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Business Innovation Observatory

Sustainable, Safe and Nutritious Food

New nutrient sources

Case study 52

Internal Market, Industry, Entrepreneurship and SMEs

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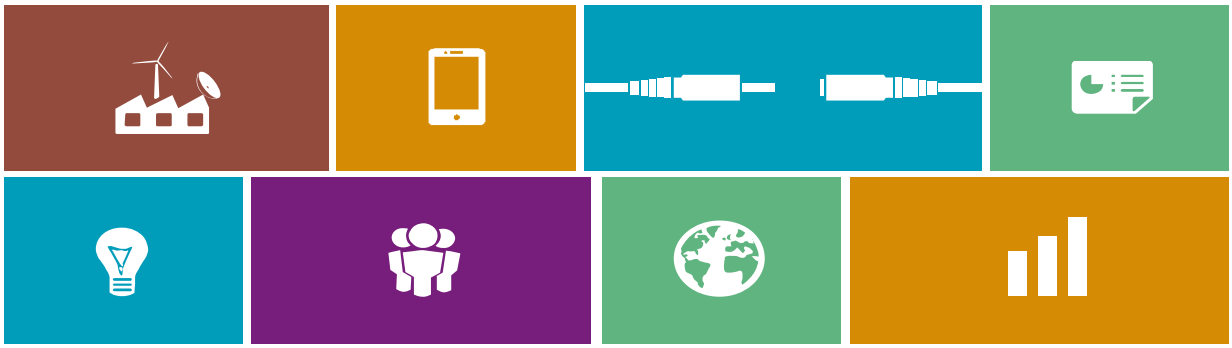


1. Executive summary

Food and feed security are predicted to be put under great stress in the coming decades, due to the steep rise in the world's population and the ensuing increase in animal protein demand. Within this context, the need for new sources of nutrients becomes evident.

The two most promising options to relieve this stress on food and feed security are insects and algae, which show potential as alternatives to animal proteins for both human consumption and feed applications. Insect consumption, known as entomophagy, entails many nutritional benefits including high protein content, minerals and vitamins. Although not currently integrated in animal feed, insects have comparable properties to traditional feed components such as fishmeal. Algae, which comprise seaweeds and microalgae, are also rich in nutrients. Seaweeds can be consumed directly as whole algae, whereas microalgae are mainly used for the extraction of food and feed complements.

Alternative proteins are estimated to make up 33% (i.e. 311 million metric tonnes, MMTs) of global protein consumption by 2054, with algae and insects accounting for about 18% and 11% of the alternative protein market, respectively. This implies that about 56 MMT of algae and 34 MMT of insects will be consumed globally by 2054. The edible insect industry alone could become a EUR 320 million business in the US and Europe within the next decade. High-value microalgal products also have a very good potential, with the market for astaxanthin being expected to treble by 2017.

New nutrient sources also have a considerable social impact across several interlinked areas. Their large scale production could revive the European agricultural industry, offer opportunities for economic diversification for both men and women, and offset job losses across the sector. From a public health perspective, new sources of nutrients could help ensure food security and decrease the incidence of cardiovascular diseases related to unhealthy food. Moreover, they will contribute to the reduction of greenhouse gas emissions associated with animal rearing, as well as preventing ocean depletion and lessening the stress on land availability.

Increased awareness of the health and environmental benefits of novel nutrient sources is undoubtedly the main driver that supports the uptake of the trend. Public and private initiatives are actively promoting insects and algae production and commercialisation. The results are visible both at an industry level, with the fitness and health food sectors booming, and at the community level, with local educational establishments adopting new nutrient sources as didactic material.

However, companies active in the production and commercialisation of insects and algae for food and feed face several obstacles. These are related to customer aversion and to the unclear regulatory environment, particularly related to the classification of insects and algae as "novel foods". This and other legislative barriers result in the cautious and hesitant attitude of investors and retailers towards the financial and commercial support of insect- and algae-based products, thus limiting production volumes and threatening the competitiveness of the business.

To unlock the large potential of novel nutrient sources, action is required at the EU level. Namely, it is recommended that the Novel Foods regulation be harmonised across Member States and that animal feed regulations be adapted to new protein sources. Moreover, it is important to evaluate the side-effects of other policies that might indirectly affect the development of the alternative nutrient source industry. To this end, close collaboration with expert associations such as the International Platform of Insects for Food and Feed (IPIFF) and the European Algae Biomass Association (EABA)[1] should be a crucial component of the decision-making process.

2. New nutrient sources

The trend "Sustainable, Safe and Nutritious Food" covers the latest developments in the food industry through three case studies. Each of them focuses on innovations occurring at different steps of the food value chain. This paper explores the production and commercialisation of new sources of nutrients, which represent a currently untapped resource.

2.1. Trend presentation

New nutrient sources are needed to face the challenges that are putting food security under great stress. The crushing weight of the world's population, projected to soar to a staggering 9.6 billion by 2050, will inevitably result in an increased demand for food, namely animal proteins[2]. Animal proteins account for about 40% of global protein consumption, but their production is highly inefficient, with about 2 to 15 kg of plant material being required for 1 kg of animal products. Furthermore, cattle breeding and meat consumption are associated with a high environmental footprint and greenhouse gas release, thus making these practices unsustainable[3].

Particularly interesting as an alternative to animal proteins for human consumption and animal feed production, novel sources of nutrients include insects, algae and in-vitro meat. The latter still being in an experimental phase and not mature enough for commercialisation, only insects and algae will be explored here.

