Future Fish Feed: Forecasting Alternative Aqua Feed Ingredients

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Executive Summary

• Since 2015, when Lux first analyzed this space, the aquaculture feed ingredients landscape has evolved.

• Insect protein, single-cell protein, and algae proteins have emerged as major options to replace fish meal.

• This report includes a PEST analysis, which makes clear that algae is poorly positioned for success as a major source of protein for aquafeed.

• While the Lux Tech Signal (above, right) shows similar levels of innovation interest in each of the three, there are significant differences in the scale and applicability of the three for use in aquafeed.

• Our projections of production show that single-cell protein sources will reach commercially relevant scales more rapidly than insect proteins.

• As these alternatives become more frequent inclusions in aquaculture feed, it will be critical for industry players to understand the dynamic of the landscape to rationalize and prioritize future feed composition.
Global fish meal demand continues to exceed production capacity

While global fish meal production has increased since 2015, as much as 15 million tons new protein will be needed for aquaculture by 2050.

- In 2018, the FAO estimate aquaculture production to reach 201 million metric tons (MT) in 2030, with demand for protein for fish growing 10% annually; however, global fish meal production has remained steady at 5 MT annually in recent years (IFFO).

Interest in alternative proteins is growing, but understandably requires strong incentives (e.g. governmental support, improved production performance, reduced cost) for adoption to reach critical mass; see insight The state of aquaculture through the lens of the 2019 North American Seafood Expo.
Venture capital (VC) funding in alternative proteins for aquafeed is unpredictable

Funding for algae production is primarily targeting fuel and chemical production; in 2016, the U.S. Department Of Energy (DOE) invested $15 million to advance algae-based biofuels and bio-products. The single greatest raise for algae proteins was $4.7 million by Algaia in 2018.

Insect protein producers raised over $170 million in funding in 2018; 40% more than the previous four years combined. In the first half of 2019, already $157 million has been seen in VC funding for insect production.

While most SCP funding rounds are undisclosed, the few large amounts raised and announced were by only a few companies; leading producer Calysta has raised about $118 million in total.
### MARKET MAP:

**ALTERNATIVE PROTEINS FOR AQUAFEED**

#### 1. ALGAE
- bioprocessalgae
- ALGAlife
- Farnamateq
- Mbio
- Corbion
- Sabtech
- Global Algae Innovations
- euglena
- Algaica
- Veramaris
- MiAlgae
- Feed Algae Ltd.

#### 2. INSECT
- Entofood
- HexaFLY
- Protix
- Protifarm
- Grubbly Farms
- nextProtein
- Beta Bioch

#### 3. SINGLE-CELL
- Kiverdi
- Calysta
- Unibio
- NovelNutrients
- Menon
- BioKind
- Novonutrients
- Kinnva
- MyCell
- Bluepha

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PEST analysis for algae, insect, and single-cell proteins for the aquafeed market

In order to better understand the current landscape and uncover market potential, we examine the political, economical, social, and technological (PEST) issues affecting each source, including the following:

**POLITICAL**

Relates to the pressures and opportunities brought by changes of the government and public attitudes toward the industry, changes in political institutions and the direction of political processes, legal issues, and the overall regulatory climate.

**SOCIAL**

Refers to cultural attitudes, ethical beliefs, shared values, level of differentiation in lifestyle, demographics, education levels, etc. Observing social factors helps organizations maintain their reputation among stakeholders.

**ECONOMIC**

Refers to a society’s economic structures and such variables as the stock exchange, interest and inflation rates, the nation’s economic policies and performance, exchange rates, etc. These variables impact differently on different industries.

**TECHNOLOGICAL**

Refers to changes in technology that can alter the firm’s competitive position. Industries merge; new strategic groups emerge; current products improve and the cost of production gets reduced by process innovation. Managerial innovation is part of the technology scan.
### PEST analysis at-a-glance

