



By Denmark

WHITE PAPERS

for solutions of tomorrow

INGREDIENTS AND BIOSOLUTIONS

SMART DANISH SOLUTIONS
FOR SUSTAINABLE FOOD SYSTEMS
AND GLOBAL FOOD SECURITY

INSIDE THIS WHITE PAPER:

- A global hub for ingredients and biosolutions
- Rethinking food in a collaborative ecosystem
- Unlocking streams of circular innovation



Solutions of tomorrow
By Denmark

Ingredients and Biosolutions

Smart Danish solutions for sustainable food systems and global food security
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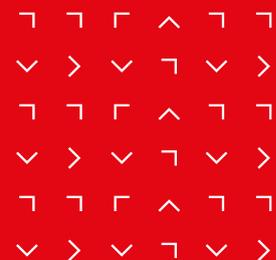
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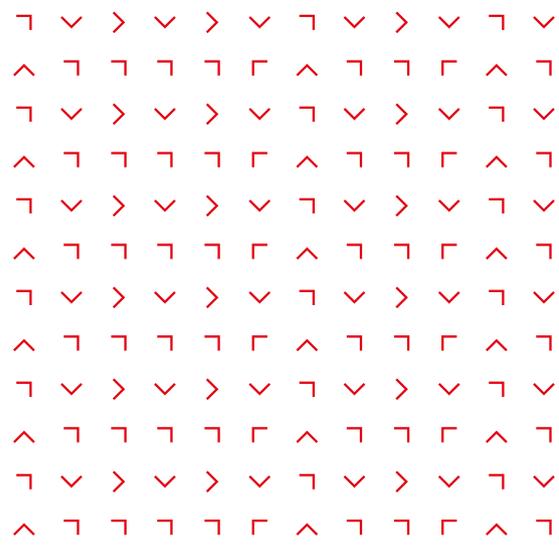
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EXECUTIVE SUMMARY

Danish ingredients and biosolutions meet urgent needs throughout the agrifood value chain – improving production efficiency, optimising resource utilisation and securing nutritious and appealing foods.

Ingredients and biosolutions – shaping the future of sustainable food

Global food systems face growing pressure to deliver more with fewer resources. As a global hub for science-backed solutions, Denmark plays a leading role in transforming agrifood production – advancing solutions that unite innovation, efficiency and sustainability.

Cross-sector partnerships between government, academia and industry enhance efficiency, reduce waste and improve the sensory and nutritional quality of food and feed. Significant efforts go into developing new protein sources to fill gaps in the global supply.

In primary production, the ingredients and biosolutions sector supports modern, climate-friendly farming practices by delivering tailored feed additives for livestock and targeted biosolutions that increase crop

yields while reducing inputs. Within food manufacturing, Danish ingredients enable producers to meet the growing demand for health-focused foods without compromising taste, texture or shelf life.

Circular innovation is another cornerstone, with new value chains emerging from under-utilised biomass and process side streams. Through advances in fermentation and bio-refining technologies, Danish scientists and entrepreneurs are creating high-value products from resources such as grass, clover and seaweed.

This progress is underpinned by a national commitment to scientific excellence. Recognised as a strategic growth area by the Danish government, biosolutions are supported by a strong ecosystem of research institutions and universities that are training the next generation of experts and innovators.

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Supporting the SDGs

How does Denmark contribute?

The UN's 17 sustainable development goals have provided a common framework for overcoming the world's most pressing challenges. Along with many other stakeholders, the Danish agriculture and food sector has taken the SDGs on board. Today, they serve as a guiding light for establishing best food production practices, prioritising research and development efforts and identifying innovation targets to drive us towards a sustainable future.

An efficient and sustainable food sector will contribute directly and indirectly to all 17 goals. However, there are some goals where the Danish food sector is expected to make a particular impact via its strongholds. These include **Goal 2** *End hunger, achieve food security and improved nutrition, and promote sustainable agriculture*; **Goal 3** *Ensure healthy lives and promote well-being for all at all ages*; **Goal 12** *Ensure sustainable consumption and*

production patterns; and **Goal 13** *Take urgent action to combat climate change and its impacts*.

Achieving the ambitious goals of the 2030 agenda requires global support and partnerships. Extensive collaboration throughout the food value chain and between industry, academia, NGOs and government is an

outstanding characteristic of the Danish food sector. By accelerating the progress of national and international initiatives, such united efforts directly contribute to **Goal 17** *Strengthen the means of implementation and revitalize the global partnership for sustainable development*.



FOREWORD



Pioneering catalysts of sustainable transformation

In Denmark, the ingredients and biosolutions sector is a dynamic space where adaptation, innovation and value creation are clearly thriving. Ever since the pioneering achievements of Danish scientists in the 19th century, the sector has developed solutions to contemporary challenges – improving the efficiency of food and feed production, setting new benchmarks for quality and food safety, and ensuring sensory appeal.

Working in strong, collaborative partnerships, businesses, universities and research institutes today identify and scale up new bio-based opportunities to drive circularity in food and feed production. Fermentation and biorefining technologies, enablers such as enzymes and cultures, and yield-improving biostimulants and biocontrols are among the innovative biosolutions that are exported to international markets.

Partnerships are also uncovering the potential of previously underutilised biomass to help meet the growing need for high-quality proteins and other bioactive compounds

that can support a healthy diet. The nation's growing community of enterprising startups includes many spinouts from such research collaborations.

The Danish government is committed to providing stable, supportive framework conditions that enable innovation, scale-up and international market access. Through targeted initiatives, including ambitions to further improve the regulatory framework allowing for further development and use of state of the art innovative solutions and technologies, the Danish Government actively aim to promote and facilitate companies in developing solutions that meet global demand for efficiency, quality and sustainability.

For international partners, this strategic focus translates into reliable collaboration, advanced technologies and long-term value creation. With ingredients and biosolutions at the heart of the green growth agenda, Denmark offers a strong platform for partnerships that can accelerate sustainable solutions worldwide.

This white paper offers a timely overview of Denmark's leading ingredients and biosolutions sector, where challenges have always been powerful catalysts for agri-food innovation. We invite you to explore how deep-rooted expertise and an entrepreneurial spirit are helping to shape a promising future.



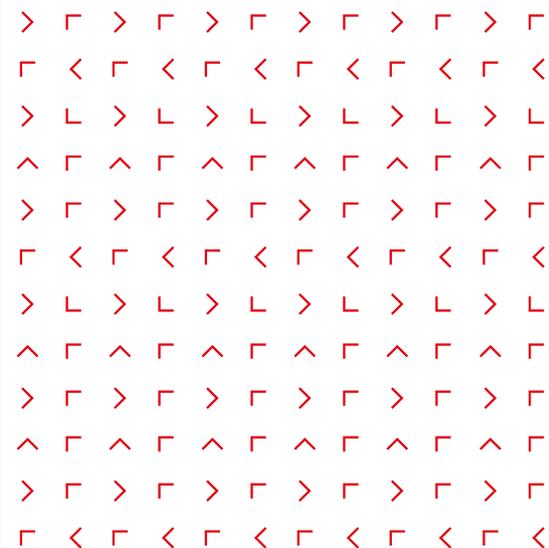
Jacob Jensen
Minister for Food, Agriculture and Fisheries



CHAPTER 1

A GLOBAL HUB FOR INGREDIENTS AND BIOSOLUTIONS

**SCIENCE-BACKED SOLUTIONS
TO FOOD SYSTEM CHALLENGES**



Danish innovation is driving the global transition to an efficient and sustainable food value chain.

Forming an innovative ecosystem, companies and research organisations play a great role in meeting the need for a safe, secure and sustainable food system

Denmark is a global hub for ingredients that facilitate an efficient agri-food sector while enhancing and ensuring the quality of feed and food. Forming an innovative ecosystem, the many companies and research organisations in the field today play an ever greater role in meeting the need for a safe, secure and sustainable food system.

In recent times, Danish agri-food biosolutions have risen in prominence. Building on the rich legacy of the science-based ingredients sector, these biosolutions are bio-based catalysts, fermentation agents and technologies that help reduce food loss and waste, save energy and water, optimise land use and biodiversity, support healthier diets and enable the transition to a circular bio-economy. Simply put, biosolutions make it possible to produce more using fewer resources, positioning them as key enablers of global food security.

