Innovate UK

# Future Food Innovation

## Driving the transition towards a healthier future for people and planet

# Contents

# Introduction by Dr Stella Peace

**Executive Director for the Healthy Living and Agriculture Domain, Innovate UK**

Nourishment extends beyond sustenance; it can be a thread weaving people, societies, and families together during moments of joy and solace. While food traditions are deeply embedded in our culture, it's crucial to recognise and address the challenges faced by those experiencing food insecurity. By fostering a greater understanding of these issues, we can work together to create a more inclusive and supportive food culture for everyone. Additionally, as we confront global challenges such as sustainability and food security, the growing economic and health concerns from diet-related disease, and an ageing population, fostering a greater understanding of these interconnected issues becomes imperative.

## The role of innovation

Innovation stands as a cornerstone for meeting the evolving needs and preferences of consumers while simultaneously addressing these pressing global challenges. Advancements such as alternative protein sources, micronutrient fortification, and vertical farming, not only enhance the quality, diversity, taste, and texture of products but also reduce environmental impact. By embracing innovation, the AgriFood industry can create a more interconnected and consumer-centric ecosystem, ensuring that we create a UK food system that produces healthy, desirable, and affordable food. This is critical to ensure that we create a more sustainable and resilient future for all.

Delivering to this multitude of expectations creates both challenges and opportunities for our end-to-end food system, from farmers through to food manufacturers. This is creating a unique moment as we rise to the challenge of future-proofing our food production and consumption.

## Innovate UK's commitment

As showcased in this brochure, Innovate UK remains dedicated to driving business growth by inspiring and unlocking innovations that make life better and will ensure the long-term resilience of UK food production. Whether through developing education and understanding with consumers, or supporting the wider push for longer, healthier lifestyles, the projects we have funded all play their own key role in these societal goals.

Across two Innovate UK competitions, we've funded a diverse range of innovations, spanning from protein-rich smoothies to novel and alternative packaging techniques for extended food shelf-life and reduced waste. These projects focus on alternative proteins like plant-based and lab-grown options, promoting sustainability by minimising the impact of food production on land and water resources. Some projects explore vertical farming solutions, offering benefits such as space efficiency, a smaller environmental footprint and year-round localised production, a key consumer driver.

Innovate UK also collaborated with venture capital firms on an Investor Partnership competition, combining grants and private equity to support business growth. In 2024, a select few projects will start, advancing novel food production systems towards commercial viability for mainstream consumer markets.

Innovate UK

# Better Food For All

The growing issue of diet-related disease is causing higher healthcare costs due to increasing numbers of people being affected. Poor diet plays a major role, contributing to chronic diseases and a significant portion of cancer cases. Obesity rates are very high in the UK, with projected costs for the NHS at £9.7 billion by 2050 and wider costs to society estimated at nearly £50 billion annually.

The UK food industry has a chance to make a positive impact on this problem. By creating innovative products and solutions, it can both address these health challenges and generate substantial profits for companies in the sector.

In 2023, Innovate UK's Better Food For All competition awarded £19.2 million to 52 projects to improve food quality, create functional foods, boost nutrition, develop new proteins, and extend the shelf life of healthy and fresh foods.

The innovations being developed range from plant-based protein-packed fruit and vegetable smoothies, to novel fortification technologies, as well as salt alternatives and drinks designed to improve gut health.

Project participants, funding and additional information is correct as of January 2024

**52**

**Projects funded**

**£26.1m**

**Full project costs**

**£19.2m**

**Amount of grant funding committed**

**£6.8m**

**Pledged co-investment**

**88**

**Business**

**3**

**Public Sector, Charity**
or non Je-S registered
research organisation

**5**

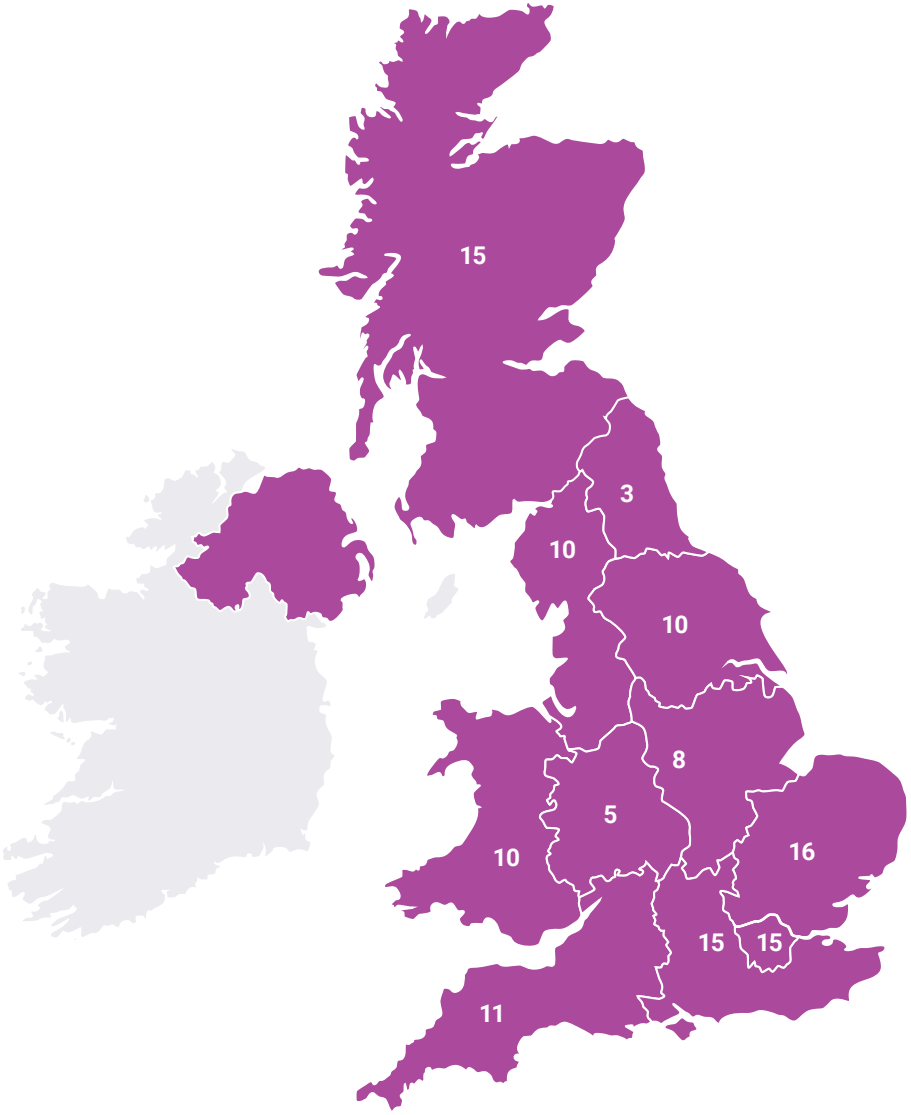
**Research & Technology Organisation (RTO)**

**25**

**Research**
mostly academic institutions

# Geographic locations of project participants

| | |
|---|---|
| East Midlands | 8 |
| East of England | 16 |
| London | 15 |
| North East | 3 |
| North West | 10 |
| Scotland | 15 |
| South East | 15 |
| South West | 11 |
| Outside UK | 3 |
| Wales | 10 |
| West Midlands | 5 |
| Yorkshire and The Humber | 10 |
| **Grand Total** | **121** |



Innovate UK and BBSRC

# Novel Low Emission Food Production Systems

Through their strategic partnership, Innovate UK and BBSRC are supporting innovations designed to drive transformation across the food industry to meet the demands of a growing population while promoting health and sustainability.

In December 2023, Innovate UK and BBSRC invested £15.6 million to 32 projects as part of the Novel Low Emission Food Production Systems competition.

These industry-led, collaborative projects encompass various aspects, including the development of alternative proteins such as plant-based and lab-grown options, which can have a lower impact on land and water resources. Additionally, the projects are looking at the sustainability of the UK insect farming industry, supporting the decarbonisation of livestock production. Furthermore, the exploration of vertical farming solutions within some of these projects presents potential advantages such as space and resource efficiency, year-round localised production, and a reduced environmental footprint.

Project participants, funding and additional information is correct as of January 2024

**32**
**Projects funded**

**£19.9m**
**Full project costs**

**£15.6m**
**Amount of grant funding committed**

**£4.2m**
**Pledged co-investment**

**48**

**Business**

**1**

**Public Sector, Charity**
or non Je-S registered
research organisation

**9**

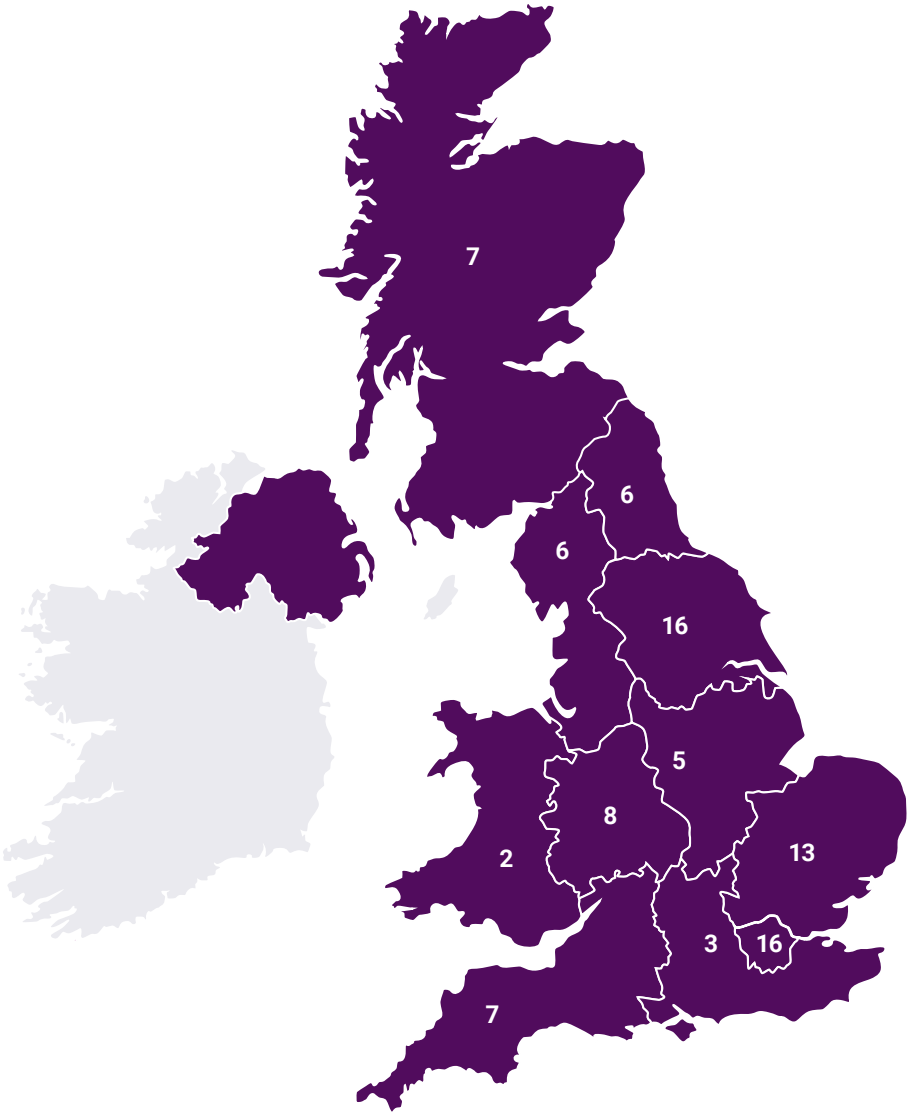
**Research & Technology Organisation (RTO)**

**31**

**Research**
mostly academic institutions

# Geographic locations of project participants

| | |
|---|---|
| East Midlands | 5 |
| East of England | 13 |
| London | 16 |
| North East | 6 |
| North West | 6 |
| Scotland | 7 |
| South East | 3 |
| South West | 7 |
| Wales | 2 |
| West Midlands | 8 |
| Yorkshire and The Humber | 16 |
| **Grand Total** | **89** |



# Better Food For All Project Portfolio



# Textured fava bean (vicia faba): manufactured at scale for nutrition, quality and sustainability


**Project lead:** Biopolymer Solutions Ltd

**Participants:** Cereform Ltd, New-Food Innovation Ltd

**Funded amount:** £165,261

Fava bean (Vicia faba) is an established UK crop that improves soil fertility and helps lock in carbon. With the increase in flexitarian and vegan diets, plus the wider encouragement of more legumes in the diet, a fava-based alternative to animal proteins would be advantageous across the UK supply chain and for the consumer. By using unusual combinations of already established food processing techniques and innovative conditions, a product has been made that compares well with other textured plant proteins to meet the texture profile expected for a meat analogue or extender. Following excellent results from the fava texturant by major food producers and retailers from their kitchen concept work, the project will now use its technologies, developed for producing 25kg a month in a research facility, to build and equip a new factory making 5,000 tonnes per year.

Success for textured fava depends on it becoming an affordable everyday food and therefore requires manufacturing at scale. As volume production occurs, not only is there concern for the product's textural quality, but also that the process embraces high environmental standards, such as low inputs (energy/water, minimal waste) and appropriate use of co-streams. Textured fava must have clean label status, be safe in terms of anti-nutrients and retain the nutritional aspects associated with fava. Over the project's nine months, it will carry out a series of trials to establish which capital equipment can make the textured fava successfully at the required scale.

# Cheese from peas: maximising use and nutritional value of UK pulses for dairy alternatives

**Project lead:** Good Pulse Foods Ltd

**Participants:** University of Nottingham

**Funded amount:** £266,294

Cheese from Peas focuses on physical processing of whole legume seeds, driving their natural nutrients to an unparalleled high degree of functionality with zero-waste generation. It enables rapid physical transformation of starch together with protein activation to achieve a pea flour delivering the desired texture and oil binding for vegan cheeses, removing the need of synthetic emulsifiers, unsustainable fats, and gelling agents.

The technology used within the project also significantly reduces the negative beany flavour and taste typical of legume seeds, and enhances their natural colour, reducing the artificial flavouring and colouring content in vegan cheese. The solution is applicable to different yellow pea varieties and designed to enable rapid scale-up. Given the compositional and structural similarities across legume seeds (pea, lentil, fava bean) it is expected that the solution can be readily applied to all legumes, thus maximising its potential of applications and business growth opportunities.

The outputs include a new process and platform for making ingredients in the form of functional flours for cheeses from pulses, benchmarking of results, early new product development trials, and validation of ingredients applications; all at laboratory scale. These will validate the technology, its application and market fit, while simultaneously significantly improving the company profile and attractiveness for raising private investment.

The project outputs will inform the next development stage of pilot trials and prototyping of cheese applications with large potential customers. Project results will also be used in the future on other applications which have already been trialled into early laboratory-scale prototypes, enabling the development of more products in other segments from the same ingredients' development platform.

# Next generation plant-based meats: optimising nutritional value and sustainability through ingredient selection and processing

**Project lead:** Brunel University London

**Participants:** Plant Meat Ltd

**Funded amount:** £396,259

THIS™ has a range of plant-based products already on the market which have a realistic taste and texture compared to meat from animals. Whilst THIS™ has data to show that $CO_2$ emissions from its range are significantly less than meat, with a similar protein content, there is still research to be done around the nutritional comparison to meat in terms of protein digestibility and bioavailability of other nutritional components.

This project will aim to address those gaps by a combination of ingredient selection and processing. Developments will be assessed against the baseline nutritional parameters, as well as sustainability measures, taste, and cost, in order to ensure that the increase in nutritional profile is not at the expense of sustainability, product quality or greater cost.

# Automated seeding and deployment of novel seaweed spores (ASDNSS)


**Project lead:** Seaweed Generation Ltd

**Participants:** Microgrow Systems Ltd, CIEL - Centre for Innovation Excellence in Livestock

**Funded amount:** £319,777

This project is a partnership between Seaweed Generation and Microgrow to establish feasibility for the UK's first commercial seeding system for dulse, a highly desirable red seaweed that could become a viable plant-based protein alternative both in the UK and globally in the next five years.

To halt warming through climate change, there is a need to reduce emissions by 75% and massively increase biodiversity across the planet. This means eliminating emissions wherever possible, finding sustainable sources of protein for food and animal feed without water and land needs, rehabilitate soils, bio-diversify agricultural land, and continue to offer appropriate nutrition to the world's population.

Seaweed offers an opportunity to grow high-protein, nutrient-dense biomass in the UK, without the need to commit more land to crop production. This feasibility study will allow full assessment of seeding techniques and practices for dulse – a particularly tasty (umami) and protein-rich red seaweed that has proved challenging to grow.

SeaGen and Microgrow will develop an automated seeding system that can reliably produce dulse spores for large scale cultivation practices.

The industry currently relies largely upon wild harvesting, which is unpredictable and potentially unsustainable. This project aims to create a system for reliable seeding stock, allowing the seaweed food industry to develop in the UK as a viable and cost-effective plant-based protein source.

# PROSPER – production of sustainable microalgal protein through enhanced recovery

**Project lead:** Arborea Ltd

**Participants:** Campden BRI (Chipping Campden) Ltd

**Funded amount:** £487,748

Moving to alternative proteins is an essential part of achieving net zero in the UK, and over the last decade, meat consumption in the UK has fallen 17% and alternative protein consumption has doubled.

It is not a simple task to replace animal protein across manufactured food. First, proteins need certain properties: they must be soluble or able to gel, emulsify or foam, to act as effective food ingredients. They also need to be cost-effective, nutritious and have low environmental impact. The vast majority of alternative proteins are imported and, in the case of soya, can have negative environmental impacts associated with their production.

Microalgae are a highly nutritious source of highly functional proteins, which offers a solution to this challenge. However, current processing techniques result in an extract with strong colour and flavour, requiring further expensive and only partially effective post-processing. Despite its many advantages, microalgae have achieved limited success as a mass-market food ingredient.

In the PROSPER project, Arborea, a developer of cutting-edge bioprocesses, is collaborating with world-leading experts in food production, Campden BRI, to tackle this challenge. The project has identified a novel pre-processing technique with the potential to eliminate flavour and colour issues. Although this technique is well established in other fields, limited research has been undertaken with microalgae – so the project will look at optimising the growth, pre-treatment and extraction processes to maximise yield and minimise cost.

Arborea has developed the world's first 'breathing' bioreactor, the BioSolar Leaf, which significantly reduces production costs of microalgae. Project success will add the remaining piece of the jigsaw to complete an end-to-end protein manufacturing solution suitable for use in the UK, delivering highly nutritious, low-cost and consumer-acceptable soluble proteins with almost zero environmental impact.

By producing directly and licensing the technology, PROSPER will create a multimillion pound UK value chain, reduce environmentally unsound protein imports and provide UK consumers with a high quality, nutritious and affordable home-grown alternative protein.