The consumption of insects, known as entomophagy, is a concept alien to the Western culture, but is estimated to be an integrant part of the diet of at least 2 billion people across Asia, Latin America and Africa. Some of the most widely consumed species include caterpillars, termites, grasshoppers, crickets, stink bugs and mealworms (Figure 1).

To make them edible, insects first need to be processed. After being wild-harvested or reared, they are freeze-dried, sun-dried or boiled. They can then be consumed in three ways: as whole insects (e.g. fried), in ground or paste form, and as an extract of protein, fat or chitin for enriching food and feed products[4].

Entomophagy entails several nutritional benefits. Nutrient contents vary according to the species, metamorphic state and preparation methods, but in general insects provide adequate amounts of energy and protein, meet amino acid requirements for humans and are high in unsaturated fatty acids, minerals and vitamins. To put things into perspective, ground beef contains more protein (23.5g/100g), but also has 288.2 calories and 21.2 grams of fat, almost three and four times the amount of crickets. Furthermore, their food conversion efficiency is about 20 times higher than traditional meats, meaning that they have a better feed-to-meat ratio[5].

The use of insects such as mealworms, crickets and maggots is currently limited to pet food in Europe. However, it is expected to be extended to feedstock for aquaculture, cattle and poultry in the near future, especially given that their properties have been shown to be comparable to fishmeal.

Figure 1: The consumption of insects, known as entomophagy, is becoming a real possibility in Europe

Source: Bug Corp[6]

Algae are simple, plant-like organisms, capable of harnessing sunlight to convert carbon dioxide into sugars and oxygen during the process of photosynthesis. They can be divided into microalgae and seaweed. Microalgae are unicellular organisms that can grow under a diverse set of environmental conditions, whereas seaweeds are complex multicellular organisms which grow in marine environments[7]. Both types present great opportunities as nutrient sources.

The most common varieties of edible seaweed include Nori, Wakame, Kombu, Dulse and Carrageen. Seaweeds are associated with many health benefits, including lowering blood pressure and preventing strokes, but most importantly, they are a valuable source of protein. For instance, the protein content of Nori varies between 25 and 35% per gram of dried seaweed, depending on the season of collection (highest in winter)[8]. In addition, seaweeds are rich in amino acids, minerals and vitamins, not to mention their negligible fat and cholesterol content.

On the other hand, microalgae are currently mainly used for the extraction of high-value food/feed supplements and colorants, rather than being commercialised at a large scale as a source of proteins. However, microalgae such as

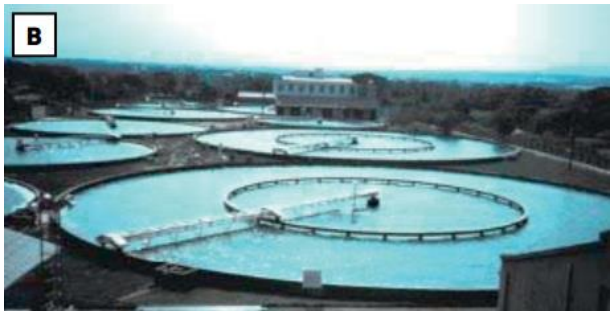
Spirulina and Chlorella can also be consumed as dietary supplements as dried whole algae.

Micro-algae are produced in a broad range of different cultivation systems that can be placed either outdoors or indoors. Such systems include open shallow ponds and closed photobioreactors. For large-scale production and commercialisation, the most widespread and used technique is the open system (Figure 2 and Figure 4).

Figure 2: Open pond systems for Spirulina

Source: Joint Research Centre[9]

Figure 3: Open pond systems for Chlorella



Source: Joint Research Centre[10]

Many innovative businesses are emerging across Europe, actively seeking to harness the power of these new sources of nutrients and turn it into sustainable, healthy and nutritious practical solutions for food and feed applications. These innovative companies are explored in the following chapters, within the broader context of the socio-economic and regulatory environment they operate in.

2.2. Overview of the companies

Table 1: Overview of the company cases referred to in this case study

Company	Location	Business innovation	Signals of success
Bioflytech	Spain	Bioflytech uses its technology to mass rear dipterans (flies) for use as live food and raw material for animal feed.	- Winner of the University of Alicante IMPULSO Award 2012, "IDEA" category - Winner of the University of Alicante IMPULSO Award 2011, "Technology-based business project" category - Winner of the Alicante-Puerto Rotary Club "Best Business project" Award 2011
Ynsect	France	Ynsect focuses on scaling-up insect processing for animal feed applications	- Ynsect raised EUR 11 million in one year (both from international private equity investors and public grants/loans) - In 2015 Ynsect is building a fully automated insect farming and processing plant in France - Winner of over 12 prizes, including the "Innovation world prize 2030" and "French cleantech company of the year 2014"
Protix	The Netherlands	Protix produces high-value insect-based products for pet food and animal feed applications	- Founding partner of the "International Producers of Insects for Feed and Food" association - Official member of NeVeDi, the Dutch Feed Industry Association - Rolling out operational plants in other markets, including Chile - Awarded Technology Pioneer 2015 by World Economic Forum
Eat Grub	United Kingdom	Eat Grub sells edible insects, focusing on their palatability	- Extensive press coverage across the UK - Experiencing increases in online sales - Encouraging turnout at their pop-up restaurant events