150 years of setting the stage

A series of 19th century innovations set the stage for the Danish culture of continuous improvement and scientific excellence that drives ingredients and biosolutions as distinct yet overlapping categories.

As early as 1873, the founder of Chr. Hansen – today Novonesis – revolutionised cheese making by enabling the production of standardised, purified rennet. Then, just a decade later, Carlsberg developed the first purified yeast culture for brewing consistently high-quality beer – a fermentation milestone that went on to benefit dairies, bakeries, wineries and pharmaceutical companies the world over.

In 1890, pioneering research into lactic acid bacteria at the Danish Royal Veterinary and Agricultural University – today the University of Copenhagen – significantly improved the quality of butter. The findings also set a new standard for food safety control in dairy production.

Primed for fast-moving trends

Denmark's leading ingredient and biosolution companies have since captured a significant share of the global market for solutions that give food products a specific taste, functionality or nutritional quality or boost the digestibility and efficiency of animal feed. The goal is to help food and feed manufacturers respond to fast-developing market trends, changes in legislation and demands for more efficiency and reduced waste in the supply chain.

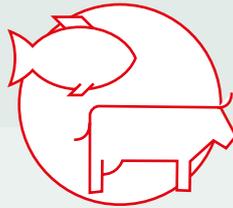
Many of these prominent businesses are also engaged in biosolution research and development, working closely with academia and a growing number of Danish biotechnology enterprises. By harnessing enzymes, microbes, functional proteins and other components from nature's own toolbox, biosolutions are helping to overcome some of the most pressing challenges to the global food system.

DANISH INGREDIENTS AND BIOSOLUTIONS IN BRIEF

INPUT



Biomass
e.g. crop residues
and food/ingredient production side streams



Animal-based
e.g. pigs, cattle, poultry,
fish, larvae, insects



Plant-based
e.g. potatoes, rapeseed,
cereals, peas, citrus fruits,
soy beans

PROCESS

Fermentation,
biorefining, filtration,
extraction and
other processing
technologies

OUTPUT

Feed & food ingredients

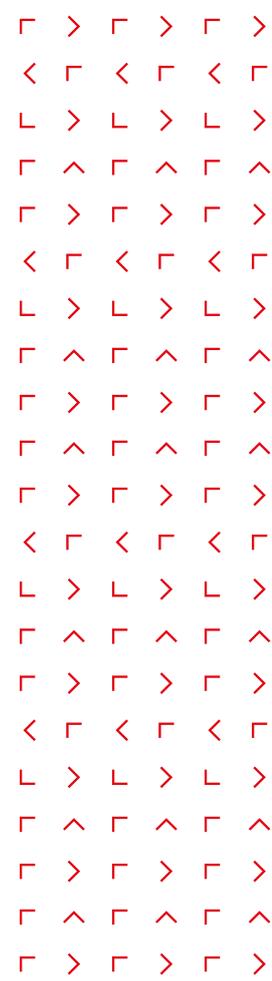
- > Directly consumed by humans or animals
- > Provide taste, texture, energy and/or nutritional value
- > Examples: proteins, fats, oils, starches, fibres, vitamins, minerals, emulsifiers, stabilisers, sweeteners, flavourings, preservatives, colourants

Feed & food biosolutions

- > Fermentation-based solutions
- > Improve taste, freshness, resource efficiency, quality and/or sustainability
- > Examples: enzymes, microbial cultures, probiotics, fermentation-derived proteins

Agri-food biosolutions

- > Bio-based innovations applied at farm or food processing level
- > Improve sustainability, resilience and/or productivity
- > Examples: microbial soil inoculants, biostimulants, biocontrol agents



FERMENTATION-BASED FLAVOUR WITH LOWER RESOURCE USE

The Danish company EvodiaBio is using fermentation technology to reinvent the production of natural flavours for food and beverages – providing an environmentally friendly alternative to traditional plant extract.

Flavours are widely used across sectors, from food and beverages to cosmetics and cleaning products. However, producing natural flavour compounds the conventional way can be highly resource-intensive. For example, one kilo of hop flavour takes nearly 3,000 litres of water, while one kilo of lavender flavour may demand up to 300 kilos of plant material.

EvodiaBio's yeast-based fermentation method replaces the need for harvested flavour crops by converting simple sugars into monoterpenes – the microscopic molecules that define flavour and scent. Years of research have enabled a scalable, industrial process where yeast cells secrete individual aroma components that are later blended to mimic the precise flavour profiles found in hops and other plants.

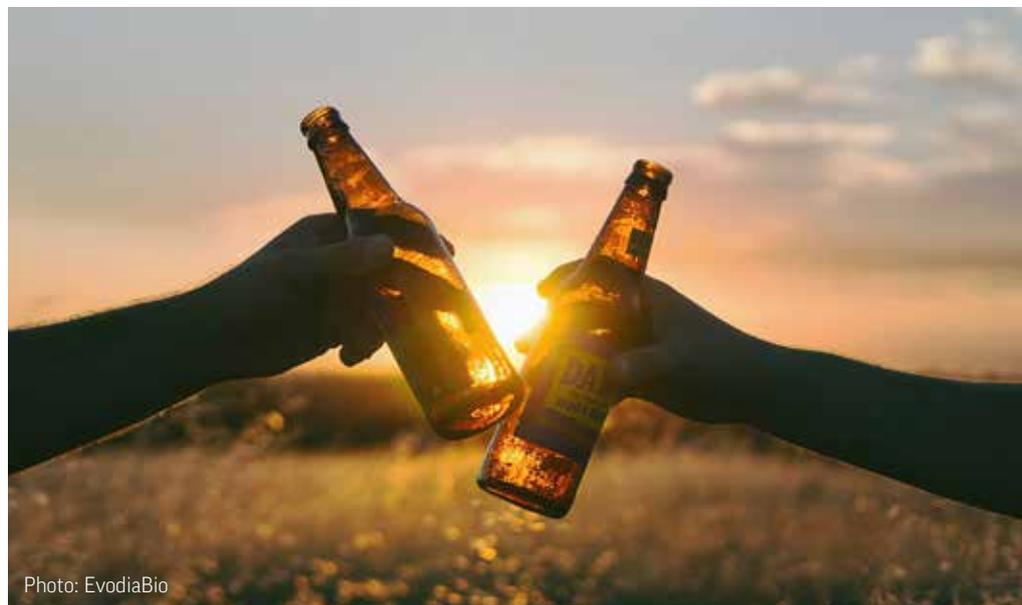
The first application targets the fast-growing market for non-alcoholic beer, where achieving an authentic beer flavour has long been a challenge. With EvodiaBio's solution, only one litre of water is needed to produce the equivalent flavour impact of one kilo of hops.

For breweries, this means a reliable flavour supply, consistent quality and significant environmental savings.

The fermentation technology cuts the carbon footprint of hop flavour by more than 80% while eliminating the need for land-intensive cultivation and irrigation. Looking ahead, EvodiaBio aims to expand the approach to beverages and other industries that rely on plant-based flavours.

Fermentation cuts the carbon footprint of hop flavour by more than 80%

Case by EvodiaBio



PURE PROTEIN FROM A HUMBLE SOURCE



Photo: KMC

World population growth has increased the need for new, sustainable protein sources. One source has long been overlooked – the potato. KMC, a Danish ingredient company owned by potato farmers, recognised this potential early on.

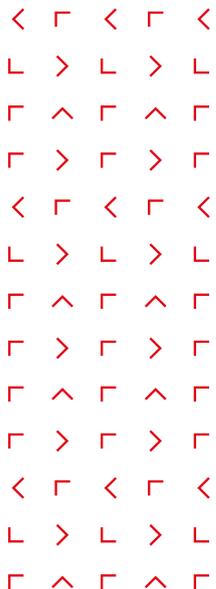
Since 1933, KMC has specialised in producing functional ingredients from potato starch for a wide range of food products. For many years, the protein-containing co-product from starch production was mainly sold as feed.

After several years of focused product development, KMC has now launched commercial potato protein for food – maximising the utilisation and value of the potato harvest while helping food manufacturers meet rising protein demands. Over time, all potato protein will be directed towards food applications.