# Project Pythagoras

**Project lead:** Dyson Farming Ltd

**Participants:** University of Lincoln

**Funded amount:** £130,444

Project Pythagoras is a 24-month feasibility study which answers, ‘is it possible to develop a protein product or ingredient, profitably and sustainably that is derived from a commercially grown UK crop?’

Countries such as Canada, Australia and France are all investing in their pea supply chains to exploit the potential of the developing plant-based market.

The UK is well placed to grow peas. Unfortunately, cropping of peas is not large in area and is often considered a minor or niche crop, so it lacks investment.

To encourage farming businesses to grow more peas for human consumption, greater confidence is needed in the reliable returns and routes to market.

Project Pythagoras will improve the knowledge of growing a pea crop which is suited for human-consumed protein products. Through this project, Dyson Farming will trial novel techniques of growing peas with the aim of improving protein availability in the resulting crop.

Meanwhile, the University of Lincoln will provide a deep understanding of how each growing technique impacts the crop’s functionality and nutritional value as a protein product or ingredient.

This consortium is passionate about raising awareness of the importance of peas in sustainable food production and healthy diets. Pulses have been grown in the UK for centuries and, as nitrogen-fixing legumes, they fit well with the government and farming industry’s objectives for sustainable production and net zero emissions over the coming next decades.

# Research and development of plant-derived nutrient blends

**Project lead:** Biovit Ltd

**Participants:** Swansea University

**Funded amount:** £409,758

Fortified foods and food supplements could help address a number of key health and environmental issues, including obesity, malnutrition and food waste, however, all current leading brands of fortified foods contain synthetic nutrients, about which not enough is currently known.

Increasing reliance on synthetic nutrients presents a growing need to understand the health implications of synthetic versus plant-derived nutrition, to enable better decision making by food manufacturers, health bodies and individuals, with far reaching potential health and environmental benefits.

Synthetic nutrients are isolated, lab-made analogues which are similar but not identical to natural equivalents, which in their isolated form, lack the synergistic compounds and cofactors which are naturally present with plant-derived nutrients. Existing studies indicate that synthetics may be less bioavailable and less effective than natural nutrients but there is limited research assessing the effects on health of synthetic versus natural nutrients incorporated in foods, over time, as they are consumed by the public.

Biovit will carry out research into the differences between synthetic and natural nutrients, in terms of bioavailability and effectiveness, when consumed as they are by the public, within food, such as nutrition shakes.

This project will deliver the following outputs:

1. Literature review of existing research on natural versus synthetic nutrients.
2. Planning and a pilot study and subsequent clinical study.
3. Completing a pilot study, assessing relative bioavailability and efficacy of plant-derived vs synthetic nutrients.
4. Based on project research findings, development of new BIOVIT products.
5. Increased public awareness and understanding of effects of synthetic versus plant-derived nutrition.
6. Help enable better nutrition choices.

# STARS® x University of Leeds better food for all

**Project lead:** STARS UK R&D Ltd

**Participants:** 3F Bio Ltd, University of Leeds

**Funded amount:** £766,498

This project has been established to develop, test and commercialise an innovative plant-based burger with similar properties to a beef burger for the plant-based and flexitarian market, using the latest technologies from food chemistry, plant proteins and value-added food processing.

The beef burger is one of the UK's most loved foods. However, 85% of all meat consumed in the UK comes from factory farms, an unethical and outdated, environmentally harmful industry. The percentage of plant-based consumers is still very small at less than 4%, so plant-based alternatives are required to match all consumers' expectations, including those who enjoy meat, for a delicious burger.

# SusProFood: optimising development of sustainable functional fibre-rich foods fortified with plant proteins

**Project lead:** University of Leeds

**Participants:** Innocent Ltd, SPG Innovation Ltd

**Funded amount:** £389,000

The global market for plant-based foods with low greenhouse gas emissions is expected to increase considerably to £13 billion by 2027. This is largely fuelled by the growing public awareness for environmental sustainability and the contribution of food production to the climate crisis, food-related health concerns associated with red meat consumption, animal welfare considerations, and a rise in vegan and flexitarian diets.

There is therefore an interest within the food industry to incorporate sustainable plant proteins into fibre-rich convenience foods such as smoothies, breakfast pots, soups and gravies to improve the nutrition of these regularly consumed accessible products.

This includes providing 'fuller for longer' benefits and health functionality, especially in terms of gut and cardio-metabolic health, as well as fulfilling the ambitions to reach net zero targets by 2050. However, the addition of plant proteins comes with severe technological challenges of unacceptable 'dry', 'non-juicy' mouthfeel that are failing to meet consumer expectations and remain a major obstacle for adoption of plant-based foods. In addition, the added plant proteins may interact and bind with fibres, which might reduce the inherent beneficial gut function effects of the fibre.

This feasibility project combines the complementary strengths of academia and industry to optimise and validate a groundbreaking technology, which involves a process-induced physical modification of plant proteins without using any chemical additive, conferring outstanding lubricity and hydration properties to plant proteins. Due to such physical modification, this limits plant proteins binding to fibres - thus synergistically allowing the colonic fermentation of dietary fibres by gut bacteria, supporting the inherent metabolic benefits of consuming fibre-rich foods. Together with two industrial partners, SPG Innovation and Innocent Drinks, the project will optimise and validate the modification of currently used in-process variables without adding any new energy-intensive resources.

The performance of the new eco-friendly formulation and processing of plant protein-rich fibrous foods, developed in developmental kitchens to large pilot scale across multiple food formats, will be tested using uniquely designed instrumental toolkits, human sensory trials, and consumer studies to quantify improved mouthfeel and nutritional benefits.

# Proof of concept study of a highly novel food fortification to boost exercise performance in younger and older adults

**Project lead:** Mitocholine Ltd

**Participants:** University of Exeter

**Funded amount:** £424,859

Mitocholine Ltd are developers of nutritional fortification platform technology that exploits various combinations of mitochondrial substrates to support physical wellbeing.

The business was founded on discovery of the synergistic action of certain mitochondrial substrates to maintain intracellular ATP generation.

Their first product is composed of a novel proprietary composition of three nutrient components which, when used separately, have a history of safe use in humans. Its composition is choline succinate salt (2:1) and nicotinamide which, when taken orally, becomes powerfully available to the cells. This new composition has been named MiBrain™ and is currently the subject of clinical studies as a food additive to improve cognitive health and function in adults with mild cognitive impairment (i.e. pathway to more serious cognitive diseases).

Mitocholine has also conducted early-stage research that has indicated that the same product could provide clear benefits to a person's physical energy levels and exercise capacity. However, this potential has yet to be formally studied. As a result, this project aims to understand how a suitably formulated additive of MiBrain™ could be used to boost exercise capacity and wellbeing in healthy young people (under 30 years) and then older adults (50+ years).

A key aim is to determine if MiBrain™ could be used to improve exercise capacity and physical activity in the ageing population. Mitocholine will work with the University of Exeter, one of the country's leading centres of excellence in Applied Physiology, to determine if MiBrain™ benefits exercise performance.

The project objectives are to:

- Develop a powdered and semi-liquid formulation of MiBrain™ that is suitable for addition to existing foods.
- Conduct a two-arm exercise capacity study in human volunteers, with the main endpoints of the study being exercise capacity through intermittent high-intensity cycle tests, oxygen uptake kinetics and maximal oxygen uptake and critical power assessments. The study will evaluate physiological responses following mitocholine vs. placebo supplementation in 15 young volunteers (under 30 years; Arm 1) and 15 older volunteers (over 50; Arm 2).
- Develop and demonstrate a more sustainable process to produce MiBrain™ at scale by removing organic solvents. If the value of MiBrain™ as a food fortification is proven, the business will be able to exploit the additive as a supplement in both healthy ageing and sports market segments globally.

# Enhancing the nutritional quality of novel whole-cut meat alternatives, using fungal fermentation, biofortification and process innovation


**Project lead:** Adamo Foods Ltd

**Participants:** University of Nottingham

**Funded amount:** £365,563

Meat provides 40% of UK protein intake, but red meat is a group 2A carcinogen and the leading cause of diet-related disease. This project therefore aims to reduce UK red meat consumption by developing healthier mycelium-based meat whole-cut alternatives.

With increasing health concerns around meat, plant-based alternatives are fast-growing; worth $12 billion globally today and $100 billion by 2030. 40% of Europeans are now flexitarian, citing health as the motivation.

Plant-based alternatives are marketed as healthy, but often have lower protein content and quality, and are often highly processed products, such as burgers, sausages or mince, with 20 or more ingredients including artificial binders (methylcellulose). Some are synthetically fortified with vitamins and minerals, but there can be low bioavailability of these nutrients, with high phytates and antinutritional factors blocking uptake. To incentivise meat reduction, healthier, more innovative alternatives are needed.

Mycelium-alternatives have huge potential, as they are high in protein and fibre. However, they have lower content than beef in specific nutrients, and some protein is lost during processing.

This feasibility study will develop innovative methods to make mycelium steak the most nutritious meat-alternative available. The innovations will be applied to Adamo Foods' steak alternative, with an ultra-realistic fibrous structure mimicking meat's muscle tissue. The 'steak' will be characterised with world-leading data, against which successful nutrition enhancements will be assessed, with recommendations for scale-up.

Success will close the nutrient 'gap' on beef, attracting more customers by addressing positive (protein/micronutrients) and negative (carcinogenic/cholesterol/antinutritional) nutritional drivers.

# Iron-enhanced varietal of GE lettuce

**Project lead:** KYOMEI Ltd

**Participants:** Reading Scientific Services Ltd

**Funded amount:** £326,005

This project is for the delivery of an iron-enhanced lettuce variety designed to improve public health, add much needed nutrition to those on plant-based diets, and advance a genetic editing approach to improving nutrition across the UK.

# Scaling up vitamin D microcapsules for improved fortification in beverages


**Project lead:** Xampla Ltd

**Participants:** Britvic Soft Drinks Ltd

**Funded amount:** £184,833

Vitamin D deficiency is prevalent worldwide which can have negative impacts on bone health and immunity. In the UK, mean intakes are well below the Recommended Nutrient Intake (RNI) of 10µg across all age groups, including up to a third of all adults. Despite a UK government recommendation to take a supplement during winter months, compliance is very low. This is a global issue with about 1 billion people with low levels.

The problem is exacerbated as more people transition towards a plant-based diet, omitting or reducing animal-derived foods that naturally contain vitamin D for both health and environmental reasons.

In response, the World Health Organisation recognises the fortification of foods as a key strategy to address widespread vitamin D deficiency.

To have the greatest impact, vitamin D needs to be included in categories consumed across all age groups regularly, which are affordable and attractive for all socio-demographics. Fruit squashes are therefore an ideal vehicle for fortification; however, this can prove challenging as vitamin D is degraded by UV light, low pH and processes such as pasteurisation.

Xampla has developed an innovative plant-based microencapsulation technology that protects vitamin D in challenging beverage formulations. Xampla has been working in partnership with Britvic to improve the fortification of their products with added vitamins.

The aim is to demonstrate and de-risk the scalability and cost efficiency of innovative vitamin D microcapsule manufacturing, to enable widespread vitamin D fortification of beverages.

This project will help accelerate ambitious plans to produce the volumes of microcapsules required to efficiently fortify more products with vitamin D and other nutrients, and deliver better, healthier food and drink for the global population.

# Developing a high fibre carbonated soft drink with improved digestive tolerance and beneficial impacts on the gut microbiome: FUNKi-2.0


**Project lead:** Funki Drinks Ltd

**Participants:** Quadram Institute Bioscience

**Funded amount:** £176,350

This project's vision is to develop a novel carbonated soft drink fortified with a fibre-blend with evidence-based benefits to gut microbes, that offers a tasty, convenient and affordable way for the UK to easily achieve their recommended fibre intake of 30g each day.

An initial assessment of the current carbonated drink formulation (FUNKi-1.0) on the gut microbiome using advanced in vitro colonic fermentation models at Quadram Institute will identify an optimal fibre-blend for reformulation. This project will then enable Funki to launch the UK's first carbonated soft drink fortified with a fibre-blend (FUNKi-2.0) that has proven digestive tolerance, benefits to gut microbes and potential to improve human health.

FUNKi-2.0 will enable consumers to increase their fibre intake in a way that is convenient. Eating plenty of fibre is associated with lower risks of heart disease, stroke, Type 2 diabetes and bowel cancer. Despite this, only 9% of the UK population achieve the recommended daily fibre intake. The UK's appetite for carbonated soft drinks is growing, with annual consumption rising from 4.6 billion litres in 2021 to an estimated 4.9 billion litres in 2026. If only 1% of the UK had one can of FUNKi-2.0 each day, that would mean 6.7 million more people would achieve their dietary fibre intake and reduce their risk of cardiovascular disease and obesity - helping to offset some of the 9% of all NHS spend on diet-related chronic disease and the estimated £49.9 billion of wider societal costs predicted to arise from obesity by 2050.

# NutriBoost: ingredients for increased fibre and carbohydrate reduction in mainstream food

**Project lead:** Cambridge Glyoscience Ltd

**Participants:** University of Cambridge

**Funded amount:** £729,563

The 20th century food system was built on readily accessible carbohydrates, such as refined sucrose and starch. It provided abundant calories but led to localised nutrient excess and health issues, such as obesity, diabetes and heart disease. The 21st century's food system must redress this nutritional imbalance. Despite well-documented negative impacts of sugar and flour, they are cheap and highly functional ingredients, making their replacement challenging. To date, the food industry's attempts at 'healthier' product reformulation have achieved only partial success. Despite being more agriculturally abundant than refined carbohydrates, fibre, the macronutrient most lacking in Western diets, has been largely ignored.

This collaboration between Cambridge Glycoscience and the University of Cambridge looks to redress this imbalance by expediting the commercialisation of CamGlyco's platform of 'From Fibre' ingredients. This will be achieved by turning agriculture's most abundant renewable resources, including by-products like corn cobs, oat hulls and wheat straw, into replacements for sugar and flour or starch in food. The project outputs will provide farmers with additional income streams from underutilised plant residues, produce more food per unit of land, without concomitant increases in greenhouse gas emissions and biodiversity loss, and give access to healthier ingredients to companies and consumers across mainstream food products.

# Vertical farming as a route to crop nutritional enhancement


**Project lead:** James Hutton Ltd

**Participants:** Vertical Future Ltd, The James Hutton Institute

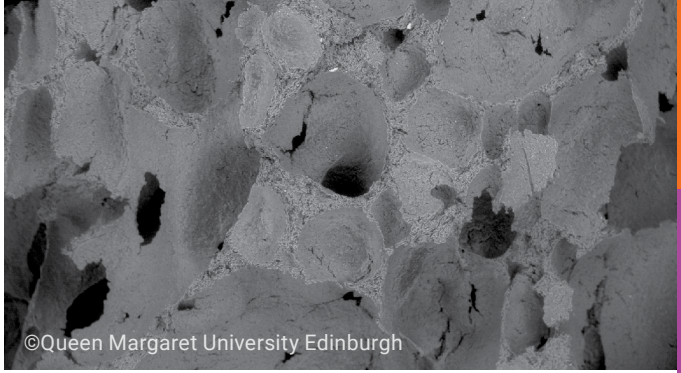
**Funded amount:** £239,325

Climate change is increasingly impacting UK food production and imported food in terms of yield, quality, and nutritional content variability - all of which mean reduced food security and increased costs. Allied to this is a changing demographic with the estimate that, by 2035, the majority of the population will be aged 40 or older. This shift to a higher age demographic comes with a need to maintain protein and balanced micronutrient levels to guard against loss of muscle mass and strength, frailty, and associated comorbidities in later life.

In the last 10 years we have seen a reduction in red meat and processed meat consumption of 13.7 and 7.0g per capita per day, respectively, with a modest uplift in white meat consumption. This, and the shift to a more varied and plant-inclusive diet, means greater effort needs to go into both providing access to a wider range of plant-based foods and ensuring that these foods have good, or ideally enhanced, nutritional compositions. However, the UK food supply chain is often fragile, which adds further problems to the existing £6 billion annual fruit and vegetable deficit.

Building on previous vertical farming projects where preliminary data identified an ability to enhance the levels of protein and micronutrients in crops, this project will expand and develop that concept. Within a consortium of plant and crop science, human nutrition, industrial growers and leading food retailers, it will exploit these identified benefits-to-date of vertically farmed crops to produce crops at a higher level of productivity and with defined nutritional enhancements and using significantly less water and nutrient inputs. The project will target microgreen kale and pak choi as established crops and explore the benefits of emergent ones, including quinoa, amaranth and buckwheat, all of which have well defined and beneficial nutritional components. The project will undertake a techno-economic assessment of vertically farmed produce against conventional production systems to establish economic feasibility. These nutritionally enhanced crops have been identified by the retail partners as having significant economic potential as fresh produce and in processed foods.

# SALT-SUST: novel salt replacement strategy using an underexploited soy industry co-product




**Project lead:** Queen Margaret University Edinburgh

**Participants:** J.C. Peacock & Co. Ltd, Macphie Ltd, Bells Food Group Ltd, Baxters Food Group Ltd, Shoda Sauces Europe Company Ltd, Tai Hua Food Industries Pte Ltd

**Funded amount:** £198,226

The SALT-SUST project proposes a gamechanging solution to significantly accelerate the reduction of salt consumption in the UK and its dramatic impact on health and the NHS. The strategy is based on the development of soy sauce cake, an underexploited by-product from the soy sauce industry, into a novel salt substitute.

Meeting Public Health England's salt reduction targets for 2024 poses several challenges to the industry, as, in addition to saltiness, salt is key to overall flavour, colour, texture, shelf life and low costs. There is currently no salt reduction strategy that meets all these challenges due to cost, health concerns, and acceptability – including flavour loss, off-flavours and clean label issues.

A preliminary study carried out at QMU showed that soy sauce cake (SSC) has the potential to meet these challenges. It is a natural material, solid residue obtained following mechanical pressing of fermented soybeans, its processing is cost-effective, and it contains high levels of umami compounds which provide flavour-enhancing properties to counterbalance flavour loss at reduced-salt levels.

The project aims to develop a novel sustainable and cost-effective salt-reducing ingredient (Shoda Sauces) and blend (Peacock & Co), as well as competitive salt-reduced products that meet the 2024 salt level targets, including bakery mixes and savoury sauces for the catering and food service industries (Macphie), pastry and meat pies (Bells) and soups (Baxters).

This early-stage project will assess the feasibility of the strategy based on technical, sensory, sustainability, cost, legislative and logistical aspects. The reproducibility of the SSC material across the industry will be assessed by comparing SSC ingredients from Shoda Sauces (UK) and Tai Hua (Singapore).