Company	Location	Business innovation	Signals of success
Entotech	France	Entotech produces and commercialises edible insects with a sustainable and fancy twist	- Extensive press coverage across France - Good sales revenues through their website - Establishment of both a B2B and B2C activity
Necton	Portugal	Necton specialises in the cultivation and commercialisation of microalgae for food and feed applications	- Slow Food Award for the Defense of Biodiversity (2001) - Best Company Prize in Agriculture and Fisheries (2003) - Innovation Prize "BES Inovação – Renewal Energy Category" (2006) - SME Leader "PME Líder" (2011)
Ocean Harvest Technology	Ireland	Ocean Harvest develops natural algae-based solutions for aquaculture and animal feed	- R&D centre in Ireland, production facilities in Vietnam and numerous bases across Asia, Australia and North America - Shortlisted for the Irish Times InterTradeIreland Innovation Awards 2015

Problem 1 – The key prerequisite for the introduction of new nutrient sources in food and feed applications is their rearing/growth under controlled conditions, as opposed to simple wild harvesting.

Innovative solution 1 – Bioflytech is a technology based company and a spin-off of the University of Alicante, dedicated to the mass rearing of over ten different species of dipterans (flies).

The company has developed an innovative technology to produce decomposer flies from organic waste. The technology essentially mimics the natural process of biotransformation, whereby the larvae of the flies feed on the organic substrate, pupate and become adults, ready to reproduce and restart the cycle. This way, organic waste is productively converted into "useful" fly biomass.

Bioflytech's dipterans can be then used as raw material for direct use in animal feed or processed for nutrient extraction.

Bioflytech specialises in the artificial rearing of dipterans on organic waste substrates

Source: Bioflytech[11]

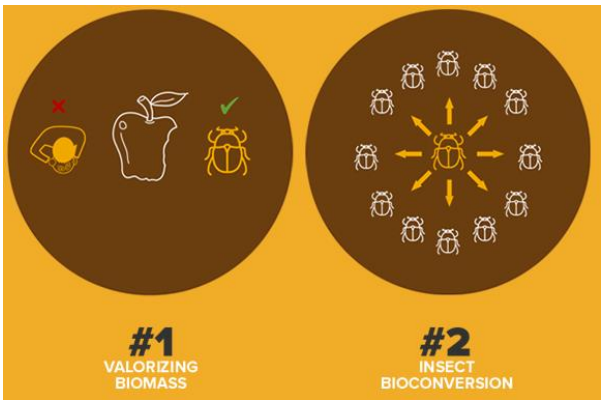
Problem 2 – The competitiveness of new sources of nutrients is dependent on the quantities produced. Once controlled growth is achieved, the next stage is the development of technologies to scale up production.

Innovative solution 2 – Founded in 2011, Ynsect is a start-up aiming to harness the power of insects to sustainably extract nutrients for agro-industries and bioactive compounds for green chemistry. Ynsect's main products include insect proteins, lipids, chitin and its derivatives.

The company has understood that, in order to tap into the promising aquaculture feed market, the prices of insect-derived products need to be lowered. For this reason, Ynsect is focusing on increasing its production capacity and consequently driving prices down.

The company is currently building a factory called "Demo-Plant", which will be used to conduct trials with interested feed companies and produce feed on a commercial scale. Ynsect expects to reach a production capacity for commercial plants of over 10,000 tonnes/year of insect proteins.

Global view of Ynsect's value chain, from insect rearing to end products



Source: Ynsect[12]

Problem 3 – Processing is a fundamental step in turning the raw nutrient sources into end products with high added-value and ensuring their suitability for the end markets.

Innovative solution 3 – Protix is a company focused on turning insect biomass into high-value, high-quality products to be used in the pet food and animal feed industries.

The company specialises in various types of products, namely insect oil and lipids, insect meal and insect fertiliser. Oil and lipids are directly extracted from the larvae. Meal is obtained through extraction and consecutive drying of larval proteins, whereas fertiliser is produced by drying and pelletising insect residues. In addition, Protix also develops chitin rich powders for a broad range of applications.

Protix prides itself on the resilience, versatility and adaptability of its technology, made possible by the integration of innovative robotics, monitoring and control systems.

Value creation: from low-value larvae to high-value end products for multiple applications

Source: adapted from Protix[13]

Problem 4 – New protein sources can become integral part of the human diet only if they can be made palatable, tasty and appealing to customers.

Innovative solution 4 – Eat Grub is a London-based start-up selling edible insects, from grasshoppers to mealworm and crickets.

Based on the realisation that sustainability and environmental arguments alone are not enough to win consumer acceptance, the company's primary focus is on the development of tasty insect-based recipes.

Eat Grub specialises in the creation of appetising and appealing products, from whole insects for the more adventurous customers, to insect-based delicacies for first-time entomophagists. An example is the latest cricket nut fudge, available both in milk and dark chocolate.

In order to promote their products and make them as palatable as possible, Eat Grub collaborates with professional chefs on the preparation of insect-based menus during pop-up restaurant events.

Eat Grub's edible insects starter pack (grasshoppers, crickets, buffalo worms and mealworms)

Source: Eat Grub[14]

Eat Grub's chocolate cricket nut fudge

Source: Eat Grub[15]

Problem 5 – Strategic marketing is essential to encourage the uptake of alternative sources of proteins. Developing an attractive brand image whilst emphasising the sustainable side can greatly enhance product acceptance and consumption.