The next step is to extract and utilise the plant fibres also present in potatoes. At the end of the process, only the mineral-rich potato juice remains, which KMC returns to the fields to nourish the next crop. This completes a fully circular supply chain, where every part of the potato is used.

Potato protein maximises the value of the entire potato harvest

Case by KMC



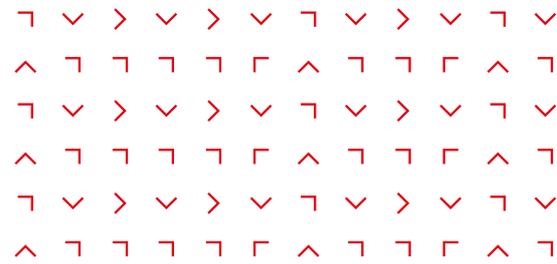




CHAPTER 2

RETHINKING FOOD IN A COLLABORATIVE ECOSYSTEM

AN EXPERT NETWORK OF POOLED RESOURCES



Denmark has a long history of cross-sector partnerships. In the agrifood sector, co-development supports ingredient and biosolution innovation for a well-balanced world.

Science-based innovation is a defining characteristic of the long Danish tradition for cross-sector collaboration. Just as Denmark's first dairy cooperatives built international export strategies in the mid-19th century, today's farmers, businesses, universities, research institutes and government work together to develop ingredients and biosolutions for agri-food production.

In many ways, biosolutions are a natural extension of Denmark's expertise in ingredient research and development. Danish companies excel in tailoring solutions to make the best use of scarce resources, extend shelf life, optimise nutrient bioavailability and minimise quality deviations on production lines.

Innovative biosolutions take this further by using biology to get the most out of every raw material. They make industrial processes cleaner and more efficient, while turning side streams from farming and food production into high-value ingredients. Many of these biosolutions are the outcome of cross-sector partnerships.

Relieving the protein challenge

One of the most urgent global challenges that biosolutions can help relieve concerns the world's growing consumption of protein, which is expected to double by 2050.

Fermentation is a powerful natural process in this regard and the subject of extensive research and development collaborations in Denmark. By improving the digestibility, nutrient availability and palatability of the proteins in legumes and other plant-based sources, a number of fermentation technologies are already contributing to the global protein supply.

Carefully selected microorganisms are another valuable tool, capable of converting residues and even methane emissions into high-quality proteins for feed and food.

By unlocking new protein sources in this way, sustainable biosolutions have the potential to boost the global supply of conventional animal-based proteins and protein-rich crops. As suppliers of the necessary biomass, farmers play an essential role in the innovation value chain.

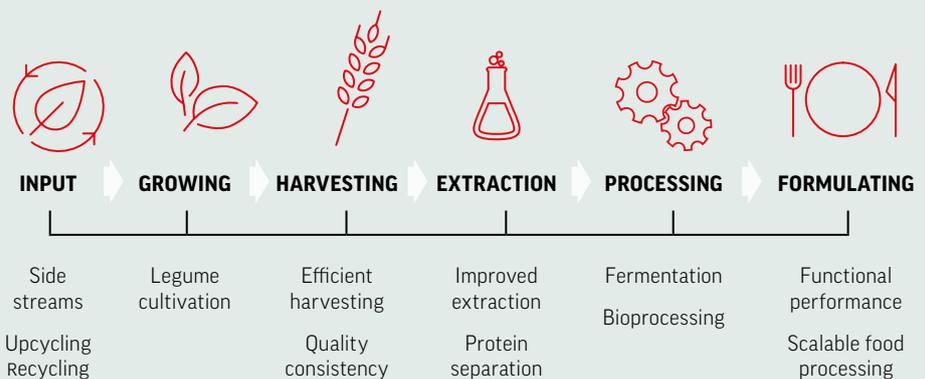
Co-development in a spirit of trust

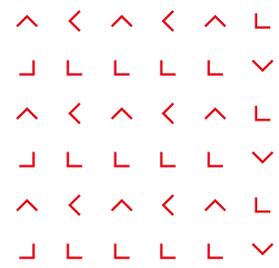
The collective effort to increase protein production focuses on utilising local biore-sources in combination with new technologies. This work involves ensuring the protein is both safe to consume and has the right functional and nutritional quality for industrial-scale processing.

For international partners seeking sustainable ingredients and biosolutions, the Danish culture for collaboration is an effective enabler of research and product development. Always in a spirit of mutual trust.

First-class quality and food safety standards are a hallmark of the Danish ingredient industry

Innovation across the value chain supports the global protein challenge





BIOINFORMATICS REVEALS BUSINESS POTENTIAL IN SIDE STREAMS



A collaboration between the Technical University of Denmark (DTU), Aalborg University and five Danish companies has resulted in a new bioinformatics-based method for identifying valuable proteins in industrial sidestreams.

As the demand for sustainable food production increases worldwide, the industry is seeking ways to utilise raw materials more efficiently and reduce waste across the value chain.

When potatoes, seaweed and other crops are processed into ingredients such as starch, alginate or carrageenan, significant volumes of protein-rich sidestreams remain. These have traditionally been used for animal feed or returned to fields as fertiliser – practices that overlook valuable components with potential uses in food production. Using modern bioinformatics, the research partners can scan sidestreams for specific proteins and convert them into functional peptides.

Early work has identified peptide emulsifiers in potato protein, which can be used for encapsulating and extending the shelf life of fish oil – a sensitive ingredient prone to oxidation.

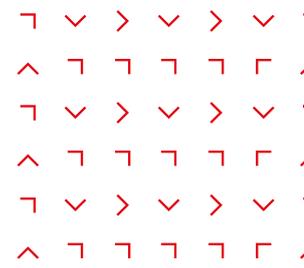
Protein extraction increases the value of side streams a thousand-fold

The same approach may reveal flavourings, preservatives and other functional ingredients in a wide range of protein-containing sidestreams.

Beyond optimising resource use, the method has significant commercial potential. The value of sidestreams can increase by a thousand-fold when proteins are extracted and upgraded into high-value food ingredients. Because these proteins originate from familiar raw materials, they also meet consumer demand for naturally functional solutions.

The technology is applicable far beyond potatoes and seaweed and can be used to analyse any protein-rich sidestream, including wastewater from fish processing.

Case by DTU and Aalborg University



FERMENTATION-BASED PROTEIN SUPPORTS RESOURCE-EFFICIENT FEED PRODUCTION

Increasing global demand for protein places pressure on land, water and conventional feed ingredients such as soy and fishmeal. At the same time, climate considerations and supply-chain volatility underline the need for new ways to produce protein efficiently and independently of agricultural constraints.

Unibio has developed a fermentation technology that converts methane into a highly concentrated and nutritious protein ingredient known as Uniprotein®. The process replicates a natural microbial mechanism and offers a stable protein source that can be used in feed for animals, aquaculture and pets. Uniprotein® is already approved for use in the EU, and development work is ongoing to explore its potential in human nutrition.

Resource-efficient protein with minimal water and no farmland

Central to the approach is Unibio's patented U-Loop® fermentation technology – a continuous flow system that achieves high conversion rates and efficient methane utilisation. This enables consistent production in controlled conditions without relying on arable land, high volumes of water or seasonal crops. The protein is subsequently purified and processed into a high-quality ingredient.

When compared with traditional feed proteins, Uniprotein® provides a reliable alternative to fishmeal and soy. It supports stable feed formulation, reduces dependency on fluctuating raw material markets and contributes to long-term food security. Because the production method requires minimal water and no farmland, it offers a resource-efficient pathway to scaling protein availability.

Case by Unibio





CHAPTER 3

A BIO-BASED PRIMARY SECTOR FROM PAST TO PRESENT

PIONEERING THE TRANSITION OF FARMING PRACTICES

Danish ingredients and biosolutions have long enabled efficient crop and livestock farming. Today they are meeting needs for more yield with less input.

Optimising land use, maximising yield and minimising environmental footprint are central pillars of the transition to competitive green farming. Denmark is at the forefront of this transformation, leveraging ingredients and biosolutions to enable efficient and responsible farming practices.