The strategy is targeting commonly eaten products to ensure the health benefits are widely accessible and at affordable prices due to the cost-effectiveness of SSC. Such development will reduce the financial burden of reduced high blood pressure and cardiovascular disease on the NHS.

# Modern Baker ACFT-blend: enhancing the nutritional value of multiple commonly eaten products


©Modern Baker Ltd

**Project lead:** Modern Baker Ltd

**Participants:** Campden BRI (Chipping Campden) Ltd, Puratos Ltd

**Funded amount:** £321,116

Modern Baker is the UK's largest healthy baking brand. In collaboration with Campden BRI and Puratos, Modern Baker intends to adapt a novel ingredient blend towards several industrially scalable end-products, including bread, pasta, breakfast cereals, ready meals, biscuits and cakes. These play a significant role in the health of the nation, so the novel blend will enhance accessibility and nutritional benefits across multiple commonly eaten products.

In this project, the consortium refocuses from the food industry's 'calorie-dense' approach, towards a new, 'nutrient-dense' approach that reformulates the production of carbohydrate-based packaged foods. This brings the health benefits that specialist baking can bring to digestion, such as reducing the glucose release and providing beneficial substrates for gut microbiota, which current packaged foods often neglect.

The development of this innovative and broadly applicable blend has the potential to transform existing commercially available processed products, and will allow the production of alternative and affordable healthy flour-based and baked goods for both B2B (food manufacturers) and B2C (retail and direct-to-consumer).

# Innovatively improving the nutrition and availability of healthy breads and snacking foods using sprouted grains to produce foods suitable for sufferers of digestive issues

**Project lead:** PM Corporation Ltd

**Participants:** The Food Incubator Ltd, The Celtic Bakers Ltd

**Funded amount:** £291,271

Everfresh is one of the UK's oldest sprouted grain bakeries. In collaboration with The Food Incubator and Celtic Bakers, Everfresh intends to create a variety of healthy sprouted-grain snack bars that can be consumed more easily by individuals with digestive issues, such as Irritable Bowel Syndrome and Crohn's disease, who typically struggle to find healthy, diet-friendly snacks. The consortium also intends to create a sprouted-grain inclusion or blend that can be used in a variety of baked goods by other bakers. Sprouted grains have a strong flavour profile, negating the need for added salt or sugar, enabling the creation of highly nutritious products.

Everfresh's knowledge of sprouted grains, coupled with The Food Incubator's capabilities and facilities for thermal processing, or retorting, alongside Celtic Bakers' expertise in baking inclusions and food production has the potential to introduce a range of completely disruptive, socially beneficial snack products and baked goods. Retorting is the heating of low-acid foods prone to microbial spoilage in hermetically sealed containers to extend their shelf life.

All of Everfresh's baked goods have no preservatives, no dairy, no eggs, no added sweeteners or refined sugars, making them ideal for those who are wheat intolerant, vegetarian, vegan or just looking for a simple and pure way of eating.

Organic food production is very important to Everfresh and so is sourcing the best quality ingredients and then keeping the processing requirements to a minimum, - thereby ensuring a low carbon footprint. The project is committed to protecting the environment for future generations and as a result, will not consider making products that are not part of a sustainable or organic food chain.

# BetterBread: developing novel milling processes for improved nutrition in white wheat flour without fortification


**Project lead:** Shipton Mill Ltd

**Participants:** Aberystwyth University

**Funded amount:** £524,790

Shipton Mill is the largest UK organic flour mill and a Royal Warrant Holder that specialises in creating award-winning, natural, and organic flours. Sustainability is central to Shipton and the mill is 100% powered by renewable energy. All their packaging is plastic-free, and they work closely with local organic farms.

Shipton works alongside multiple large companies to innovate new products and is a key part of a company group that includes other specialist bakeries.

The primary consumer motivations underpinning this project include demand for cost-effective health benefits, including increased nutritional value, 'all-natural' clean-label products with reduced or no added preservatives. It will also consider industry regulations, including the Bread and Flour Regulations of 1998, that have been introduced to add calcium, iron, thiamine (vitamin B1) and niacin (vitamin B3) to all white and brown flour.

Shipton will be collaborating with Aberystwyth University, who will be supporting nutritional analysis during this project. With this project, Shipton and Aberystwyth University are seeking to improve the nutritional quality of flour by altering blend composition and implementing modifications to the milling process.

The project has the potential to bring significant social and economic benefits to the UK and will further establish the UK as a leader in the flour and flour-based food markets.

# Transitioning crops into innovative and affordable healthy food products for hard-to-reach communities in the North East of Scotland

**Project lead:** University of Aberdeen

**Participants:** Murdoch Allan & Son Ltd

**Funded amount:** £184,736

This project aims to improve the nutritional quality of commonly consumed staple foods by innovative reformulation with environmentally beneficial crops. It will target hard-to-reach individuals living with, or at risk of, metabolic disorders such as Type 2 diabetes mellitus and cardiovascular disease, contributing to the ambition to deliver on climate, biodiversity and diet targets, while delivering opportunities for a stronger and more resilient economy and a healthier and fairer society.

Four commonly consumed bakery products will be the focus - the square roll, the round roll, the buttery, and oatcakes, which will be reformulated with hemp and buckwheat, which has been shown through human studies to reduce hunger and beneficially modulate blood glucose, as well as specialised food barley lines containing nutrients with a recognised health claim for reducing blood cholesterol.

Reduction of blood glucose and cholesterol are key targets for the prevention and maintenance of metabolic disorders, but the products developed through this project will also boost fibre intake, which is well below the recommended level of 30g per day in the UK, as well as providing a source of plant protein that contributes to a reduction in consumption of animal-based protein. It will also help individuals to meet their reference nutrient intakes of micronutrients, which is especially important for younger adults who are currently vulnerable to micronutrient shortfalls from food sources. The scientists involved in this project have technologies available to deliver functional and palatable products, and the business has the scope to deliver these products at scale. These attributes will contribute to meeting major societal challenges, namely the health, climate and biodiversity crisis, delivering research that will drive not only economic and societal benefits but will support much needed adaptation of our agri food system.

# Improving the nutritional qualities and nationwide health benefits of milk via a novel, epigenomics-driven platform, EPIHERD, for UK dairy farmers

**Project lead:** Antler Bio (UK) Ltd

**Participants:** University of Nottingham, CIELIVESTOCK Ltd

**Funded amount:** £422,346

Milk is one of the most nutritionally-complete foods available, and one of the most regularly consumed foods across the globe. The UK alone produced over 14.9 billion litres of milk in 2021/22 – consumed by approximately 96% of our population.

Cow's milk is a source of essential fatty acids, including conjugated linoleic acid (CLA) and omega-3/6. These are vital for a balanced diet and are linked to preventing various health problems, including cardiovascular disease, depression, and cognitive decline. However, the UK's average is well below the recommended intake.

The nutritional content of milk can vary, with a cow's genetics being a major influencing factor. Whilst advanced genetics – focused on the presence/absence of a gene – has seen success in developing breeding plans for farmers to improve their herds' milk quality, genetics is only one factor that affects milk nutritional composition. Epigenomics, however, focuses on gene activity (expression), and is a field that can significantly contribute to influencing desirable characteristics in cattle, such as milk quality.

Antler Bio is developing EPIHERD; an innovative Epigenomics-AI-platform that uses sophisticated Bioinformatics, Machine-Learning and Artificial Intelligence to identify specific epigenomic factors that influence desirable traits in cattle.

In collaboration with University of Nottingham's Centre for Dairy Science Innovation and the Centre for Innovation Excellence in Livestock, this project will investigate how the expression of key identified biomarkers within dairy cattle affects their performance. EPIHERD will ultimately translate this into data-driven recommendations for dairy farmers to improve milk nutrition.

By understanding gene expression, dairy farmers will have access to novel, actionable data which enables them to maximise the yield and nutritional composition of the milk they produce. Key benefits include increased Omega-3 consumption, improved nutrition of milk-based foods, reduced food loss/waste, improved productivity and sustainability.

This ground-breaking project will unlock novel insights into how nutritional content of milk, and wider foods, can be enhanced via new epigenomic approaches and understanding.

# Nutritionally enhanced, sweet bakery for all: low sugar, HFSS compliant product development

**Project lead:** Jnck Bakery Ltd

**Participants:** Young Foodies Ltd, Frutarom (UK) Ltd

**Funded amount:** £314,449

Jnck Bakery is on a mission to re-define junk food and show that health and indulgence can come together. Within this project, Jnck wishes to develop two further bakery products that are High Fat Sugar Salt (HFSS) compliant, low in sugar, reduced saturated fat and with added protein and fibre.

With over two thirds of the UK adult population overweight or obese, the project believes it can positively impact the nutrition of the nation through innovative bakery products, including better understanding the market and where the value, volume and growth is for maximum impact.

With the introduction of two new bakery products, Jnck believes it can remove 2,400 tonnes of sugar and 600 tonnes of saturated fat from the supply chain in the next three years. Furthermore, it believes it can add in 750 tonnes of fibre and 300 tonnes of protein. This will support the government's HFSS regulations, introduced to tackle obesity.

Beyond its impact on the nutrition of the nation, Jnck believes that by 2027 it will create around 150 jobs throughout its supply chain, while its frozen supply chain will support the reduction of food wastage and a reduction in plastic, as it adopts 100% recyclable packaging.

# Enhanced health & nutrition through vertical farming


**Project lead:** FYTO Ltd

**Participants:** Newcastle University

**Funded amount:** £225,399

The vision for this project is to provide a means to reverse a national trend in falling levels of nutrition. As part of the agricultural family in the UK, Fyto Ltd believe that hydroponic vertical farming has untapped potential to act as a nutritional concentrator technology, which has the potential to significantly improve lives in this country and beyond.

The project will explore how effectively to increase the level of key nutrients (vitamins and minerals) in fresh crops which are grown in hydroponic systems. Nutrient deficiency is a significant global health concern, costing over $2 trillion/year. In developed countries, deficiencies of vitamin D, B12 and calcium are common, and often result in more serious health concerns which are a drain on the public purse. Fyto has previously developed flexible and robust hydroponic systems which are optimised to rapid experimental growing, and Newcastle University have previously researched biofortification. The current project builds upon this expertise to test the feasibility of hydroponic systems to deliver local/domestic production of fortified fresh produce. Our approach to this project will be to conduct a feasibility study in which we focus on the potential of a range of 'manageable' inputs to fortify key nutrients in a selection of popular fresh produce crops. We will grow a number of cultivars of each crop and attempt to significantly increase, through lighting recipes, nutrient mixes, and other approaches, key minerals and vitamins in the products. This will test whether CEA, in combination with controlled inputs, is an appropriate technology to use for biofortification.

# A novel approach to scaling up production of Brazzein – a natural, non-caloric protein sweetener and sugar alternative that can address UK and global sugar-related obesity epidemics and health challenges

**Project lead:** Magellan Life Sciences Ltd

**Participants:** Centre for Process Innovation Ltd

**Funded amount:** £293,152

Magellan Life Sciences is a synthetic biology company that specialises in developing cost-competitive production processes for novel, natural protein molecules. Using its proprietary E.coli-based technology X-Seed®, Magellan uses precision fermentation to bridge the gap between R&D and industry requirements.

BRZZ®, a trademarked name of their natural high-intensity protein sweetener, is derived from Brazzein, a protein found in the West African fruit oubli. With an almost cane sugar like taste, and no bitter, metallic or lingering after taste, this natural sweetener is a seamless match for various industry food and beverage formulations. In addition to its taste, this protein's amplification effect of being up to 1,000 times sweeter than sugar makes it the most commercially viable replacement for both zero sugar as well as reduced sugar product lines. With patents granted in all major markets including the US, EU, UK, and India, Magellan's BRZZ® is set to capture the B2B sweetener market. Magellan's patented process also compares well with sugar, by offering high titers with excellent downstream recovery.

# Better food for all: the development of innovative and functional probiotic yogurt


**Project lead:** Aberystwyth University

**Participants:** PhytoQuest Ltd, Innovation Strategy Ltd, Llaeth Y Llan Cyf, Tetrim Teas Cyf

**Funded amount:** £277,428

In order for the UK to effectively manage non-communicable diseases, chronic conditions and improve recovery from long-term systemic inflammatory conditions, emphasis needs to shift to healthier diets with foods providing basic nutrition, alongside high value, niche functional foods that have health benefits. Consumers are increasingly purchasing food products for health and functional purposes, and the market is primed.

Dairy innovation, through enrichment and functional development, can result in products that, besides basic healthy nourishment, confer additional health and wellbeing benefits. Yogurt and smoothie consumption provides adequate intake of micro and macro nutrients, and improves digestion and gastrointestinal problems, and reduces systemic inflammation, osteoporosis, cardiovascular disease and metabolic syndrome risk factors such as obesity.

This project aims to test the feasibility of innovative and functional foods using yogurt and smoothies as a base combined with locally sourced, sustainable ingredients and side streams including green tea, honey, iminosugars and related compounds, rhubarb root, high vitamin D mushroom, and heritage apple, to improve nutrition and enhance food quality. Innovative technologies and processes will be used, including advanced spray and freeze-drying technology, fermentation, reverse osmosis, separation, and fractionating.

Supplements with enhanced ‘bioactive’ composition will be included in whole blood stimulation (in vitro) experiments to look for anti-inflammatory activity. This will be followed by a human feasibility food trial investigating effects of the food product on biofluid composition, wellness, and health.

Nutritional analysis from a nutritionist perspective will explore the functionality of the key ingredients and products. Market research will assess the use, appeal, and demand of these novel and functional ingredients and foods. Support will be provided for their commercialisation, along with IP exploitation, to fill the gap for high value niche functional foods and deliver tasty and desirable products to market.

# Project nudge fibre – nudge nutrition for improvement in societal health

**Project lead:** Biopower Technologies Ltd

**Participants:** Puratos Ltd, Food Science Fusion Ltd, Pukka Pies Ltd

**Funded amount:** £287,261

UK diets lack fibre and nutritional research links this to both mild and chronic disease in gut health, diabetes and coronary disease.

UK fibre consumption consistently falls below the government guidelines in all age and socioeconomic categories, while the proportion of people who are overweight or obese has increased in every age group since 1993. Almost half of the poorest people are obese compared with just one-fifth of the richest.

'Food on the go' is a continually expanding food category, with a significant portion of products in the pastry sub-category. Public health education has failed to deliver the lifestyle changes necessary to impact community health, so High Fibre Salt and Sugar (HFSS) regulations are emerging as a policy solution to address this challenge.

The UK food industry produces significant volumes of fibre rich side streams that can be utilised to enhance product quality, and this project is focused on using nudge nutrition to increase fibre uptake to meet HFSS targets using new and novel approaches. Typically, the cheapest products lack dietary fibre, have poor HFSS scores and face significant consumer resistance to change.

The development of high-quality commercial bakery pastry will use UK-sourced food side streams that are currently by-products of food processing, and have lower carbohydrates, increased protein and up to 12 times the fibre content. The use of side stream products results in a UK-supplied, cost-competitive product in a price and nutrition sensitive market.

By using the nudge nutritional theory and cost-effective ingredients, the project will deliver levels of fibre in high volume 'food on the go' and value range products to increase consumption of dietary fibre that can be applied across a range of applications, ensuring the highest possible impact.

The project will focus on sensory, performance and mechanical properties of increasing levels of fibre in industrial bakery pastry products, and will combine industrial production methods with novel formulation and state-of-the-art sensory analysis to develop a clear route to market.

# Biodiversification of nutrients to meet dietary needs of the UK population: prevention and control of Type 2 diabetes and promotion of a healthy gut

**Project lead:** Perubien Ltd

**Participants:** Rowett Institute, University of Aberdeen

**Funded amount:** £283,341

The quality of the UK's diet is a key public health issue. In 2017, 63% of the UK adult population was overweight, and 27% obese. Poor diet and being overweight or obese can lead to an increased risk of developing non-communicable diseases such as diabetes and cardiovascular disease, costing the NHS more than £6 billion per year in 2018 - and an estimated £9.7 billion annually by 2050.

One of the main reasons the UK is facing challenges in promoting healthy eating habits and ensuring access to nutritious food for all, is the limited availability of diverse nutritious foods and food ingredients, particularly in low-income areas.

This collaborative research project will develop novel functional food ingredients using Peruvian crops, such as purple corn and yacon crops that are recognised for their positive impact on health, to meet and diversify dietary needs of the UK population. Its special focus will be on prevention and self-control of Type 2 diabetes (T2D) and promotion of a healthy gut.

The project involves the design of specialised functional ingredients, the characterisation of their nutrient and bioactive content and understanding their potential systemic and gut health benefits (in vitro). The project will also deliver a detailed consumer research analysis and assessing of the ingredients nutrients and bioactives metabolism and bioavailability (in vitro).

By utilising food crops that cannot be readily produced domestically due to regulatory restrictions, and land and climate limitations, the project will help diversify the UK dietary nutrients and contribute towards food and nutrition security while supplementing dietary needs of people at risk or living with T2D, and therefore reducing the burden of the UK's healthcare system.

# Large-scale, sustainable, nutrient-dense microveg: generating health evidence & production capacity to support incorporation into UK diet

**Project lead:** Advanced Growers Ltd

**Participants:** University of Exeter

**Funded amount:** £422,841

Nearly 45 million British adults and children don't meet the guidelines to consume five portions of fruit and vegetables per day, increasing the risk of poor health and early death.

Microvegetables are sprouted vegetable seeds to cotyledons (first two leaves). They can be grown quickly and are a concentrated source of micronutrients.

Advanced Growers is a Hereford-based business which produces freeze-dried microvegetables, a low volume product with long shelf life that is easy to consume as part of a regular diet. They can be integrated into meals without substantially altering the taste, lending them to inclusion in diets with low baseline vegetable consumption.

Microvegetables are thought to have broad health benefits, including for many inflammatory conditions such as metabolic, cardiovascular and cognitive diseases. This could have important implications for the health of an ageing UK population. However, the scientific literature is not yet extensive enough to support definitive health claims, meaning high-quality studies relevant to human nutrition are needed.

Creating a robust health evidence base for freeze-dried microvegetables will facilitate Advanced Growers' growth in the market, while sustainable production also needs to be scaled-up in the UK. This will leave Advanced Growers well placed to exploit the improved evidence base and promote consumer trust in the market, helping to facilitate around £400 million investment and 200 jobs into a rural environment to create a globally leading microvegetables hub in the UK.

# NutriNano: feasibility study on application of natural and liposomal bioactive ingredients for improved nutrition

**Project lead:** University of Chester

**Participants:** Efficiency Technologies Ltd, Agrifood X Ltd, HTC Group Ltd, Nutritional Insight Ltd

**Funded amount:** £350,279

Dietary intake of omega-3 long chain polyunsaturated fatty acids (O3LC-PUFAs) play an important role in the regulation of the development of the brain and normal heart function, as well as the regulation of blood triglyceride content, including inflammatory and immune responses. The European Food Standards Authority (EFSA) approval of health claims relating to the benefits of O3LC-PUFA intake concluded that 250mg per day is required for the maintenance of general cardiovascular health among healthy adults and children, and 2-4g per day is needed for maintenance of blood pressure and triglyceride levels.