Innovative solution 5 – Established in 2013, Entotech is a company that produces, imports and supplies edible insects to retailers, agri-food industries, restaurants and consumers by the way of insectescomestibles.com. Entotech believes that the effective marketing and branding of insects could incentivise customers to integrate them in their diets.

The company therefore developed a line of insects ("Insectéo") to be used as cocktail food, aiming to sell them as "trendy", upscale and refined delicacies, and counteract the "filthy" stereotype. In this respect, packaging plays an important role in conferring the products an elegant-looking and upmarket image.

Entotech also stresses the social and sustainable side of its insects. These come from the company's own farm in Thailand and are fed only with seasonal fruits and vegetables. Moreover, part of the insect production is destined to the local people, in an attempt to improve their livelihoods.

Entotech's cocktail finger food "Insectéo"

Source: Entotech[16]

Problem 6 – The development of innovative and efficient technologies for the cultivation of microalgae is essential for their integration in food and feed applications.

Innovative solution 6 – Necton was established as a spin-off of the Portuguese Catholic University, with the aim of cultivating and commercialising microalgae for a broad range of applications.

Necton has experience in designing and operating different microalgae cultivation technologies, ranging from open to closed systems. It produces around 30 different microalgae species, both marine and freshwater, thanks to its proprietary technology.

Microalgae are then sold under the brand "PhytoBloom" as pure concentrates, and can be supplied as a liquid, paste or powder. The final products are characterised by a high cell concentration, a biochemical composition suitable for various applications and are pathogen-free. Furthermore, they have a long shelf-life whilst containing no preservatives.

Necton's "PhytoBloom" logo

Source: Necton[17]

Problem 7 – Exploiting the intrinsic beneficial properties of algae will ensure the development of high added-value products and their successful adoption by the animal feed industry.

Innovative solution 7 – Founded in 2005, Ocean Harvest develops a range of natural feed solutions to replace the synthetic components found in traditional feed preparations.

Namely, the company created a variety of patented seaweed-based ingredients (OceanFeed™) for aquaculture and animal feed. Its products have been shown to enhance animal health, tackling common diseases in farmed animals, increasing their omega-3 levels and reducing mortality rates. This contributes to productivity gains in the feed industry.

Ocean Harvest bases its feed ingredients on a sustainably harvested mixture of brown, green and red seaweeds. These are dried and milled, mixed, bagged and then dispatched to customers all around the world.

Ocean Harvest's "OceanFeed™"

Source: Ocean Harvest[18]

3. Impact of the trend

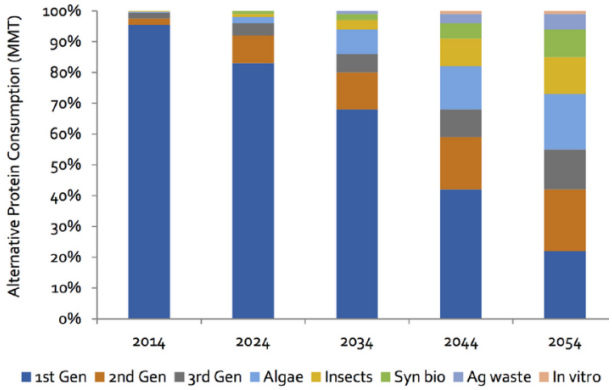
In order to assess and appreciate the full repercussions of the trend, both its economic potential and its social relevance are discussed in the following sections.

3.1. The market potential of the trend

Very recent studies are seeking to characterise the evolution of the market for alternative sources of proteins, both from a consumption and economic value perspective. These are analysed below, with respect to both insects and algae.

According to a report by Lux Research, the current dominance of animal proteins will decrease over the next decades. In contrast, as global protein consumption is estimated to reach 944 million metric tonnes (MMT) by 2054, consumption of alternative protein sources is predicted to grow by an annual rate of 9%. This will result in a market share of up to 33% of the total protein consumption by 2054, equivalent to about 311 MMT[19]. In particular, sales of insects and algae are expected to each account for 2% of the alternative protein market share by 2024. The outlook for 2054 is promising, with algae and insects accounting for about 18% and 11% of the alternative protein market, respectively. This implies that about 56 MMT of algae and 34 MMT of insects will be consumed globally by 2054 (Figure 4 on page 8).

Figure 4: Shifts in market proportions of alternative protein sources until 2054



Source: Lux populi[20]

As previously mentioned, insects are currently not included in animal feed preparation. However, recent studies have shown that insects such as black soldier fly larvae, mealworms, grasshoppers or silkworm have nutrient contents comparable to traditional feeds, and could potentially replace between 10 and 50% of soymeal in poultry and cattle feed[21]. Considering that soymeal production accounts for over 65% of the global animal feed market[22], which is expected to exceed 1.5 billion tons per year by 2020[23], it can be argued that insect based meals have the potential to account for an average 300 million tonnes of animal feed. As for fishmeal, out of the 6 million tonnes produced annually, 4 million tonnes are used for aquaculture (fish farming). Introducing up to 20% of insect meal into fish feed to replace fishmeal would mean a market potential of almost 1 million tonnes for insect-based feed in the aquaculture sector.

Attempts at monetising the market potential of insects and algae have also recently been carried out. A report by New Nutrition Business claims that the edible insect food industry alone could become a EUR 320 million business in the US and Europe within the next 10 to 15 years[24].

