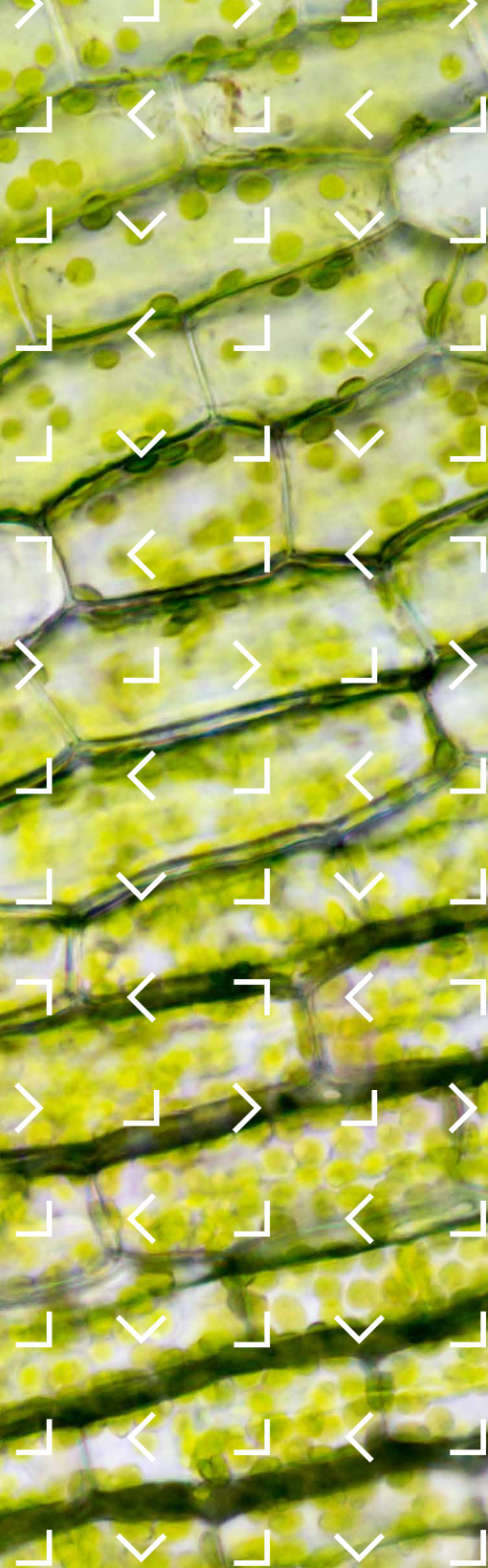




Solutions of tomorrow  
By Denmark



# BIOSOLUTIONS

WITHIN AGRICULTURE AND FOOD

Case collection By Denmark



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# SUSTAINABLE DEVELOPMENT GOALS



## Supporting the SDGs How does Denmark contribute?

With the 17 Sustainable Development Goals (SDGs), the United Nations has created a common framework for global challenges. The Danish agriculture and food sector have taken the SDGs on board, alongside many other stakeholders within the Danish food sector.

The SDGs serve as a guiding light for establishing sustainable food production practices, prioritising research and development efforts and identifying innovation targets that will drive us towards a sustainable future. An efficient and sustainable food sector will directly or indirectly contribute to all 17 goals. However, there are some goals where the food and agriculture sector are expected to have a particular impact.

These include **Goal 2**: Zero hunger, **Goal 3**: Ensure healthy lives and promote well-being for all at all ages, **Goal 13**: Take urgent action to combat climate change and its impacts and, especially in this case collection **Goal 12**: Ensure sustainable consumption and production patterns with target 12.3 aimed directly at halving food loss and waste by 2030.

Achieving the ambitious goals of the 2030 agenda requires global support and partnerships. Extensive collaboration throughout the food value chain between industry, academia, organisations and government are an outstanding characteristic of the Danish food sector – accelerating progress with national and international initiatives and directly contributing to **Goal 17**: Revitalise the global partnership for sustainable development.

## INGREDIENT INDUSTRY

Producers of enzymes,  
cultures and other ingredients

## PRIMARY PRODUCTION

Agriculture, fishing  
& horticulture

## PROCESSING INDUSTRY

Producers of food,  
beverages & animal feed

## RESEARCH & INNOVATION

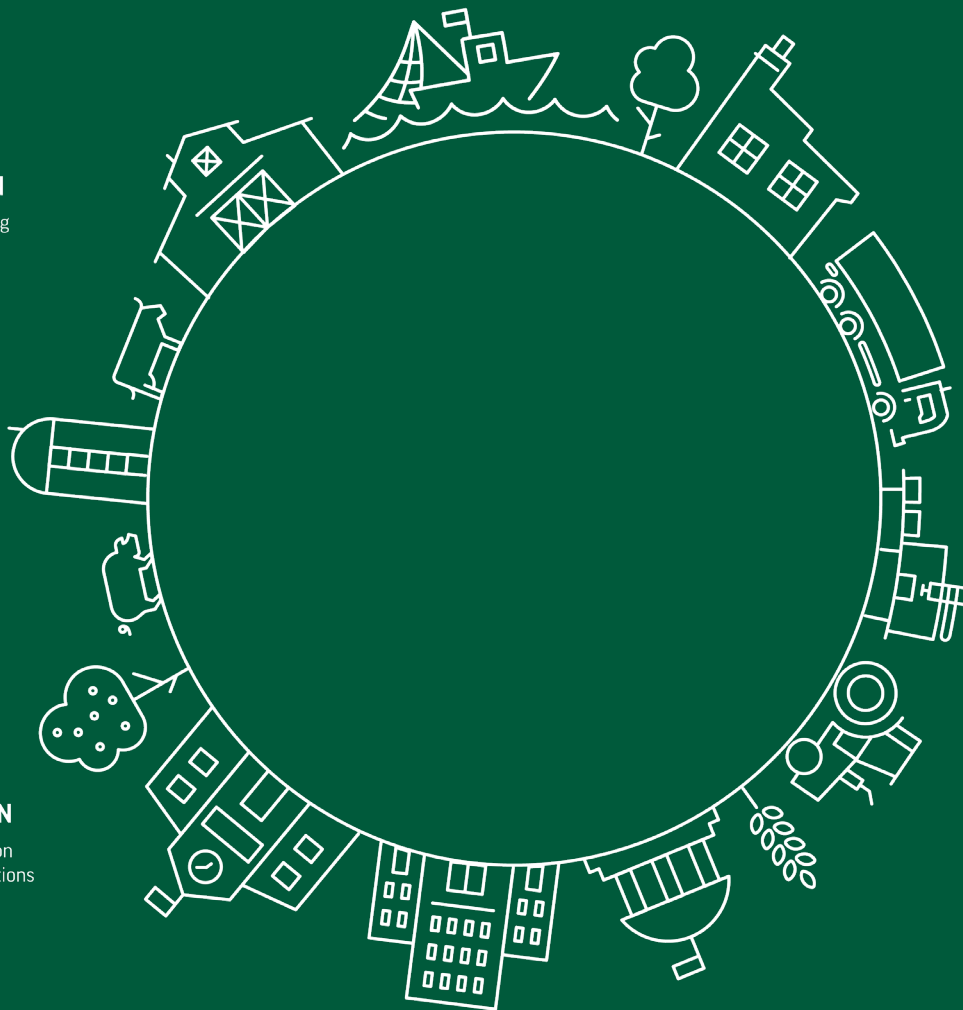
Research, education  
& counselling institutions

## INNOVATIVE TECHNOLOGY

Producers of machines,  
technology & equipment

## GASTRONOMY & THE CONSUMER

Retail, consumers, restaurant,  
authorities, tourism & other  
related industries





# FOREWORD

The world is faced with a major challenge when it comes to food. We need to re-think our food systems to accommodate a growing global population and declining biodiversity. We need more resilient supply systems in a world where conflict may disrupt supply chains in the blink of an eye. And more than anything, we need new products and solutions that will reduce the climate footprint of our food production and consumption.