Farmers have long relied on Danish ingredient companies to deliver solutions that improve animal welfare and performance and enhance the efficiency and sustainability of crop cultivation. This pioneering tradition is behind the well-documented solutions that Denmark brings to international markets.

Danish biosolutions enable farmers to produce more with less – improving yields while reducing environmental impact

Tailored advances in animal nutrition

In modern livestock production, tailored feed additives play a vital role in enhancing animal health and growth. Enzymes improve the digestibility of feed, allowing animals to extract more nutrients from their diets. Probiotic cultures are widely used to improve feed efficiency and maintain a balanced gut microbiota. Other additives help reduce the impact of naturally occurring toxins in feed crops or mitigate methane emissions from cattle.

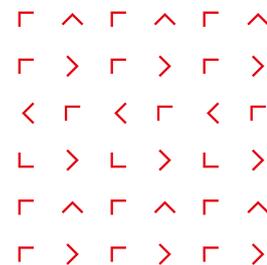
Innovative ingredients also help farmers adapt to new legislation. In pig production, for instance, ingredients are overcoming the challenges associated with EU restrictions on zinc and antibiotics. As always, the priority is to support animal health and welfare without compromising productivity.

Biological strategies for high-yield crops

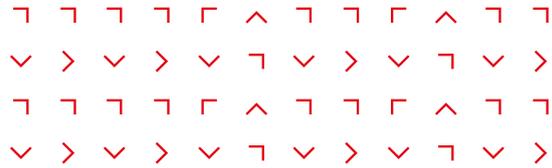
Biosolutions address growing challenges in crop cultivation, from nutrient losses and soil degradation to the stress of climate change.

Biostimulants enhance plant growth and resilience to stress, biofertilisers improve nutrient availability and biological plant protection helps plants resist pests and diseases, reducing reliance on conventional inputs. Effective use contributes to more sustainable and resilient agricultural systems.

Alongside these innovations in the field, Danish plant breeders increasingly draw on modern biotechnology in the development of crop varieties for sustainable farming. Yield, robustness and adaptability to various soils and climates are all in focus. The aim, as always, is to build an efficient primary sector in balance with the planet.



MICROBIAL SEED TREATMENTS THAT IMPROVE CROP PERFORMANCE



Nordic microbes develops microbial seed treatments designed to enhance crop growth and make more efficient use of resources. The company aims to enable crop production that maintains yield and farmer income while lowering the environmental footprint. One of its main products, SeedSpeed®, has been tested in spring barley, winter wheat, faba beans, peas and maize.

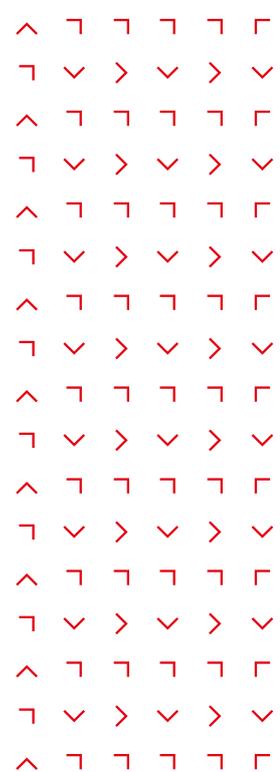
In field trials with maize, SeedSpeed® increased yield by 13.3%, increased protein content by 28%, and ensure taller plants and fully filled cobs compared to untreated crops. These results illustrate how microbial seed treatments can improve performance without adding synthetic fertilisers or pesticides.

Field trials show yield increases of 13.3% in maize when using microbial seed treatment

Interest in microbial solutions is growing in response to farmer needs to maintain productivity while reducing their reliance on synthetic inputs. Beneficial microorganisms can support seed germination, root development and early plant establishment – areas where small improvements can translate into measurable differences in yield and crop quality.

By supporting stronger root systems and better nutrient uptake, microbial seed treatments help reduce dependency on chemical inputs while preserving crop productivity. For farmers, this translates into improved feed efficiency, reduced waste and a pathway to increased profitability. At a broader level, microbial technologies contribute to more resource-efficient agricultural systems that address sustainability targets without compromising output or stability.

Case by Nordic microbes



PHEROMONE-BASED PEST CONTROL SUPPORTS HEALTHIER CROPS

Biological alternatives to synthetic pesticides are gaining traction as a means to reduce the environmental impact of farming without compromising yield.

One effective approach uses insect pheromones – natural compounds released in tiny amounts by insects to attract mates. When applied in fields, these compounds disrupt mating cycles and limit the emergence of new pest generations without affecting beneficial insects.

To make pheromone-based pest control widely accessible, scalable production methods are required. FMC has developed a biosolution-driven technology that combines yeast modification, fermentation and chemical processing to produce pheromones at industrial scale. This approach significantly lowers production costs and makes it possible to supply pheromones target a wide range of pests across crops such as corn, rice, fruit, cotton and vegetables.

Field trials in Brazil, Mexico, the USA, Spain, Hungary, China and Indonesia have demonstrated a strong effect on major pests, including fall armyworm. By reducing pest pressure and crop damage, pheromone-based tools support healthier crops throughout the growing season and help maintain yield quality and quantity.



Because pheromones are species-specific, they leave bees and other beneficial insects unharmed. This supports biodiversity and provides farmers with an environmentally friendly pest control. With a scalable production method, pheromones are becoming a practical biosolution for integrated pest management across global farming systems.

Biosolution-enabled pheromone production increases availability for farmers globally

Case by FMC

FEED STABILISATION IMPROVES NUTRIENT RETENTION AND SUPPORTS MILK YIELD



Preventing feed overheating helps reduce nutrient loss in dairy production

The solution is particularly relevant during periods of high temperatures or for feed mixes that are prepared less frequently, such as those used for young animals. By extending the time before heating occurs, FreshFoss supports better feed utilisation and reduces waste.

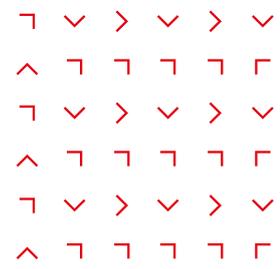
Field observations from Bulgaria indicate that dairy cows offered FreshFoss-treated rations consumed more dry matter and that ration temperatures remained significantly lower up to eight hours after mixing. Farmers also reported improved average daily milk yield, highlighting the potential benefits of feed stabilisation for productivity and resource efficiency.

FreshFoss demonstrates how targeted feed innovations can support farmers in maintaining production efficiency while minimising nutrient loss and feed waste.

Warmer weather is increasingly affecting agricultural production, leading to challenges in maintaining feed quality and efficiency in dairy systems. During hot periods, feed rations for dairy cows can heat up rapidly on the feeding table, causing yeast and mould growth. This reduces feed intake, leads to nutrient loss and increases waste, ultimately impacting animal health and milk production.

Vilofoss has developed the feed solution FreshFoss to address these challenges by stabilising rations and protecting their nutritional value. FreshFoss consists of acid salts in powder form that are mixed into the feed before distribution. The acids inhibit the growth of yeast and mould, reducing the biological activity that causes heating. As a result, the feed remains palatable for longer, retains more nutrients and can be used more efficiently by the animals.

Case by Vilofoss



A NATURE-BASED SOLUTION FOR REDUCING NITROGEN LEACHING AND IMPROVING SOIL HEALTH

Soil health and biodiversity are essential foundations for sustainable farming. Yet intensive agricultural practices can lead to nutrient runoff, disturbing soil ecosystems and reducing the diversity of microorganisms that are vital for nutrient cycling. Maintaining soil biodiversity is, therefore, key to improving resilience in agricultural systems and enabling farmers to adapt to environmental changes.

To address these challenges, Danish seed company DLF has developed Agritain – a nature-based forage solution that reduces nitrogen leaching while enhancing soil health. When integrated into pastures, Agritain functions both during and after digestion in livestock by reducing the amount of nitrogen excreted in urine and diluting its concentration. This results in less nitrogen being released into the soil over time.

As a biosolution, Agritain harnesses plant biology to manage nitrogen naturally – providing an alternative to synthetic fertiliser interventions and supporting a biological approach to nutrient efficiency.

Agritain can reduce nitrogen leaching by 20-60%



Photo: DLF

Agritain also contains natural compounds that slow the conversion of ammonium to nitrate. This allows plants to absorb more nitrogen directly, lowering the risk of leaching into groundwater and nearby ecosystems.

