole insects (i.e. their organs, cells, symbiotic microbes) in the fields of medicine and pharmaceutical and other industries have led to a growing research area called yellow biotechnology. Singapore seeks to be at the forefront of these innovations, with Insectta, our first insect biotech startup paving the way.

Case Study: Insectta

Picture Source: World Economic Forum

Insectta is not a traditional BSF farm. Instead of developing feed or fertiliser, the startup offtakes the pupae shell discards generated from BSF farming operations to extract biomaterials such as Chitosan and Melanin for use in pharmaceuticals and electronics industries. Working in conjunction with Singapore's national research institute, the Agency for Science, Technology and Research (A*STAR), Insectta is the first company in the world to have developed a patented technology that uses a proprietary and environmentally friendly process to extract biomaterials – Melanin and Chitosan from black soldier fly larvae.

Melanin conducts electricity and can be used in semiconductors, supercapacitors or batteries. Chitosan has anti-inflammatory properties and is useful in cosmetics or pharmaceuticals. With the global market valued at US$7 billion, these lucrative substances are highly valuable even in small quantities, pointing to a huge market potential. Insectta seeks to scale current lab-scale production with a pilot facility in Singapore, slated to launch in 2023.

Market growth projections for *Chitosan*

Market Value

Total (2019)	**Projected** (2027)
US$1.78B	**US$4.7B**

Market data for *Melanin*

Market Price (2022)

US$800/gram

1. Number of Companies

The number of incorporated Singapore-based insect companies currently in operation stands at 15 as of end-2021 with business activities in over 10 countries. Most local insect companies focus on farming insects for animal feed and pet food.

Animal Feed/ Frass

Cosmetics, Pharmaceutical, Biomedical, others

Solution/ System Provider

Human Consumption

2. Main Markets Targeted by Insect Producers

The markets targeted by insect producers continue to expand as companies scale up production. Currently, aquaculture and pet food markets are the two focus segments of local insect players. Smaller insect producers that are not yet producing at significant scale typically operate a Direct-To-Consumer business model, retailing on specialty retail stores for personal consumption.

3. Investments

To date, Singapore has seen a total of ~US$40 million[32] invested into Singapore-based insect companies from 2019 - 2022 as follows:

Year	Company	Amount (USD)	Round	Participating investors
2017	Nutrition Technologies	$0.35m	Seed	Explora Capital
2019	Nutrition Technologies	$8.5m	A	Openspace Ventures, Seeds Capital
2020	Protenga	$1.6m	Seed	Roslin Technologies, Seeds Capital
2020	Insectta	Undisclosed	Seed	Trendlines AFIC
2021	Inseact	$1.3m	Seed	ADB Ventures Loyal VC, INSEAD Asia Angels Club, Angels
2021	Nutrition Technologies	$5m	Pre-B	Hera Capital, Openspace Ventures, Seeds Capital
2022	Protenga	$2m	Venture Debt	Syndicate of Singapore based investors
2022	Insect Feed Technologies	$0.92m	Seed	Mistletoe, Juniper Capital, and EcoImpact Capital, EnGro Corporation
2022	Insect Feed Technologies	$0.18m	Seed+	DesignFutures Venture
2022	Nutrition Technologies	$20m	A2	PTT Ventures, Sumitomo, ING Sustainable Investments, Mandala Capital, Openspace Ventures, Seeds Capital, Hera Capital

4. Key Overseas Markets of Interest

The priority markets for internationalisation and export of Singapore-based insect companies are mainly in Southeast Asia, with keen interests in Asia Pacific (Taiwan, Korea, Australia), European Union, Middle East and the United States. Both Nutrition Technologies and Protenga have their insect facilities in Johor, Malaysia, and more companies such as Inseact are setting sights on neighbouring countries to build their pilot or commercial facilities.

Opportunities and Challenges

Europe and specifically The Netherlands

Opportunities Europe

Market size

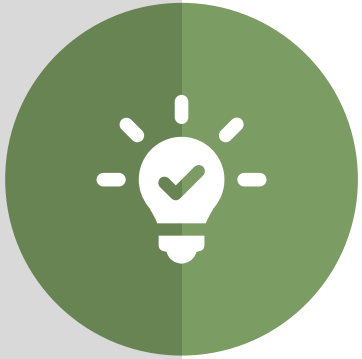
As of 2021, multiple sources mention that the demand for insect protein in Europe seemed higher than its supply.[22] In addition, recent amendments to EU legislation now allow insect-based feed to be manufactured for pigs and poultry, which has created a new market in 2022. The market size in line with the interest for insect protein signals positively for a burgeoning industry.

Industry growth & Potential

In 2019, the European edible insect food market consisted of 450 tonnes of insect-based products, which is expected to increase to 235,000 tonnes by 2030, making Europe the second highest growth region worldwide[17]. Finally, the consumer acceptance of European consumers towards insects as food is relatively low as compared to other regions. This means that there is even more growth potential in this market segment that can be reached with good marketing and education.

Regulatory Environment

The EU's favourable regulatory prospects over the next years provides a conducive environment for insect companies to grow. Please see information about the EU regulation and legislations developments on IPIFF's website.



Opportunities The Netherlands

Collaborative environment

The Dutch edible insect industry is home to a collaborative environment. It is an innovation hub which has resulted in three relatively large Dutch scale-up companies active in the production of edible insect products[18]. Moreover, this hub is strengthened by multiple academic and industrial partnerships, such as VENIK and InsectPoint. These collaborations in particular form a crucial part of a successful edible insect market, as through these partnerships, crucial knowledge can be exchanged to improve operations and decrease production prices, which is deemed necessary for edible insects to be available to the mainstream market.[38,14] On top of this, consolidation of supply (production and expertise of enterprises) in northern Europe is likely, which could further improve the strategic business climate of the edible insect industry of the Netherlands.[36]

Favourable national legislation

In addition, the national legislation in the Netherlands enables innovation and development in the edible insect industry to a much larger extent than in most other European member states.[36]

Large farming sector

The Netherlands already has a relatively large farming industry (the second largest farm food exporter in the world) which means that extensive farming industry know-how and infrastructure is already present. Besides, large amounts of feed can be sold within national borders. This avoids the hustle of complying with often different legislation in different European member states.

Deep research expertise & world-class academic and research institutions

Europe houses global leading academic and research institutes in agriculture technology. Specifically in The Netherlands, **Wageningen University and Research Centre** seeks to pave the way to scaling the insect industry in Europe through research and development. Some examples of research projects started at Wageningen University and Research centre include:

SUStainable INsect CHAIN, or SUSINCHAIN, is a project coordinated by Wageningen Livestock Research. The project aims to contribute to novel protein provision for feed and food in Europe by overcoming the barriers of economic viability of the insect value chain. SUSINCHAIN provides knowledge and data for actors in the insect value chain to decrease the cost price of insect products, process insects more efficiently, and market safe and sustainable insect protein in animal feed and regular human diets. This paves the way for further upscaling and commercialisation of the European insect sector.