Presently, the main sources for O3LC-PUFAs are fish and fish oils, however, the production of these sources is unsustainable and unlikely to meet the growing demand, especially for vegan sources. Only 25% of the UK population are oily fish consumers and further decreases are anticipated due to growing plant-based diets and sustainability concerns. Microalgae such as Chlorella vulgaris provide a sustainable alternative source of O3LC-PUFAs, however food products containing them have poor consumer acceptance due to strong 'fishy' odours. Furthermore, they lack efficacy around the dose of O3LC-PUFAs delivered, increasing the gap between dietary intake and recommendations which has significant implications for human health in current and future generations.

Liposomes are small oil droplets that exist in many foods naturally in the form of emulsions, such as human milk. Ultrasonic cavitation (UCav) of oils generates nano-liposomes which, in the presence of water or aqueous solutions, create nano-emulsions. Oils in nano-emulsions survive passage through the digestive system (bioaccessibility) and are more readily digested and absorbed from the gut (bioavailability). UCav is energy intensive and has limited scope for industrial scale nano-emulsion production, so this project will evaluate more sustainable, scalable, mechanical cavitation methods for microalgal oil nanoliposome production. This, in association with flavour masking techniques, will aim to produce various readily consumed foods and supplements containing O3LC-PUFAs with improved bioaccessibility and bioavailability.

This project will help to pave the way towards the development of a wider range of functional foods, which have the potential to help close the omega-3 dietary gap and promote health in adults and children.

# MAFFIN – microalgae based food formulations for improved nutrition

**Project lead:** University of Sheffield

**Participants:** Agrifood X Ltd, Efficiency Technologies Ltd

**Funded amount:** £397,812

Inflammation is a natural response to injury, infection, or tissue damage, however, chronic inflammation can also contribute to the development of age-related diseases, including cardiovascular disease, Alzheimer's disease, Type 2 diabetes, arthritis, and some cancers. These chronic diseases present a significant healthcare and economic burden.

Carotenoids have been shown to have anti-inflammatory properties and help control or prevent inflammation. They occur in many fruits and vegetables and are known for their antioxidant properties. Consuming a high carotenoid diet is associated with reduced inflammation and a lower risk of chronic diseases.

Elderly people often have lower levels of carotenoids, including those with anti-inflammatory and antioxidant activity, in their diets compared to younger adults. This is due to various factors, such as changes in dietary habits, reduced appetite, and limited access to nutrient-rich foods. The absorption and uptake of carotenoids also declines with age due to digestive system changes. Other factors include medication, chronic diseases, poor dietary habits, restricted diets due to health conditions and decreased appetite.

Supplementation of frequently consumed foods with carotenoids to create functional foods will help address these issues. The challenge is to sustainably produce the functional foods so that they are acceptable to consumers, while ensuring the carotenoids are bioaccessible and readily absorbed.

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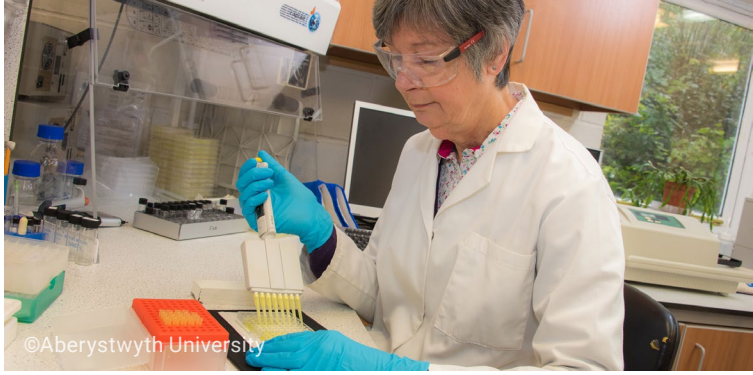
Green microalgae such as Chlorella can potentially provide a sustainable source of carotenoids with lower environmental impact and land usage compared to traditional agriculture, with scope for production in urban environments, however, they can have a strong and distinctive flavour that some people find unpleasant. This project aims to address the challenge through:

- Selection of high-yielding microalgae with reduced off-flavours and efficient production of carotenoid-enriched biomass and extracts for food.
- Identification of off-flavour components and formulation of extracts and functional foods to include natural ingredients that mask unacceptable flavours to ensure consumer acceptance.
- Evaluation of carotenoid bioaccessibility.

# Better fermented food: cognitive support and wellbeing




**Project lead:** Aberystwyth University

**Participants:** PhytoQuest Ltd, Conwy Kombucha Ltd

**Funded amount:** £333,027

Public interest in naturally derived food and drink products that can generate health benefits, known as functional foods, has grown significantly.

Functional foods can improve gut health - an area of significant focus both academically and commercially - helping mitigate against various chronic illnesses, promoting physical and mental health, and improved wellbeing.

The development and production of such foods and beverages can also reduce health inequalities, allowing more people to access healthy and nutritious foods.

More people are starting to choose dietary options that were once considered ‘fads’ or ‘trendy’ - but are now becoming established lifestyles, especially in the context of environmental and food supply concerns.

One very traditional functional food is fermented tea, or kombucha. The plant-based credentials of tea mean it can be a key part of all diets and it is important to understand how this might help compliment individuals’ dietary choices and health.

Within this project, the main commercial partner, Conwy Kombucha, is a producer and manufacturer of high-quality organic kombucha that follows a natural method of production and is naturally carbonated, providing antioxidants, polyphenols and other beneficial bioactive compounds produced during the fermentation process. This method is unlike the majority of competitors that use artificial carbonation and instant mixes instead of natural, authentic fermentation.

This project will develop and refine the innovative ‘make at home’ kombucha kits and wellness-enhanced products from Conwy Kombucha. The project will assess tea, high-antioxidant berry blends and resultant kombucha for health-promoting markers, including enzyme activity, bioactives, antioxidants, polyphenols, and amino acids.

A key part of the project aims to investigate possible direct and indirect anti-inflammatory properties of kombucha by exploring physical or emotional health benefits after consumption. The feasibility of using a home brewing system to produce kombucha will also be tested, while the project will also explore consumer preferences and barriers to consumption to inform the development and marketing of functional beverages.

# Better Brain for All


**Project lead:** Agroceutical Products Ltd

**Participants:** Aberystwyth University, Neurodyn Life Sciences Inc, Postbiotics Inc

**Funded amount:** £301,381

As people age there is reduction in the effectiveness with which their gastrointestinal tract functions, which has the consequence of reducing the absorption of nutrients from their diet. This is one of the contributors to the malnutrition suffered by many older individuals, while the changes to gastrointestinal tract function also lead to increased inflammation throughout people's bodies, as well as increased inflammation in their brains.

The research team within this project has the combined expertise required to address the consequences of reduced gastrointestinal tract function in ageing. The three companies involved, Agroceutical Products (Wales), Neurodyn Life Sciences Inc (Canada), and PostBiotics Inc. (USA), have used a common approach to exploit natural product-based strategies to maintain and extend the human healthspan. They will collaborate with Aberystwyth University's Departments of Life Sciences and Psychology, who's academic team are experienced in working on translational research and development with the food, drink and supplement industry partners.

Neurodyn Life Sciences Inc. has developed a natural product-based formulation called Cerbella, that is composed of a proprietary blend of specific components of ginseng, green tea, and essential fatty acids – such as omega-3s. This formulation has been demonstrated clinically to improve the efficiency of brain function in healthy elderly people.

Postbiotics Inc. has developed a dietary supplement POZIBIO, based on a component of bacterial cell walls, that improves gastrointestinal tract function by restoring the protective mucus layer that coats the intestine lining facing the ingested food that is being digested and absorbed.

The project will determine if the improved function of the gut and brain following intervention with both POZIBIO or Cerbella leads to an overall health benefit when compared with placebo control, and will examine changes in cognition and blood inflammation indicators in an older people cohort who receive POZIBIO and Cerbella in their diet.

# Enhancing food quality through a novel low-energy dehydration machine using GaN solid-state RF generators to maintain nutritional value of dried foods for nutraceuticals

**Project lead:** Mildtech UK Ltd

**Participants:** Harper Adams University

**Funded amount:** £557,785

Natural ingredients are the source of the majority of health-benefitting vitamins, minerals and enzymes consumed by humans. Spinach and carrots alone contribute over 13 different vitamins and minerals. These become denatured when dried using high temperatures (48°C) meaning that their organoleptic and nutritional quality is diminished. When used in nutraceuticals and functional foods, health benefits are therefore limited.

The specific need and challenge that this project proposes to address is the preservation of key chemicals and nutrients in natural ingredients during the dehydration or drying process. Traditional approaches to drying foods for consumption comprise freeze-drying and heat-drying. These processes are high energy and reduce the nutritional value of the foodstuff, denaturing vitamins, minerals and enzymes through heating, with freeze-drying taking 36 hours.

This project seeks to unlock the health benefits of dried natural ingredients by preserving key nutrients through a novel alternative for drying.

This technology is truly gamechanging for the nutraceutical industry, with critical improvements over current processing technology, including: maximum nutrient retention, reduced carbon emissions, improved energy efficiency, faster processing times and lower cost. The project is positioned significantly ahead of incumbent competitors, and on completion, will be set for rapid commercialisation.

# Collaborative development of a fortifying functional food ingredient testing in industrial facilities and human trials


**Project lead:** BioMara Ltd

**Participants:** Abertay University, Macphie Ltd

**Funded amount:** £431,540

BioMara is a UK-based biotechnology start-up building a cascading biorefinery platform utilising UK-sourced ocean-farmed seaweed biomass. Following a zero-waste approach, BioMara will utilise a residual biomass stream to produce an affordable and sustainable fortifying functional food ingredient for common foods, rich in minerals, protein and fibre.

Innovative food production technologies and healthy food sources must be developed in research partnerships with universities and food manufacturers, as healthy alternatives or additive ingredients are needed for incorporation in common processed and convenience foods. Ingredients should be sourced from traceable and sustainable UK plant-based feedstocks to tackle nutritional challenges in an economically and environmentally sustainable manner.

This project leverages the functionality and nutrition profile of BioMara's high-volume residual-biomass to develop a healthy fortifying functional ingredient for incorporation into products such as bread, pastries and cakes. Product development in collaboration with Abertay University includes human trials in the University's state-of-the-art sensory laboratory. Collaboration with Macphie, a food ingredient manufacturer, incorporates the treated and processed seaweed ingredient into products using their pilot-scale kitchen and factory. This project will help meet the increasing demand for healthy, natural, plant-based, affordable foods in commonly eaten baked goods.

The project outcome is a fortifying functional food ingredient for common foods, such as bread-based products. Bread is a staple eaten by 99.8% of households. Therefore, the new ingredient could improve the nutrition profile of millions, affecting positive health outcomes throughout the UK population. The bespoke processing techniques retain the nutrition attributes of BioMara's residual biomass stream output, including minerals, protein and fibre.

# Formulation and validation of reducose as a functional food ingredient to reduce risk of metabolic disorders


**Project lead:** Phynova Group Ltd

**Participants:** Oxford Brookes University

**Funded amount:** £508,305

Increasing occurrence of Type 2 diabetes has been driven primarily by changes in diet and lifestyle. It costs the NHS around £8.8 billion per year, which is about 9% of the NHS budget.

Phynova is a UK SME applying cutting-edge technology to develop functional food ingredients using medicinal plants. Phynova has developed Reducose, a water extract of white mulberry leaves, which blocks alpha-glucosidase in the small intestine, allowing carbohydrates to pass through undigested. Clinical trials have proven that Reducose lowers blood glucose after eating foods containing sugars and other carbohydrates, without side-effects, and lowers the glycaemic index (GI) of sugar, starch, and bread to low GI levels (i.e. below 55).

The challenge in this project is to reformulate Reducose into 'ReducosePlus' so it can be incorporated straight into food manufacturers' product lines, including bread, pasta, ready meals and convenience foods, without affecting the recipe, flavour or physical properties of the food.

The project will target the functional food ingredient market, specifically nutraceutical ingredients – a market predicted to be worth £16 billion by 2025.

In this 30-month industrial research project, Phynova will develop Reducose into a neutrally flavoured ingredient using microencapsulation. Significant innovation is required to ensure consistent dose, ensure bioavailability, while having a neutral effect on organoleptics.

A nutritional trial with Oxford Brookes University Centre for Nutrition and Health will be undertaken to look at the long-term effect on metabolic health and weight. The project will give food manufacturers an easy way to reduce the GI of their foods without reformulating to remove carbohydrates, costing only around 10p per meal, and easier access to food that supports weight loss and blood glucose management without making significant lifestyle changes.

# Developing the first 100% real food solution for tube feeding that is prescription ready: improving access to a healthy balanced diet for all


**Project lead:** Wilbo's Blends Ltd

**Participants:** University of Manchester, Manchester University NHS Foundation Trust

**Funded amount:** £279,608

Over one million individuals in the EU and North America, and over 70,000 people in the UK, require long-term tube feeding, typically using formula through a tube inserted directly into the stomach. Commercial formula is expensive, costing the NHS more than £200 million per year. Formula feeding can cause various side effects including nausea, vomiting, reflux, and constipation which impact quality of life and NHS budgets, and can result in hospitalisation and a reliance on long-term medicines to manage them.

In response, there has been a huge growth in the use of home-blended food, 'blended diet', as an alternative to formula. Blended diet has fewer side effects, improving quality of life and reducing reliance on other medicines. Crucially, home-blended food is far cheaper for society to sustain, costing £10-£20 per-person per-week, versus up to £245 for formula, an 80% cost reduction for the NHS.

Wilbo's Blends' vision is to help everyone with a feeding tube have equitable access to real food via prescription to reduce diet-related inequalities, with projected £30 million per year savings that could be realised within five years by reducing formula, the medicines required alongside formula and the cost of unnecessary hospitalisations.

This project will create a set of organic, 100% real food products for people aged 3+ that are tube fed, which will be the first to meet Food for Special Medical Purposes regulations, be approved by the Advisory Committee on Borderline Substances and be available on prescription.

The products can also be accessed by people with an oral diet who have an unsafe swallow, called dysphagia, including stroke and cancer patients.

# Nutrient-dense infant meals from regenerative agriculture

**Project lead:** Little Origins Ltd

**Participants:** University of Lincoln

**Funded amount:** £358,753

Little Origins is leading a project to design a radical new infant food business to provide busy families with convenient, nutrient-dense meals. In collaboration with leading research institutions, farmers at the pioneering end of sustainable agriculture, paediatric dietitians and food system experts, this project seeks to design a new business model for a frozen ready-made, nutrient-dense, sustainable baby food subscription service.

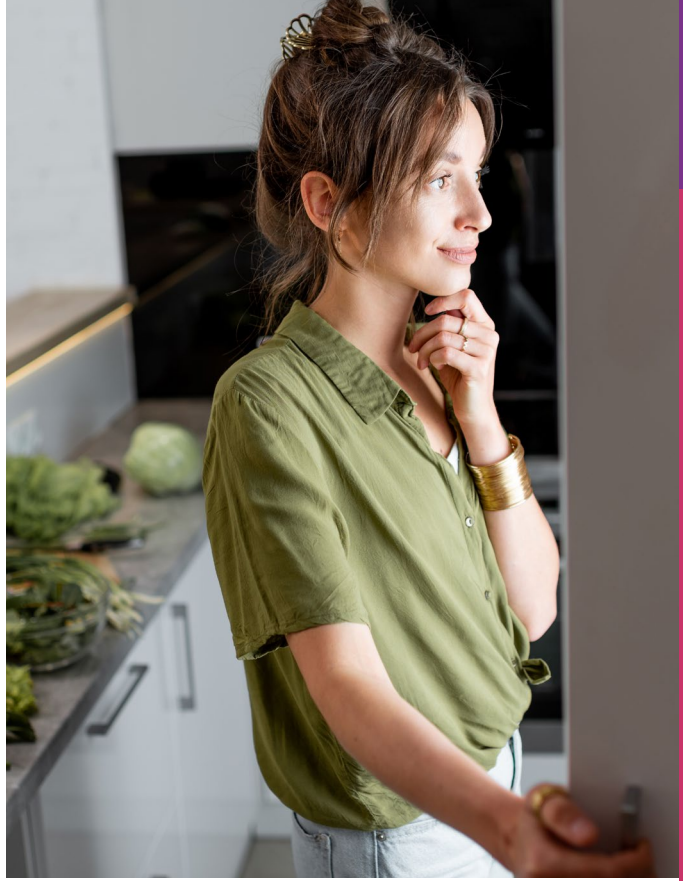
This project will focus on:

1. The power of regenerative agriculture in providing customers with nutrient-dense, better-quality ingredients at the point of purchase.
2. Testing new product development processes for food companies, putting evidence behind as-good-as-homemade and providing much needed transparency to customers on nutritional quality and freshness of baby food products.
3. Developing a system of reusable packaging which provides a better customer experience, reducing significant amounts of food and packaging waste.

This project is key to the future of food, aiming to improve the nutrition of children across the UK, where obesity of four to five-year-olds has reached 14.4%, improving the nutritional profile of convenient, commercially available products for children. The project will grow the market for regenerative agriculture and circular economy solutions within the food sector, of crucial importance in the UK's transition to sustainable agriculture, circular economy, net zero and a healthy and thriving society.

The project is carried out over the course of two years, in collaboration with leading experts from the National Centre for Food Manufacturing, University of Leeds and food research specialists at University of Lincoln, and Campden BRI. The project will also involve technical expertise at the leading edge of food system change.

# Developing research-backed, nutritionally-supportive ready meals specifically for post-treatment breast cancer survivors



**Project lead:** Field Doctor Ltd

**Participants:** Perci Health Ltd

**Funded amount:** £338,897

With survival rates of over 85% in the UK, more people are now living with breast cancer than ever before. However, due to post-pandemic national and international healthcare system strains, survivors are not receiving the support required to transition healthily back to a higher quality of life after their cancer treatment finishes. Nutrition has been identified as the cornerstone of full recovery and an antidote to the multitude of detrimental symptoms brought about by treatment. However, bespoke nutrition advice is currently only available via expensive, private nutritionists or registered dietitian appointments, reducing accessibility.

Field Doctor is developing a range of functional food-based frozen meals for stratified nutrition, directed at breast cancer survivors and focussed on NHS-recommended, registered-dietitian-approved macronutrient- and micronutrient-profiles tested on post-treatment patient groups.