Beyond reducing nitrogen runoff, Agritain contributes to healthier soils through its deep-root system, which adds organic matter and improves soil structure. These improvements support a more diverse ecosystem of beneficial organisms – including

bacteria, fungi, earthworms and insects – all of which are essential for nutrient cycling and long-term soil vitality.

Through innovation in forage breeding, DLF demonstrates how biosolutions can strengthen the circularity and resilience of agricultural systems – improving productivity while reducing environmental impact.

Case by DLF

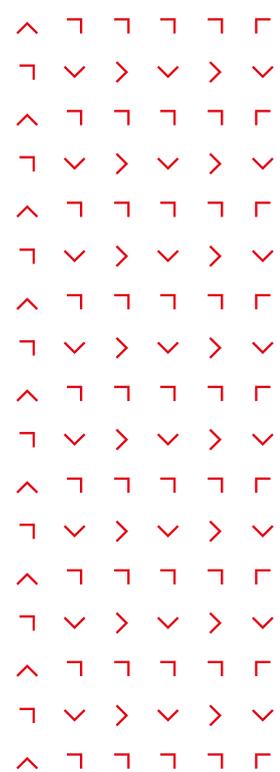
A close-up photograph of a white ceramic bowl with a green rim, filled with white yogurt. The yogurt is topped with a generous amount of golden-brown granola, fresh blueberries, and sliced strawberries. The background is softly blurred, showing more of the same ingredients and a glass of water. The overall lighting is bright and natural, highlighting the textures of the food.

CHAPTER 4

**THE TASTE OF SUCCESS
IN HEALTHIER FOOD**

**ONLY THE BEST QUALITY FOR
INTERNATIONAL MARKETS**





Danish food science meets global demands for functionality and nutrition. Local innovation hubs tailor solutions to regional preferences

Responsible food production has many perspectives. As global market surveys show again and again, a great taste is key to success. Moreover, the ability of food products to stay appealing and safe throughout their shelf life is crucial to minimising waste.

The Danish ingredients and biosolutions sector is rich in opportunities to improve the flavour and functionality of processed foods and help prevent spoilage during distribution and storage. As the link between diet and health draws increasing attention, many companies are also leading the way with solutions that balance nutrition with indulgence.

Improving the nutritional quality of everyday foods may involve reducing the content of sugar, salt or fat. Here, food manufacturers can look to enzymes that increase the natural sweetness of foods, whey proteins that mimic the creaminess of fat, or cultures that improve taste and texture or enable salt reduction – to name just a few examples. They are all part of a powerful toolkit for producing healthier foods without sacrificing shelf life or consumer enjoyment.

Benefits for health and wellbeing

Many Danish companies use bioscience to develop ingredients that support health-focused food innovation. In close collaboration with universities and research institutes, they are advancing scientific understanding of proteins, dietary fibres, probiotic cultures and nutrient compounds.

Microbial fermentation is among the bio-based technologies driving new developments within specialised nutrition. These innovations make it possible to tailor ingredients and biosolutions to varying nutritional needs throughout life. Ongoing research is exploring their possible role in supporting the human microbiome, recovery after illness and overall dietary well-being.

Adapting solutions to local needs

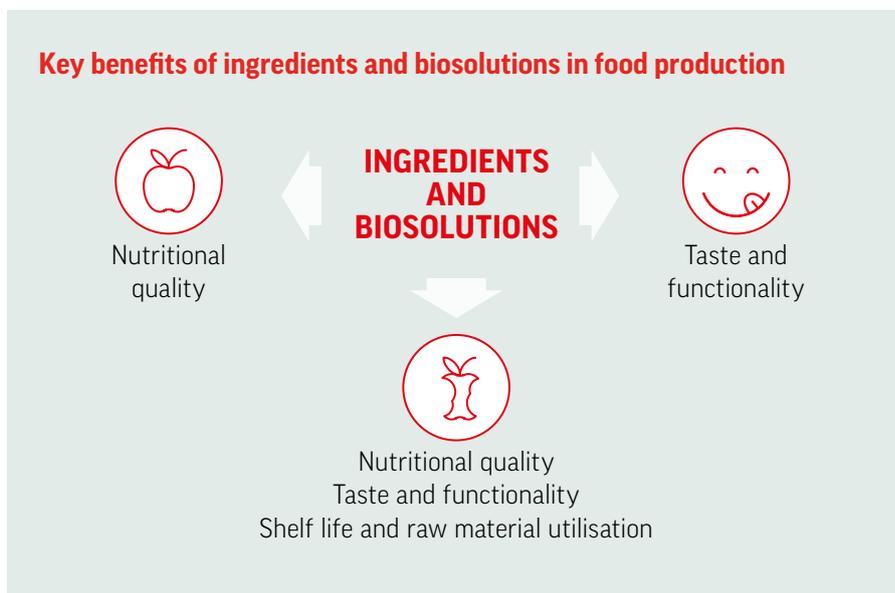
Food manufacturers increasingly look to ingredient and biosolution suppliers for ideas and inspiration as well as tailored formulations. To meet this need, many of Denmark's international companies operate innovation hubs around the world, where they adapt solutions to local raw materials, preferences and regulatory requirements. This global-local approach is a sure way to staying relevant and effective across markets.

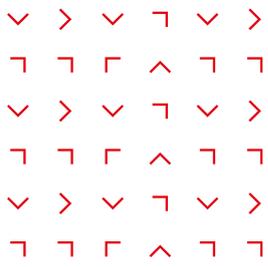
Building trust on global markets

Denmark's ingredients and biosolutions sector is known for high standards of quality and food safety, a reputation that builds trust and facilitates access to global markets.

By consistently complying with some of the world's most demanding food safety regulations and certification schemes, Danish companies demonstrate reliability and professionalism, giving international partners confidence in the safety and quality of their products.

Danish science helps food producers balance great taste, nutrition and sustainability





PRESERVING FRESHNESS TO REDUCE FOOD WASTE

Large volumes of bread and dairy products are lost every year due to spoilage, staling and quality decline before consumption. Bread can lose freshness rapidly, while yoghurt is vulnerable to mould growth even during refrigerated storage. These losses represent wasted raw materials, energy, transport emissions and labour across the food value chain. With increasing demands for high-quality foods and fewer synthetic additives, manufacturers are seeking new ways to extend shelf life without compromising taste or texture.

Novonesis has developed enzyme and culture-based preservation solutions that help maintain freshness by slowing microbial spoilage and delaying staling. In yoghurt, selected beneficial cultures inhibit the growth of unwanted microorganisms, protecting both quality and taste. In bread, enzymes act during baking to help starch molecules retain moisture and remain flexible for longer, preventing the stiff crystals that cause rapid staling. The approach supports better taste retention, improved mouthfeel and extended shelf life.

The same preservation principles can be applied to a broader range of foods, including ready-made meals, fish and other perishable categories where microbial growth or texture decline limits usable life. By maintaining freshness for longer, biological preservation reduces food waste and increases the proportion of products that reach consumers in prime condition.

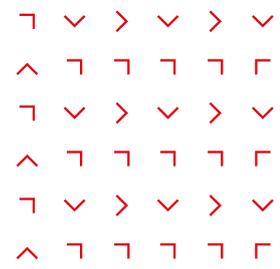
Improved preservation technologies from Novonesis have cut yoghurt waste by more than a million tonnes over the past decade

Novonesis reports that more than one million tons of yogurt have been saved through improved preservation technologies over the past ten years. Bread waste has been reduced by billions of loaves since 1990, cutting CO₂ emissions by millions of tonnes. Extending shelf life helps ensure more food is eaten rather than lost – using fewer resources along the way.

Case by Novonesis



Photo: Novonesis



STRENGTHENING NATURAL FOOD COLOUR PRODUCTION THROUGH TARGETED PLANT BREEDING

Oterra has more than doubled pigment concentration in black carrots, reducing land use and resource requirements

Demand for natural food colours is rising globally, driven by consumer interest in transparency, nutrition and sustainable ingredient choices. Denmark has strong capabilities in this field. Active in more than 120 markets, Oterra is one of the world's leading suppliers of natural food colours.