Approximately a third of all greenhouse gas emissions are linked to food<sup>1</sup>. To transition to a truly sustainable global food system, we need concrete solutions that will allow us to address issues such as: reducing methane emissions from cattle's digestive processes, plant-based alternatives to meat, food production that demands less land and makes room for biodiversity, countering food waste and exploiting side streams from food production, as well as replacing traditional fertilizers and plant protection products with biologically based solutions.

In short, the world needs biosolutions. Biosolutions are solutions based on nature's own tools applied at industrial scale. Enzymes, pheromones, fermentation, bio-refining, and bacteria cultures are put to work as the driving forces in the transition from a fossil-based to a bio-based economy. Biosolutions enable us to make the most of resources and raw materials, reduce the

use of fossil-based resources and waste, and enable food systems to produce more with less.

In this case collection, you will find examples of biosolutions from Denmark for the global food system. Biosolutions that, for example, allow us to produce bioplastic from grass juice, replace meat with plant-based proteins, protect plants with no damage to biodiversity, and combat food waste by extending the shelf life of dairy using natural processes.

Biosolutions is a Danish stronghold. Enzymes, probiotics, and bacteria cultures from major Danish companies are already used globally throughout the food sector value chain: in dairy, beer, wine, animal feed, and several other areas. And as a society, Denmark is at the forefront of applying biosolutions. Denmark has set some of the world's most ambitious climate targets, and they can only be achieved in close cooperation with authorities, research institutions, and the business community, including the food sector.

Denmark offers not only a range of well-proven biosolutions from major companies with centuries-long heritage. There is much more to come in a growing pipeline of solutions for the entire value chain. From start-ups, scale-ups, and major companies alike. So, be inspired by the biosolutions in this case collection. See them as an appetizer and keep an eye out for Denmark and Danish biosolutions.

**We need to rethink our food systems to accommodate a growing global population and declining biodiversity.**

**Lise Walbom**  
CEO, Food Nation



<sup>1</sup><https://www.un.org/en/climatechange/science/climate-issues/food>



Photo: Food Nation & Niels Hougaard

CASE BY KMC

# PURE PROTEIN FROM A HUMBLE SOURCE

The Danish ingredient company, KMC, has launched a commercial potato protein that can serve as a sustainable alternative to animal proteins.

**Potato protein maximises the utilisation and value of potato harvest and helps food manufacturers meet rising protein demands**

World population growth has created an urgent need for new sustainable sources of protein which among other things can help maintain muscle mass. This ongoing search is often focused on plant-based proteins that can serve as a more climate-friendly alternative to animal proteins. However, there is one source that has long gone under the radar - the humble potato. The potato is a non-GMO, non-allergenic and high yield crop with a very low climate impact, thus presenting a valuable potential for the development of sustainable protein sources.

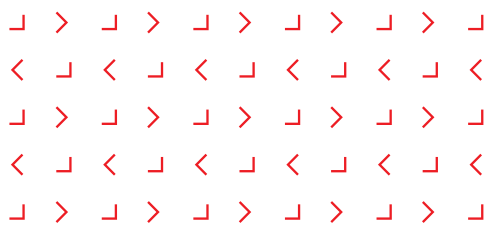
### Danish specialisation is paving the way for new developments

The Danish ingredient company, KMC, which is owned by potato farmers, has recognised the potential of the potato and has specialised in producing functional ingredients from potato starch for a wide range of food products since 1933. During that time, the company has mainly sold the protein-containing side stream from starch production for feed. Today, following intense product development and a major

investment in processing technology, the company has launched its first commercial potato protein - a development that both maximises the utilisation and value of the potato harvest and helps food manufacturers meet rising protein demands.

### Cutting waste by efficient resource-utilisation

Now only the mineral-containing potato juice remains at the end of the KMC production line. KMC sends this back to the fields to nourish the next season's crops - completing a circular supply chain, where nothing goes to waste.



# CULTURES PROVIDE LONGER SHELF LIFE FOR PLANT-BASED YOGHURT

Up to 17% of all milk-based yoghurt is wasted in the EU and mainly because of an expired use-by date, according to the UK Waste and Resources Action Programme (WRAP). As demand grows for non-dairy yoghurts based on plants, the risk of waste could increase even more.

In Denmark, ingredient companies have long worked with natural protective cultures to extend the shelf life of fresh fermented dairy products by delaying yeast and mould spoilage. One of them is DuPont Nutrition & Biosciences.

So, when plant-based yoghurts started to capture the attention of flexitarian, vegetarian and vegan consumers around the world, DuPont had the right expertise to develop a

new line of cultures to help them stay on the shelf for longer.

## Up to 30% less waste

In 2019, DuPont developed HOLDBAC® YM VEGE, a new culture line especially designed for fermented plant-based products. HOLDBAC® YM VEGE is based on a formulation of bacteria specifically designed to extend the shelf-life of plant-based fermented food by reducing yeast and mould spoilage.

**New culture line designed for fermented plant-based products can cut yoghurt waste by 30% in Europe**

With DuPont's HOLDBAC® YM VEGE protective cultures, manufacturers can expect up to 10 days of extra shelf life. WRAP estimates that an extra week's shelf life can cut yoghurt waste by 30% in Europe.

As a result, food manufacturers can make plant-based yogurt and other fresh fermented products with a much lower environmental impact than regular dairy alternatives – while reducing food waste.



Photo: DuPont

# AWARD-WINNING CULTURE REDUCES ADDED SUGAR IN FERMENTED DAIRY PRODUCTS

In 2016, more than 1.9 billion adults, 18 years and older, were overweight. Of these over 650 million were obese. This equates to 13% of the global adult population. Besides that, 41 million children under the age of 5 were overweight or obese in 2016. Danish bio-science company Chr. Hansen has produced a product that decreases added sugars in fermented dairy products to decrease global obesity.

Globally, sugar reduction is a very relevant area of action where the food industry can contribute positively through partnerships, research and innovation. Health organisations and governments are setting objectives to reduce sugar in foods, while retailers are pledging their commitment to reducing sugar in products in their stores. Consumers are increasingly focusing on sugar content, while looking for natural products that taste great. This leaves dairy manufacturers with the challenge of reducing the amount of added sugar, especially in yogurt, without compromising on quality.