Led by Dr. Teun Veldkemp, the project **'Role of insects in new production cycles'** focuses on the first stage in the insect chain. It investigates the possibilities for a circular and climate-neutral conversion of vegetable residual flows, by-products and waste into insect protein. The potential of using residual flows from the food industry, and other waste flows as substrates for insect farming is determined by availability, composition, suitability, transport, costs, consumer acceptance, safety and sustainability. A selection of the most promising substrates are tested to determine the development, growth and survival of black soldier fly larvae, as well as food safety.

SAFE INSECTS aims to gather the necessary data which proves the safety of various currntly prohibited organic residual flows as a potential substrate for insect rearing, and the safe application of these insects in food and feed. The hypothesis is that underutilised residual flows such as food waste, slaughter by-products and animal manure contain nutrients. Insects can convert these into high-quality food products for feed and food. The project aims to arrive at a procedure that is required for the legal authorisation of residual flows for insect rearing. The goal is to further widen the range of organic residual flows in the food chain as much as possible by 2030.

Composting and mycoremediation of low-value residual streams for safe insect rearing (COMYSECT) aims to develop safe and nutritious substrates for insect rearing from low-value organic residual streams by making use of composting, fermentation and mycoremediation. The project will utilise the auto-pasteurization properties of composting, and the unique properties of fungi to biodegrade and/or absorb hazardous substances (mycoremediation). These processing techniques will contribute to biodegradation of possible hazardous substances and convert undigestible substances such as lignin into digestible substances. The project will investigate several residual streams and possible combinations to ensure optimal insect growth.

A consortium of Dutch companies in the poultry value chain are also joining forces in a public-private partnership on insects as a source of protein in poultry feed. This includes Protix, ForFarmers, The Dutch entity of PHW Group, Esbro, Venik and Wageningen Livestock Research.

Challenges Europe

Complex Regulations

Innovation and production of large-scale edible insect products in the European Union are mostly hampered by complex (food safety) regulations. European regulations currently limits the application of insects for a wide product range, limiting upcycling possibilities and subsequently decrease willingness to invest in the industry.[36,41,42] Besides European legislation, another hurdle for the edible insect industry to thrive are the differences between national legislation of each member state. This national legislation ranges from industry supportive to industry opposing, varying for each member state.[36]

Niche Food market

Furthermore, different research papers point out that the edible insect market for human food is currently a niche market, and that considerable action is needed in the form of education (school systems) to increase consumer acceptance.[20,21] Finally, as the industry comprises mostly of small business operators, a lack of specific data on companies, production methods and supply chain relations hampers analysis of both the market and the industry.[18,36]

High costs

The nascent but growing insect industry requires large investments to develop more efficient and competitive production systems.[18,36] The high cost prices[44] may be a significant barrier to many.

Challenges The Netherlands

Cost Price

The insect industry is still small, resulting in a lack of adequate data which hampers market analysis studies.[18,36] The lack of scale also means that cost prices are high.[44] The price of insect protein today is still too high compared to fishmeal and soy protein.[44]

Expensive Food Safety Procedures

Although national legislations may offer possibilities to the edible insect industry in the Netherlands, it also has a downside. The favourable legislation is accompanied by expensive food safety procedures that have ramifications for the economic feasibility of insect-based products.[37,43,]

Climate Control Necessary

Moreover, the temperature in the Netherlands is not suitable for open air rearing of insects and thus expensive incubation machines are necessary to sustain extensive climate control to keep a constant temperature above 25 degrees celcius.[39]

Opportunities and Challenges

Singapore

Oportunities: Global and local insect players can leverage Singapore's strengths as a Global-Asia hub for R&D and a pro-business environment to access opportunities in Southeast Asia.

1. Strategic geographical positioning

Ideal Climate

Singapore enjoys a year-round tropical climate with abundant rainfall, high and uniform temperatures, and high humidity – providing the ideal environmental conditions for farming insects. Unlike countries that experience seasonal weather changes, operating costs dedicated to controlling environmental parameters are significantly lower for insect producers operating in Singapore and the nearby region, resulting in a cost advantage.

Access to regional market and resources

Singapore's close proximity to big agri-commodity markets such as Indonesia and Malaysia makes it the ideal gateway to access regional business opportunities and resources. Indonesia is the world's top producer and exporter of palm oil. In 2021, its production of this commodity amounted to approximately 46.2 million metric tonnes.[45] With steady double digit growth rates, the huge palm oil industry provides insect producers the opportunity to work with the largest palm oil players and access widely available feedstock. Countries like Malaysia and Indonesia are also progressing their efforts to support sustainable palm oil practices and sustainable reporting which have significant relevance to insect producers concerned about sustainability.

2. Growing investment landscape in Agri-Food tech

The Singapore agri-food tech startup ecosystem has seen vibrant growth since 2019, following the announcement of its domestic food production targets i.e. 30 by 30 goal. The number of agri-food tech startups more than doubled in the last three years to 150 in 2021[46] and continues to grow. According to the 2022 Agfunder Investment Report, Singapore ranked 10th place globally with US$1 billion of agri-food investments over 54 deals.[47] The nation's vibrant investment landscape was catalysed in part through public-private collaborations. In 2019, Enterprise Singapore's investment arm SEEDS Capital appointed seven co-investment partners to pump more than S$90 million (~US$67 million) into Singapore agri-food tech startups. Today, Singapore sees a growing corpus of early and growth stage investors including Temasek, Agfunder, Trendlines AFIC and The Yield Lab. Singapore has seen a total of ~US$40 million of investments into Singapore-based insect companies from 2019 - 2022, with SEEDS Capital co-investing into Nutrition Technologies and Protenga. Singapore's investment landscape continues to transform the agri-food tech industry and provide solutions for sustainable agriculture.

Insect Feed Technolgies at Agritech Deal Fridays. Picture Source: StartupSG

3. Strong Talent Base and Research Capabilities

Talent

Singapore's strong talent pool, excellent education system and quality human capital are pull factors for innovators to set up their R&D bases in Singapore. While Singapore is not historically an agricultural nation, this has not halted Singapore's efforts to increasingly attract talent in Agronomy and Entomology. Moreover, Singapore has strong capabilities in adjacent sectors which have close synergies with insect production, such as specialty chemicals (study of nutritional and chemical composition of BSF outputs), biotechnology, and engineering (automation and robotics for farming systems, which are essential for driving down costs for insect production).