To meet growing demand efficiently, the company has strengthened each part of its value chain from plant development to final ingredient production.

A key element of Oterra's approach is targeted plant breeding. By crossbreeding parent plants and selecting offspring with naturally higher pigment concentrations, Oterra increases pigment yield per hectare. One example is the black carrot, a source of anthocyanins. Through systematic breeding, pigment content in black carrots has been more than doubled, improving productivity on farms and reducing the amount of land, transport and processing capacity needed to achieve the same output.



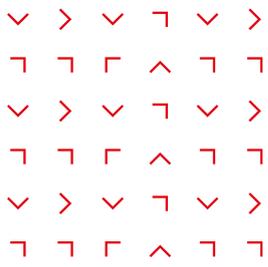
Photo: Oterra

In addition to plant breeding, Oterra applies a production method known as 'colouring foodstuff', in which juice concentrates are produced, instead of being obtained by direct extraction from the plant. This preserves more of the raw material's original nutritional value, offering additional benefits in the final food product.

The combined approach supports a more resource-efficient production of natural

colours. Higher pigment yields reduce the environmental footprint per kilo of colour produced, while tailored natural colourants offer manufacturers a clean-label alternative to synthetic options. By advancing both plant breeding and processing methods, Oterra supports growing demand for natural and sustainably produced food colour solutions.

Case by Oterra



PLANT-BASED FOODS THAT MATR

Feeding the world's growing population calls for innovative production technologies that can produce more protein on very little land and with a low impact on nature and the climate.

Danish food tech enterprise MATR Foods has taken on the challenge. Using fungal fermentation, the company has developed a

new generation of plant-based products that are rich in protein, fibre and taste – and have the potential to free up to 15% of the world's agricultural land.

Each product contains MATR's signature fermented ingredient, based on a mix of five locally sourced, organic raw materials: oats, split peas, lupins, beetroot and potatoes.

For the fermentation process, MATR Foods identified and developed a distinctive fungus, which transforms the structure and consistency of the raw materials. This is what gives them a juiciness, bite and umami flavour that closely resembles meat.

MATR Foods has the potential to free up to 15% of the world's agricultural land

The process requires no additives, very little energy and just a tenth of the crops that go into conventional meat production.

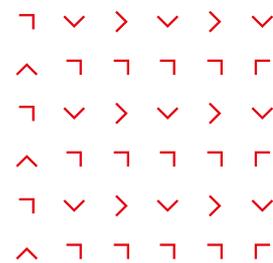
At MATR Foods, the goal is to make satisfying plant-based foods easily available to consumers who want to eat less meat without sacrificing taste and texture. Supporting local farmers and reducing the environmental impact of food production are also key to the mission.

For now, the plant-based ingredient is made with classic Danish crops. However, the fermentation process works with many other plant raw materials. They could be the next recipe for positive change.



Photo: MATR

Case by MATR Foods



TRANSFORMING WHEY INTO HIGH-VALUE NUTRITION

Global life expectancy has doubled over the past century and is now estimated at around 73 years. As populations age, demand is increasing for foods that support active lifestyles, mobility and overall health. This creates a need for protein ingredients with high nutritional value that can be used across a wide range of food categories.

Arla Foods Ingredients, a Danish farmer-owned company, specialises in upgrading whey – formerly regarded as a low-value by-product of cheese production – into high-quality nutrition for human nutrition. By refining and fractionating whey proteins, the company develops solutions for early-life nutrition, sports nutrition and a growing range of everyday foods where protein functionality and digestibility are important.

The development of whey-based ingredients has created a new value chain within the dairy sector. Modern processing technologies allow Arla Foods Ingredients to extract and isolate specific proteins with tailored functionality, enabling food manufacturers to design recipes with improved texture, nutrition and stability. Whey proteins are rich in essential amino acids and easy to digest, making them ideal for foods that support active and healthy lifestyles at any age.



By turning whey into a valuable resource, Arla Foods Ingredients reduces waste streams in dairy processing and increases the utilisation of raw materials. In this way, by-products can be reintroduced to the value chain as high-quality nutrition, supporting nutrition and contributing to more resource-efficient production.

Whey proteins improve texture, nutrition and stability

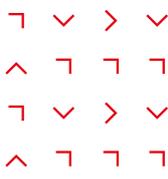
Case by Arla Foods Ingredients



CHAPTER 5

UNLOCKING STREAMS OF CIRCULAR INNOVATION

NEW VALUE CHAINS WHERE EVERYTHING COUNTS



Ingredient and biosolution technologies are creating new opportunities to make the most of all components in process side streams and unexplored biomass.

Danish ingredient and biosolution companies embrace circularity as a core principle of innovation. For decades, they have extracted useful components from the by-products of other production lines. Pectin from juice processors' leftover citrus peel; proteins from the whey side streams of cheese production; and fishmeal and oil from fish offcuts are just some examples. The outcome is functional enablers and high-quality nutrients for food, feed and dietary supplements.

Strategies for cascade utilisation

Ongoing research and innovation continues to discover high-value nutrients in side streams that were previously spread on fields, used as low-cost animal feed or burned as fuel. As knowledge and technology progresses, traditional perceptions of waste are being transformed.

Advanced biotechnologies transform side streams into high-value ingredients – where nothing goes to waste

Spent coffee grounds, rapeseed cake and potato fibres are among the side streams that are gaining new life as valuable raw materials – coffee grounds for their content of bioactive compounds; rapeseed cake and potato fibres as sources of high-quality protein. Advanced biotechnologies enable efficient extraction, supporting cascade utilisation of natural resources and minimising waste.

The hidden value in biomass

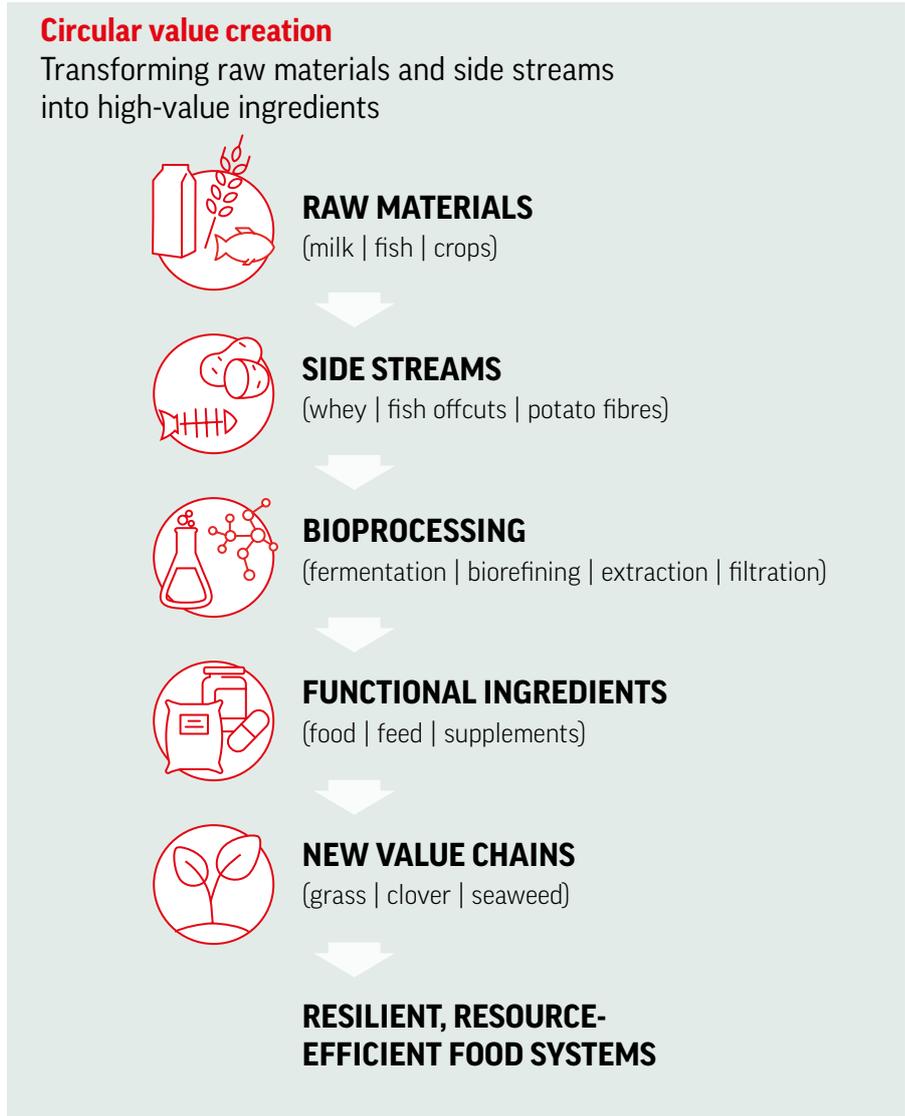
Bio-based innovation does more than enable circularity. In Denmark, it is also creating entirely new value chains by unlocking the potential of biomass such as grass, clover and seaweed. Developments within fermentation and biorefining are paving the way to exciting new ingredients from these and