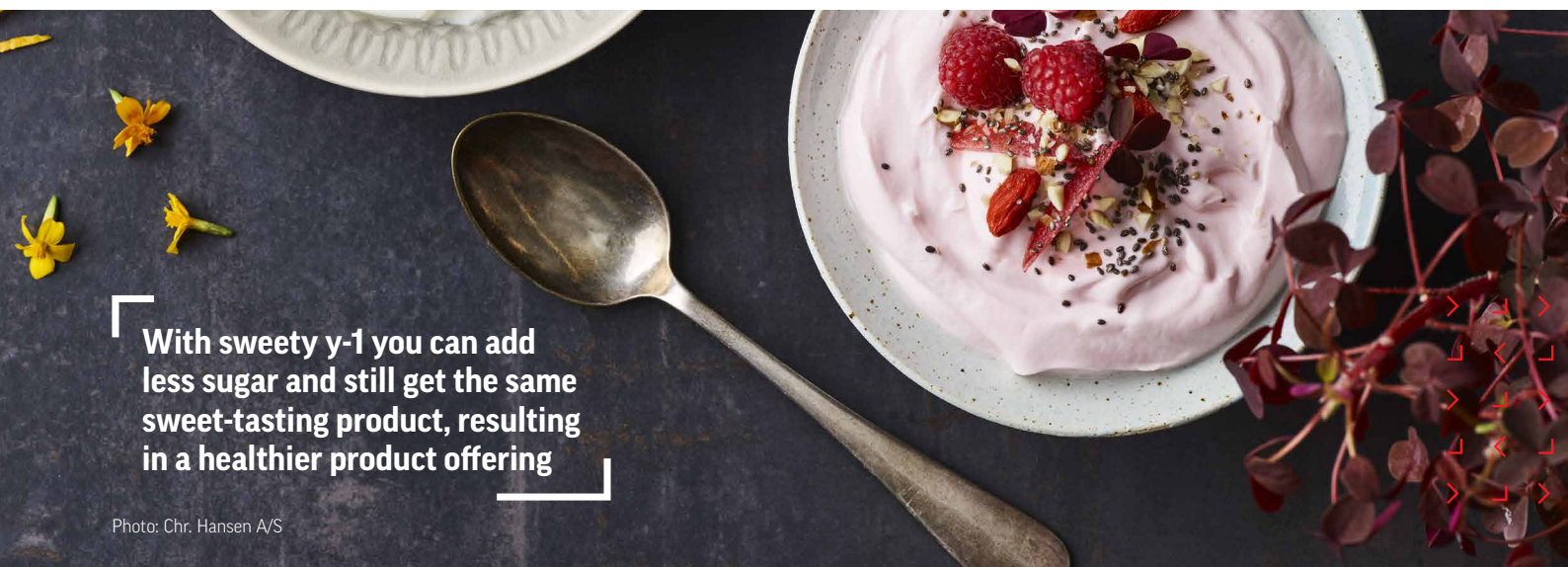
Chr. Hansen might have part of the solution. Their new Sweetie® Y-1 is an

innovative culture solution allowing the natural creation of sweetness by unlocking milk's own resource – lactose. Sweetie® Y-1 is a culture solution using *Streptococcus thermophilus* and *Lactobacillus bulgaricus* cultures.

The culture, which won the Food Ingredients Europe Innovation Award 2019 in the Reformulation Innovation category, works by converting the naturally occurring sugars in milk, using more of the lactose and leaving glucose – which provides a greater sweetness intensity. This means you can add less sugar and still get the same sweet-tasting product, resulting in a healthier product offering.

In today's market for fermented dairy products, the pressure is on dairy manufacturers to reduce added sugar, especially in yogurt. The new culture solution Sweetie® Y-1 enables the development of natural and clean label products without the use of artificial sweeteners. Thus, Chr. Hansen is offering a more healthy alternative to the often calorie-heavy overly sweetened yogurts.

The Sweetie solution can therefore take the dairy industry forward by helping to reduce the added sugar while maintaining the sweet taste in a natural way.



With sweetie y-1 you can add less sugar and still get the same sweet-tasting product, resulting in a healthier product offering

Photo: Chr. Hansen A/S





Photo: Arla Foods Ingredients

What was once regarded a low-value by-product of cheese production is now one of the best raw materials for developing high quality protein ingredients and other nutrient rich food ingredients

CASE BY ARLA FOODS INGREDIENTS GROUP P/S

# NUTRITION FOR LIFE - ALL IN A WHEY PROTEIN

With rising living ages across the world, the farmer-owned ingredients supplier, Arla Foods Ingredients, has built a business on developing high quality protein ingredients that can help the elderly meet dietary protein requirements and maintain a healthy lifestyle.

solutions tailored for use in a wide range of food. Arla Food Ingredients was the first to see the potential in whey and today they drive the development of a whole new whey based ingredient category. Today, whey proteins are widely used for their functional and nutritious benefits in a wide range of foods – including early life nutrition, sports nutrition and a broad variety of staple foods.

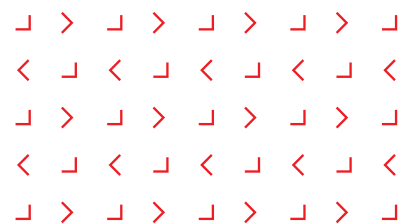
## Showcasing the pioneering spirit

The discovery of the value of whey proteins are just one example of the Danish pioneering spirit where by-products from essential parts of Danish food production – such as cheese – are creating value and new business opportunities. The whey proteins from Arla Foods Ingredients brings a waste product such as whey back into the value chain and thus not only contribute to increase the nutritional profile of foods but also cut down on food loss during the production processes.

The United Nations estimates that the current global expected living age is around 73 years which is a doubling compared to 100 years ago. Food companies around the world thus have a large business opportunity in providing healthy and nutritious foods that can uphold a modern, active lifestyle throughout life.

## From waste to valuable ingredients

The farmer-owned ingredients supplier, Arla Foods Ingredients, has specialised in using the former residual product from cheese production, whey, and now produces and researches in special whey derived ingredient





CASE BY BIOREFINE (PARTNERS DLG, DANISH AGRO, DLF)

# PARTNERING TO DEVELOP THE PROTEIN OF TOMORROW

In efforts to explore the opportunities to create alternative, local production of sustainable plant protein for feed and food, Danish companies have together with leading, Danish universities established the Danish Protein Innovation partnership in 2018.

Global food production is in a challenging situation. With an increasing global focus on the green transition and exponential upsurges in global demand, livestock producers are having a tough time finding enough sustainable protein for their productions. Danish actors have looked towards grass as it currently holds the biggest potential as a protein-source for feed.

## Using grass as feed

At Aarhus University, pilot production trials have demonstrated the suitability of concentrated, biorefined grass protein in feed for pigs and poultry, which are unable to digest grass directly from the field. With additional refining, the protein could also be fit for human consumption.

In cooperation with other agricultural companies and with the support of a public Innovative partners develop sustainable local protein grant, the farmer-owned agricultural supply company DLG is now establishing Denmark's first commercial green biorefinery. The first priority is to produce

organic protein feed for poultry and cattle from clover grass and alfalfa, which can be grown without pesticides and nitrogen addition. Initially grown on 2,000 hectares of land, these crops will provide the raw material for producing 4,000 tonnes of protein a year.

## Paving the way for alternative protein feed

The results are promising and show as a symbol of the Danish approach for finding alternative solutions to produce food for more people without compromising on the world's current sustainability efforts.