# Development of a novel circular economy plant protein derivative as a readily digestible dietary ingredient to support healthy ageing

**Project lead:** Bell & Loxton Innovations Ltd

**Participants:** University of Plymouth

**Funded amount:** £286,882

Sarcopenia, or the decline of skeletal muscle tissue with age, is one of the most important causes of functional decline, frailty, and loss of independence in older adults leading to increased hospitalisations and mortality rates. There will be around two billion people over the age of 65 by 2050, representing the world's fastest growing age group with a corresponding increase of 68% in the incidence of sarcopenia.

However, as life expectancy continues to increase, older demographics are likely to play more significant roles in societies and economies.

Adequate nutrition and targeted exercise remain the gold standard for the therapeutic treatment of sarcopenia. The annual cost to the NHS of treating age-related musculoskeletal decline is estimated at £5.7 billion, or 5% of net expenditure, and in the US sarcopenia has been estimated to have an economic burden related to healthcare expenditure of $18.5 billion per year.

Bell & Loxton Innovations Ltd is addressing this growing health challenge by developing an easily digestible, sustainable plant-based food ingredient that can be incorporated into normal food via fortification or as a standalone food supplement. The ability to digest various food groups decreases with age, which is further compounded by the need to consume a greater amount of certain nutrient classes than a younger person to maintain health and strength. Bell & Loxton Innovations Ltd is a circular economy company which innovates through extracting high-value biorenewables from abundant agrifood waste streams to create active ingredients of therapeutic and nutritional value. This plant-based product will be made available to seniors to contribute towards a healthy diet that supports mobility and strength and prolongs independent living, thereby reducing the burden on the NHS and the wider care system.

# Developing innovative lighting regimes for nutritionally-optimised hyper-local living greens for Alder Hey Hospital patients

**Project lead:** Farm Urban Ltd

**Participants:** University of York, A.L.Tozer Ltd, Vertically Urban Ltd, Lynch Health Enterprises Ltd, Alder Hey Living Hospital Ltd

**Funded amount:** £384,273

Urban vertical farming (UVF) is an exciting new development where plants are grown indoors in cities, without using soil and under energy-efficient LED lights. This type of farming can save water and nutrients, eliminate the use of pesticides, reduce land use, and could form the foundation of a resilient new urban economy focussed on health and rebuilding trust in the food system. Farm Urban produces hyper-local living greens in one of the UK's longest-running urban vertical farms in Liverpool and has shown how this type of farming can not only provide nutritious food, but can also engage people in discussions around health, wellbeing and sustainability issues, and help to change attitudes and behaviour.

In this project, Farm Urban will work with leading plant scientists and seed producers to discover the most nutritious varieties that can be grown in UVF, and then work with UK-based LED manufacturers to develop lighting strategies that mimic sunrise and sunset to maximise nutrition and yield, allowing the creation of leafy-green superfoods.

These greens will have numerous health benefits, but the boxes of living greens also act as a way to engage people in discussions around nutrition and wellbeing. The project will work with Alder Hey Children's Hospital where nutritionists will distribute these boxes to families at hospital clinics, not only providing the families with fresh food, but engaging them in discussions around health and wellbeing.

This could open the door to hospitals using the food as part of overall treatment strategies and pave the way for hospitals working closely with local urban farms; something that ties in well with both NHS and government procurement strategies.

This project brings together experts from a range of different disciplines and sectors, working to create a solution that could not only address issues in food production sustainability, but also have a significant impact for health and wellbeing for some of the most vulnerable members of society.

# Development of novel seaweed-based ‘English breakfast’ black tea for improved nutrition and cardiovascular health support in postmenopausal women


**Project lead:** Oshun Labs Ltd

**Participants:** Abertay University

**Funded amount:** £358,791

Oshun Labs develops sustainable solutions for women’s health, with a particular interest in postmenopausal health. Postmenopausal women require additional nutritional support due to decreased oestrogen, which can lead to additional health challenges such as increased risk of deep vein thrombosis and cardiovascular disease, a leading cause of premature death for women in the UK.

This project will develop a novel tea enriched with bioactive seaweed extracts to deliver improved nutrition to postmenopausal women to improve cardiovascular outcomes. This will be an ‘English breakfast’ black tea with no discernible seaweed smell or flavour. The UK is a nation of tea drinkers, with tea consumed by 78% of the population, providing an excellent opportunity to deliver improved nutrition without the need for significant consumer behaviour change. Oshun Labs is partnering with Abertay University, who have significant expertise in food science, nutrition, and development of seaweed-based foods.

Seaweed has significant potential as a sustainable source of nutrition as it doesn’t require land, freshwater, fertiliser, or insecticides during production. The project will work with sustainable seaweed producers to source the seaweed, and a certified ethical and sustainable tea producer to source and manufacture the tea.

Seaweed is particularly rich in fucoidan and polyphenols, with both believed to promote longevity through a wide range of effects, including antioxidant, cardioprotective and immunomodulating effects. Despite their potential, seaweeds remain poorly studied in clinical trials, and their effect on cardiovascular function remains largely unknown, especially in postmenopausal women. Therefore, the project will undertake a nutritional intervention to measure the anti-thrombotic and vascular effects of the product on a trial group of postmenopausal women, which will be used to evidence and support any cardioprotective claims.

# Kendacare: disrupting the UK snack market with healthy, convenient and delicious personalised-nutrition

**Project lead:** Kendal Nutricare Ltd

**Participants:** Reaseheath College

**Funded amount:** £560,717

There is a growing burden from diet-related disease within the UK, leading to severe healthcare cost inflation as increasing numbers become affected. Poor diet is a significant factor, today attributable to 9% of all NHS spend.

Since 2011, the UK has experienced a halt in overall life-expectancy gains, with a widening gap between rich and poor. Under-50s in the UK are experiencing increased 'avoidable deaths', while the UK's obesity rate is among the worlds' highest. These challenges have been exacerbated by the dominance of unhealthy snacks that are high in fat, sugar, salt and additives (HFSS). These 'convenience-snacks', an £11 billion per year industry in the UK, offer an easy-to-find, tempting and affordable option for a time-poor, stressed, on-the-go UK adult population, and are a leading cause of unhealthy diets among the mainstream population, leading to severe health issues including obesity, diabetes, high cholesterol and cardiovascular disease.

This project will help disrupt the convenience-snack market by developing a nutritious, delicious, inclusive and affordable food-supplement unlike anything available in the UK today. 'Kendacare', an ambient food supplement, consumable as a shake or everyday meal supplement, will be the first food supplement range with personalised formulations designed to address several stratified nutritional needs and health challenges of adults aged between 25-50 in the UK - beginning with obesity, diabetes, high cholesterol and healthy joints. The Kendacare range will come in a variety of delicious flavours, empowering healthier habits within UK adult diets and reducing food waste.

Kendacare is an ambitious project that will include detailed market research and expert collaboration to develop stratified, bespoke recipes that proactively address the most pressing health issues impacting UK adults today. The project will comprise several technical challenges, from incorporating novel natural ingredients to incorporating innovative manufacturing steps, to delivering enhanced nutrition in a format that is tasty, convenient, inclusive, accessible and affordable for UK adults.

# ProSauce: the development and testing of a plant-based, protein-dense sauce to optimise taste, cost and nutrition of meals for the elderly

**Project lead:** Dartmoor Community Kitchen Hub

**Participants:** University of Exeter, University of Plymouth

**Funded amount:** £733,961

An estimated 1.3 million older people in the UK are malnourished and the number of older people is increasing worldwide. Protein requirements increase with age and providing a higher amount of protein to older adults, around 1.2g of protein per kg body weight per day or more than 30g protein per meal, can maximise muscle protein synthesis and minimise protein breakdown rates - supporting good health and maintaining functionality, independence, and quality of life. Sustainable solutions towards freshly cooked, protein-dense meals for the elderly population are urgently needed to address the burden of undernourishment and malnutrition among the elderly in our communities.

The initial study leading up to this project provided a daily meal supplying more than 50% of the daily reference intake of protein (0.6g protein per kg of body weight) to community-dwelling undernourished older adults. However, participants were unable to finish their meals due to the volume of food, including additional meat or fish, leading to plate waste.

The University of Plymouth research team will support ProSauce formulation and recipe development by analysing nutritional composition, particularly protein content and quality including essential amino acids. The University of Exeter team will evaluate the taste and sensory properties of prototype sauces and recipes to support the optimisation of the formulation and acceptability to the target audience. Also, the digestibility of proteins provided by the ProSauce-containing recipes will be compared to non-fortified mixed meals to generate evidence to support a claim that ProSauce is more effective at delivering metabolically available amino acids to healthy older adults. This will support maintenance of body protein and hence reduce risk of sarcopenia and frailty.

ProSauce, an innovative, plant-based protein product, will enhance the nutritional content of meals for the elderly. ProSauce will be developed from plant-based protein sources and will, therefore, be more financially and environmentally sustainable than conventional animal-based protein alternatives.

# The most sustainable and carbon reducing spray coating system, to significantly extend the shelf life of protein intensive fresh fish and meat for display to reduce protein food waste

**Project lead:** Algreen Ltd

**Participants:** Spraying Systems Ltd

**Funded amount:** £333,900

Food loss and waste is a worldwide problem. Globally, 690 million or 8.9% of people are hungry, and the food waste management market is expected to reach $116.4 billion by 2023.

According to The Grocer magazine, supermarkets throw away 100,000 tons of edible food annually in the UK which could feed upwards of 30 million people. As a result, supermarkets have a responsibility to reduce food waste.

There is a distinction between case-life and shelf life of meat. Case-life (also called colour shelf life or display-life) is described as the length of time meat can be displayed under refrigeration before a colour change occurs. This colour change from the bright, cherry-red colour of beef to another colour, such as brown, is caused by a change in the protein myoglobin. Myoglobin is the colour pigment in muscle and is responsible for binding oxygen. While this colour change is not harmful and does not denote spoilage, it results in a colour customers find undesirable. Fresh meat contains up to 75% water, which combines with water-soluble proteins such as myoglobin to form 'purge'. Display meat is easily dehydrated and correspondingly loses protein through purge, so an effective way to sustainably extend display fresh meat shelf life is urgently needed.

Currently, the most convenient way to extend fresh food shelf life is to use wrapping, such as air-permeable overwrap with clear transparent film. An air-permeable package typically consists of a foam tray and absorbent pad that rests under the meat. The tray is wrapped in a clear film that is permeable to moisture and oxygen, helping change the colour from purple to bright cherry-red. Such individual packaging wrap is both cost and labour-intensive, and usually found in high-end supermarkets. This project aims to extend fresh meat shelf life with protein preservation using Algreen's sprayable and edible biobased packaging, phasing out the conventional plastic packaging in the most economical scalable way.

# Fish for all


**Project lead:** iBoxit Ltd

**Participants:** University of East Anglia

**Funded amount:** £661,729

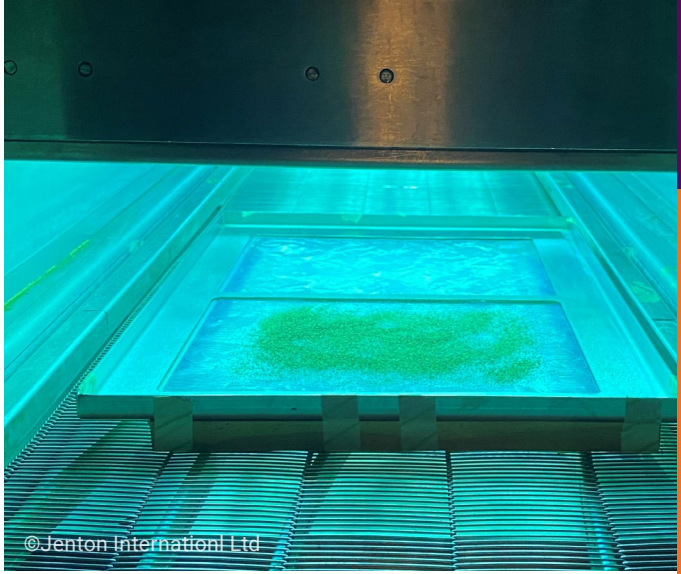
Fresh seafood, such as salmon, is highly nutritious and rich in protein and essential nutrients such as omega-3. Each year, the Scottish fishing industry lands over 430,000 tonnes of seafood with a gross value of £560 million, making up to 5% of Scotland's GDP, and this continues to grow. However, fresh seafood has a short shelf life and, on average, over 4% is spoiled during transportation. This short shelf life and expensive cold-chain transportation leads to high supermarket prices, making it unaffordable to many consumers, particularly those on lower incomes.

The single type of carrier currently used by 99% of the fishing industry is expanded polystyrene boxes (EPS) with fresh ice. EPS is often mislabelled as biodegradable, which, although theoretically true, it takes hundreds of years for EPS to be naturally degraded - resulting in high volumes of pollution from this supply chain.

The project's vision is to create a packaging solution that increases the shelf life of salmon by up to 21 days, whilst reducing the use of EPS with a more sustainable solution which meets the needs of the end-to-end supply chain. The environmental profile of the product will be further enhanced by using a range of biomass wastes in the new packaging media.

Reducing the spoilage of seafood during the transportation, will bring down the unit price and make highly nutritious food with high-quality protein and healthy fat contents available and affordable to more consumers.

# UV-TOP: UV treatment of powders




**Project lead:** Jenton International Ltd

**Participants:** Campden BRI (Chipping Campden) Ltd

**Funded amount:** £354,456

Huge volumes of powders are processed within the food industry in the UK. They are vulnerable to biological contamination and this proposed project will allow mitigation of that risk and therefore reduce outbreaks of food-related illness and expensive recalls.

Jenton is a UK-based family-run SME that is pioneering the next non-thermal powder decontamination technology. Over the last five years, seven major outbreaks of foodborne disease have affected the UK and EU, sadly, including some fatalities. The Rapid Alert System for Food and Feed (RASFF) for seeds and spice show that the majority of border restrictions have been due to harmful bacteria, such as Salmonella, Cronobacter and E. coli. Last year the US ran short of infant formulae due to a potential harmful organism, causing the need for shipment of baby food from Europe.

Jenton is a specialist in ultraviolet (UV) decontamination and will develop a powder decontamination system to keep consumers and infants safe from these harmful pathogens. Reduction in germs will also help to reduce food waste due to product recalls and extend product shelf life. By using a non-thermal technology, this research will help the UK to reach its goal of net zero by 2050.

The project will also help Jenton to expand their export sales and enable the development of a UK-based solution for which there are currently only international competitors.

To enable this step change in technology, Jenton has partnered with Campden BRI, a specialist in applied research in the food and drink industry.

# INSPeCT: improving nutrition and storage of parsnips and carrots


**Project lead:** Vegetable Consultancy Services (UK) Ltd

**Participants:** Frederick Hiam Ltd, Crop Health and Protection Ltd

**Funded amount:** £258,680

The INSPeCT project focuses on improving the nutritional quality of carrots and parsnips by developing new and innovative post-harvest storage practices, removing or minimising the need for in-field storage. Presently, the future sustainability of the sector is at risk from high crop wastage and production costs, coupled with a need to ensure carrots and parsnips remain affordable for consumers. Reducing the cost and quality losses associated with in-field storage would significantly contribute to this, whilst also leading to crop nutritional benefits.

This project's approach will encompass benchmarking of nutritional and aesthetic quality characteristics and how agronomy and processing methods impact on these. Utilising this information, the project will optimise processes to minimise degradation throughout production and processing and explore new and novel technologies to improve post-harvest storage.

# Advanced continuous flow ohmic heating for solid-liquid foods: balancing quality, safety, sustainability, and intelligent process control


**Project lead:** Sheffield Hallam University

**Participants:** Premier Foods Plc

**Funded amount:** £232,368

This project aims to enhance food quality and nutrition, improve food safety, promote sustainability, and boost energy efficiency in food processing techniques through the development and application of an innovative Continuous Flow Ohmic Heater (CFOH), equipped with cutting-edge process controls.

The enhanced CFOH system will incorporate additional heat treatment capabilities, making it applicable across various food processing segments. By addressing the challenges faced by the food industry, such as uneven heating, reduced food quality through over-processing, energy inefficiencies, and potential negative environmental impacts, this innovative technology is poised to transform conventional heating and processing methods.

The project is a collaborative effort between industrial and academic partners, combining their expertise to jointly develop a scalable, advanced, and energy-efficient heating solution. The interdisciplinary approach will bridge the gap between research and practical applications, accelerating the technology's progress toward an industrial operational environment within the food manufacturing industry.

The innovation of this project lies in the enhancement of the current CFOH technology by incorporating advanced process controls including the use of artificial intelligence and machine learning, which ensure consistent heating and optimal food quality. Additionally, the advanced model-based approach will optimise process controls, further improving food quality and safety.

The successful implementation of the enhanced CFOH system will have far-reaching implications for the food industry. It will not only improve food quality and safety but also promote sustainability and energy efficiency. This technology has the potential to create new business opportunities, secure jobs, and contribute to the UK's energy security.

# OSY Group – extending the shelf life of fresh produce through novel antimicrobial coating technology

**Project lead:** OSY Group

**Participants:** Marks and Spencer Plc

**Funded amount:** £517,824

Food waste is an issue of global significance, affecting food security and environmental sustainability with about one third of all food produced, equivalent to 1.3 billion tonnes per year, wasted in the food production and consumption systems. In the UK, approximately 15 million tonnes of food waste is created every year, with a value of over £6.7 billion, the majority of which is made up of perishable or short shelf life products, known as avoidable waste - with bread representing 32% of edible purchases being wasted, and fruits and vegetables equating to 24%. Similar shelf life challenges are found within the retail sector, with most retailers operating with significant fresh produce waste levels.

OSY Group aim to address this global challenge, through the further development and exploitation of a truly disruptive food packaging solution that has already been proven in its ability to extend the shelf life of perishable food by 30%-100%. The innovation centres on a novel and safe antimicrobial solution that can be applied to any packaging product. The solution contains antimicrobial functionality lasting over 30 days that can withstand strong abrasion, whilst killing 99.9% of pathogens and reducing microbial activity within the packaging that contribute to mould growth and therefore product deterioration.

This project will explore new product formulations for different types of fresh produce and packaging formats, and trial shelf life extension capabilities across a wider range of fresh produce. If successful, the proposed innovation has the potential to reduce the volume of food waste levels generated in stores and in UK homes by up to 50%, improving access to fresh nutritious foods, with significant economic and environmental benefits across the entire food supply chain.

# Development of sustainable bionanocomposite materials for perishable foods & drinks shelf life extension: delivering better food for all

**Project lead:** Metalchemy Ltd

**Participants:** University of Reading

**Funded amount:** £585,573

Food waste is a major global challenge, and the UK is no exception, having an estimated food waste of 9.5 million tonnes in 2018. This has a significant annual impact on the UK's environment (25 million tonnes of greenhouse gas (GHG) emissions), society (8.4 million people live with food insecurity) and economy (£19 billion loss). To tackle this challenge, the UK government has set targets such as reducing food waste by 50% by 2030.