Research Capabilities

Insect players looking to anchor business activities in Singapore and the region can tap the nation's growing insect R&D capabilities led by our research institutes, universities and tertiary institutions. For example, Singapore-based edible insect company, Asia Insect Farm Solutions (AIFS) and Food Innovation & Resource Centre (FIRC) collaborated to optimise the taste and flavour profiles of cricket protein-enriched flavoured chips. The collaboration supported by EnterpriseSG saw the development of 3 flavours of chips. For more information on Singapore's knowledge providers for alternative proteins, refer to EnterpriseSG x Foodvalley NL's joint publication "Protein Shift Innovation Scan".

Picture Source: AIFS

Case Study: Singapore researchers from world-class academic and research institutes develop a blueprint for sustainable food systems using BSF

From left: Dr. Nalini, Prof Stephen Cairns, Niraly Mangal, Adrian Fuhrmann, Dr. Moritz Gold

National University of Singapore (NUS) Department of Biological Sciences Assistant Professor Nalini Puniamoorthy, and Professor Stephen Cairns from the Singapore-ETH Future Cities Lab Global Programme are leading a National Research Institute (NRF)-funded three-year international collaborative project to develop a blueprint to integrate food waste management and sustainable food production using black soldier flies. The project is done in collaboration with ETH Zurich and Nanyang Technological University (NTU).

The five themes of the project span across insect rearing, urban design, sustainability, as well as food safety and nutrition.

Professor Nalini also founded NUS' Reproductive Evolution lab to study the sexual selection and reproduction of insects.

Singapore's national research institute, A*STAR has also developed their research capabilities for the insect industry, expanded in 5 core focus areas in the table below.

Focus Area	Research Expertise
Black Soldier Flies (BSF) gut enzymes & microbia	• Proteomics, high throughput screening and characterisation • Cloning and expression of recombinant enzymes from BSF microbes • High throughput gene candidate cloning, characterisation and engineering for scaled production • Enzyme production strain development • Microbiome analysis and isolation. Cellulolytic probiotics for BSFL
Insect feed from waste	• Fermentation of lignocellulosic-food waste fermentation for single-cell protein and insect feed. • Development of microbes or a microbial consortium for lignocelluloylticenzymes and bioconversion of agro-food industry waste to insect feed
Novel food and feed additives	Allergen detection in insect protein
Closed-loop sustainable urban aquaculture & life cycle analysis	• AMPs scalable extraction and identification; aquaculture feed protein profiling and digestibility; pathogen identification and monitoring • Life Cycle Assessment (LCA) of insect production.
Chitin, Chitosan extraction from BSF	Chitin/chitosan characterisation, acid/base-guided downstream purification, alkaline/enzymatic chitin deacetylation to chitosan, fermentative deproteinization

Case Study: Wildlife Reserves Singapore (WRS) and Republic Polytechnic's collaboration to manage carnivorous waste using black soldier flies (BSF)


Picture Source: Widlife Reserves Singapore

Led by Principal Investigator Dr Lily Ganda and her team of colleagues and students from Republic Polytechnic, in collaboration with Dr Francis Cabana, Assistant Director, Zoology from WRS, the one-year study aims to potentially identify environmentally sustainable and closed-loop waste management systems. The team studied the viability of BSF to manage carnivorous waste from WRS, and validate the safety of using BSF larvae reared on carnivorous waste as animal feed for insectivorous species.

Case Study: Nanyang Polytechnic (NYP) works with industry for edible insect food safety checks

NYP Food Safety Centre (FSC) – A key food training facility for students which enables students to understand the entire food safety management process from farm to fork. FSC is an ISO17025 certified food testing laboratory accredited by the Singapore Accreditation Council (SAC). NYP works with industry partners to conduct food safety checks for edible insect products.

4. Enabling Regulatory Environment

To promote food waste valorisation via black solider fly (BSF), the Singapore government set up a BSF Taskforce in 2020 as part of the Industry Steering Committee – Circular Economy (Food). Co-chaired by the Singapore Food Agency (SFA) and the National Environment Agency (NEA), the BSF taskforce was joined by members of relevant agencies and industry associations including National Parks Board (NParks), EnterpriseSG and Singapore Agro Food Enterprises Federation (SAFEF).

The BSF taskforce sought to determine the feasibility of BSF as a food waste valorisation solution in Singapore. Through engagements with multiple BSF companies and industry players, the taskforce identified regulations and lack of awareness as some of the main hurdles towards setting up a BSF facility in Singapore. To provide greater regulatory clarity and build awareness of BSF technology, the taskforce put together a BSF regulatory workflow to consolidate the relevant regulations of various agencies, and with the support of SAFEF, conducted a BSF webinar to raise awareness of BSF technology. The initiative demonstrated Singapore government's commitment to develop a conducive regulatory and business environment for new industries where processes and regulations may not have been developed yet.

5. Positive Regulatory Developments

Due to the nascency of the insect industry and lack of regulatory clarity in Singapore, local insect companies in the early days faced major challenges in setting up their farms, scaling up and gaining market access. Some of the challenges that the commercial insect producer faced were (i) limited types of feeding substrates allowed and (ii) no insects/insect protein approval for sale and consumption in Singapore.

Understanding the need to develop clearer regulatory frameworks to support enterprise growth while ensuring food safety from farm to fork, SFA has developed an insect regulatory framework to guide the nation's approach to insects for human consumption and insect feed. The overall approach is based on a scientific risk assessment, which identifies potential hazards. These hazards will be addressed by risk management measures and supported by risk communication.

Overview of Singapore's newly developed regulatory framework

Background

Previously, the import and sale of insects as food for human consumption in Singapore was not allowed. Permitted substrates for use on insects for animal feed were approved on a case-by-case basis and mainly homogenous plant-based waste were approved.

Allowing Insects for Human Consumption

With its principal focus on food safety, the new insect regulatory framework has allowed the import and sale of insects and insect products for human consumption and as animal feed, subject to import conditions, and additional pre-licensing requirements for local farming and processing of insects and insect products. With a wider range of substrates which can be used for production, companies will be able to increase output volume.

SFA's safety objectives and baseline criteria that apply to insect imports and local production are based on four identified key points to ensure safety of the insects and insect products as outlined in page 28.