Looking ahead, green biorefining can pave the way to a partial conversion of corn crop production to grass crops. Great environmental benefits await due to the ability of grass to bind carbon into the soil, cutting emissions, and the reduction of nitrogen runoff into waterways. In addition, the pesticide-free grass production improves the soil's humus layer and strengthens biodiversity.

On 2.000 hectares of land, crops will provide raw material for producing 4.000 tonnes of protein a year

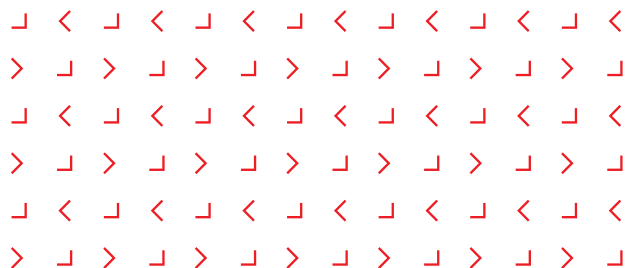


Photo: Food Nation

CASE BY UNIBIO

# A NEW WAY OF MAKING SUSTAINABLE FEED

Unibio has developed a technology that can produce almost unlimited amounts of protein through fermentation. This ensures a clean and sustainable product approved as feed for animal-, fish- and petfood.

With the world's population growing and conventional food ingredients becoming increasingly scarce, we need to improve food security. This, coupled with a growing demand for more sustainable sources, requires us to rethink how today's food is produced.

## Unlimited protein production

The Danish protein-company Unibio has developed a technology that can produce almost unlimited amounts of protein through fermentation – replicating a natural process happening every day.

Through fermentation, Uniprotein® – a highly concentrated and nutritious protein – is derived and can be used as a direct ingredient in petfood and in diets for animals and fish. Uniprotein® is approved as feed for animal, aqua/fish, and pet food in the EU, and is now under development for human consumption.

Unibio uses the patented U-Loop® technology, a continuous-flow fermentation process that allows for a high conversion-rate and efficient utilisation of gases, all within an economically viable production framework.

Using fermentation to produce protein ensures a clean and sustainable product with a very consistent quality. The water usage is very low, and no arable land is needed.

Through its proprietary process, the gases are converted to protein that is subsequently treated and purified to a nutritious, high-quality protein.

Today, Unibio has taken the technology to industrial scale and is rolling it out globally.

## Ensuring food sustainability

Using fermentation to produce protein ensures a clean and sustainable product with a very consistent quality. The water usage is very low, and no arable land is needed.

The protein from Unibio is comparable to fishmeal or soy, the two primary protein sources mainly used in animal feed. Substituting these with Uniprotein® offers a more sustainable and reliable approach to animal nutrition and contributes to global food security.



Photo: Unibio

CASE BY FMC

# WHEN INSECT MATING STOPS, IT IS GOOD FOR THE CROPS

A biosolution-based technology, developed by the company FMC, has made pheromones more cost-effective, giving more farmers around the world access to an environmentally friendly way of controlling insect pests in agriculture.

The agricultural industry plays a crucial role in securing enough food for a growing world population. New technologies are required to continue enhancing crop yields while reducing our overall impact on the environment, biodiversity, and natural resources.

## **Biosolutions lower the price of and increase the access to pheromones**

FMC Corporation is one of the leading developers of biological crop solutions like insect pheromones, and they are dedicated to use their solutions to accelerate the green transition in agriculture.

Their insect pheromones are used to control insect pests by disrupting their mating and

thereby preventing new generations of targeted pests from emerging.

While the use of insect pheromones in agriculture is not new, the manufacturing method from FMC is. Their innovative manufacturing method combines yeast modification, fermentation, and chemical processing to produce pheromones at an industrial scale. This biosolution-based technology has made pheromones more cost-effective, giving more farmers around the world access to an environmentally friendly way of controlling insect pests in agriculture.

Furthermore, FMC's yeast fermentation is scalable both in terms of quantity and types of pheromones, making it possible to

**As insect pheromones are natural compounds released by insects in small quantities to attract a mating partner of the same species, they leave bees and other beneficial insects to thrive.**

produce pheromones for a wide range of insect pests in many different crops from corn and rice to fruits and cotton.

## **Yields are increased and biodiversity is preserved**

FMC has conducted dozens of field trials around the world in countries such as Brazil, Mexico, USA, Spain, Hungary, China, and Indonesia with the objective to develop pheromone-based products for the row crop market.

The pheromone products show promise in controlling major pests in row crops, such as the fall armyworm by reducing pest pressure and damages to the crop, giving farmers a biological tool to improve the protection and health of crops throughout the growing season and, consequently, the quality and quantity of the harvest.

As insect pheromones are natural compounds released by insects in small quantities to attract a mating partner of the same species, they leave bees and other beneficial insects to thrive.



Photo: FMC/Shutterstock



Photo: MATR

#### CASE BY MATR FOODS

# PLANT-BASED FOOD THAT MATR

MATR Foods has found a simple recipe of five organic ingredients sourced from Danish farms and combined it with a thousand-year-old method called fungal fermentation. The result is a new generation of tasty plant-based meat alternatives that carries the possibility to free up to 15% of the world's agricultural land for nature and biodiversity.

**Their product consists of five organic ingredients sourced from Danish farms: oats, split peas, lupins, beetroots, and potatoes.**

What we put on our plate and the way we produce our food today has a big impact on our nature and climate. In a world where land is a scarce resource, new solutions and types of protein that require less use of land are necessary.

The consumer demand for plant-based proteins is already present, as almost 50% of the Danish population say they would like to cut down on their meat consumption. But only 10% act on it. This highlights a need for quality plant-based protein options.

#### **Fungal fermentation provides meat-like flavour and texture**

The Danish foodtech startup company, MATR Foods, has developed a new generation of plant-based meat alternatives, as well as a new way of producing them.

MATR Foods adopts biosolutions, specifically utilising fungal fermentation technology

to produce a plant-based meat alternative that is both tasty and nutritious. Their product consists of five organic ingredients sourced from Danish farms: oats, split peas, lupins, beetroots, and potatoes. But instead of mechanically transforming the vegetable parts into a product, MATR Foods has developed and selected a distinctive fungi which transforms the structure of vegetables through classic fermentation, so that it becomes like meat in terms of bite, juiciness, and deep umami flavour.

The process requires no additives, very little energy, and just a tenth of the crop amount needed to produce regular meat.

For now, the protein alternative from MATR Foods is based on classic Danish crops, but the fungal fermentation technology allows for other ingredients to be used as well – making the production method scalable for other parts of the world with other key crops.

#### **Less meat, more nature**

If just 30% of the meat that is produced worldwide today were replaced with plant-based alternatives like the products from MATR Foods, it has the potential to save 3 billion tonnes of CO<sub>2</sub> annually, and free up to 15% of the world's agricultural land for nature and biodiversity.



Photo: Novozymes

The strictly controlled process delivers a reliable protein supply, independent of climate change, harvest variations or zoonotic epidemics.

CASE BY NOVOZYMES A/S

# LEADING THE WAY IN SUSTAINABLE PROTEIN PRODUCTION THROUGH PRECISION FERMENTATION

With the help from microorganisms in a tank, Novozymes delivers the tools to produce new protein ingredients with a nutritional quality equivalent to the proteins in meat and milk. This technological advancement reduces carbon emissions, water consumption, and land use with 90% compared to animal-based protein.