Around two-thirds of all food and drink packaging in the UK is made from plastic, the majority being single-use, resulting in 3 million tonnes of waste. These contribute towards vast amounts of GHG emissions, microplastic pollution, and accumulation in landfills.

Healthy food accessibility is still a major economic barrier, being around three times more expensive than unhealthy options.

In this project, Metalchemy will develop an advanced bionanocomposite material aimed towards food packaging for nutritious products – such as meat, fruits, vegetables and fortified products and juices - to improve food shelf life, affordability, nutrition and safety, whilst being biodegradable. The project's technology integration aims to match key properties of synthetic plastics, prevent nutrient loss and avoid fungi and bacteria growth.

Benefits of Metalchemy's packaging include:

- Improved food nutritional value that will boost public health, reduce healthcare costs and NHS burden.
- Food waste reduction that will reduce economic losses for both businesses and consumers, decrease GHG emissions, and increase UK supply chain resilience.
- Plastic waste reduction through its replacement with sustainable packaging.

Metalchemy owns patented green silver nanotechnology and has know-how in bionanocomposite development to deliver the outputs of this project. Their team will also be complemented by experts in food science from the Department of Food and Nutritional Sciences at the University of Reading, who are partners in this project.

# Precision pollination for improved nutrition and shelf life


**Project lead:** Crop Health and Protection Ltd

**Participants:** National Institute of Agricultural Botany (NIAB), Biobest UK Ltd, Pherosyn Ltd, Agrisound Ltd

**Funded amount:** £364,567

Strawberries are one of the most commercially important fruit crops in the UK and are a good source of nutrients, including vitamin C. Insect pollination is vital to the production of commercial strawberries and is required to ensure a successful and marketable crop, but over or under pollination can lead to low quality and misshapen fruit that is not suitable for sale. Effective pollination can also increase the shelf life of berries and is likely to influence their nutritional content.

This project will further develop acoustic sensors to monitor pollinator activity in strawberry farms. These sensors will identify areas of over or under pollination, which will inform interventions to influence pollinator activity. Growers currently have few options for how to alter pollinator behaviour, therefore as part of this project a chemical volatile scents for commercial bumblebee colonies will be developed to influence the foraging of bumblebees over the short-term, especially in young bumblebees.

Trials will be done at NIAB to provide data for calibration of sensors with pollinator activity and fruit quality. It will also investigate whether lures affect pollinator activity on a more ecologically and commercially relevant scale than initial laboratory trials. Berries will be harvested from these experiments and the fruit quality, nutritional profile and shelf life will be measured to understand the impact of pollinators on these characteristics.

This project will have significant benefits for growers, retailers and consumers by:

- Improving the nutritional content of strawberries, including vitamin C, phenolics and antioxidants.
- Increasing the marketable yield of strawberries by reducing misshapes associated with under or over pollination.
- Improving the shelf life of strawberries, reducing in-shop and at-home wastage.
- Delivering technologies that can be used to improve yield, shelf life or nutritional content of other crops reliant on pollination.
- Higher resolution pollinator data would allow growers to adjust pollination programs, potentially saving time, labour and money.

# Novel Low Emission Food Production Systems Project Portfolio



# Mobile artemia production unit: toward sustainable protein production


©Aquanzo Ltd

**Project lead:** Aquanzo Ltd

**Participants:** University of Glasgow

**Funded amount:** £349,834

Aquaculture is now the fastest-growing food sector and is as big as traditional fisheries in production volume. Aquaculture feed is following this trend, relying heavily on plant-based ingredients complemented by essential marine ingredients, such as fishmeal, which represent 20% of the total fisheries volumes. However, this strategic ingredient is now a fully exploited resource and alternative ingredients cannot fully replace fishmeal, creating a marine protein crisis that endangers the sustainable growth of aquaculture and human nutrition.

Aquanzo is pioneering the transition of marine ingredients production from harvesting to farming. They are developing technologies that focus on engineering, genetics and feedstock nutrition, to farm artemia, a marine zooplankton, on land and at scale using agricultural by-products. They have demonstrated that artemia meal is nutritionally comparable to fishmeal, and are now moving forward with plans to scale up production operations.

To achieve this, they have assembled a team of experts from fish nutrition to engineering and have produced several kilos of product, with several trials planned in both fish and poultry diets to validate and iterate the first farmed marine ingredients for animal feed available globally.

This project will innovate the novel farming system by analysing the feasibility of a mobile unit to leverage underused industries' nutrient-rich wastewater and reduce environmental impact of operation. This project is being carried out in collaboration with the University of Glasgow (CENSIS), who will help develop the mobile unit's IoT monitoring.

Through this project, a mobile unit approach will be developed and tested that assesses the economic and environmental impact of farmed marine ingredients using nutrient-rich wastewater. This innovative approach will help accelerate the commercialisation of these technologies, benefitting industries such as malting, distilleries, and dairy that produce large volumes of wastewater.

This fundamental shift in producing marine ingredients will support the growth of aquaculture, animal feed and human nutrition, while reducing the environmental impact by producing locally. It will also cement the role of the UK as a leader in innovative solutions to global problems.

# Novel seaweed chicken feed feasibility (NSCFF)

**Project lead:** Seaweed Generation Ltd

**Participants:** CIELivestock Ltd, Microgrow Systems Ltd, SRUC, University of West London

**Funded amount:** £423,109

Seaweed offers an opportunity to grow nutrient-dense biomass in the UK without the need to commit more land to crop production. Seaweed farms also have the potential to be co-located alongside offshore wind farms, with benefits to both industries.

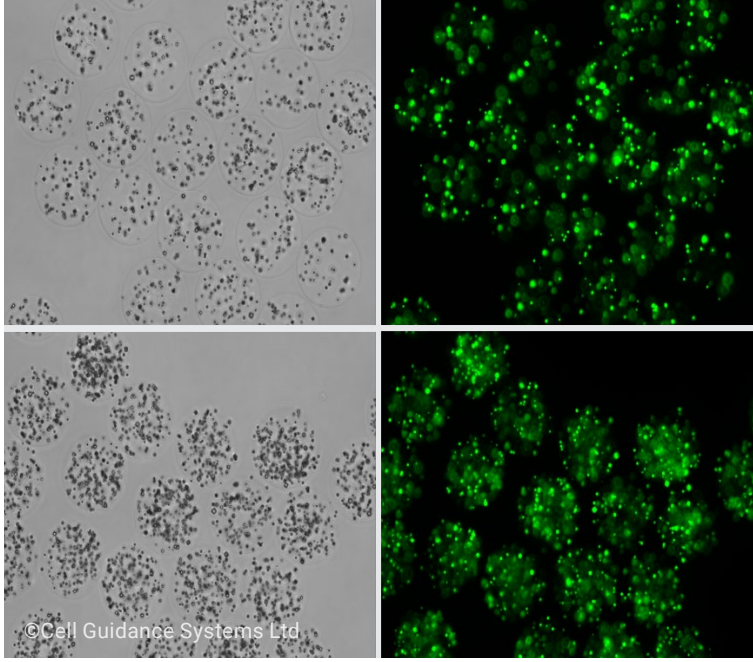
This project is focused on creating technology and infrastructure that can unlock the potential of seaweed in the global battle against climate change. This project aims to establish the UK's first commercial cultivation system for dulse, a highly desirable red seaweed that could become a viable low-emission, home-grown protein alternative to replace soyabean meal i.e. in chicken feed in UK.

Dulse is a particularly desirable, protein-rich red seaweed with many growth-promoting effects that has so far proved challenging to grow.

This feasibility study will allow a full assessment of the cultivation inputs required and their corresponding emissions, for pure tank-based versus at-sea cultivation. The project will establish the most biologically and commercially viable route to successful cultivation of dulse, while the biochemical analysis of the pure tank-based versus at-sea cultivated seaweed will enable selection of the most nutritious and protein-rich production methods of dulse.

The efficacy and potential of dulse will be tested in poultry feed trials to explore the potential of seaweed as a soyabean meal replacement. As dulse has great potential to improve gut health, arising from its immune-modulating functions, its impact on the poultry gut microbiome could contribute to the use of seaweed to reduce reliance on antibiotics. The impact of dulse on the gut microbiome will be further explored by studying its impact on gut microbial diversity, antimicrobial resistance and the occurrence of zoonotic pathogens.

# Tools and technologies for cultured meat production




**Project lead:** Cell Guidance Systems Ltd

**Participants:** Aston University, Marrabio Ltd, University of Manchester, Unicorn Biotechnologies Ltd, University of Birmingham, Zimmer & Peacock

**Funded amount:** £396,751

Cultivated meat grows animal cells in bioreactors to produce a product similar to conventional meat, and the global cultivated meat market of $246.9 million is set to increase to $6.8 billion by 2030. However, to achieve this forecast, this new approach needs to produce meat at scale before it can address future meat shortages.

The first cultivated meat burger cost $330,000, demonstrating edible CM products are possible albeit at very high costs. The challenge now is to make cultivated meat in large amounts, using a cost-effective and market-competitive process. Millions of tons of meat are consumed annually, so this will ultimately necessitate the development of massive, 10,000 litre bioreactors capable of generating very high-density cell cultures. This requires cells capable of growing under demanding conditions and carefully balancing nutrients and cell-toxic by-products. These nutrients, such as growth factors, need to be cheap, well-characterised and to perform consistently.

This project combines the skills and capabilities of three UK universities and four UK companies developing livestock cell lines, recombinant protein technologies, hydrogels and bioreactor components to collaboratively develop technological solutions for cultivated meat production.

# High potency food grade growth factor mimics for low cost cultivated meat manufacture


**Project lead:** MarraBio

**Participants:** Aelius Biotech Ltd, Centre for Process Innovation Ltd

**Funded amount:** £409,220

Cultivated meat promises to revolutionise the food industry by providing a more ethical and greener alternative to animal products, whilst retaining the same taste and texture. However, these products are being held back by the technical complexity of production and the high cost of materials used in their manufacture. It is estimated that costs need to be reduced by 99% or more.

Major contributors to these costs are the proteins used in production, which supply biological cues to stimulate growth and ensure that the right type of meat cells are produced. Unless the cost of these proteins can be reduced, the sector will not be economically viable.

MarraBio has developed a radical new way to make alternatives to the proteins currently used. Its materials can be made in very large quantities, and at a cost which will make cultivated meat economically viable. So far, MarraBio has produced research grade versions of the products and have preliminary evidence that they will meet the needs of the sector.

In this project, MarraBio will demonstrate that the products can be produced at scale and at a quality where they will meet the regulatory requirements needed for their use in cultivated meat production.

If successful, by the end of the project they will be ready to launch products into this rapidly growing market.

To achieve these aims, MarraBio are partnering with the Centre for Process Innovation (CPI) and Aelius Biotech. CPI is a leader in protein manufacturing and analysis and will assist MarraBio in refining its manufacturing techniques to provide tight control over product quality and potency. Aelius have developed a model of the gut that predicts how ingested substances will affect the digestive system. Their involvement will allow MarraBio to test how their products are processed on ingestion - a critical safety step - while allowing Aelius to further develop their technology towards the needs of this sector.

# Standardising food safety testing for the cultivated meat industry: feasibility study to accelerate innovation

**Project lead:** Multus Biotechnology Ltd

**Participants:** Aberystwyth University, Extracellular Ltd

**Funded amount:** £333,855

Multus is a leader in the development of animal-free culture media ingredients. High-quality, cost-effective growth media is essential for the commercialisation of cultivated meat production. However, a barrier to commercial production and public and regulatory acceptance is the lack of standardised safety assessment methods and publicly available data supporting the safe use of these media components in food.

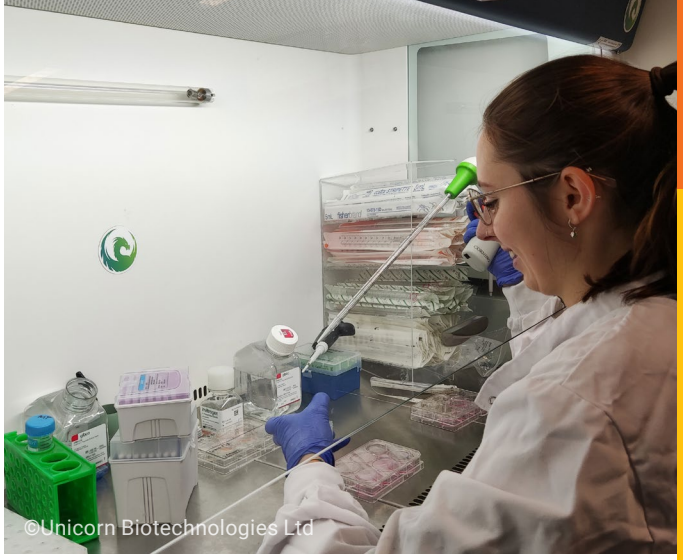
Cell culture media is made up of components that allow cells to grow. Most are already naturally present in foods; however, some have not previously been used as food ingredients and have not been evaluated for safety as processing aids or food additives. An industry goal is to remove any animal-derived components, such as serum, based on ethical and safety concerns. This requires the use of recombinant proteins, which can exhibit bioactive properties and require a novel approach to safety evaluation not yet established for food ingredients.

Multus and its partners, Aberystwyth University, cultivated meat developers Extracellular, and outreach coordinator Endorphin Capital, will collectively develop methods to demonstrate the safety of media components. They will also coordinate multi-stakeholder outreach, including established standards bodies, and information dissemination on open-access platforms for the benefit of all stakeholders and companies.

The first aim of this project is to develop and substantiate methods to evaluate the safety of media components, with a focus on novel and bioactive substances. Multus and its partners will refine and validate several in silico and in vitro (animal-free) testing methods and disseminate this work publicly.

There are few peer-reviewed publications on the safety evaluation of cultivated meat inputs. Method development has occurred within industry, but little information has been published. This project will engage multiple stakeholder groups to provide insight into the validity of the methods from industry, governmental, societal and academic perspectives. The overall goal is to demonstrate the feasibility of multi-stakeholder collaborations to develop widely accepted methods for safety evaluation of serum-free culture media ingredients and then to apply this model to other safety aspects of cultivated meat production.

# Developing novel animal cell lines and processes incorporating engineered caf1 to scale cultured meat protein manufacturing




**Project lead:** Unicorn Biotechnologies Ltd

**Participants:** MarraBio Ltd

**Funded amount:** £248,387

World meat consumption has tripled since 1970 and will increase by a further 76% by 2050, posing a significant sustainability challenge. Livestock farming contributes up to 15% of human-made greenhouse gas (GHG) emissions, which further exacerbates climate change, environmental destruction, and infectious disease outbreaks.

Cultivated meat is an approach that, rather than utilising animal agriculture as a source of proteins for human consumption, uses cell-based technologies to grow protein in a slaughter-free way. Cultivated meat requires fewer resources, including energy, land and water, and generates fewer GHG emissions compared to traditional livestock farming. It also eliminates concerns related to animal welfare and excessive antibiotic use.

The major barriers preventing this approach from entering the consumer market relate to a mixture of economic and technical barriers. For this technological approach to be realised, three principle components are needed: cells, growth media, and machines.

This project seeks to develop panels of cell lines, which are the starting basis of all cultivated meat, that will be released for sale to cultivated meat R&D tool developers and commercial manufacturers.

Furthermore, the project seeks to develop growth media additives that, simultaneously, significantly extend the variety of cell types amenable to be manufactured at industrial scales and vastly reduce the cost of such production.

This thereby enables the industry to move towards techno-economic feasibility, as well as the mass manufacture and consumer market entry of such products.

# Stability and shelf life of regenerative raw materials for cultivated meat

**Project lead:** University of Birmingham

**Participants:** Quest Meat Ltd

**Funded amount:** £345,134

The major challenge for cultivated meat producers is scalability and the high cost of reaching industrial production. This is because culture media that provides nutrition to the meat cells during production is very expensive, and it is hard to intensify the process to get more product per unit volume.

The University of Birmingham have a world leading academic team of chemical engineers working on food manufacturing and engineering. They will partner with regional start-up Quest Meat, who are developing patent-pending ingredients for the cultivated meat sector that will facilitate the acceleration of cultivated meat to consumers by reducing cost, energy use and inconsistency that production methods to date have brought.

The project will deliver a gamechanging innovation in the form of low-cost, regenerative, food-grade ingredients, called NEUTRIX and NEUSOL, that completely transform the economics of cultivated meat and improve meat-product consistency, driving down costs to make them comparable to current farmed-meat prices.

The projects initial feasibility work indicates other advantages including: the feedstocks can be easily produced in large quantities at very low cost; they can support many different meat cell types in bioreactor culture; and they can contribute to final product formation. The University of Birmingham will lead a feasibility study that seeks to understand and extend stability and shelf life, to lower costs and energy use even further, because ingredients often have to be shipped refrigerated or frozen, which is costly and consumes energy.

The project will make ingredients commercially available to the whole global cultivated meat industry to accelerate market uptake of this revolutionary food platform that is so critically needed now to address food security, climate change and health challenges.

# Prototyping and validating novel scalable biomimetic bioreactors for low carbon cultivated meat production

**Project lead:** Cellcraft Ltd

**Participants:** University of Manchester, University of Cambridge

**Funded amount:** £737,012

Global food systems need to produce 50% more food to sustain growing populations over the next 40 years, whilst substantially reducing greenhouse gas (GHG) emissions associated with food production and consumption (Social Market Foundation, 2020). According to the Independent Panel on Climate Change (IPCC), 14% of total GHG emissions are attributable to the world's meat supply, without changes throughout the value chain, food systems emissions are likely to increase by 30-40% by 2050 (IPCC, 2020).

Research shows that within a decade cultivated meat will reduce GHG by 17% for the creation of chicken, 52% for the creation of pork and 92% for the creation of beef. It will also reduce land use by 63% for chicken, 72% for pork and 95% for beef (Good Food Institute, 2021). While production costs are currently between 100-10,000 times higher for comparable animal meat products, with the right scale up technologies and prices, they could reach a competitive point earlier than 2030. Progress in the industry has been slow but in the last decade cultivated meat has gone from the first lab grown burger costing >$250,000 in 2013 to cultivated chicken being approved in the USA and sold in Singapore restaurants/ markets in 2023.

Cellcraft is an engineering B2B company based in the University of Cambridge. We are creating a scalable, end-to-end ecosystem for cultivated meat production, including specialist processes, enabling technologies, software, hardware and raw materials. Our mission is to democratise access to sustainable food and tackle some of the world's biggest sustainability and food security challenges. Our collaboration with the University of Manchester and University of Cambridge during this R&D project aims to develop a novel bioreactor technology that enables meat producers to create their own tailored, cultivated meat products for market at scale. We will do this by developing our novel scaffold and bioreactor system which enables cultivated meat producers to produce a plethora of affordable meat products (starting with lamb and pork), that are scalable, nutritious, delicious, for general consumption, with a lower environmental impact, higher quality meat, stronger local supply chains, and ethically sourced.