S/N	Objective	Key Requirements
1	**Ensure species of insects are safe for consumption, and do not inherently have any toxic substances.**	The species of insects is limited to a list of specific species with known history of human consumption. Insects not on this list will be considered as Novel Food and companies will be required to submit a food assessment for SFA's review.
2	**Ensure insects are farmed under controlled environments and not harvested from the wild. This is to prevent the introduction of diseases and contaminants.**	• Insects are not harvested from the wild. • Proper biosecurity and husbandry practices to prevent contamination.
3	**As substrate is the main input, substrate used must not impart contaminants (microbiological, chemical etc) to the insects.**	Manure, decomposing organic material and materials of ruminant origin shall not be used as feeding substrates.
4	**Ensure the final product is safe.**	• Meet the requirements of the Singapore Food Regulations, which include RTE microbiological (Regulation 35), chemical and, toxin Maximum Limits (Regulations 29 to 34). • Ensure RTE products have been subjected to sufficient heat treatment, or an equivalent bactericidal process, to kill pathogens prior to consumption. • Ensure products are processed, packed, transported and stored in a hygienic manner that prevents contamination. • Require HACCP for farms and processors.

Surveillance plans to support food safety of insect products

As part of the insect regulatory framework, SFA will carry out inspection and sampling of imported insect consignments, as well as insects produced by local farms for human consumption. This is to verify that these products meet the agency's requirements, including (i) microbiological pathogens and (ii) chemical contaminants (e.g. heavy metals, toxins).

As part of the pre-licensing requirements, industry players will have to provide laboratory reports on pathogens and chemical contaminants from accredited private laboratories under SFA's Laboratory Recognition Programme.

Food Safety is a Joint Responsibility

It is important for the industry and the public to each play their part, to ensure food safety, together with SFA. SFA will be publishing risk communications material to introduce the likely risks of insect food products, what SFA is doing to regulate these and offer food safety tips to consumers.

As the insect sector is nascent, SFA will periodically review the regulatory approach based on new scientific developments. SFA welcomes industry to share research findings from their pilot projects and other experiments, particularly in the area of food safety, to support regulatory policy.

Case Study: Future Protein Solutions (FPS)

Picture Source: FPS

Ensuring high food safety and product quality is an upmost priority. Hence, FPS works closely with Stendard — a Singapore-based regulatory consultancy and technology start-up, as well as SFA to ensure compliance to HACCP and GMP standards for the production of roasted crickets and cricket powder. Lab tests for nutritional content, microbial pathogens, heavy metals, and shelf life are conducted to ensure safety.

Challenges: Resource constraints and a lack of consumer acceptance for edible insects among key impediments to scalling up locally.

1. Limited resources for scaling production

To be considered a sustainable alternative to conventional protein sources, insect companies need to increase production volumes exponentially and drive down costs to match the market price and volume of current animal feed. In a forecast report by Rabobank, analysts estimate that 500,000 tonnes of insect protein will be produced by 2030, of which aquafeed will utilise 200,000 tonnes.[47] While 200,000 tonnes might seem substantial, it only represents less than one percent of the global aquafeed market in today's volumes.[48] This reveals the massive scale that insect producers need to rise up to. As there are many competing uses for land in land-scarce Singapore, insect companies may find it untenable to scale up production in Singapore and instead prefer setting up their corporate headquarters and R&D bases here whilst scaling production operations in the region.

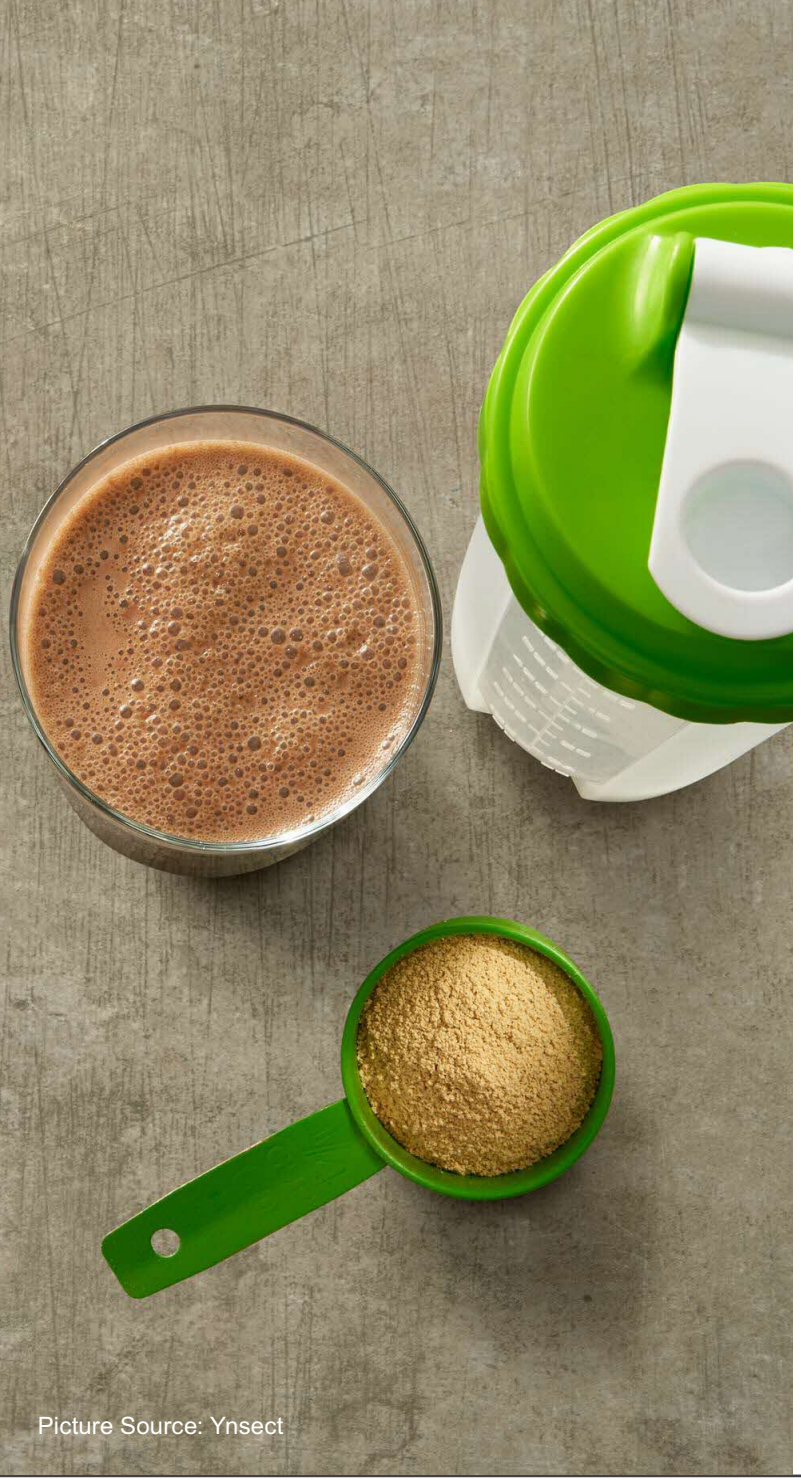
2. Nascent consumer awareness for insect-based products

Unlike much of Southeast Asia, insects have not historically been part of the Singaporean cuisine. Furthermore, before the launch of the insect regulatory framework, the import or sale of insects for human consumption was not allowed, which meant that gaining consumer acceptance for edible insects in Singapore is just at its beginning stages. However, we expect that just as other alternative proteins such as plant-based meats or cell-cultured meats have gained traction in the local market, it is merely a matter of time before edible insects find their way onto the dinner table.