29% of the world's greenhouse gas emissions stem from our food consumption. Still, the global demand for food is expected to double by 2050 due to population growth and rising incomes.

According to a study by Copenhagen Economics, replacing 10% of animal protein with alternative proteins globally, can potentially free up 900,000 km<sup>2</sup> (347,491.94 square miles) of land and reduce 700 million tonnes of CO<sub>2</sub>.

### Leading the way in sustainable protein solutions through biotechnology

In Denmark, pioneering research is developing a new source of low-carbon protein to meet this need. For decades, the biotech company Novozymes has produced functional enzymes for food and beverages, and the technology is now at the heart of the company's advanced protein solutions.

By applying precision fermentation, Novozymes delivers the tools for new protein ingredients with a nutritional quality equivalent to the proteins in meat and milk.

In short, Novozymes utilises a traditional fermentation process incorporating encoded microorganisms, like yeast or fungi, to generate a specific protein. After being added to a large fermentation tank – similar to those used in brewing – these microorganisms initiate the fermentation process. The result is a protein source that is stable, scalable, and sustainable.

### Carbon emissions are up to 90% lower

Because the proteins are produced by microorganisms in a tank based on sugar and water, carbon emissions are up to 90% lower compared to animal-based protein. Water consumption and land use are also reduced by 90%.

At the same time, the strictly controlled process delivers a reliable protein supply, independent of climate change, harvest variations or zoonotic epidemics. In addition, the new protein offers improved taste, texture, and nutritional value.

By creating proteins to meet numerous needs, Novozymes will be able to contribute to the next generation of health-enabling proteins through fermentation – in a sustainable and efficient way.

# MICROALGAE SUPPORT THE FUTURE OF SUSTAINABLE FISH FEED

Marine ingredients are a fantastic source of nutrition for farm-grown fish. But, if you ask one of the world leaders in high-performance feed for the aquaculture industry, the search for novel ingredients to advance innovation and sustainability is ongoing.

This is why Danish BioMar was first to introduce the microalgae product AlgaPrime™ DHA as a sustainable alternative to marine-derived omega-3 fatty acids for use in fish feed.

The goal is to reduce the so-called Fish in – Fish out ratio, which refers to the volume of live fish required to produce enough fishmeal or fish oil to grow a unit of farmed seafood. At the same time, BioMar wants to ensure that feed for aquaculture does not compete with food supply chains for human consumption.

As a natural source of omega fatty acids, microalgae are an obvious alternative. It is from these microalgae that fish and fish oil actually obtain their content of omega fatty acids in the first place. In other words, by formulating feed mixes with microalgae, it is possible to skip the 'middle fish'.

Using BioMar feed mixes with AlgaPrime™ DHA, fish farms can reduce their dependence on wild fish stocks, lowering the environmental impact of their production and helping to keep more nutrients in the value chain.

The transition to more sustainable fish feed is well underway, as the first commercially available feed mix with microalgae was launched in 2016. Today, microalgae is no longer a niche ingredient – but a commercially viable choice.

**The first commercial feeds containing microalgae hit the markets in 2016, and by 2021 biomar had reached one million tonnes of salmon feeds containing microalgae**



CASE BY AQUAPORIN

# NEW CONCENTRATION TECHNOLOGY ENHANCES FLAVOURS WHILE REDUCING CLIMATE IMPACT

Replacing heat and cold storage with aquaporin proteins enable the company Aquaporin to concentrate food products using less energy compared to traditional thermal methods. This results in both lower energy costs and fewer greenhouse gas emissions.

Producers in the food industry are continuously innovating to find processing solutions that combine the best of both worlds: maintaining high quality while optimising energy consumption.

Traditional methods of concentration use heat to remove water from food, often altering its original flavour and requiring significant energy consumption. Similarly, maintaining the quality and freshness of fresh food products demands energy-intensive cold storage and shipping.

## **Remove water with the help of protein – not heat**

A new cold concentration technology is under pilot testing by the Danish biotech company Aquaporin A/S.

The technology is based on Aquaporin's unique membranes, which contain natural aquaporin proteins. In nature, the aquaporin protein is placed inside the cell membrane, and selectively transport only water molecules in and out of the cell. This allows Aquaporin's membranes to extract water from food products for preservation without the use of heat. The technology maintains high sugar levels in food products like fruit

juice, thereby preserving both flavour and nutrients in the concentrated form while consuming less energy.

Aquaporin A/S is currently testing the cold concentration technology with customers in several food categories including E&J Gallo Inc, a global leader in the wine industry. Here, the technology can concentrate the juice from freshly harvested grapes and preserve it to enable wine production across an extended season, thereby extending the use of production facilities over a longer period.

## **More flavours and less energy costs**

By concentrating food products without heat and with no need for cold storage and shipping, in some cases, Aquaporin's cold concentration technology requires as little as one tenth of the energy used by traditional thermal methods, helping to reducing energy costs and greenhouse gas emissions.

The technology maintains high sugar levels in food products like fruit juice, thereby preserving both flavour and nutrients in the concentrated form while consuming less energy.

Photo: Aquaporin



# TURNING CO<sub>2</sub> INTO FEED, FOOD, AND SKIN CARE INGREDIENTS

The start-up-company, Algiecel, has developed a new technology that convert CO<sub>2</sub>-emissions from industries into green algae-based products – a valuable and climate friendly ingredient in aquaculture feed, petfood, and cosmetics.

**The photobioreactor fits into a standard 40' shipping container and the only thing it requires, is a flat surface, a supply of CO<sub>2</sub>, and the necessary power capacity.**

While greenhouse gas emissions are causing serious climate changes, industries are searching for solutions to bring down their negative carbon footprints. One solution that holds great potential is carbon capture and carbon reuse.

Until recently, small to mid-sized companies, both lacking the space and financial resources for expansive carbon capture systems, had no viable options for capturing and reusing their carbon emissions.

## **A plug & play photobioreactor to capture CO<sub>2</sub>**

The Danish firm Algiecel has developed a new technology, a plug & play photobioreactor, that captures CO<sub>2</sub> emissions

continuously and transforms it into microalgae biomass using LED light via photosynthesis.

The technology enables companies like biogas and fermentation plants to utilise CO<sub>2</sub> from their industrial processes on sight and turn it into microalgae oil and microalgae biomass. These products can be applied as a valuable ingredient in aquaculture feed or petfood, in human dietary supplements, and in cosmetics like skin care products.

The photobioreactor fits into a standard 40 shipping container and the only thing it requires, is a flat surface, a supply of CO<sub>2</sub>, and the necessary power capacity. The system is modular, allowing for stacking of multiple

containers to maximize space efficiency. The only by-products left are oxygen and residual heat both of which can be reused, for example in heating up the biomass at a biogas plant.

## **More sustainable food production**

The global markets for alternative protein in food, food supplements, and animal feed is expected to reach DKK 4,000 billion by 2030.

Scaling the technology developed by Algiecel holds two great potentials: an innovative, climate friendly solution for the food and feed industry as well as a reduction of industrial CO<sub>2</sub> emissions.