As for the algae biomass industry, its total annual value is estimated at up to EUR 6.3 billion[25]. In particular, the value of all products from the seaweed industry accounts for about EUR 4.9 billion, whereas the microalgal biomass market accounts for the other EUR 1.4 billion. In terms of the market share per application, food products for human consumption are estimated to be worth EUR 4.6 billion, with other various uses such as fertilizers and animal feed additives making up for the remaining value[26].

Microalgae-based products for food and feed applications consist of both whole dried biomass (Spirulina and Chlorella) and microalgae components (Astaxanthin, β-carotene, Phycocyanin and the two omega-3 fatty acids EPA and DHA). Dried Spirulina and Chlorella have the largest production volumes, but their market value is not very high (estimated at EUR 36 and EUR 34 million in 2005, respectively[27]). On the contrary, high-value microalgal products have a very good potential for growth. For instance, the current global market size of natural astaxanthin from Haematococcus for the human consumption is estimated to be about EUR 180 million. This is expected to increase to EUR 630 million by 2017.[28] However, its synthetic form is currently dominant due to the higher price of algal astaxanthin. ß-carotene extraction from Dunaliella is also a growing business, with several industrial plants in operation in countries like Australia, Israel, USA and China. Dry Dunaliella biomass production was valued at EUR 220 million in 2007, and is predicted to be worth EUR 255 million by 2015.

3.2. The social potential of the trend

The uptake of the trend entails numerous social benefits across several interconnected areas, from job creation, economic diversification and gender empowerment, to food security and improved public health. Most importantly, it

stands to help reduce greenhouse gas (GHG) emissions and contribute towards environmental protection. It is important to appreciate the broad relevance and scope of such social benefits, which reach far beyond the European level.

From an **employment perspective**, the integration of alternative sources of nutrients into food and feed will offer the opportunity to transition from a currently small-scale localised production to a proper industrialised large-scale process, paving the way for the growth of a new branch of agriculture. This will be made possible by the ongoing and considerable efforts into the development of insect mass-rearing and algal cultivation technologies. Considering that between 2000 and 2012 about 4.8 million full-time agriculture jobs were lost in the EU[29], large-scale production of alternative nutrient sources could boost and revive this industry, counteracting the decline in employment. In addition, it could offer an opportunity for diversification away from conventional animal feedstock, thus protecting farmers from price fluctuations of soymeal and fishmeal. Moreover, given the potential of new protein sources in food and feed applications, producing insects and algae could provide excellent prospects for expansion into both markets.

Public health, namely with regard to food security and cardiovascular diseases, is perhaps one of the most relevant areas that have the potential to be positively affected by the advent of new nutrient sources. The awareness that Europe might face serious food shortages is pushing for the so-called "sustainable intensification" of farming, based on more resource-efficient crops and increased use of biotechnologies. However, these technologies face widespread public resistance within the EU. This is especially true in light of the possibility that US food produced via intensification such as hormone treatments and GMOs could be entering the EU market as a result of the ongoing EU-US free-trade talks. In this respect, EU production of insects and algae could find even more favourable grounds to its kick off, since they offer a safer, locally sourced option that could shield the EU food industry from geopolitical instabilities and offset the predicted food crisis.

The introduction of alternative nutrient sources in the European food chain as a substitute or complement of animal proteins could also help alleviate the incidence of cardiovascular diseases and even some types of cancers. In fact, it is now widely accepted that a diet rich in animal proteins is associated with an increased risk in prostate, breast and bowel cancer. On the other hand, widespread consumption of insects and algae could prevent heart conditions due to their considerable omega-3 fatty acid content and negligible cholesterol. From a social perspective, this implies that the overall improved health of the population could contribute to important savings in European healthcare expenditure, which amounts to EUR 169 billion for cardiovascular diseases alone[30].

Production of novel protein sources will also have a major positive impact on **environmental protection**, helping to address specific concerns such as climate change, land use and ocean depletion.

Firstly, both algae and insects are important actors in the circular economy, having the ability to thrive on GHGs and waste streams, thus "closing the loop". In particular, algae can be grown in waters enriched with carbon dioxide pumped directly from CO_2 generating activities, such as a power plants and factories. As for insects, they feed on organic waste from various industries, thus recovering the nutrients and converting them into useful insect biomass.

This "circularity"[31] results in the considerably lower GHG emissions profiles associated with algae and insect production, compared to conventional animal proteins. Indeed, the livestock sector is currently responsible for over 15% of the total GHG emissions[32], and this will be exacerbated by the expansion of agricultural land by land clearing in response to increased animal protein demand. Livestock rearing is therefore one of the biggest contributors to global warming and climate change. Shifting towards production and consumption of proteins from lower impact sources can therefore alleviate this environmental burden. As a matter of fact, studies have shown that insect rearing produces between 2 and 122 grams of GHGs for each kilogram of mass gain. In comparison, cattle produce 2,850 g/kg mass gain and pigs between 80 and 1,130 g/kg mass gain[33].

Secondly, in addition to reducing GHG emissions, new protein sources score positively on land use. Lifecycle assessments have demonstrated that production of one kilogram of protein from dairy, chicken, pork or beef requires much more land than insects. Specifically, 90% and 43% less land is required to produce mealworms compared to beef and milk, respectively[34]. This is particularly relevant considering that livestock currently uses around 70% of all agricultural land. Similarly, algae cultivation does not put a stress on land availability, since it uses both land and water sources that are unsuitable for traditional agriculture, such as sea and brackish water.