Picture Source: Altimate Nutrition

Picture source: Ergo Mediaproducties

Europe-Singapore Collaboration Programmes, Grants and Resources



Picture Source: Ynsect

Insect players in Europe and Singapore have access to a multitude of grants, resources and programmes to foster co-innovation.

Global Foodture Programme

The Global Foodture is designed to boost the sustainable transition of the food system worldwide through collaboration and innovation. Set up by 7 European Clusters, the programe supports European SMEs in internationalising their technologies/services in food production and processing to 4 Asian countries (Singapore, Thailand, South Korea and Japan). More information here.

Co-Innovation through Eureka Eurostars

Eureka Eurostars is a funding instrument that supports innovative SMEs and project partners by funding international collaborative R&D and innovation projects. Organisations from 37 Eureka member countries including Singapore and the Netherlands can access public funding. More infomation here.

Global Innovation Alliance (France, Germany, UK)

The Global Innovation Alliance (GIA) is a network of Singapore and overseas partners in major innovation hubs to run inbound and outbound GIA Acceleration Programmes. More information here.

UK-Singapore Collaborative R&D call

Singapore and UK companies keen to embark on joint-innovation projects can receive support by participating in a joint call for proposals for UK-Singapore technological R&D projects. More information here.

Network for Insect Knowledge (The Netherlands)

The Network for Insect Knowledge (NIK) is a large network of insect players in The Netherlands, which gathers knowledge about insects as food for animals and humans and other applications. The NIK not only unlocks knowledge, but also shares it with current or aspiring entrepreneurs. More information here.

Shared Facilities of Foodvalley NL

An initiative of Foodvalley NL and Wageningen University and Research, the shared facility finder helps companies and institutions active in healthy food and living to find or offer a facility for temporary use. It provides financial advice on the possibilities of realising shared new facilities. The aim is to encourage users to achieve maximum productivity and accelerate innovation. More information here.

Conclusion

The global insect industry is at a tipping point led by technological breakthroughs which improve the scalability of insect farming and processing systems; progressive changes in regulations to enable a conducive operating environment; and increasing consumer acceptance of insects as feed and food.

Though miles apart, there are many parallels to the opportunities and challenges encountered by the insect industries in Europe and Singapore. Majority of the insect players in both ecosystems are micro-sized enterprises (less than 10 employees) punching above their weight; their primary business activity centers around the production of insect protein as alternative feed and food; and venture funding into the sector has seen an upward trajectory in recent years.

While both Europe and Singapore have made strides in fostering regulatory clarity for the insect industry, more can be done to ensure the costs of regulatory compliance does not become prohibitive. Although edible insects are gaining traction, both ecosystems will need to double down on marketing efforts to drive mass consumer acceptance of insects as a safe, sustainable alternative protein source.

Tapping on the various joint innovation partnerships and R&D calls catalysed by Foodvalley Netherlands and Enterprise Singapore, current and aspiring insect industry players from Europe and Singapore now have full access to resources to power the next growth stage of the global insect industry.

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Annex: Market Scan of Insect companies

Europe

Ynsect France/ Founded 2011/ $625M net worth

Company Description	Transforms insects into high-performance natural protein solutions for food and feed. Currently operates 3 production units.
Key products/ services	Feed for pets and aquaculture, soil fertiliser and human food applications made out of self-bred mealworms (Molitor beetle). As of 2021, Ynsect acquired protifarm and subsequently also produces Buffalo mealworms
USP(s)	Positions itself as essential partner for food industry professionals, research laboratories, investors and public institutions. Biggest player on the market with regards to capacity so can offer low prices
Active market regions	Worldwide but mostly Europe and North America
Waste streams	Use field crop co-products to feed insects (Upcycling)
Key market segments	Pet Food, Aquaculture Feed, Fertilisers, Bio-fuels
Output volume	Holder of >300 patents, feed now largest contributor to its revenues with human consumption food being 5-10% of its revenue. Currently 100.000 tonnes per year with possibility to rise to 230.000 tonnes on medium term
Future plans	Aiming at 500 M$ in annual global business by 2025/2026 with 25-50% from the U.S. Recently started research into genetics of beetles

InnovaFeed France/ Founded 2016/ $616M net worth

Company Description	Innovafeed is a biotechnology company, and leading insect producer for animal and plant nutrition
Key products/ services	Utilises the Hermetia Illucens (Black Soldier Fly) as one of the sector`s largest aquafeed producer. Also uses the insect for pet feed, soil fertiliser and feed for poultry and swine
USP(s)	Cutting-edge R&D (>10 M€ invested over the last 4 years), unique vertical farm technology combined with real-time data analysis systems
Active market regions	Europe, announced expansion to US pet food market by means of ADM partnership (2022)
Waste streams	100 types of co-products fed to the insects **(Upcycling)**
Output volume	It claims to have the largest insect production capacity in the world with 2 sites (France) in operation and a 3rd one announced in the US
Future plans	Entering US market (via production location)

Agronutris France/ Founded 2011/ $220M net worth

Company Description	Agronutris is a French biotech company specialised in rearing and transforming insects into proteins for animal nutrition
Key products/ services	They focus on the breeding of Black Soldier Fly (BSF) for animal insect meal (powder), lipids (oil) and soil fertiliser (powder) applications. Also coverts by-products into protein
Unique Selling Proposition(s)	A sustainable world fed and preserved through bioconversion
Active market regions	Europe, supplies its output currently to an unnamed European pet food industry player
Waste streams	Use by-products of the agro-industry **(Upcycling)**
Output volume	Currently one pilot-scale laboratory (in France). Industrial plant will open in 2023 and process up to 70.000 tons of organic residues yearly (built by Buhler group)
Future plans	Second factory with processing capacity of roughly 190.000 tonnes will be launched in 2024. Company plans to further scale up to secure leading position in Europe