# Development of Hollow-fibre Bioreactor Technology (HFB) to enable resource-efficient cultivated meat production

**Project lead:** Cellular Agriculture Ltd

**Participants:** Campden BRI (Chipping Campden) Ltd

**Funded amount:** £756,704

For years, meat has been the main source of protein globally. However, the health, environmental and animal welfare concerns of traditional meat production have driven the search for alternatives. Cultivated meat products represent an incredible opportunity to provide an alternative (and complementary) method to traditional farming methods to keep up with the growing demand of the global population.

However, the cultivated meat industry is still in its infancy and scaling the technology at low-cost remains an immense challenge.

This consortium brings together innovative tissue engineering and bioreactor specialist, Cellular Agriculture (CellAg), and Campden BRI (CBRI), the UK's largest independent food and drinks R&D organisation. This project intends to optimise, test and validate the scalability of HFB to produce cultivated meat products. HFB has significant advantages compared to current state-of-the-art bioreactors (e.g. stirred-tank/fixed-bed) with increased cell density, compact design, cost-efficiency and lower emissions.

Building on proof-of-concept work led by CellAg, the consortium will develop an HFB system prototype demonstrator that will be optimised at CBRI's facilities. CBRI will then collaborate with CellAg to test production samples and develop food quality, safety, regulatory, economic and sustainability assessments.

This project will enable CellAg to further develop and test the HFB to rapidly commercialise their technology post-project to food manufacturers and cultivated meat companies. This project will put CBRI at the forefront of innovative food research by developing a cutting-edge cultivated meat production system. The knowledge acquired during the project will also be productised by CBRI in the form of e-learning courses and supporting services.

# CULT-GRO: a game-changing growth enhancer to accelerate the affordable scale-up of cultivated meat

**Project lead:** Quest Meat Ltd

**Participants:** Multus Biotechnology Ltd, University College London

**Funded amount:** £693,636

Rising meat/protein demand and awareness for environmental protection needs are driving changed outlooks within the meat industry. The growing need for alternative protein sources to combat meat shortages along with a fast-growing population is enhancing the need for cultured meat production. However, persistent technical challenges in manufacturing and in deriving low-cost end-products hampers rapid growth potential.

End-consumers are shifting their focus towards sustainable lifestyles, seeking meat with lower environmental impacts than resource-intensive traditionally-farmed meat. The UK is set to become a world-leading developer of cultured meat, with a predicted 31% (£1.7 billion) market-share by 2030.

Quest Meat and Multus are pioneering biotechnology start-ups within the cultivated meat sector. Together with UCL, this consortium will develop 'CULT-GRO', a formulation for cultured meat production.

This project will respond to the cultivated meat production need and deliver more sustainable, lower-emission alternative protein sources, with faster production and adaptive supply strategies of proven formulations at-scale. This will enable the UK's cultivated meat market to respond to food supply chain demands more rapidly, reducing carbon emissions and addressing the shortages in meat globally.

This project is anticipated to deliver transformative effects for Quest Meat and Multus, and will lead to a huge impact on the UK's cultured meat supply chain. CULT-GRO is an enabler to catalyse/accelerate the commercial implementation of new cultivated meat products and provide multiple interface points for cell-line development, ingredient suppliers and cultured meat manufacturers. This project will benefit the UK economy, generating local and export revenues and headcount growth across the cultivated meat sector.

# Scaling up a novel low-emission fungal fermentation-based production system to commercialise ultra-realistic meat whole-cuts alternatives

**Project lead:** Adamo Foods Ltd

**Participants:** Centre for Process Innovation Ltd

**Funded amount:** £808,112

We aim to decrease UK meat consumption, causing climate change (14.5% GHGs) and diet-related disease (WHO), by scaling up our novel low-emission production system to commercialise the UK's first ultra-realistic meat whole-cuts alternatives.

With growing sustainability/health concerns around meat, meat-alternatives are fast-growing; worth $12bn globally today (BCG; Bloomberg), reaching $103bn (7% of meat) by 2030. Whole-cuts (steaks/fillets/ etc) represent 85% of meat sales, but are near-absent from meat-alternatives; a huge untapped opportunity.

Plant-proteins have short fibres, with which it is difficult to replicate the fibrous texture of meat whole-cuts, and most products mimic processed meats (burgers/mince/sausages).

Mycoprotein has huge potential for meat whole-cuts alternatives, with long fibres (hyphae), exceptional protein quality, fibre and micronutrients (highly nutritious), and sustainability benefits (our products emit 93% lower GHGs than beef).

However, conventional mycelium production processes deliver products with limited textural appeal. To continue reducing meat consumption we need better quality, more innovative alternatives.

Adamo Foods has developed a ground-breaking mycelium-based steak, for which we have developed a game-changing, novel low-emission production process to address this challenge. We now need to design our commercial-scale production system. To do this, we aim to significantly shift the state-of-the-art.

We have developed a comprehensive 15-month project plan with UK-based leading experts in fungal fermentation, leveraging UK strengths and expertise to create new production systems and technologies.

Technical innovations: We will design a scaled-up production process, prototype core aspects of it, and run a demonstrator proof of concept.

# Next-generation adaptive evolution toolkit to increase protein production in precision fermentation

**Project lead:** Evolutor Ltd

**Participants:** University of Sheffield

**Funded amount:** £355,470

After taste, cost is the greatest blocker to public acceptance and adoption of alternative proteins. It is therefore vital that the industry develops production methods and technologies that decrease the manufacturing cost of novel low-emission proteins to allow them to compete on the market with incumbent products. Products such as traditional cow's milk, hen's eggs and beef have decades or centuries of infrastructure and economies-of-scale behind them. Competing with these industries is no small challenge, but a challenge that is vitally necessary to realise net zero ambitions.

Evolutor's focus is on the production of food proteins using microbes, yeast and bacteria, in precision fermentation systems. Much like how yeast is used to convert sugar into alcohol for beer and wine production, Evolutor can engineer these microbial strains to produce meat, dairy and egg proteins. There are many companies around the world already focussed on doing this, but they all face a major challenge: how to maximise the protein production capabilities of their precision fermentation manufacturing to drive down cost and hit price parity with traditional proteins.

Through the innovations in this project, Evolutor and the University of Sheffield are developing Protein-Infinity: a microbe optimisation toolkit that will solve this problem in an entirely new way that is protein-agnostic and can be applied across diverse precision fermentation sectors to maximise the project's commercial value and climate impact.

The project is doing this by linking protein production to evolutionary selection pressures, creating environments where survival-of-the-fittest means survival-of-the-highest-protein-producer. This strategy and the groundbreaking way in which Protein-Infinity will execute it will rapidly accelerate the commercial viability of precision fermentation UK-wide and beyond. The project aims to double protein production, driving novel proteins towards price parity and moving their economy closer to a bio-industrial revolution: producing food proteins that are affordable, delicious, nutritious, sustainable and accessible by all.

# Unlocking the next-generation protein expression systems for animal-free cheese production

**Project lead:** Herlab Ltd

**Participants:** University of Kent

**Funded amount:** £379,353

The demand for dairy products is growing globally due to rising incomes, increasing population, and dietary changes. Concerningly, dairy production is one of the biggest methane emitters in the world. Animal-free alternatives for dairy products have the potential to reduce pollution by offering sustainable production practices. However, while plant-based alternatives for milk have nearly reached price, taste, and convenience parity to animal-derived milk, plant-based cheese still fails to offer an adequate consumer experience.

In the last 10 years, the potential use of precision fermentation has been investigated for food protein production. While in principle precision fermentation offers a sustainable and ethical way of producing food proteins, to date no major alternative protein company has been able to offer affordable and scalable solutions to casein, the main cheese protein.

This project considers that the lack of progress is mainly due to the attempts to genetically engineer conventional industrial microorganisms such as E. coli and S. cerevisiae that require multiple modifications to utilise cheap food sources, withstand environmental pressures in bioreactors, and produce complex proteins.

Instead, this project proposes that larger gains can be achieved by adopting unconventional yeast species that might be naturally more suitable for food production, but currently lack the necessary genetic engineering tools. The project aims to develop the next generation of microbial factories using unconventional microbial species. Its methodology will be validated in pilot-scale bioreactors evaluating the novel strains for the industrial production of casein proteins. This proof-of-principle project will serve the whole precision fermentation sector by massively expanding the choice of protein expression systems, tailored for industrial level scalability.

# AdvanceYeastPro – advanced and sustainable yeast-based novel food, grown in vegetable derived scaffolds for a high-structured and protein rich product

**Project lead:** University of Leeds

**Participants:** Agrifood X Ltd, G's Fresh Ltd

**Funded amount:** £421,909

AdvanceYeastPro aims to create an unprecedented low-emission, indulgent, highly structured protein and vitamin-enriched, yeast-based whole-cut food product, to answer consumer and market demands.

The development of this innovative biotechnology and a new high-protein product locally will aid the UK's reliance on imports and help deliver stated government targets on net zero and environmental obligations.

The project aims to meet consumer expectations of quality – including flavour, texture and mouthfeel – as well as improved nutrient value, clean-label, reproducibility and affordability compared to the current alternative protein products in the market. The product aims to:

- Be more nutritious and healthier than the competitors: in high-quality protein.
- Have other attributes, such as a) no use of antibiotics or growth hormones, b) be associated with a meaty umami flavour, c) less processed, and d) with less additives, than the competitors.
- Be a raw "whole-cut" alternative which will provide the domestic consumer with the opportunity to cook as they desire.

The project will further innovate by engineering the technological process to make it more sustainable and economic, providing marketing solutions to prevent and reduce food loss.

It will incorporate vegetable industry side streams that otherwise would normally be disposed of on the soil, which will add the texture, nutrients and the required water (which is an expensive resource and in short supply) to the product.

# BioPro – low emission protein production from anaerobic digestion gases

**Project lead:** Novatica Technologies Ltd

**Participants:** University of Chester

**Funded amount:** £213,565

In this project, the team of researchers from Novatica Technologies and the University of Chester aim to develop a technology to convert biomethane and biogas from anaerobic digestion into single-cell protein using methanotrophic bacteria to meet the growing need for sustainable animal protein.

The use of biomethane and biogas as a feedstock to produce animal feed proteins can reduce waste, create value, contribute to a circular economy, and provide a low-cost and sustainable alternative to traditional protein sources. By turning greenhouse C1 gases, produced via anaerobic digestion of various organic wastes, into high-value products, the project will create a novel closed-loop low emission food and feed production system.

The proposed value chain of biomethane and biogas-to-animal feed proteins will help to reduce waste disposal and methane emissions from landfills, positively affect the UK's network of anaerobic digestors, increase revenues from waste and greenhouse gas utilisation, reduce the reliance on energy-intensive, hydrogen-based processes and high-risk imports in food and feed, and bring the UK to the forefront of innovative sustainable biotechnologies for protein production.

# PROFILE – protein recovery for food using innovative sustainable extraction

**Project lead:** Arborea Ltd

**Participants:** Imperial College London, University of Greenwich

**Funded amount:** £604,163

By 2050, the world will need to produce twice as much protein as it does today to feed its population. At Arborea, we believe the answer lies in photosynthetic microalgae. These microscopic organisms can be cultivated in bioreactors, removing the need for precious agricultural land, and can produce up to 100-times more protein per hectare than soya.

However, production costs and customer perceptions have prevented microalgae becoming a commodity protein for human consumption. Several compounds create unpleasant 'off-flavours', limiting the applications in which microalgae can be used to niche supplements and animal feed.

The PROFILE project will develop a novel approach to microalgae protein production towards commercial viability. Using University of Greenwich's state-of-the-art facilities, we will identify key flavour compounds, before using innovative extraction developed with Imperial College London to remove the unwanted compounds through a low-cost, environmentally friendly process.

This is made possible through the use of waste carbon dioxide during production and non-toxic, sustainable processes for protein extraction. The resultant protein product will have low off flavours and low colour, making it an attractive food ingredient.

By licensing the technology to food manufacturers, we will create a UK value chain for microalgae protein worth over £135 million. In doing so, Arborea and its licensees will produce 26,500 tonnes of carbon-neutral, UK-produced protein by 2030, eliminating 1 million tonnes of $CO_2$ emissions compared to beef production and displacing imports of environmentally destructive soya.

# Clean palm: scale-up and genetic tools for sustainable UK palm oil production


**Project lead:** Clean Food Group Ltd

**Participants:** University of Bath

**Funded amount:** £728,391

Palm oil is the most widely used of all oil crops, with over 69 million tonnes produced annually. The market for palm oil is projected to continue expanding at a rate of approximately 2% per year. The main application for palm oil, accounting for 70% of total global use, is as a cooking oil and food ingredient. Palm oil is neutral-tasting and has a smooth texture, which can give food products an appealing mouth-feel. The high stability of palm oil means it can contribute to extending the shelf life for processed foods.

From a sustainability standpoint the production and consumption of palm oil can have significant negative impacts on both the environment and society, making it an unsustainable option for the UK and other countries seeking to reduce their environmental footprint and promote sustainable practices.

With significant consumer interest in healthy and sustainable alternatives to saturated fats from ingredients such as palm oil, the UK-based foodtech SME, Clean Food Group are commercialising an alternative technology for palm oil production using precision fermentation of microorganisms. The Clean Palm project brings together a world-leading team of foodtech entrepreneurs, chemical engineers, synthetic biologists and experts in microbial evolution. The 18-month project will enable UK-based production of palm oil at industrial scale, using microbes and processes that are proprietary to the Clean Food Group. Funding the Clean Palm project will give the UK a competitive edge over companies.

# Feasibility and optimisation study for modular cricket farming and harvesting system

**Project lead:** Oko Protein Ltd

**Participants:** Food & Drink Forum Ltd, University of Nottingham

**Funded amount:** £228,057

Oko Protein, the University of Nottingham School of Biosciences, and the non-profit Food & Drink Forum, are teaming up to help make the UK a world leader in the emerging multibillion pound edible insect industry.

The Oko Box is a unique modular intensive farming system developed by Oko Protein to affordably and sustainably farm crickets for human consumption. Importantly, it eliminates most labour costs by exploiting the behaviour of the crickets, with their movement being utilised to generate heat, thereby cutting energy costs.

Four successive prototypes have been hand-built and tested, proving the fundamental innovations of the system, which, when compared to traditional methods, offers:

- Five to sixfold reduction in output costs
- Fourfold reduction in capital outlay
- 50 times reduction in set-up time
- Requires no indoor facility
- Requires less energy and has a lower carbon footprint
- Is the only system not to require deconstruction of habitat during harvest
- Requires no dehumidification
- Is a net producer of heat over a harvest cycle, where other systems require heating
- Is easy to use
- Can be used by individual farmers as it doesn't require huge capital investment.

The project aims to confirm the feasibility of the Oko Box on a commercial level. A showcase farm of 14 Oko Boxes will be set up in an outdoor location to test and optimise various factors including: temperature, airflow, feed ingredients and blend, feed amount and population size.

Circular and sustainable options for feed will be explored and tested. Inputs such as labour, energy, feed and water requirements will be monitored, as well as subsequent yield and nutritional value of the crickets.

Since the Oko Box produces heat, the project will also explore its feasibility as a supplementary heat source for greenhouses.

By its conclusion, the project aims to demonstrate the ability of the Oko Box to produce protein at prices that are comparable to, or better than, existing forms, such as soya, meat and milk. It will also produce instructions and training materials for farmers allowing them to diversify and utilise the Oko Box in a way that produces maximum yield at minimal cost.

# Decarbonisation and decentralisation of synthetic nitrogen fertiliser production


Conceptual design for a 100kW plasma reactor system.

**Project lead:** Debye Ltd

**Participants:** Agri-Epi Centre Ltd, Crop Health and Protection Ltd

**Funded amount:** £292,594

Along with water and sunlight, nitrogen is essential to the growth of plants and life on the planet. Until the early 20th century, farmers were relying on manure as a scarce commodity to enrich their crops, before the Haber-Bosch process enabled the production of synthetic nitrogen fertiliser. Agricultural productivity skyrocketed and food became more available and affordable, but production, distribution and application of synthetic nitrogen fertilisers now account for 5% in total global $CO_2$ equivalent emissions (2.6Gt $CO_2$eq for 2021). Production relies heavily on fossil fuels, leading to greenhouse gas emissions, and it is centralised, while the consumption is dispersed globally. In fact, there are only about 600 fertiliser manufacturing facilities in the world. The fertilisers made in these facilities are distributed to five billion acres of agricultural land, so the need for transportation further increases emissions.

The way soil is fertilised must fundamentally change, and this project aims to replace this centralised carbon-intensive process with a decentralised electricity-based one. In this process, farmers would not rely on resource and capital-intensive fertiliser factories and the associated high-cost distribution networks, but instead produce their own fertiliser on site using air, water and electricity. It has the advantage of integration with renewable energy making the production completely sustainable.

This project aims to show the feasibility of a plasma-based mobile fertiliser machine that produces synthetic nitrogen fertiliser in a completely sustainable and affordable way.

# InSAFE – securing the future of the UK's insect farming industry

**Project lead:** University of Leeds

**Participants:** Entocycle Ltd

**Funded amount:** £367,768

Growth of the UK insect farming industry is currently curtailed by three key things:

1. Tight legislation on the use of processed animal proteins, including insect proteins, severely limiting the markets for insect products
2. A lack of protocols covering occupational health of staff involved in insect rearing under high-density monoculture conditions in enclosed artificial environments
3. Food safety and quality standards, and codes of practice for insect rearing that align with global standards and retailers' 'codes of supply'. These currently do not exist for permissive feedstocks, but are crucial to the development and future viability of this emerging sector.

This is also limiting the development of additional revenue streams, such as insect by-products as these barriers also apply.

Insect rearing systems that utilise non-permissive feedstocks could unlock the sector's potential towards production scales that are required for insect farming to be of global significance within the alternative protein industry.

InSAFE will inform the feasibility of developing protocols, codes of practice and standards appropriate for larvae-rearing facilities spanning a range of feedstocks and production scales, including containerised units, 20 tonne and 1,000 tonne insects per day units. Research will provide robust data to underpin the development of these documents.

The National Pig Centre at the University of Leeds is home to a containerised insect rearing unit built to specification in collaboration with Entocycle, serving as a novel demonstrator facility to rear black soldier fly (BSF) larvae on non-permissive feedstocks such as pig slurry, sewage sludge and chicken manure.