Thirdly, the integration of insects and algae in feed for aquaculture would contribute to relieving ocean depletion. Currently, due to unsustainable fishing practices, 61% of commercially important marine fish stocks worldwide are fully fished, 29% are overfished and about 90% of large predatory fish is already depleted[35]. Aquaculture is a key contributor to this issue, since it accounts for 88% of global fish oil consumption to feed the farmed fish. Algae and insect based feed could thus reduce the dependency on fishmeal and solve the paradox of using fish to feed fish.

"Microalgae are a component of plankton. Including them in feed is like going back to the beginning of the food chain: it is only logical" – ***Necton***

As a final remark, looking ahead at the future beyond the EU level, Western interest and technological advances in the production of new nutrient sources could represent an opportunity to export European expertise and know-how to developing countries and establish a profitable international presence across the world. Furthermore, this could help promote local entrepreneurship, generate employment, alleviate hunger and improve the health and livelihoods of the local population, thus strengthening the social as well as the financial impact of EU businesses.

4. Drivers and obstacles

The diffusion of new nutrient sources is supported by their numerous social and environmental benefits, which contribute to their public acceptance and future uptake. However, several obstacles are faced by companies trying to promote their production and commercialisation. These include cultural barriers affecting customer acceptance, the restrictive EU regulatory environment as well as production and scaling-up costs, as discussed below.

4.1. Health and environmental awareness initiatives

The main driver that will ensure the integration of alternative protein sources in Western diets is the enhancement of health and environmental awareness. Many initiatives have been launched recently to sensitise customers and other stakeholders to the environmental burden of animal rearing and to raise their interest in alternative proteins. Furthermore, research consortia have been established to provide better scientific evidence to support such initiatives.

For instance, the first international conference on "Insects to feed the world", jointly organised by Wageningen University and the United Nations Food and Agriculture Organisation (FAO), aimed to bring together global stakeholders to publicise the potential of insects as food and feed, and stress the environmental benefits of insect rearing (Figure 5). The high rate of participation and diverse origins of the attendees (over 450 people from 45 countries) shows the considerable increase in interest in insects across the world[36].

Figure 5: The 1st international conference on "Insects to feed the world" was held in Wageningen (NL)

Source: Wageningen University

Similarly, the European Algae Biomass Association (see 5.4) recently organised the "Novel Foods Workshop", aiming to discuss the large scale commercial production of microalgae for food ingredients and supplements, and the admission of new algal species into the food supply. The association reported the keenness of consumers towards incorporation of algae in products, due to the "green", sustainable and healthy image they convey.

Another interesting example is the EU initiative PROteINSECT, a multidisciplinary consortium coordinated by the Food and Environmental Research Agency (FERA) in the United Kingdom. The project brings together the expertise of 12 partners from 7 countries across Europe, China and Africa, ranging from feed industry multinationals, research centres and universities, to farmers and policy experts. The consortium aims to support and facilitate the adoption of fly larvae proteins in animal feed both from a technological and regulatory perspective. The project was launched in 2013 and has a duration of three years.

Entotech and Eat Grub confirmed that nutritional and sustainability awareness are indeed positively contributing to the promotion of their edible insect products. Consumers are increasingly concerned with the nutritional properties of their food. This results in the rapid growth of the fitness and health food sector and in increased interest in the benefits of protein-rich "super foods", such as algae and insects. Alternative nutrient sources also appeal to consumers from a sustainability perspective. In fact, insect production is more resource-friendly and ethical compared to conventional livestock, thus gaining increasing popularity even among vegans. Rising awareness and interest is also being expressed at the community level by educational institutions. For instance, Eat Grub's products are being sold to local schools as teaching material for lessons on nutrition and sustainability.

4.2. Customer aversion – the « yuck factor »

Despite the previously mentioned awareness efforts, the so-called "yuck factor" remains a major obstacle to the uptake of new sources of proteins. This holds true especially for insects. The disgust factor is completely unjustified from a dietary perspective, given the nutritional equivalence of insects and algae with fish and cattle. In the Western culture,

prejudice against entomophagy stems from the conception that insects are only consumed by the population of developing countries as a response to starvation, due to the lack of other food sources. Furthermore, insects are often associated with poor hygiene standards and, according to scientists, the disgust reaction can therefore originate as a defence mechanism to protect us from things that may pose a hazard to our health.

A recent example of insect phobia in the food industry was the revelation that Starbucks was using cochineal beetles as a red colorant in some of its drinks. The uproar caused among consumers, who saw this as a dangerous, "dirty" and unethical practice, pushed the company to replace the insect-derived dye with tomato extract.

"It doesn't matter how sustainable it is, if it doesn't taste good, no one's going to eat it" – ***Eat Grub***

Bringing about a change of mentality is therefore a long and challenging process, though not impossible. Until recently, lobster and shrimps were deemed to be a poor man's food. Today, these are highly desirable delicacies.

4.3. The 'Novel Foods Regulation' and human consumption of new nutrient sources

Companies active in the production and commercialisation of insects and algae for human consumption are faced with the lack of legal guidance regarding the regulatory status of their products at the EU level. In particular, there is confusion as to whether insects and algae should be classified as Novel Foods.

Since the Commission has not yet explicitly ruled on whether or not insects and algae should be considered Novel Foods, Member States are applying their own rules for the commercialisation of products intended for human consumption. Regulation (EC) no 258/97 states that foods or food ingredients which have not been used for human consumption before 1997 are novel foods, and must therefore be submitted to a risk assessment and authorised by the European Commission before being legally marketed.