Tebrio Spain/ Founded 2014/ $220M net worth

Company Description	Spanish mealworm (Tenebrio Molitor) breeding company that produces premium ingredients from processing of the mealworm
Key products/ services	They produce pet and aquaculture feed, plant fertiliser and technical uses of chitin and derivatives (antimicrobial, antiviral, antifungal activities, water treatment, food additives, medicine, cosmetics, paper industry, agriculture, biotechnology)
Unique Selling Proposition(s)	Only focus on Tenebrio Molitor mealworm
Active market regions	Europe
Waste streams	Usage of food industry by-products to feed the insects **(Upcycling)**
Output volume	Multiplies its production capacity in 2024 (to 90.700 tonnes of insect products per year)
Future plans	Wants to enter the human nutrition market in the near future

BioFlyTech Spain/ Founded 2012/ $70M net worth

Company Description	One of the leading companies in Europe in the industrial production of insect protein from the Black Soldier Fly for animal feed
Key products/ services	Protein flours and functional fats for pet feed (dogs) and feed for aquaculture, pigs and poultry). They win small amounts of chitin for the pharmaceutical industry
Unique selling proposition(s)	By using by-products and massive biomass production high quality ingredients are obtained. First Spanish company to achieve up-scaling in the edible insect industry
Active market regions	Europe
Waste streams	Using organic by-products **(Upcycling)**
Output volume	1000 tonnes yearly, will be 4000 tonnes at the end of 2022
Future plans	Wants to increase its capacity to 24.000 tonnes by next year. Wants to open 20 factories in Spain in the next 6 years

Protix B.V The Netherlands/ Founded 2009/ $68M net worth

Company Description	Since its foundation in 2009, Protix has become the leading insect ingredient company with a broad range of ingredients
Key products/ services	Protein powder for pets with common food-related allergies, insect based: lipids (oil), puree for wet pet food, chicken diet, soil fertiliser, aquacultural feed all derived from the Black Soldier Fly
Unique selling proposition(s)	Protix established a high level of technology and operates on industrial scale. Science is at the core of what they do and they have a strong focus on research and engineering to continuously further improve quality, controllability, efficiency and overall competitiveness
Active market regions	Active in 18 countries (mostly Europe)
Waste streams	No
Output volume	>20 patents, has received multiple recent investments (2022) to transfer from growing to producing company
Future plans	Industrial production plans with help of investments

NextProtein

France (Tunisia)/ Founded 2015/ $35M net worth

Company Description	NextProtein produces insect-based protein for animal feed stocks in a quest to accelerate sustainable agriculture and tackle resource scarcity with close to no carbon footprint
Key products/ services	Protein powder, protein lipids (oil) and soil fertiliser made from Black Soldier Fly larvae
Unique selling proposition(s)	Partly Europe
Active market regions	Europe
Waste streams	Using biowaste from food **(Upcycling)**
Output volume	Plans to scale production to 100.000 tonnes per year by 2025 (or 10% of total market demand)
Future plans	Will be building a second production facility

Entocycle

United Kingdom/ Founded 2015/ $27M net worth

Company Description	Operator of insect farming company intended to farm Black Soldier Flies as a sustainable source of protein to feed animals
Key products/ services	Mainly, the sale of hardware: Neonate Counter (larvae egg counter), complete end-to-end breeding system, assisting in building new Black Soldier Fly farms. Usage of robotics, computer vision and IoT (via internet) sensor networks. Also sells insects to the pet and animal feed industry
Unique selling proposition(s)	The company's insect-based organic waste management process converts organic waste from farms, restaurants, and supermarkets into insect-based biomass, enabling farmers to create sustainable insect protein from organic waste anywhere in the world throughout the year. Position themselves as engineers to facilitate efficient and optimised insect farming. Biggest in the United Kingdom
Active market regions	United Kingdom
Waste streams	Farming on food waste **(Upcycling)**
Output volume	Current commercial site runs 6 tonnes a year
Future plans	New commercial site will produce an additional 2200 tonnes a year

Entogreen **Portugal/ Founded 2014/ $23M net worth**

Company Description	EntoGreen aims to contribute to the development of sustainable food, focusing on the development of bio-based technologies that make it possible to reuse nutritional waste that occurs in the agri-food sector, reintroducing them into the value chain
Key products/ services	Feed is sold either as larvae (for animals whose natural food is insects) or as flour and oil. They also sell soil fertiliser and offer the bioconversion of waste as a service
USP(s)	Development of a plant waste bioconversion process that is a bio-based technology that uses Black Fly Soldier flies as an engine
Active market regions	Mostly Portugal
Waste streams	Transforms lost nutrients into nutritional sources for plants and animals **(Upcycling)**
Output volume	One factory converts 36.000 tonnes of plant waste into soil fertiliser to feed the Black Soldier Fly
Future plans	Are looking for partners interested in developing animal feed production lines

Nasekomo **Bulgaria/ Founded 2017/ $18M networth**

Company Description	Nasekomo produces protein-rich products by using protein extracted from Black Soldier Flies grown on food waste
Key products/ services	Whole dried larvae, defatted protein meal (powder), insect oil, organic insect fertiliser, Black Soldier Fly Eggs for pet feed, aquacultural feed, pig feed and soil fertiliser
USP(s)	Selective breeding technologies (actively using genetics)
Active market regions	Mostly Bulgaria
Waste streams	Using food waste **(Upcycling)**
Output volume	-
Future plans	Scaling up in Norway as a result of a grant offered by the Norwegian Government. Want to produce 100.000 tonnes by 2026

Annex: Market Scan of Insect Companies

Singapore

Protenga Singapore, Malaysia/ Founded 2016

Company Description	Protenga makes insects work for you and create A Sustainable Food System. The company produces insect products and Smart Insect Farm technology for sustainable and natural pet food, animal feed, and agriculture.
Key products/ services	• Insect-based Pet Food - Yumgrubs Pet Food, OEM/White Label Manufacturing • Clean Proteins and Insect Products – Hermet Protein, Hermet Oil, Hermet Frass • Smart Insect Farm Technology
Unique selling proposition(s)	Farm to Fork Manufacturer of Insect-based Pet Food, with Clean Proteins by Protenga and OEM or white label manufacturing of pet foodProprietary Smart Insect Farm Technology for biomass owners to upcycle their nutrients
Waste streams	Agricultural and traceable food manufacturing by-products
Key market segments	Pet Food, Aquaculture Feed, Fertilisers, Bio-fuels
Output volume	100+ MT/month per Smart Insect Farm
Financing / Funds raised	Latest round 2+m in equity funding + venture debt.
Future plans	Replication of the Smart Insect Farm model regionally and beyond with expansion of product range.
Collaboration Opportunities	Pet Food Retail & Distribution, Product R&D collaborations, Insect biology R&D collaboration
Contact	Leo Wein, Founder & CEO Email: leo@protenga.com, sales@protenga.com
Website	https://www.protenga.com/

