COMPLETED PROJECT CASE STUDY

NOVEL FARMING SYSTEM TO PRODUCE SUSTAINABLE MARINE ZOOPLANKTON PROTEIN FOR AQUAFEED

PARTNERS

Aquanzo Ltd

PROJECT LEADS

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FUNDING

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** The UK Seafood Innovation Fund supports new ideas to deliver cutting-edge technology and innovation to the UK's fishing, aquaculture and seafood industries.*

BACKGROUND

The volume of aquafeed required to support the rapidly developing aquaculture sector has urged feed manufacturers to seek alternative, novel, and sustainable ingredients for inclusion in marine aquaculture diets. Traditionally, fishmeal, harvested from marine fisheries, has been the main protein source incorporated in marine aquaculture feeds; however, this resource is limited, and as a result many manufactured diets are now primarily plant-based. The increased reliance on more widely available plant-based proteins poses issues with the diets' nutritional value and reduced performance of carnivorous marine aquaculture species, and as such, the search for alternative protein sources is a rapidly developing market.

Two of the most promising aquafeed protein alternatives to date are industrially farmed insects and single cell proteins, both with the potential to support sustainable aquaculture development due to their scalability. However, the nutritional profiles – as well as palatant and attractant properties – of these alternative proteins differ from the optimal of harvested marine ingredients, and therefore cannot fully replace marine ingredients in marine fishes and shrimps.

To address this shortfall, project leader Aquanzo Ltd has established a mission to increase the availability of marine ingredients for the aquafeed industry, rather than develop another alternative, by domesticating and sustainably farming marine zooplankton on a large scale. Production will be focused on *Artemia*, which are small marine crustaceans similar to krill, and one of the most nutritious ingredients available for marine fish and shrimp in the wild.

Physiologically, artemia offers significant advantages for industrial production. They reach adult size and sexual maturity in under 21 days, can be reared at 28 degrees Celsius, and are able to grow to 130 times their egg weight feeding on multiple sources of feedstocks. Moreover, the development of technologies that enable scalable and sustainable farming of marine zooplankton, on land, using agricultural by-products, will allow marine aquaculture to improve the productivity of plant-based diets as well as support its long-term sustainable development.

AIMS

The main aim of this feasibility study is to establish the innovations required at lab-scale to inform the design and operation of future scaled-up industrial facilities to produce marine zooplankton ingredients economically and sustainably. To this end, the following objectives were established to determine the biological and technical parameters necessary for the development of the artemia product lab prototype:

1. To design a novel tank design of an artemia production unit in a recirculating aquaculture system (RAS).
2. To produce artemia biomass efficiently at scale, while minimising energy consumption and waste production.
3. To develop a nutritional platform (portfolio of products with different nutritional profile) using agricultural by-products as well as advanced feedstocks.

> *Through this work, Aquanzo has successfully designed and built the first iteration system and scaled the production volume more than fiftyfold, from 80L to over 4000L over the course of the project, and integrated it within a RAS.*

NOVEL TANK DESIGN FOR ARTEMIA PRODUCTION UNIT

Work done

Aquanzo explored the feasibility of producing artemia biomass and dry meal in custom-designed tanks connected to a recirculating aquaculture system (RAS).

In order to develop a system to easily scale the artemia production, the design work included a series of steps to find a solution to the biological and environmental requirements for this novel production system. The team designed, specified, ordered, and built the tank set-up to conduct various tests using three different sizes (250 litre, 1,000 litre and 1,300 litre) and two options of tank shape (conical and square). Parameters such as vessel shape and size, as well as the position of in- and outlets, water circulation and dissolved oxygen, were optimised to obtain the most efficient design.

Furthermore, feeding parameters of the scaled tanks were optimised, including the testing of various feeding regimes as well as two different feedstocks (rice bran and spirulina powder) to compare the effectiveness of the system.

Outcomes

Technical design, equipment specifications, and the built artemia lab-scale production facility were optimised and delivered.

ENERGY CONSUMPTION INDEX EVALUATION IN LAB PROTOTYPE SET-UP

In order to achieve production targets and scale this process to an industrial pilot size, the project aim was to achieve an energy consumption index of 5 kWh/kg. This index varies widely (2.9 - 81.5 kWh/kg) in the aquaculture industry, as it differs by species and RAS specifications and depends on factors such as location and production volume. Developing a process that operates on the lower end of this range will be key to sustainably producing artemia at scale globally.

Work done

The main energy requirements for system operation to produce artemia biomass include feeding, air supply, water recirculation and cleaning, as well as heating the water in the tanks to maintain a steady temperature.

The final energy consumption was analysed for the designed unit, which was connected to the recirculation system in a temperature-controlled room.

Outcomes

Results indicated that using an oversized recirculation system for a single unit is inefficient, however the connection of multiple units could allow target energy consumption index below 5 kWh/kg.

The designed artemia tanks can be connected to the RAS, enabling a batch operation, with the benefit of producing more product while sharing certain processes within the set-up. However, energy consumers – such as aeration or feeding – are currently scaled linearly, which can be combined to a shared system as the production increases, giving economies of scale.

Heating and cooling are the biggest energy consumers in the current set-up. Energy calculations suggest that the heating requirements for a system as used in the current set-up could be reduced by at least 30% by optimising size specifications of the heaters.

PRODUCTION OF ARTEMIA MEAL AT A MINIMUM 90% DRY MATTER USING TWO FEEDSTOCKS

Work done

The nutritional profile of artemia biomass powder was analysed to demonstrate the range of products and capabilities of the system.

Artemia were produced using two feedstock formulations: 100% spirulina (a single-cell dried microalgae) and a combination of spirulina followed by rice bran, using the optimal stocking density, time post first feeding (juvenile to adult stage) and growth temperature (21C, 26C and 32C).

Outcomes

Aquanzo was able to grow artemia on two feedstock formulations in the built lab prototype set-up.

Results indicated that the amino acid profiles of artemia meals do not differ significantly based on feedstock, although feeding spirulina only produces a meal with slightly higher crude protein compared to spirulina + rice bran. Moreover, feeding spirulina + rice bran produces a meal with a higher crude lipid level.

Overall, the concept of developing a nutritional platform by using a combination of feedstocks is validated, as demonstrated by the differences in lipid profiles between spirulina only or in combination with rice bran.

The Aquanzo team at work

IMPACT

This project demonstrated the feasibility of growing artemia in a prototype lab-scale system, under controlled conditions, using agricultural by-products to ultimately be processed into a meal that has similar characteristics to fishmeal.

Through this work, Aquanzo has successfully designed and built the first iteration system and scaled the production volume more than fiftyfold, from 80L to over 4000L over the course of the project, and integrated it within a RAS. Several parameters and processes were optimised to consistently produce biomass, which included an almost threefold yield increase over the first five months, and the analysis of the energy consumption of the system. Furthermore, it was demonstrated that the use of different feedstocks leads to differences in the nutritional profile of the final product, validating the potential to tailor products.

The innovations developed as part of this project have laid the groundwork to develop a novel farming system, sustainably produce marine ingredients, and in the medium-term create a new industry sector alongside insect and single cells to supply the aquafeed industry, which could ultimately support the continued development of the aquaculture sector.

ADDITIONAL INFORMATION

Although this feasibility study set a baseline for achievable improvement of biological and technical parameters, it has also shown that there are areas such as product yields, energy consumption and water treatment that require further optimisation. Aquanzo has therefore developed a project proposal for further R&D to address and develop the necessary and sufficient technologies for achieving the next steps, along with the basic and detailed engineering necessary for building the pilot-scale facility.