<table>
<thead>
<tr>
<th>POLITICAL</th>
<th>ECONOMICAL</th>
<th>SOCIAL</th>
<th>TECHNOLOGICAL</th>
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<tbody>
<tr>
<td><strong>ALGAE</strong></td>
<td>Federal government agencies continue to support algae production for nonfeed industries</td>
<td>Many algae producers have gone bankrupt; alga protein production remains economically unviable to compete against existing protein sources</td>
<td>High demand from competing sectors hinders algae innovation for the aquaculture feed industry</td>
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<td><strong>INSECTS</strong></td>
<td>Changes in legislation to promote sustainability are enabling the use of insect protein within feed and promoting production in many geographies</td>
<td>Many insect producers are raising VC funding and have announced construction plans to increase production capacity; this should decrease product costs</td>
<td>Unfavored in Western cultures for food application, but sentiment towards insect protein as a feed ingredient is more positive</td>
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<td><strong>SINGLE-CELL</strong></td>
<td>Incentives for industrial facilities to reduce greenhouse gas emissions and collaboration for SCP feedstocks are seen through federal research funding and carbon emission fees</td>
<td>Very few companies scaling at this point; these efforts appear to achieve economies of scale earlier than other protein sources</td>
<td>Developers are seeking safety recognition through extensive feed trialing and securing GRAS status; reliance on methane or natural gas may impact social perceptions</td>
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Lux Tech Signal

The Lux Tech Signal is based on our analysis of innovation data including:

- Patents
- Academic papers
- VC funding
- Government funding
- Lux proprietary data

The **Innovation Interest** score is calculated by analyzing multiple, diverse datasets weighted based on our evaluation of the role innovation sources play in each stage of commercial technology development; empirically tested and validated against real world historical data.

The maximum possible score is 100, indicating the highest observed rate of research, patenting, funding, etc.
How will insect protein production change going forward?

Projected insect protein production capacity
Metric Tons of protein per year

While global food waste is abundant, insect production is not strongly restricted by its availability as a feedstock. The largest insect production facility constructed to date produces about 10,000 MT of insect protein per year (InnovaFeed). There is a relatively high number of insect producers, and many of them are scaling; Ynsect is constructing a 18,000 MT to 20,000 MT/yr facility and AgriProtein has multiple 5,500 MT/yr production facilities planned. To this end, growth in insect protein production will be relatively stagnant in the next five years based on the increase in many, yet small-scale, insect production facilities; greater volumes may come from changes in EU regulations that will support insect production.
Calysta

Develops fermentation process to produce aquaculture feed and chemicals from natural gas

- Calysta develops a fermentation process using natural gas to produce aquaculture feed and chemicals.
- The company uses a wild type methanotroph to produce its aquaculture feed product, branded FeedKind; FeedKind is approximately 71% protein, 10% fat, and 7% ash.
- Calysta also uses genetically modified methanorophs to produce intermediate chemicals, including isoprene, butanediol, propylene, and methanol.
- The company partnered with Cargill in November 2016 to build and operate a new facility that will produce 200,000 metric tons of FeedKind per year.
- To date, the company has raised about $118 million in funding, with a $30 million investment from BP Ventures in 2019.
- Clients interested in alternative protein sources should engage; Calysta claims FeedKind will be cost competitive with super prime grade fishmeal, and it is one of the few developers in this space to achieve commercial scale.
Insect and single-cell protein show real potential as fish meal alternatives; consider algae for fish oil alternatives

As insect and SCP sources both leverage waste stream valorization and demonstrate high growth rates, these protein sources will continue to be attractive as replacements for fish meal. In the future, we expect that:

• Changes in feed legislation will continue to be a major driver, especially for insect protein. With anticipated EU authorization of insect protein for livestock rations beyond aquaculture in the near future, anticipate a major spike in insect production scaling.

• Many insect and SCP producers will use recent VC funding for construction of facilities that will increase production capacity and should decrease production costs. Rising fishmeal costs and reduced production have contributed to higher overall feed costs; this scarcity has made feed a primary industrywide concern. Changes in cost parity for protein may favor alternatives as they become economically sustainable.

• Public sentiment will not be opposed to the use of alternative proteins in feed, provided that those alternatives communicate traceability and safety to consumers and are cost-competitive with fishmeal.

• Genetic engineering (GE) technologies will significantly impact protein quality and efficiency of production. While some segments of agriculture struggle with negative consumer sentiments toward GE approaches, developments in cellular agriculture and GE fish will contribute to improved consumer impressions here.

Algae will be a significant replacement for fish oil to complement alternative proteins. Efforts to increase production of algae-based ingredients are currently focused on competing industries like biofuels, nutraceuticals, and human food. However, algae’s attractive amino acid composition and algal oil production developments seen by Veramaris and TerraVia highlight opportunities within aquaculture feed beyond replacing fish meal.
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