Nutrition Technologies **Singapore, Malaysia/ Founded 2017**

Company Description	Nutrition Technologies is a manufacturer of value-added Black Soldier Fly products, specialising in integrating biotechnology with large scale insect production in tropical environments. Our protein and oil are used as high value animal feed ingredients for aquaculture and pet food and our frass is used as premium soil amendment.
Key products/ services	Animal feed ingredients: BSFL dry larvae, BSFL meal, BSFL oil, BSFL Frass-based soil ammendments.
Unique selling proposition(s)	• Production System: BSFL production system designed for tropical conditions. Incorporating biotechnology into insect rearing. • Products: low-cost high quality insect feed ingredients, premium soil additives that promote plant health.
Waste streams	Factory-grade food waste
Key market segments	Aquaculture feed, Swine feed, Pet food, organic soil amendments
Output volume	2000 t/ year insect protein meal expected in 2023
Financing / Funds raised	USD $30 million > latest funding round US$20 million (Series A2) led by PTT Ventures, Sumitomo Corporation, ING Sustainable Investments, Mandala Capital, Openspace Ventures, Seeds Capital, Hera Capital
Future plans	Expansion of R&D capabilities in Singapore, expansion of commercial production facilities in SEA
Collaboration Opportunities	*R&D:* Plant pathology / immunology , Animal feed trials , pet food trials, Insect feed safety, Insect microbial ecology, BSFL physiology , BSFL nutritional requirements *Non-R&D:* All products available for purchase at commercial volumes, open to collaborations
Contact	Martin Zorrilla, CTO Email: martin@nutrition-technologies.com
Website	https://www.nutrition-technologies.com/

Insect Feed Technologies Singapore/ Founded 2020

Company Description	Based in Singapore, Insect Feed Technologies (IFT) is an insect technology company and a leading insect producer for plant and animal nutrition.
Key products/ services	BSF Dried larvae, BSF Oil, BSF frass Organic Fertiliser, BSF-based Shrimp Feed
Unique selling proposition(s)	1) Microbiology-based solutions to use low grade agri and food waste for insects 2) Propietary advanced manufacturing systems for production 3) Functionality benefits of insect-based ingredients for feed and fertiliser
Waste streams	Pre-consumer/ food manufacturing waste (okara, spent beer grains), low-value agriculture waste (palm oil waste)
Key market segments	BSF protein for pet food and aquaculture feed BSF oil for animal nutrition and biodiesal BSF frass for landscaping companies
Output volume	Currently 1 ton per month. Aim to ramp up to 30 tons per month by Q2 2023.
Financing / Funds raised	Raised US$1m
Future plans	• Increase waste processing capabilities to 30ton/day • Further develop integrated manufacturing capabilities to 200tons/ day • Market expansion & internationalization • Fundraising $7m Series A round equity financing
Collaboration Opportunities	JV wuth waste/ land partners overseas, offtake partners (including distribution to Europe/US), Research collaboration
Contact	Sean Tan, Co-founder & CEO Email: sean@insectfeedtechnologies.com
Website	https://www.ift-group.sg/

Inseact Singapore, Founded 2019

Company Description	INSEACT is a local Black Soldier Fly company that upcycles palm oil waste into high quality feed for the aquaculture industry.
Key products/ services	(i) INSEACT's XFprotein shrimp feed, (ii) dried black soldier fly larvae, (iii) Defatted BSF meal, (iv) Organic fertiliser and (v) BSF lipids and chitin
Unique selling proposition(s)	• Through research on feedstock optimisation, Inseact is able to use an otherwise indigestible waste that is largely available from palm oil plantations as feedstock. This allows Inseact to scale at large volumes of waste, consistent output at low cost of production to be price competitive. • Inseact deploys a modular insect rearing system catered for flexible and predictable scaling of production capacity. The system makes scaling-up easy by enabling lean, evidence-based decisions to determine incremental changes in production capacity.
Waste streams	Agricultural by-products; Palm oil waste
Key market segments	Aquaculture companies (Southeast Asia)
Output volume	Pilot scale facility in Singapore is meant for R&D purposes.
Financing / Funds raised	$1.3 mil seed round, with ADB Ventures, large global shrimp producers, European FO, Loyal VC, INSEAD Asia Angels Club, and private angels.
Future plans	• Raising Series A round in 2022 • Plans to build first industrial scale unit in Malaysia to be closely located to sources of waste streams. • To reach 100,000 MT/year which will address 10% of shrimp feed market and upcycle 10% of palm waste
Collaboration Opportunities	Offtake partnerships, Research collaborators
Contact	John Lum, Strategic Partnerships Manager Email: John.Lum@inseact.com
Website	https://inseact.com/

Ento Industries **Singapore, Founded 2020**

Company Description	Ento Industries uses insects and machines to redefine traditional practices of organic waste management. They are a biotechnology company that transforms low value organic waste into high value feed and fertilisers for the Pet, Gardening and Agriculture Industries. Working with their partners and customers in the F&B sectors, they provide these companies with an alternative to disposal that is both low in cost, and environmentally-friendly.
Key products/ services	ECO GRUB (animal feed), ECO BOOST (fertiliser)
Unique selling proposition(s)	• Proprietary BSF farming system designed with the biology of the insects in mind. The system is designed to be automated in a controlled environment that optimises production cleanly, and sustainably. • Strong relationships with local food manufacturers • Existing capabilities by parent company Tiong Lam Supplies, a waste management company–processes to efficiently segregate inorganic waste from organic waste and process food waste into usable products.
Waste streams	Organic food waste
Key market segments	Aquaculture and poultry farms, Pet food industry, Landscaping, fertiliser companies
Output volume	Building pilot scale facility in Singapore capable of valorising 10 tons of waste/ day
Financing / Funds raised	DBS Social Enterprise Foundation grant – S$150k, currently fundraising seed round
Future plans	• Complete their pilot facility & expand into commercial scale by 2023 • Continue research collaboration projects with IHLs (NUS)
Collaboration Opportunities	Offtake partnerships, Research collaborators, process optimisation
Contact, Website	Nathaniel Phua, Co-founder & CEO Email: nathaniel@entoindustries.com
Website	https://www.entoindustries.com