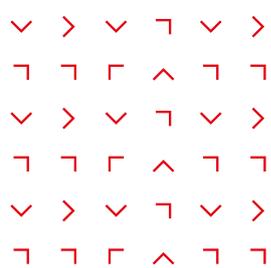
other raw materials. By generating local revenue streams, such technologies promise to support rural economies and contribute to a more resilient, diversified bioeconomy.

Further promising advances within fermentation include harnessing microorganisms present in nature to cultivate new raw mate-

rials for feed and food – another area where Danish scientists and start-up enterprises are collaborating to develop and scale the technology.

As global food security becomes an increasingly urgent priority, circular innovation is a vital pathway to resilient, resource-efficient food systems.





TRANSFORMING SURPLUS INGREDIENTS INTO HIGH-QUALITY FLAVOUR SOLUTIONS

REDUCED has upcycled more than 100 tonnes of by-products into natural savoury flavours

Food loss is a major sustainability challenge. Globally, around 1.6 billion tonnes of food are lost or wasted every year, contributing an estimated eight percent of total greenhouse gas emissions. These losses represent not only wasted resources but also a missed opportunity to create value from under-utilised raw materials across the food system.

REDUCED, a Danish flavour solutions company, develops natural savoury products using surplus ingredients that would otherwise

be discarded. The company sources by-products from agriculture and the food industry – including rapeseed cake, broken lentils, surplus chickens from egg production, shore crabs and second-grade vegetables – and transforms them into concentrated flavour profiles. This approach supports both resource efficiency and the development of new flavour systems.

At the core of REDUCED's method is an accelerated fermentation process that combines artisanal fermentation principles with modern biotechnology. By using a specific koji fungal spore that produces flavour-enhancing enzymes, REDUCED can unlock umami characteristics in diverse raw material streams. The process allows the company to convert by-products into additive-free savoury flavours within a shorter production timeframe than conventional fermentation methods.

To date, REDUCED has a continuous focus on reducing processing time, improving energy efficiency and expanding production capacity. The next milestone is to achieve a capacity of 500 tonnes of upcycled ingredients.

Case by REDUCED



EXTENDING SHELF LIFE OF MEAT PRODUCTS TO REDUCE WASTE

Consumer perception of fresh meat and poultry is heavily influenced by appearance. Products that lose colour or release liquid early in shelf life are often perceived as inferior and discarded. This contributes to retail and consumer-level food waste – a key barrier to achieving global food waste targets.

Turning by-products into proteins that reduce meat waste

To address this, Essentia Protein Solutions develops natural functional ingredients from meat processing side streams, such as pork rind and greaves. These materials are transformed into proteins and pigments that improve product stability and appearance in chilled meat counters. For example, microgranulated meat pigment maintains colour, while functional meat proteins minimise liquid seepage and support shape retention in patties and meatballs.

By utilising these upcycled raw materials, the company reduces waste at two levels: first, by converting industry side streams into functional food ingredients and, second, by extending the shelf life and appeal of finished meat products, reducing waste

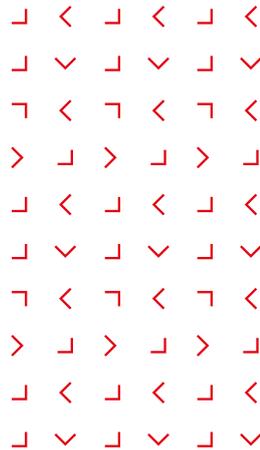


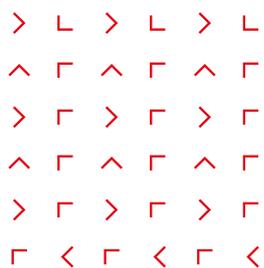
Photo: Essentia Protein Solutions

due to perceived quality decline. These solutions also support producers and retailers in meeting consumer demand for cleaner-label ingredients and greater transparency.

Through enhanced freshness, stable appearance and efficient use of side streams, Essentia's approach contributes to retail-ready meat and poultry products that reach more consumers and waste less.

Case by Essentia Protein Solutions





RICH INGREDIENTS FRESH FROM THE SEA

In climate-smart feed formulations, marine ingredients reduce reliance on land-intensive crops and optimise the use of natural resources

Safe and efficient feed is essential to profitable aquaculture and terrestrial livestock production. This is why fishmeal and fish oil are such important ingredients to farmers all over the world. Rich in amino acids, vitamins and omega-3 fatty acids, there is nothing quite like them for supporting the growth, health and immune function of marine and land-based animals.

Denmark is Europe's leading producer. With annual exports valued at around US\$936 million, the Danish fishmeal and fish oil sector delivers premium ingredients to feed and pet food manufacturers in more than 40 countries.

Production is rooted in responsible resource use and modern biorefinery technology. Most of the raw materials are short-lived pelagic species such as sprat and sandeel, which have limited use in direct food production. Around 25% are upcycled trimmings from seafood processing.

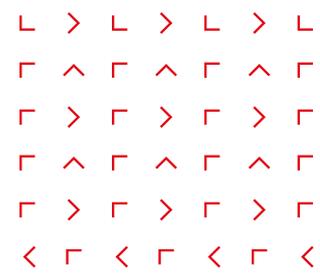
Strict traceability, species separation and continuous quality control underline the commitment to sustainability and transparent sourcing - along with international certifications which include Marine Stewardship Council (MSC), Aquaculture Stewardship Council (ASC) and MarinTrust. The mid-water gear used for pelagic fishing avoids seabed impacts and minimises ecosystem disturbance

In climate-smart feed formulations, marine ingredients reduce reliance on land-intensive crops and optimise the use of natural resources. Danish biorefining innovation and the continuous improvement of sustainability standards demonstrates the vast potential of marine biomass to contribute to a circular, bio-based economy.



Photo: Mai Mortensen

Case by Marine Ingredients Denmark



PLUG-AND-PLAY INGREDIENTS FROM UPCYCLED SIDE STREAMS

Many valuable raw materials end up as side streams in food manufacturing plants. For manufacturers, these often unavoidable by-products require expensive handling and disposal. High volumes of untapped resources go to waste in this way.

For every kilo of regular flour replaced, 2 m² of land normally used for flour production are saved on average



Photo: Agrain

Danish Agrain is on a mission to turn waste into value. Using a patented process, the young enterprise upcycles plant-based side streams into innovative powder ingredients that utilise all raw materials. They can even replace some of the conventional ingredients in food production – saving costs and creating a big circular win for business.

The process is designed to handle highly variable side streams, including spent grain from breweries and discards from juice, coffee and oat drink production. Food safety and the consistent taste, nutrition and quality of the upcycled ingredients are priorities to ensure their easy integration in existing food production lines.

Upcycling is at its best when the solutions are plug-and-play. Agrain's spent grain ingredients can, for example, partly replace regular flour in a wide range of baked foods, pasta and snacks. For every kilo of regular flour replaced, around two square metres of land normally used for flour production are saved, as no new grains need to be grown. Water, CO₂ emissions, and fertiliser and pesticide use are also reduced in the same way.

Recognising the challenges facing cocoa production, Agrain has also developed a 100% upcycled replacement for up to 50% of the cocoa powder in a wide range of applications. Selected spent grain and cocoa bean shells are the upcycled raw materials.