Photo: Algiecel



Photo: Food Nation

CASE BY NOVOZYMES

# MORE SUSTAINABLE AGRICULTURE WITH MICROBES

With the world population projected to rise considerably, and thereby demand for sustainable agriculture and food systems, crop yield is one intervention area with great potential. The demand for agricultural resources drives up the demand for crop land, potentially at the cost of deforestation and the depletion of natural resources. Improving crop efficiency can boost yields without increasing the acreage.

For crops to become more efficient, a number of factors, including improved nutrient uptake, improved genetics, and the ability to counter environmental threats are critical. When it comes to the environmental impact of crop production, all efforts are important. Sustainable agriculture also means growing more with less or the same resources.

The Danish biotechnology company, Novozymes, has developed two microbial seed inoculants, Jumpstart® and Optimize®, that give crop seeds an extra sustainable edge. By treating soy, wheat, corn, forage grasses and other types of seeds with these

inoculants, biological processes can be enhanced and higher yields can be achieved. By utilizing naturally occurring microbes and molecules, uptake of phosphorus and nitrogen is boosted to make better use of the available nutrients.

### Increased yield with same input

By inoculating seeds with products from Novozymes, yield increases between 3-7% were observed in field tests, depending on soil and crop type. For instance, it has been shown to increase yields of soybeans in different regions. This suggests that small amounts of the products can increase

yields while keeping resources at the same level, (without adding anything else than the usual fertilizers etc.) potentially leaving more profit for the farmer. Additionally, the improved use of the available nutrients can lead to other beneficial aspects such as reduced need for fertilizer, reduced tractor runs through the field etc.

### A win for the farmer, a win for the climate

An increase in productivity by using microbial inoculants can lead to environmental benefits that add to the sustainability of the crops being grown. More output with the same input is obviously more sustainable, but other, slightly more hidden benefits, can be achieved:

- Larger roots of the plants mean more carbon stored in the soil.
- Reduced nitrogen losses to the aquatic environment.
- Less nitrogen is converted to nitrous oxide, a potent greenhouse gas, reducing the emissions to the atmosphere.
- Up to 15% less CO<sub>2</sub> emissions from the whole life cycle of the crop, shown in US field tests with corn.
- Healthier soil.

**By inoculating seeds with products from Novozymes, yield increases between 3-7%**

# INNOVATIVE PROCESS LEADS TO LIFELONG BENEFITS

Danish manufacturer, Hamlet Protein, produces high-quality soy proteins used for piglet weaning feed – ensuring easy digestion and low environmental impact.

**Hamlet Protein produces high-quality feed using its customised bio-conversion process with a minimal environmental footprint**

To solve the global challenge of producing more food for a rising population while also reducing climate impact, more efficient utilisation of resources – including animal feed – is an important step towards a solution.

Piglets and other young animals have an immature gut with a limited ability to absorb nutrients. So, if their feed is too hard to digest, the consequences can be severe for their health, growth and feed utilisation. These issues impose serious risks to the farmers who need to produce high-yield livestock with fewer resources and full consideration for animal welfare.

## **Danish innovation has become a global benchmark**

The Danish supplier of speciality feed proteins, Hamlet Protein, began working on a solution to the problem three decades ago. In the early stages of the company's life, one their innovations became the benchmark for a whole new category of easily digestible, premium soy proteins for piglet weaning feed. Hamlet Protein's success is rooted in its customised bio-conversion process, which minimises the anti-nutritional factors that compromise the bioavailability of soy protein while keeping the amino acid profile intact. Hamlet Protein produces its high-quality feed ingredients at facilities in Denmark and the USA, using a process with a minimal environmental footprint.

## **Benefits on both animal welfare and business results**

International feeding trials have documented lifelong benefits for animal welfare, growth and performance – at least on a par with the benefits of animal-derived proteins. In terms of feed efficiency, the speciality proteins give farmers an optimum return on investment – ensuring a more sustainable production where less is wasted, and climate impact is reduced.



Photo: Hamlet Protein

# DEEP ROOTS HOLD THE SECRET TO DROUGHT-RESILIENT CROPS

Droughts are growing in frequency and severity as global temperatures rise. For farmers, the impact on crop yields can be devastating, with knock-on consequences for feed and food supplies.

**New forage varieties have 30% deeper roots, higher drought tolerance and increased nitrogen uptake**

Today, farmers around the world look to Danish seed company DLF for a solution. Specialised in breeding seeds for temperate climate zones, DLF has a reputation for staying ahead. So, when climate change hit the global agenda, long-rooted plant varieties were already in the product portfolio.

A strategic investment in the world's largest and most advanced root-screening facility – RadiMax – has helped accelerate the development of new climate-resilient plant varieties. Initiated by DLF in partnership with Danish

universities and other breeders, the facility enables researchers to follow plant root growth under increasing drought stress.

Other climate benefits include a natural ability to bind carbon in the soil and minimise nitrogen leaching. The clover varieties among DLF's solutions reduce the need for synthetic fertilisers due to nitrogen fixation from the air.

All varieties produce high-quality feed that is easy to digest and improves the milk yield of dairy cattle, for example.

Drought, flooding and disease are continuously changing factors in crop production. Through dedicated plant breeding, DLF's breeders are on a mission to deliver solutions for sustainable land use with high yields.



Photo: DLF

# THE FUTURE OF SUSTAINABLE PLASTICS MADE FROM GRASS

The company Pond has developed a technology that makes it possible to convert side streams from agricultural crops like grass, duckweed, and sugar beets into a biobased plastic. A product that is both biodegradable and able to store CO<sub>2</sub>.

Every year, 400 million tonnes of plastic are produced globally. A production based on crude oil, and responsible for emitting more than 2 billion tonnes of CO<sub>2</sub> annually. Meanwhile, less than 7% of the plastic is recycled.

Despite this, the demand for plastic is increasing and is expected to reach around 800 million tonnes by 2050.

## Fermentation can turn grass into bioplastic

A new method for producing bioplastic is already a reality, and the potential is enormous. The Danish company Pond has developed a technology that makes it possible to convert side streams from agricultural crops into a biobased plastic.

Pond extracts the carbohydrates from plants such as grass, duckweed and sugar beet, and with the help of a special fermentation technique the carbohydrates are then converted into a bioplastic in the form of lactid polymer (PLA).

## The bioplastic absorbs and store CO<sub>2</sub>

Pond's bioplastic is not only strong enough to replace nearly all current forms of fossil-based plastics, but it also has unique environmental benefits. Because the material originates from plants that undergo

photosynthesis, this form of bioplastic has the ability to absorb and store up to 2 kg of CO<sub>2</sub> per kg, a process known as Biogen Carbon Capture Storage.

Furthermore, Pond's bioplastic is biodegradable, compostable, and can be recycled endlessly – without losing quality. This means that grass, duckweed, and sugar beets can become the future key ingredient in the plastic bowl in your kitchen cabinet, and in your sportswear currently made of nylon and polyester.

**Grass, duckweed, and sugar beets can become the future key ingredient in the plastic bowl in your kitchen cabinet, and in your sportswear currently made of nylon and polyester**



Photo: Pond



Photo: Ferm Food

## CASE BY FERM FOOD

# LOCAL GRAINS THAT NATURALLY BINDS OUR FOOD TOGETHER

A large demand within the food industry for better, healthier, and more natural binders has pushed the company FERM FOOD to develop a unique, natural, and multi-functional binder based on fermented local grain. A production method with a potential to reduce CO2 emissions by up to 60%.