In practical terms, this lack of harmonisation across the EU is negatively affecting business such as Entotech and Eat Grub. In fact, Entotech stated that larger supermarket chains are often reluctant to sell their products due to fear of fines. Indeed, about 60 stores have stopped commercialising Entotech's insects and about 100 others have refused to become distributors. Similar difficulties are faced by Eat Grub when seeking to establish commercial partnerships with retailers. Necton stated that only 4 types of microalgae are currently approved for food applications, and only two are commercialised (Spirulina and Chlorella). At least 15-20 types should be approved in Europe for algae to significantly contribute the food sector.

4.4. Lack of harmonised regulation hampers access to finance

Due to the unclear stance of the Commission on novel nutrient sources as feed and food, finding investors who are willing to take the risk to invest in an emerging and relatively unregulated sector is a challenge.

Business Angels and Venture Capitalists are concerned that the precarious regulatory environment may never allow the alternative nutrient industry to fully take off and achieve the expected revenues, thus negatively affecting their return on the investments in the long run. Moreover, Necton explained that some past bad investments in the algae field are further discouraging Venture Capitalists from taking the risk.

"We need bold investors with a long-term vision, who recognise that there is no other option but algae" – ***European Algae Biomass Association***

With regards to access to EU finance, all the showcased companies felt that that they lacked the necessary internal resources to deal with the application procedures, considered to be too complex, laborious and time-consuming. Therefore, Entotech was self-financed, and is currently resorting to crowdfunding to fund its activities. Similarly, Eat Grub, Ocean Harvest and Necton felt that Business Angels and Venture Capitalists were a more accessible and suitable option, despite the aforementioned concerns.

4.5. Animal proteins restriction in feed

Businesses involved in the production and processing of insects intended for use as animal feed components face a major regulatory bottleneck related to the ban of processed animal proteins (PAPs) in feed.

This prohibition was promulgated by the Commission through regulation (EC) 999/2001, following the BSE outbreak in the 1990s, and also extends to insects. The regulation was subsequently amended in 2013 by regulation EC 56/2013, allowing non-ruminant animal proteins to be included in aquaculture feed, thus theoretically lifting the ban on insect-based meal. However, a restrictive element persists in the form of tight requirements on .the slaughtering of animals for PAPs production.

"The pet market offers good money, but it is not enough to ensure a sustainable growth for the insect industry" – ***Ynsect***

Since slaughtering does not apply to insects, insect-derived proteins are non-compliant with the regulation, meaning that insect-derived proteins are currently not allowed as a constituent of animal feed within the EU. This clearly harms businesses such as Bioflytech, Protix and Ynsect, whose market is therefore currently restricted to the pet food

industry which, being a niche market, has only limited potential for growth.

4.6. Inflated substrate costs and limited variety

Another regulatory obstacle encountered by companies producing insects for animal feed is the elevated cost of the organic material used for insect rearing, as well as the limited types of waste allowed as substrate.

The prices of organic waste matter are being artificially inflated as a result of the subsidies for bioenergy applications, making the access to organic substrates more difficult and expensive. This is especially the case for SMEs and start-ups seeking to enter the market for insect meal production, and is therefore a threat to their competitiveness, as confirmed by Protix.

*"In the Netherlands, we are competing with subsidised bioenergy initiatives and we have to pay too much for the organic waste" – **Protix***

The previously mentioned restrictions on the use of animal proteins in feed imply that currently insects can only be grown on vegetable waste. This could also constitute a barrier to the development of a large-scale insect rearing industry due to substrate availability. Bioflytech therefore expressed the importance of allowing insects to grow on a broader range of waste streams from other industries, particularly animal waste.

4.7. Production costs and scaling-up

Another frequently mentioned issue is the currently high and uncompetitive cost of production, linked to the small-scale of operations. Bioflytech stated that the relatively small quantities of insects produced force them to sell their insect meal at higher prices compared to traditional feed components. Due to the suboptimal availability of funding, research and business development are limited, making insect processing technology very expensive. Thus, on average, the price of insect meal is more than EUR 3,000 per tonne, which is affordable for the pet feed market, but not competitive for aquaculture. As a comparison, prices of fishmeal for aquaculture are around EUR 1,600 per tonne. For this reason, the showcased companies aim to decrease their prices in the coming years by scaling up their production capacity and optimizing their products and technology, in order to be competitive with fishmeal and extend their market to aquaculture.

*"We are confident that, at the right production scale, we can become competitive with fishmeal for aquaculture" – **Protix***

For companies such as Eat Grub, low production volumes from their suppliers are also an obstacle. In fact, the limited number of food-grade insect farms in Europe and the relatively small quantities of insects produced, imply that the price for insect is higher than it should be. In addition, the shortage in supply means that Eat Grub cannot produce enough of its edible insect products for commercialisation in larger retailers, thus restricting its outlets and limiting its profits. For this reason, Eat Grub is planning to open its own insect farms across the UK to increase insect supply and drive down costs. Indeed, Entotech has already adopted this approach, obtaining its insects from its own farms in Thailand, and planning to open more in Congo DRC.