Samples will be collected from the unit, in addition to Entocycle's BSF rearing set-up for permissive feedstocks, including segregated food waste. The project will analyse the bacterial microbiome, pathogen loads, presence of antimicrobial resistance genes, and heavy metal content of permissive and non-permissive feedstocks before and after insect bioconversion, alongside analysis of the BSF larvae and by-products such as frass.

# Nutritional-enhancement of waste and Black Soldier Fly Meal (BSFLM) to make the UK a world-leader in BSFLM industry economics

**Project lead:** Mana Biosystems Ltd

**Participants:** Nottingham Trent University

**Funded amount:** £772,266

The consortium aims to deliver the world's first nano-material enhanced BSFLM, as well as to improve the growth performance and nutritional value of Black Soldier Fly Larvae (BSFL) through the biofortification of a range of waste substrates they are fed on, some of which are currently underutilised by the insect protein industry.

The project will enable an adoption tipping point for this emerging alternative protein solution by reducing the cost of production of BSFL and adding value to the insect meal end product.

# Scaling the UK insect protein sector: industrial research for low-emission protein production

**Project lead:** AgriGrub Ltd

**Participants:** Aston University, Beta Bugs Ltd

**Funded amount:** £700,729

The core aim of this project is to accelerate the UK's insect protein sector by addressing major barriers to scaling. AgriGrub, the UK's largest insect protein producer, will work alongside Beta Bugs, an insect breeder, and Aston University, supply chain analysis specialists, to address these challenges and build a roadmap for scaling insect production in the UK to meet demand.

The major barriers addressed include the high cost of capital equipment, operational efficiency, insufficient supply chain segmentation and a lack of sector wide strategy.

This project will result in the UK's first high-scale Black Soldier Fly larvae production facility, which will produce 550 tonnes of insect protein production annually, for use in net zero carbon livestock feed.

AgriGrub and Beta Bugs will both produce new products which will allow UK farmers to quickly and cheaply start producing insect protein to meet huge demand. Aston University will analyse the whole insect protein supply chain and produce a roadmap to scale the sector.

The team intends to use the project outputs to scale their own operations, but to also make the outputs available to anyone who wants to start farming insects, and to collaborate with interested farmers.

The project takes a systems approach; combining and validating individual innovations from each project partner to produce a unique and innovative combined offering to UK agriculture. The core aim is to accelerate the insect protein sector in time to facilitate decarbonisation of UK food production by 2050.

# Emerging mycoforestry technology for carbon-negative food production

**Project lead:** Mycorrhizal Systems Ltd

**Participants:** University of Stirling

**Funded amount:** £553,874

All major food production categories in the UK emit greenhouse gases in their production, contributing to anthropogenically driven climate change. The development of novel technologies and approaches that can reduce this issue is important, not just for the UK, but also globally. An emerging technology of cultivating mushrooms with living trees, by covering the root system of tree planting stock with different edible fungi and planting new woodland, shows great promise to produce carbon negative food.

Research shows that using this approach in the UK climate can produce an annual food crop from newly planted trees of around 405kg per acre. With a protein content of around 17%, every kilogram of protein produced by this method can sequester around 406kg of carbon.

This two-year research project will develop the technology to a stage where it is ready to be employed and rolled-out on a commercial scale. This will create a carbon negative food crop, whilst also contributing all the benefits that woodland creation brings. These include biodiversity, conservational and flood mitigation benefits whilst triggering socio-economic development in rural areas.

Fostering collaboration between industry and academia through project partners Mycorrhizal Systems and the University of Stirling, this innovative project allows food production and afforestation goals to be achieved from the same parcel of land.

# Investigate the commercial viability of growing alliums in a protected cropping environment

**Project lead:** Stourgarden Ltd

**Participants:** University of Essex

**Funded amount:** £374,210

Standard growing practices for field crops such as alliums must be updated to overcome challenges presented by climate change and the increasing prevalence of soil-borne diseases.

Onions, which represent the main focus of this project, are a staple for UK households - in constant demand throughout the year as a foundation ingredient in dishes prepared by families across the nation.

Onions are susceptible to diseases such as fusarium, white rot, neck rot, and downy mildew, and land used for growing onions can only support their growth for one in every six or seven years - as any traces of plant matter left in the ground post-harvest can lead to re-infection.

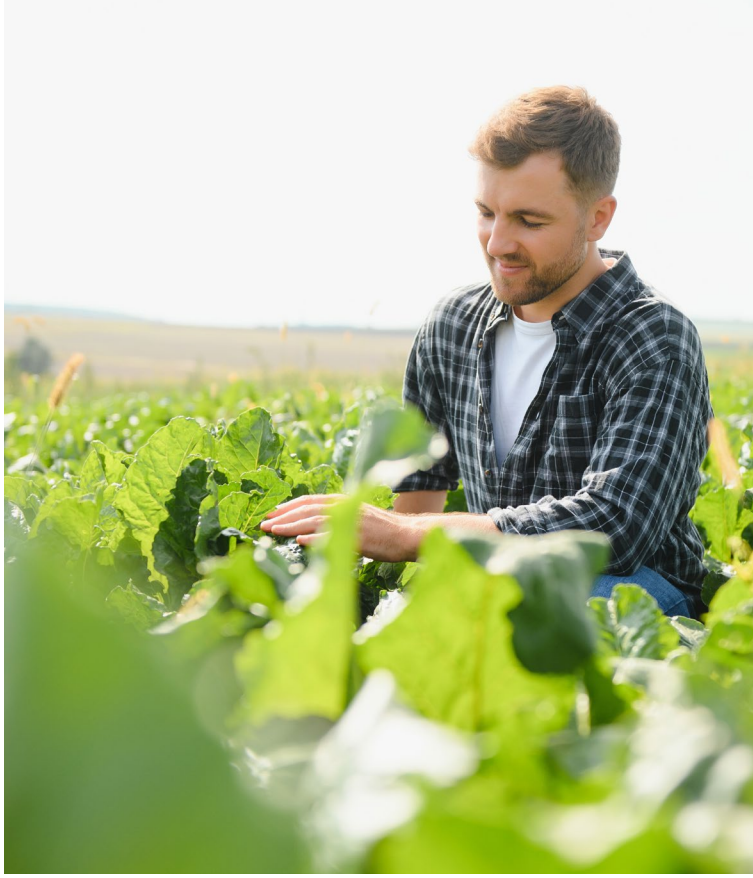
It is becoming increasingly difficult to secure suitable 'clean' land for farming onions to meet demand. Alongside land pressures, farmers are being urged to contribute to improving UK food security and reducing food miles by growing more produce locally.

One approach to addressing land scarcity, reducing $CO_2$-heavy inputs, and better controlling disease in the growing of onions, is to move this traditional 'field crop' into a controlled environment (CE).

Through this project, Stourgarden will be the first UK growers to test the viability of protected growing for onions on a commercial scale. They anticipate the multiple benefits flowing from the development of a CE system for onions to include:

- Avoidance of infection of soil borne diseases such as fusarium
- Significant reduction of nutrient inputs, and elimination of any risk of nutrient run-off impacting waterways and ecosystems
- Increased automation leading to decreased reliance on low-skilled labour, with new, skilled technical and engineering roles created as Stourgarden develops its CE capability
- Removing the reliance on importing onions to cover gaps in the UK growing season, thereby vastly reducing transport-related emissions and improving the UK's trading position
- Removing the impact from climate change related adverse weather during the growing season, which can typically affect crop yield by up to 30%
- A more reliable crop will deliver supply chain security for retailers and households.

# Use of crop leaves for high-value animal protein production



**Project lead:** Kyomei Ltd

**Participants:** National Institute of Agricultural Botany

**Funded amount:** £358,847

This project is a demonstration of feasibility for a sustainable food ingredient production platform in crops, beginning with bovine-identical proteins for the rapidly growing alternative meat industry.

By enabling the production of identical meat proteins entirely produced within the biomass of plants, and designed and produced to enhance the taste, nutritional benefits and quality of existing plant-based offerings, the project will help enable wider adoption of products that directly contribute to bettering of the climate emergency.

Moreover, the project is demonstrating an entirely new production platform and ecosystem, ultimately powered by photosynthesis, directly addressing the future of agricultural production and the alternative meat industry.

# Building UK capability to deliver innovative alternative proteins


**Project lead:** SPG Innovation Ltd

**Participants:** Baker Perkins Ltd, University of Leeds

**Funded amount:** £377,654

SPG Innovation, the University of Leeds and Baker Perkins Ltd are exploring the feasibility of developing new products for the protein sector.

This project will explore the boundaries of current low-emission processes for texturising proteins, and the feasibility of alternative technologies to produce alternative proteins in support of the UK's capability to supply and advance the alternative protein market.

# Revolutionising rice cultivation: a novel low-emission rice line to mitigate agriculture's environmental $CO_2$ impact

**Project lead:** Tropic Biosciences UK Ltd

**Participants:** National Institute of Agricultural Botany

**Funded amount:** £748,408

Rice is a staple for nearly half of the world's 7 billion population and is mainly produced in south-east Asia (Mohanty, 2013). As the global population rises, to over nine billion by 2030, there will be huge pressure on land for food and rice yields must increase by 25% (Fernandez and Orth, 2018). However, rice yields are decreasing due to climate change (Zhao et al, 2017). In addition, rice cultivation accounts for 12% of global methane emissions (World Economics Forum, 2019), which is 30-times more a potent green house gas (GHG) than $CO_2$ (National Geographic).

Today, global rice production is doing as much harm as 1,200 average-sized coal power stations, and by 2030, will be responsible for 6% of total GHG emissions (We Forum, 2019). Despite sustained initiatives particularly in China, Japan, Korea and at the International Rice Research institute in the Philippines, established approaches are unable to produce high enough yields, and have effectively plateaued in China, Indonesia, Japan and Korea, and although rising linearly in some key countries such as India and Vietnam, the rates of increase are too slow to meet demand (Grassini and Cassman, 2013).

This project advances the state-of-the-art in a plant product (rice) and it's production system (gene editing to increase rice yield), creating a unique UK technology and product export opportunity, and significantly contributes to net zero (reducing emissions from rice cultivation), demonstrated through glasshouse trials initially with field performance confirmation latterly (TRL7).

We will use our know-how to build this novel production system, including technical work, utilising knock-down and knock-out gene editing to modify yield-related regions of interest in rice and select the best target genes. By the end of this project, we will be in a position to utilise our patented 'GEiGS' technology to create non-GMO rice in several rice varieties, which we will then commercialise. Increasing rice yield has the potential to massively cut GHG emissions, whilst producing more grain, and thus keeping the land-mass utilised constantly. We have predicted that higher yielding rice could lead to a total $CO_2$ reduction for rain-fed rice of 730kg $CO_2$/ha, and for irrigated rice 1330kg $CO_2$/ha.

# V-FAST – vertical farming and storage technologies

**Project lead:** UKUAT Ltd

**Participants:** RheEnergise Ltd, The James Hutton Institute, Intelligent Growth Solutions Ltd

**Funded amount:** £370,747

The V-FAST project aims to demonstrate a new type of infrastructural hub at the heart of the food-energy-water nexus. Focussing on the inextricable link between food and energy, this project aims to accelerate the decarbonisation targets, and broader environmental goals of both sectors through cooperation and making the most of interdependent relationships, within and between each domain.

The co-location of a new type of pumped hydroelectric energy storage with controlled environment agriculture could open up thousands of potential sites, where the power of water can regulate the intermittency of renewable generation, to serve the needs of weather-agnostic farms growing energy-hungry crops for protein-hungry people.

Food produced will feed into local supply chains all year round, at the same time as having global environmental benefits by preventing the conversion of vital ecosystems into farmland, eliminating the emissions of transport and field mechanisation, and avoiding the impact of agricultural chemicals entering local ecosystems.

Over the course of this two-year feasibility study, this partnership between vertical farmers Intelligent Growth Solutions, energy storage innovators RheEnergise, leading agricultural researchers at the James Hutton Institute, and controlled environment agriculture members network UKUAT, will tackle all aspects of the feasibility assessment. This includes: the cultivation of novel crops in vertical farms and the assessment of their nutritive value; the sizing, siting and integration of RheEnergise's High-Density Hydro storage; the environmental and economic sustainability of these food-energy systems; and the commercial landscape and routes from farm to plate.

The completion of this comprehensive feasibility work, and any subsequent practical demonstrator project, will mark a major step towards realising the longstanding ambitions of controlled environment agriculture to contribute meaningfully to a sustainable, decarbonised food system, as well as revealing many lessons applicable to energy storage co-locations in other sectors.

By completing this work, the consortium will move one step closer to delivering sustainable, decarbonised food and energy directly to local communities.

# Developing a circular model for low-emission, healthy TCEA food production

**Project lead:** Kilnsey Park Ltd

**Participants:** The Biorenewables Development Centre Ltd, University of York

**Funded amount:** £414,999

The project will drive the growth of world-leading Total Controlled Environment Agriculture (TCEA) capacity in the UK by creating and testing a new circular and scalable model for local, low-emission food production. This will be achieved by optimising TCEA production technologies to reduce running costs and improve productivity, and by developing a nutrient-rich biofertiliser that grows healthy, high-nutrition foods.

To achieve this, the project will create a containerised TCEA food production facility, powered by renewable energy, to inspire increased sustainable local food production in the UK. The project will increase the productivity of TCEA through a number of innovations, including developing a nutrient-rich biofertiliser using anaerobic digestion (AD) to produce a low-cost, lower-emission alternative to commercial fertilisers. It will also optimise TCEA efficiency by testing different production methods - including growing system technologies and substrates such as wool - to maximise the nutritional value of the food produced.

The project will reduce the high overheads and emissions of TCEA by powering its containerised growing facility using renewable energy, including solar power and, for the first time, biogas from AD, to achieve a projected 30% reduction in emissions.


The project will develop a genuine circular food production system that emphasises sustainable local production to achieve shorter, less centralised and decarbonised supply chains. It will demonstrate how to reduce the amount of land needed for food production by operating a TCEA on disused land.

The project will work in collaboration with experts from the Biorenewables Development Centre (BDC) and the University of York's Centre for Novel Agricultural Products. This is a centre of excellence, using cutting-edge research to harness the power of nature for development of new products and processes, helping to deliver the FixOurFood programme and running its own experimental vertical farm.

# GyroPlant – making TCEA farms sustainable

**Project lead:** GyroPlant Ltd

**Participants:** Crop Health and Protection Ltd

**Funded amount:** £369,198

To meet global and local climate targets, industries must radically transform to more efficient and sustainable ways of working. GyroPlant is addressing some of the inefficiencies in Total Controlled Environment Agriculture (TCEA) and has developed an innovation to deal with growing waste in indoor farms.

TCEA is the practice of growing crops where traditional soil is replaced with alternative substrates. This has advantages, such as growing food in less space, reliable year-round production, no use of chemicals or pesticides, water savings of up to 90% and food production much closer to the consumer. However currently, non-reusable growing substrates, such as pots or matting, are used to grow plants.

Some organic alternatives such as bark and coconut husk are available, however they are expensive, unreliable and allow contaminants to grow.

GyroPlant has designed a patented novel reusable rubber cup, GyroCup, which replaces substrates and addresses the issue of growing substrate waste in agriculture. Our technology is a simple silicone rubber plug that you place seeds in using a variety of germination techniques, compatible with most vertical farming set-ups. GyroPlant has been researching and testing GyroCup over the past year with assistance from Innovate UK.

In this project, we are testing the potential of gels and seed tape, in combination with GyroCup. These techniques are substantially cheaper and a more sustainable alternative to the most commonly used substrates in the TCEA market. As a result of this project, we aim to bring this new sustainable approach using gel-based media and GyroCup to the market, making the TCEA sector more self-sufficient and sustainable.

# ACDC: Advanced Crop Dynamic Control for sustainable leaf protein production in vertical farms

**Project lead:** LettUs Grow Ltd

**Participants:** Crop Health and Protection Ltd, Fotenix Ltd, Perfectly Fresh Ltd, Rothamsted Research, Vertically Urban Ltd

**Funded amount:** £757,151

This project addresses UK food security challenges amidst a climate crisis by offering a gamechanging solution to transform inefficient Total Controlled Environment Agriculture (TCEA) operations into sustainable, energy-efficient crop growing systems. By collaborating to integrate innovative technologies, the project will characterise and demonstrate novel, responsive TCEA growing methods to optimise the efficiencies of environmental control including lighting, irrigation and nutrient supply to reduce the largest contributors responsible for high carbon footprint. The solution will also automate manual operations and improve the safety, consistency, quality and shelf-life of produce for retailers and consumers, by dynamically altering the growth environment.

This innovative project will, for the first time, use the measurement of crop physiological status, measured using an integrated spectral imaging system, to inform the illumination intensity/composition, as well as the energy management (including renewables integration); ultimately using plant health to develop greener production recipes using advanced responsive control methodologies. The project's impact will be measured by changes to crop yield versus operational impact benchmarked over cost/benefit and compared to the existing state-of-the-art. The key crop identified is the high-protein leaf crop spinach, not only as a test crop to validate this integrated TCEA technology, but as an alternative protein crop to unlock new markets.

The project is delivered by a highly competent consortium led by LettUs Grow and including another two technology companies: Fotenix and Vertically Urban, an RTO: CHAP, an academic partner: Rothamsted Research and a vertical farm grower: Perfectly Fresh.

# Harnessing the power of the microbiome to establish world-leading Total Controlled Environment Agriculture (TCEA) capacity

**Project lead:** Concert Bio Ltd

**Participants:** Imperial College London

**Funded amount:** £739,985

Total controlled-environment agriculture (TCEA) is a novel food production system that offers a sustainable and scalable alternative to traditional soil-based agriculture. Although immune to many soil diseases, TCEA systems remain susceptible to plant pathogens, with outbreaks causing catastrophic impacts since pathogens (particularly water-borne pathogens) can spread easily and affect entire crops. In addition, rigorous TCEA cleaning and sanitising protocols employed to eliminate human and plant pathogens also eliminate beneficial microbes. These beneficial microbes, widespread in soil but often eradicated in the soilless context of TCEA, are increasingly recognised as performing a vital role in plant performance in terms of both yield and quality.

Concert Bio is developing a microbiome optimisation platform for TCEA growers, which combines next-generation sequencing-based monitoring with environmental and probiotic interventions to maximise resource-efficient, low-emission TCEA crop production and minimise wasted operational costs through improving productivity, sustainability, and resilience.

Innovate UK funding supports the development of a new formal collaborative R&D relationship between Concert Bio and Imperial College London, combining Concert Bio's expertise in TCEA microbiome sequencing and biocomputational modelling with Professor Thomas Bell's expertise in studying microbial community invasions.

The project timeliness is extremely high, with the energy crisis placing further pressure on TCEA growers to increase productivity, profitability, and resilience in the face of rising operational costs. The UK is uniquely placed to take a global leadership position in TCEA, benefitting from a strong academic research base in microbiome science and already home to several of the world's largest TCEA farms.

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