Binders play an important role in food products, for instance, providing plant steaks with the desired shape, texture, and juice while holding the plant ingredients together. Currently, many binders in the food industry contain numerous additives, undergo extensive processing, and come at a higher cost. Today, there is a growing interest in the food industry for binders that are perceived as healthier, more natural, and cost-effective.

### Using fermentation to turn grain into a multifunctional ingredient

FERM FOOD is a Danish manufacturer of plant ingredients for food, based on local crops. After several years of development using biotechnology, the company has come up with a new type of binder based on locally produced grain.

FERM FOOD produce its binder by adding natural lactic acid bacteria to grains, like rye, oats, and wheat followed by a controlled fermentation process. This way, FERM FOOD is able to make a combined filler, texturiser, and binder.

The ingredients based on fermented grains has shown to hold a wide range of different properties, including malleability and high-water retention capacity. The product also holds nutritional benefits, such as a high content of dietary fibre and improved availability of vitamins and minerals.

### Multiple functions with a lower carbon footprint

Fermented grains have a wide range of properties that multiple food categories can benefit from. The product can be used as

an ingredient in both baked goods, meat products and the plant-based category and contributes with binding capacity, malleability, fullness, texture, and a low carbon footprint.

Compared to the production of other fillers, texturizers, and ordinary binders for food, the bio solutions-method developed by FERM FOOD is expected to reduce CO2-emissions by up to 60%.

**Today, there is a growing interest in the food industry for binders that are perceived as healthier, more natural, and cost-effective.**

# A SUSTAINABLE FUTURE OF GREAT SMELL AND TASTE

Using fermentation, the Danish company EvodiaBio has reinvented the production of plant aromas. For a start, they are providing brewers with a more environmentally friendly way of making non-alcoholic beer taste right. The technology holds great potential for several other industries that relies on plant aromas for their products.

Today, aromas for food, perfumes, cosmetics, and cleaning products are primarily made one of two ways:

Synthetically, using various compounds and solvents or via direct extraction from cultivated plants.

These conventional methods can have environmental implications, with some being resource-intensive and necessitating expansive land usage. One example is aroma from lavender, which requires up to 300 kilo of plant material to yield merely one kilo of monoterpenes – the aroma molecules known to provide flavour and scent in plants.

## Natural aromas by fermentation

In Denmark, a third, and more environmentally friendly production method, based

on biotechnology is now a reality as the company EvodiaBio has reinvented natural aromas by fermentation, using yeast. The technology has been developed after years of research and enables an industrial-scale production of essential, aromatic molecules known as monoterpenes. A method that EvodiaBio plan to scale and develop for different beverages, perfumes, and a range of other segments using plant aromas.

Non-alcoholic beer is the first segment that EvodiaBio has addressed, as getting the taste of the beer right has been a major challenge for the brewing industry. EvodiaBio's monoterpenoid aromas are produced using yeast cells that secrete the individual aroma components. These are then blended to replicate the aromatic profiles of various hops used in beer brewing.

The result is a natural, pure, and sustainable product, enhancing the taste of non-alcoholic beer.

## From 3,000 to just 1 litre of water

The natural aromas produced through fermentation can partly replace the need for harvested aromatic compounds. This enables a cost-effective and sustainable biotechnological production of aroma molecules without depleting scarce resources.

Aroma hops used for non-alcoholic beer are typically purchased in the United States, where nearly 3,000 litres of water are used to grow 1 kg of aroma hops. To get the same aroma potential, EvodiaBio uses 1 litre of water while also reducing the carbon footprint with more than 90% compared to the conventional production.

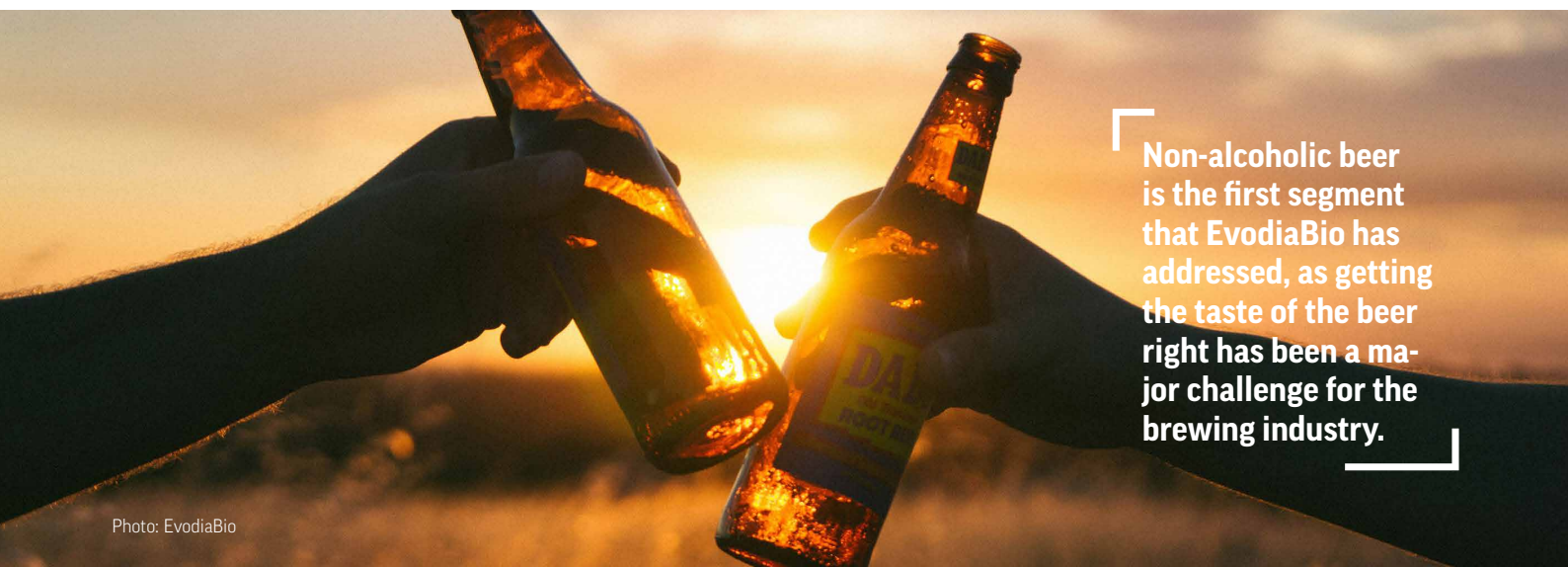


Photo: EvodiaBio

Non-alcoholic beer is the first segment that EvodiaBio has addressed, as getting the taste of the beer right has been a major challenge for the brewing industry.



CASE BY REDUCED

# FROM WASTE TO TASTE

Using biotechnology to reduce food loss, the Danish company REDUCED has specialized in creating high-quality natural flavour solutions using ingredients that are typically discarded.

Representing 8% of global greenhouse gas emission, the total amount of food that is lost or wasted globally corresponds to 1.6 billion tons of food.