Yellow Biotech Pte. Ltd. Singapore, Founded 2022

Company Description	Yellow Biotech is a developer of products utilising yellow biotechnology techniques alongside German and Singaporean Research Institutes
Key products/ services	Performance inoculants/ enzymes for feedstocks and end-products
Unique selling proposition(s)	Products are able to valorise low-cost sustainable agricultural waste
Waste streams	RSPO palm oil side-streams including empty fruit bunch, mesocarp, logs, fronds, palm oil mill effluent sludge
Key market segments	Product sales and services to palm oil companies with side streams and/or BSF producers wishing to utilise low-cost side streams
Output volume	2023: inoculant product servicing 1 million tonnes of palm oil side-streams
Financing / Funds raised	Undisclosed (funded solely by founders to date)
Future plans	Expand yellow biotechnology products beyond palm oil sector and expand production in Singapore
Collaboration Opportunities	BSF breeders wishing to reduce costs of production and biotech companies looking for new product categories
Contact, Website	Edwin Khew, Chairman Email: ep_khew@iesnet.org.sg

Insectta Singapore, Founded 2018

Company Description	Insectta is Singapore's first Black Soldier Fly biotech company, extracting high-value biomaterials for the pharmaceutical, bioelectronics, and personal wellness industries. Insectta combines Deep Tech with nature, harnessing the waste valorisation abilities of black soldier flies to create sustainable, high-quality, and renewable materials for current and future generations.
Key products/ services	BSF-based biomaterials (e.g. Chitosan, Melanin)
Unique selling proposition(s)	• Insectta is the first company in the world to develop a patented single process that sustainably extracts high quality, pure chitosan, and water soluble, low cost melanin • Strong technical expertise and R&D capabilities
Waste streams	NA. Insectta offtakes pupae shells/ discards from partner BSF farms
Key market segments	Biomedical and pharmaceutical industries, bioelectronics, cosmetics/ supplements
Output volume	NA
Financing / Funds raised	Seed funding (undisclosed) from Trendlines AFIC
Future plans	• Complete Series A fundraising round • Set up a biomaterial extraction pilot plant to scale production beyond the lab --> Commercialise products • Expand research collaborations for industrial applications for Chitosan and Melanin
Collaboration Opportunities	Investment, Research collaborations in melanin & chitosan use case applications, Offtake partnerships
Contact	Chua Kai-Ning, Co-founder and Chief Marketing Officer Email: kai@insectta.com
Website	https://www.insectta.com/

Blue Aqua Food Tech **Singapore, Founded 2021**

Company Description	Powered by Blue Aqua International, Blue Aqua Food Tech is a newly incorporated insect company to valorise organic waste as feedstock to insects into shrimp and fish feed meal which can contain higher compositions of protein and amino acids compared to animal-based protein. The objective is to upcycle waste and produce insect feed meal which will increase the yield and decrease mortality on shrimps and fish.
Key products/ services	Animal feed for fish and shrimps
Unique selling proposition(s)	• Extremely strong expertise in aquaculture from its parent company Blue Aqua International • Feedmill capabilities
Waste streams	Food waste (uncooked organic food waste), signed MOU with dnata
Key market segments	Blue Aqua Closed loop aquaculture ecosystem
Output volume	NA
Financing / Funds raised	NA
Future plans	Set up their in Singapore and begin productions
Collaboration Opportunities	Research collaboration, process optimisation
Contact	Parham Mansor Safaian, Founder Email: parham@blueaquaint.com
Website	https://www.blueaquaint.com

Entomo Ventures Singapore, Founded 2018

Company Description	Entomo Ventures is Singapore-based AI-powered company delivering technologies for the fast-growing insect farming sector. The company helps to create an ecosystem of cutting-edge technologies for optimising and industrialising the growing of insect for human and animal consumption, as well as organic waste management. The main purpose of the company is to make insect farming more efficient and support sustainability using AI technologies.
Key products/ services	• ERP: farm management system • Dashboard: Monitoring and controlling system • Video detection module • Acoustic modules to monitor crickets chirping • Q-SAR: Nutrition solutions to enhance protein quality and consumption for insects • Unique functions, such as insect counting
Unique selling proposition(s)	• Current insect industry innovation is mostly still at automation and IoT farm sensors to improve operational efficiency. Entomo Ventures could potentially bring insect farms to the next level with Artificial Intelligence and Machine Learning capabilities, organic feed analysis and adjustment, and other unique functions. Entomo Ventures can help with farm's operational capabilities and efficiencies. • Strong technology and R&D team with CTO at School of Computing, National University of Singapore
Key market segments	Black Soldier Fly farms/ Cricket farms/ Mealworm farms/ Grasshopper farms
Future plans	Expanding functionality through intensive R&D work, conducting trials in industrial setting, collecting farm datasets to intensify machine learning and imrpove AI efficiency, collaborate with academia to continue research, connect with insect farms to identify challenges and propose digital solutions.
Collaboration Opportunities	Pilot and research trials, partnership collaborations with equipment providers, advanced insect farming players or aquaculture companies.
Contact	Rudolf Davidov, Head of Business Development Email: rd@entomoventures.com
Website	https://entomoventures.com

Future Protein Solutions **Singapore, Founded 2019**

Company Description	Future Protein Solutions is an insect agriculture-technology company that focuses on cultivating insects for human food.
Key products/ services	Roasted cricket powder
Unique selling proposition(s)	Key focus on utilising technologies such as robotics and IOT to enable highest possible productivity whilst minimising energy and water usage
Waste streams	Experimenting on spent brewery grains and okara
Key market segments	Food nutrition companies, focusing on protein bars, shakes or snacks
Output volume	Current output is purely for R&D
Financing/ Funds raised	Raised S$600,000 in seed investments through Rapzo Capital
Future plans	• Raising Series A funding in 2022/2023 • Plans to set up a commercial farm to commence commercial production in 2023 in the region, with Singapore as the HQ • Targeting 100% power and water self-sufficiency for farming process
Collaboration Opportunities	Food technology companies, food manufacturing companies, investors
Contact	Christopher Leow, CEO Email: chris@fps.sg +65 9296 6864
Website	https://fps.sg

Werms. Inc **Singapore, Founded 2020**

Company Description	Werms.Inc is an online live feeder farm that upcycles food waste into animal feed and fertilisers for the pets and plants community
Key products/ services	Variety of live insect subscription, range of dried insects, Wermeal™ Bloom
Unique selling proposition(s)	• Convenience and accessibility for pet feed • Targeted benefits of fertiliser
Waste Streams	Clean cosmetic filtered plant waste
Key market segments	Ornamental pets and plants
Output volume	<10 ton/ year
Financing/ funds raised	Privately funded
Future plans	Increase market share in Singapore, increase volume of output
Collaboration Opportunities	Schools (preschool-universities), grassroots, environmental/CSR office of corporates
Contact	Aaron Chen, Co-founder & CEO Email: hello@wermsinc.com
Website	https://wermsinc.com/

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