The same applies to microalgae. Their low volumes and high production costs (which can reach up to EUR 29,000 per tonne[37]) currently restrict their applications to the production of high-value supplements for human consumption, rather than of substantial quantities of proteins and carbohydrates for food and feed. Scaling-up is therefore crucial if algae-derived products are to contribute significantly to European food and feed security. Necton explained that the main obstacle to scaling-up is the low demand, in turn dependent on low production. Ocean Harvest added that obtaining the marine licence for seaweed farming takes up to three years, thus slowing down operations, limiting the quantities produced and perpetuating the "low production- low demand" vicious loop.

*"If we can control production we can control the demand, so we can put pressure on the market to include algae in feed" – **Ocean Harvest***

5. Policy recommendations

From the analysis of the drivers and obstacles, it is clear that the new protein sources industry is being held back by the current restrictive and unclear regulatory environment of the EU, identified as the most hindering factor encountered by the showcased companies.

Indeed, some companies have expressed an intention to shift their focus to the Asian market, due to the more favourable regulatory setting and the high demand for insect-based animal feed.

Action from the EU side is therefore required to offset this trend. In this context, the following policy recommendations could significantly contribute to unlocking the potential of the new nutrient sources industry and keep talent and innovation in Europe.

5.1. Harmonising the Novel Foods Regulation across the EU

The lack of a clear position at the EU level on the classification of insects and algae as Novel Foods results in a legislative ambiguity across Member States. Consequently, countries like Belgium have ruled some insects fit for food markets until such unified position is adopted. However, food ingredients isolated from insects, such as protein extracts, are not allowed on the market. In France, 21 macroalgae (seaweeds) and 3 microalgae are currently authorised as vegetables and condiments, and production and commercialisation of insects is also taking place despite not being explicitly authorised. On the contrary, in Luxembourg and to a certain extent Italy, the marketing of edible insects is forbidden until a position is reached at the EU level.

This lack of coherence could negatively affect the image of the EU, creating conflicts and weakening its internal cohesion. For this reason, policy makers should be aiming to harmonise the Novel Foods regulation, so as to facilitate product access to market, legalise the trade between Member States and provide an environment more conducive to the growth of the sector.

In 2013, the Commission presented a proposal for a Regulation aiming at rendering the authorisation procedure for novel food more efficient, though fully centralised at the EU level. This efficient procedure should enable safe and innovative food to be placed faster on the EU market without compromising public health.

5.2. Adapting feed legislation to alternative proteins

As discussed in the previous chapter, non-ruminant processed animal proteins (PAPs) have been allowed in aquaculture feed. However, the slaughtering requirements exclude insect proteins from benefiting from this policy relaxation. In order to enable European SMEs to take full advantage of the large market potential offered by the aquaculture sector, the scope of the concerned legislations should therefore be broadened, updated and made relevant to alternative protein sources.

Moreover, non-ruminant PAPs are not currently allowed in pig and poultry feed, since the legislation prohibits intra-species recycling of proteins (for instance, pork proteins cannot be fed to pigs), and there are no reliable diagnostic tests that can ensure that feed complies with this ban. Again, even though these restrictions are not theoretically applicable to insects, the use of insect proteins in feed is being hindered by the lack of precision in defining the scope of the regulations.

It is thus worthwhile to support the revision of the regulations through investments in the development of accurate and reliable tests to detect the presence of non-ruminant proteins in animal feed.

5.3. More rigorous evaluation of policy side-effects

Price inflation of organic waste matter as a result of the heavily subsidised bioenergy sector constitutes a considerable barrier to insect rearing. This is a typical example of how a policy aiming to support one industry can inadvertently harm the development potential of another.

For this reason, it would be advisable to set up a committee to rigorously analyse current and proposed policies across potentially interconnected sectors, so as to identify and assess any barriers and unintended hindrances to the uptake of the trend. This step would help ensure minimal policy overlap and better efficiency.

Furthermore, expanding the range of substrates apt for insect breeding should be envisaged, so as to offer companies an alternative substrate and decrease competition with the bioenergy industry.

5.4. Recognising the value of expert associations

The many challenges faced by companies active in the production and commercialisation of alternative proteins for food and feed applications cannot be addressed by single individuals. Associations that bring together all the concerned parties and stakeholders are therefore emerging, both at a local and international level. Instances include the "International Platform of Insects for Food and Feed" (IPIFF), dedicated to the promotion of insect proteins for food and feed applications, and the "European Algae Biomass Association" (EABA), supporting the development of research, technology and industrialisation in the field of algal biomass production and use.

Given the novelty of the sector, as well as the recent establishment of the supporting organisations, the relevance and significance of such joint efforts could be easily overlooked and underestimated. Hence, it is important to ensure that due recognition is granted to them, and that the industry knowledge and skills of the experts is taken into account during the decision-making process.

6. Appendix

6.1. Interviews

Company	Interviewee	Position
Bioflytech	Berta Pastor Monllor	R&D manager
Ynsect	Antoine Hubert	CEO & co-founder
Protix	Tarique Arsiwalla	Founder & director
Eat Grub	Shami Radia	Co-founder
Entotech	Romain Fessard	Founder
Necton	Vitor Verdelho Vieira	CEO
Ocean Harvest	Stefan Kraan	Co-founder & scientific director

6.2. Websites

Company	Web address
Bioflytech	www.bioflytech.com
Ynsect	www.ynsect.com
Protix	www.protix.eu
Eat Grub	www.eatgrub.co.uk
Entotech	www.entotech.fr
Necton	www.phytobloom.com
Ocean Harvest	www.oceanharvest.ie

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