Therefore, reducing food loss and waste is not only a necessary step towards sustainable development, but also a good business opportunity.

## From second-grade vegetables to umami flavours

In Denmark, REDUCED, an innovative flavour solutions company, has specialized in creating high-quality savoury flavours using upcycled agricultural and food industry by-products.

By utilising surplus ingredients from the agriculture- and food industry, such as rape seed cakes, broken lentils, chickens from egg production, shore crabs, and second-grade vegetables, REDUCED is fighting food loss while contributing to a more sustainable food industry.

The company transforms the surplus ingredients into high-quality flavours with a unique and patented method. The method is called accelerated fermentation and is a combination of artisanal fermentation and new biotechnology. This method incorporates a specific fungal spore known as koji, which generates enzymes capable of unlocking umami characteristics in the by-products. As a result, REDUCED can efficiently transform diverse waste streams into a variety of additive-free savoury flavourings within a limited time frame.

## 60 tonnes of food waste – not wasted

For now, REDUCED has taken 60 tonnes of agricultural and food industry by-products and transformed it into natural food products using biotechnology in their IFS Global Markets Food certified production in Copenhagen.

The company is on the trajectory to process 500 tonnes of agricultural and food industry by-products in the two next years and has decreased its processing time with 300% during the past year, resulting in massive energy savings. All with the purpose to create taste from by-products.

REDUCED has taken 60 tonnes of agricultural and food industry by-products and transformed it into natural food products

Photo: REDUCED





Neutral in taste and smell, the peptides, which are presented in a powder form, consist of more than 90% highly digestible salmon proteins

Photo: Biomega, Nina Lerbekkk

#### CASE BY BIOMEGA

# TRANSFORMING HIGH-QUALITY SALMON OFF-CUTS INTO PREMIUM HUMAN NUTRITION

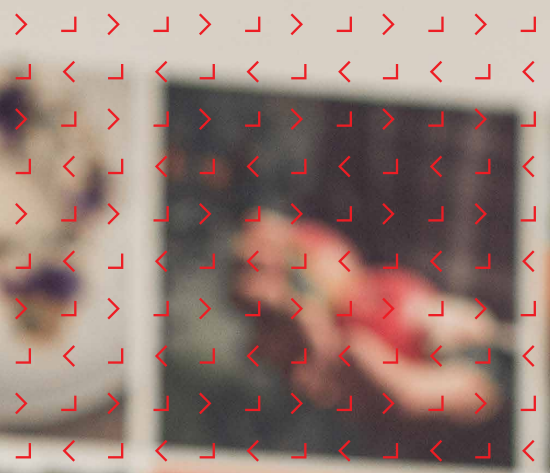
Innovative approaches are constantly working on increasing the intensity and effectiveness of utilization of the whole fish – from head to tail – and finding new ways to add more value and generate new products. For Biomega® Denmark, that means applying sustainable biotechnology in the production of value-added ingredients from food-grade salmon off-cuts.

Biomega® Denmark produces high quality ingredients for human and pet nutrition. In its modern biorefinery, they turn food-grade fresh raw materials into premium ingredients such as salmon oil, pure salmon peptides and collagen suitable for human nutrition.

The company uses a patented continuous enzymatic hydrolysis process to carefully separate the nutritional components. It is this gentle technology that produces Biomega® SalMe Peptides.

That makes them a high value, natural protein source for dietary supplements and many other nutritional food concepts. The peptides are 100% water soluble and are absorbed by the body faster than intact native protein, which maximises nutrient delivery to muscle tissues.

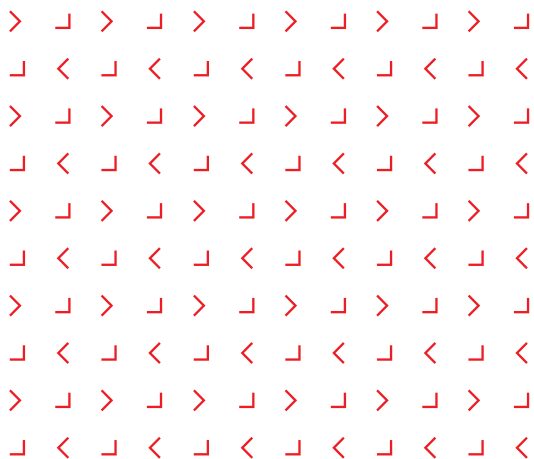
Biomega® has a zero-waste approach to its production process. The remaining side-streams are used to produce petfood.



**FOOD  
NATION**

VIRTUAL REALITY

Discover the  
power of food  
to create a  
better world



## **Interested in hearing more about Denmark's strengths as a hub for agrifood innovation? Contact Food Nation.**

Food Nation is a non-profit partnership established by the Danish government and leading private organisations and companies. It is your gateway to information about the Danish food cluster and knowhow that can accelerate the growth of international businesses through better solutions, innovative products and trusting cooperation.

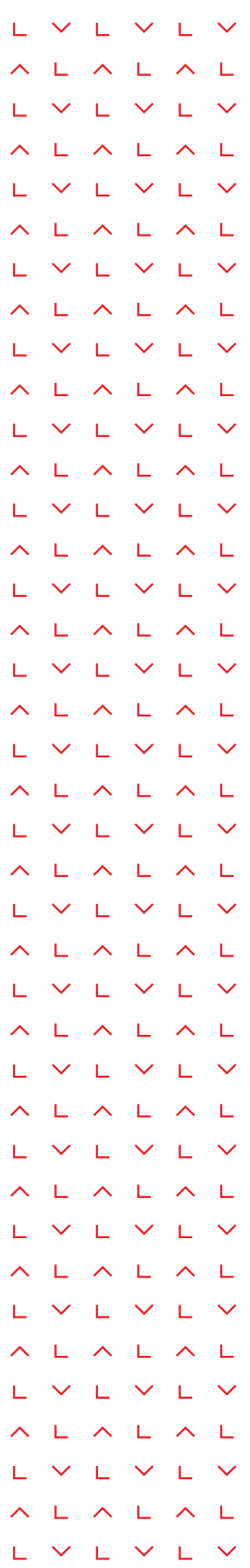
The Danish food cluster encompasses everything from primary production in agriculture and the fishing industry to the food products consumers buy in stores. Companies, universities, research institutes, local and national authorities and other private and public organisations belong to the extensive, collaborative network. Together, they work hand-in-hand with international partners to maintain and improve food quality and safety along the value chain.

### **Take an interactive tour**

Food Nation's Visitor Centre in central Copenhagen and in Agro Food Park in

Aarhus welcomes international delegations, providing them with an introduction to Danish capabilities within food and agriculture. An interactive installation at the centre gives visitors an up-to-date overview of the food value chain based on their individual interests. It is the ideal starting point before visiting Danish food producers and production facilities. An inspiring preview is also available from the Food Nation digital universe. Here, inspirational publications, webinars, videos and talks provide insights into how Denmark can contribute to the green transition. Visit the digital platform at [foodnation.virtualhive.live](https://foodnation.virtualhive.live), register as a user and take a browse.

Food Nation is a great place to start learning about how Denmark support sustainable development through collaboration. Find out more about our services, the Danish food arena and arranging a visit to the Food Nation visitor centre at [foodnationdenmark.com](https://foodnationdenmark.com)



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