Agrain is currently the only upcycling company in Europe with Upcycled Certified® status. A circular food system is the goal – in partnership with likeminded food industry players.

Case by Agrain

A close-up photograph of a hand holding a small, green, grass-like plant with a visible root system. The plant is being held over a petri dish on a laboratory bench. In the background, other petri dishes and laboratory equipment are visible, though out of focus. The lighting is bright, highlighting the green of the plant and the texture of the hand.

CHAPTER 6

NATIONAL COMMITMENT TO BIOECONOMY LEADERSHIP

INNOVATION ROOTED IN WORLD-CLASS RESEARCH

The Danish government has earmarked biosolutions as a strategic growth area. A country-wide network of knowledge providers is the scientific foundation.

Ingredients and biosolutions are a national priority in Denmark. Recognising their potential, the Danish government has launched strategic initiatives to drive innovation and create a supportive framework for bio-economy leadership. A primary goal is to accelerate the green transition through the development of sustainable biosolutions that address key global challenges.

Established international businesses and agile startups do not stand alone in realising this national ambition. At their foundation lies a world-class research environment.

Denmark's universities and knowledge institutes are essential partners in creating and validating new bio-based solutions and technologies. Working closely with industry, they provide critical insights across the value chain, supporting the transition to a more circular food system where health, nutrition and environmental impact are central considerations.

Faster time to market

For the vibrant startup community, a number of highly specialised facilities exist to derisk innovation and speed up time to market. These include the Danish Technological Institute's Biosolutions Technology Centre, where lab-scale technologies can be tried and demonstrated.

Several more centres of excellence exist for trials with biofermentation of proteins and other molecules relevant to food, agriculture and the materials industry. With proof of concept in hand, startup enterprises are well-positioned to seek commercial partners and further capital investment.

The next generation of experts

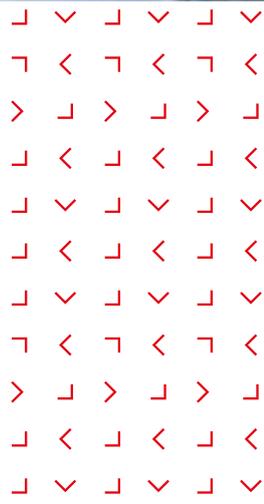
At universities in Copenhagen, Aarhus and Aalborg, the next generation of biosolution experts is well on its way. Specialised master's degree and PhD programmes provide comprehensive training in biosolutions and biotechnologies, agriculture and food technologies – again often in partnership with industry.

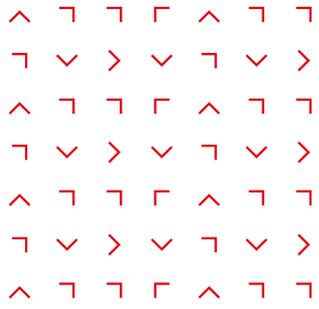
Within the inspiring educational environment, many ideas for new enterprises are born. This is encouraged and supported by university networks for startups and spinouts.

A strong academic base and vibrant startup ecosystem secure Denmark's leadership in the global bioeconomy



Photo: Novozymes





JOINT RESEARCH IDENTIFIES PLANT PROTEINS WITH EGG REPLACEMENT POTENTIAL



Using plant-based ingredients in the confectionery sector has strong potential to significantly reduce CO₂ emissions

The distinctive functionality of eggs is well known in food production. Their ability to add texture and enable foaming, gelling and emulsification is hard to match. Yet, as global demand for high-quality protein continues to grow, more manufacturers are seeking reliable egg alternatives that deliver a similar performance at a stable price and with a low environmental footprint.

In Denmark, Palsgaard, its R&D company Nexus and Aarhus University have joined forces to develop plant-based ingredients

that can partially replace egg and egg powder in industrial food applications. Innovation Fund Denmark has provided funding for the project.

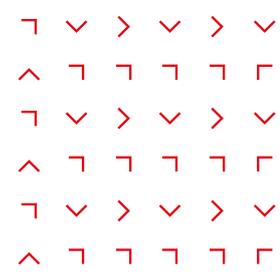
Using bioinformatics and advanced ingredient screening, the partners aim to identify plant proteins with the potential to replicate key egg functionalities. Food manufacturers are working with the team to test existing recipes and develop new formulations using prototype ingredients. This collaborative approach ensures real-world validation and accelerates the development of scalable solutions.

The emerging solutions have potential to reduce the cost and environmental impact of food ingredients significantly.

Using plant-based ingredients in the confectionery sector has strong potential to significantly reduce CO₂ emissions – in addition to supporting a more resilient and diverse protein supply.

For food manufacturers, a new generation of plant-based ingredients could be on the way, strengthening the sustainability of their production without compromising quality or performance.

Case by Palsgaard



USING CAPTURED CO₂ TO PRODUCE ALGAE-BASED INGREDIENTS

Is it possible to meet the world's growing need for nutrition without exceeding planetary boundaries? The answer is a clear yes. But it will take innovative solutions that can be rapidly delivered at industrial scale.

Algiecel is on a mission to achieve this goal. Using compact photobioreactors, the Danish biosolutions enterprise harnesses light and carbon dioxide to grow nutritious microalgae naturally and sustainably.

Algiecel's modular photobioreactor system enables low-risk, flexible scaling, making sustainable growth possible one module at a time



Photo: Algiecel

The microalgae are the raw material for ingredients that are rich in protein, omega-3 fatty acids and other bioactive components for food, feed and cosmetics. Due to their low carbon footprint, water consumption and land use, the marine ingredients provide the food, feed and cosmetics industry with a new opportunity to decarbonise their value chain.

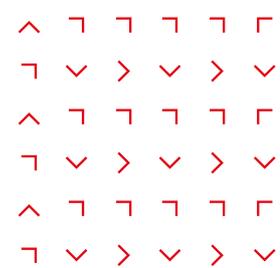
Algiecel's modular photobioreactor system enables low-risk, flexible scaling, making sustainable growth possible one module at

a time. Most importantly for modern food supply chains, the process ensures consistent ingredient functionality and traceability and meets international standards for food safety and quality.

Since its founding in 2021, Algiecel has made significant progress. The first protein and omega-3 products are now available as direct substitutes for traditional fish oil and fish meal in pet food, for example – providing the same high nutritional value without burdening nature.

Algiecel's technology continues to attract commercial interest, creating a strong foundation for further commercialisation and expansion to export markets.

Case by Algiecel



A woman with blonde hair, wearing a dark blue patterned shirt, is using a red and white VR headset. The headset has "FOOD NATION" printed on it. She is looking upwards and to the right. The background is a wall covered in various photographs and posters, including a red poster with text. The overall scene is brightly lit and appears to be an interactive exhibit or gallery.

CHAPTER 7

ABOUT FOOD NATION

**GATEWAY TO KNOWLEDGE ABOUT
THE DANISH FOOD CLUSTER**

Explore Denmark's innovation in ingredients and biosolutions – reach out to Food Nation.

The Danish food cluster works hand-in-hand with international partners to advance biosolutions and ingredient innovation



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 safety and quality, solve food system challenges and create new business opportunities along the value chain.

Take an interactive tour

Food Nation's Visitor Centre in central Copenhagen welcomes international delegations. An interactive installation gives visitors an up-to-date overview of the Danish food and agriculture sector, tailored to individual interests. It is the ideal starting point before visiting Danish food producers and production facilities.

Food Nation is a great place to start learning about how Denmark supports sustainable development through collaboration. Find out more about our services, the Danish food arena and visiting the Food Nation visitor centre at foodnationdenmark.com.

INGREDIENTS & BIOSOLUTIONS

Producers of functional ingredients, flavours and biotechnology

PRIMARY PRODUCTION

Agriculture, fishing & horticulture

PROCESSING INDUSTRY

Producers of food, beverages & animal feed

The Danish food cluster

Denmark's agriculture and food sector is built on a strong tradition of collaboration, sustainability, innovation, food safety and quality across a coherent and well-connected value chain.

RESEARCH & INNOVATION

Research, education & counselling institutions

INNOVATIVE TECHNOLOGY

Producers of machines, technology & equipment

GASTRONOMY & THE CONSUMER

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

READ MORE

FOODNATIONDENMARK.COM

