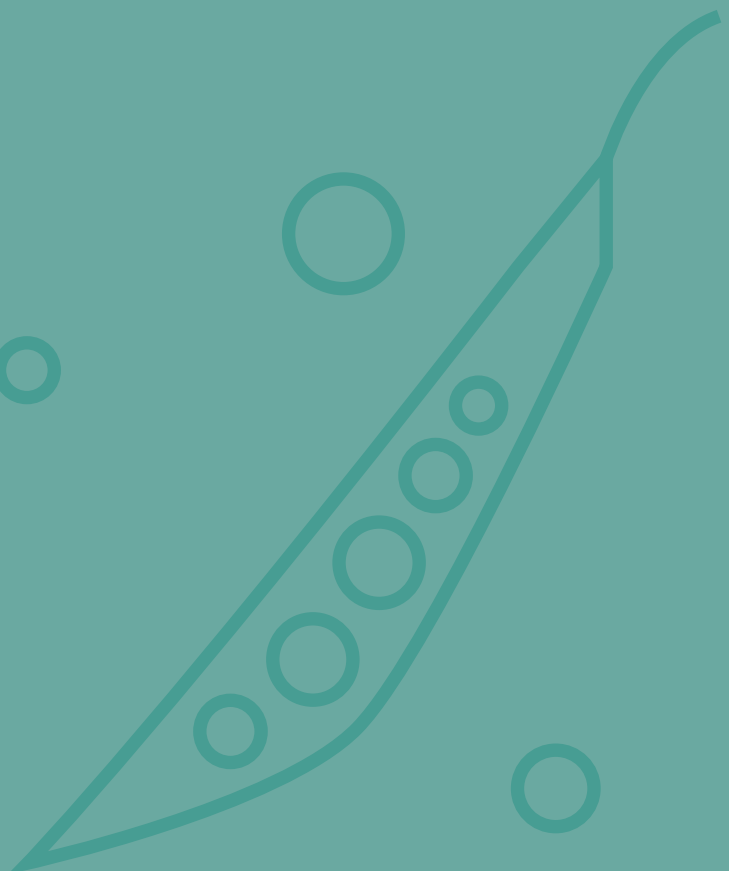
Ministry of Food, Agriculture
and Fisheries of Denmark

Danish strategy for green proteins for animals and humans



December 2023

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Ministry of Food, Agriculture
and Fisheries of Denmark
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1.0
Preface

Proteins are a fundamental part of the diet of both humans and animals. The challenges we face does not concern the amount of protein in the Danes' diet, but rather its quality and origin. We need to change the Danish protein supply for both feed and food so that it comprises more high-quality proteins that are also less harmful to our climate. New green proteins such as legumes, seaweed, proteins from precision fermentation and insects are protein alternatives that are not only more climate-friendly but also support the green transition of the agricultural sector.

Both the COVID-19 pandemic and the unfortunate war in Ukraine have led to sup-ply crises and challenges. There is increased focus on supply security, both domes-tically and in the EU. Denmark is dependent on a relatively large import of proteins, even compared to other European countries. An increased production of green pro-teins in Denmark could contribute to reducing dependence on imported soy.

An increased production of Danish proteins should be based on protein sources that have a low environmental and climate footprint, particularly if we want to address the large impact that our food consumption currently has on our climate, environment and nature. But the Danish proteins of the future must not only be environ-mentally and climate-sustainable. They must also be able to compete on price and quality. Green protein production is a potentially great business opportunity for Danish companies. Analyses indicate a rising global demand for proteins, and Danish companies can contribute to meeting the future needs with highquality proteins that are more climate-friendly. The development of new proteins thus holds the potential for new jobs in Denmark and increased value creation in the agrifood sectors. And this is already well underway. Danish businesses are at the forefront of developing new technologies and solutions.

Common for many of the new sources of protein is their excellent longterm poten-tial. However, more research and development is still needed. In other areas, there are mature technologies, but they are inhibited by regulatory barriers that prevent or delay the introduction of new products from entering the market. As such, we need a targeted focus on new green sources of Danish protein if we are to reap the benefits later. There are both climate and economic benefits to be gained from a better utilisation of the resources we already grow and harvest. This is a commitment we owe to ourselves and the planet to take advantage of.

Happy reading!



Jacob Jensen
Minister for Food, Agriculture and Fisheries in Denmark



2.0
Summary

The Danish strategy for green proteins for animals and humans is based on the Danish government's vision for green proteins in Denmark and is designed to help boost the country's production in this field. It is the government's vision that by 2030, Denmark will be producing a significantly higher quantity of highquality green proteins. These will help replace imported feed such as soy, and support the transition to a more plantbased food sector. They will also provide alternative income opportunities for Danish businesses and have an overall reduced environmental and climate impact.

Based on analyses from Aarhus University and the University of Copenhagen, the Department of Food and Resource Economics (IFRO) at the University of Copenha-gen has conducted an analysis of promising green protein sources. The analysis pinpoints three groups of protein sources that will have the greatest potential to boost the production of green proteins for animals and humans in Denmark by 2030: grass protein from green biorefining, protein-rich crops such as legumes, and new protein sources such as insects.

As part of the analysis, IFRO has also identified significant barriers to increased Danish production of green proteins. These include a lack of consumer acceptance of new proteins, regulatory challenges, and economic obstacles.

This government strategy is a compilation of initiatives that will address the above barriers and promote the development of green proteins in Denmark. The initiatives include funding for research and development, which could help provide tastier and more climatefriendly proteins for food. The government is also striving to pro-vide more innovation friendly regulations in Denmark and the EU without compromising nature, environment, health, feed and food safety and animal health. Development projects are supported through support schemes and funds in agri-culture, which in the long term will build knowledge and understanding of the field, and improve the competitiveness of Danish produced protein. The strategy also includes the government's efforts to increase the internationalisation and export of Danish products and solutions, which could boost sales and thus make having a green proteins production in Denmark more financially viable.



3.0 Introduction

This strategy will set the course for increasing the production of green proteins in Denmark. It is the government's vision that by 2030, Denmark will be producing a significantly higher quantity of highquality green proteins. These will help replace imported feed such as soy, and support the transition to a more plantbased food sector. They will also provide alternative income opportunities for Danish business-es and have an overall reduced environmental and climate impact.

Green proteins refer to proteins that can be produced with a lower climate and environmental footprint compared to current protein sources such as soy for feed and meat for food. The proteins must also be tasty and of a high quality. Finally, the pro-duction of proteins must be economically viable.

To investigate the real potential of increasing the production of Danish green proteins, the Ministry of Food, Agriculture and Fisheries has commissioned three analyses. Department of Food and Resource Economics at the University of Copenhagen and the Department of Food Science at Aarhus University were asked to pinpoint the potentials of and barriers to producing a number of promising green proteins for feed (University of Copenhagen report) and food (Aarhus University report). Additionally, an analysis has been commissioned from the University of Copenhagen to identify green protein sources with particularly high potential and to illustrate possible measures that can support an increased production of green proteins in Den-mark (University of Copenhagen report).

As part of this strategy, the Ministry of Food, Agriculture and Fisheries has also invited a large number of stakeholders to contribute to the strategy's content. The strategy interfaces with a number of other initiatives, which also originate from *The agreement on a green transition of*

Definitions

Green sources of protein
Green proteins refer to the alternative protein sources that support a supply chain that averts or limits anthropogenic greenhouse gas emissions, while their production process respects nature and biodiversity to a much greater extent than the production process of original protein sources (imported soy or conventional animal products).

Alternative protein sources

for feed
Denmark is currently a major consumer of imported soy for animal feed. Soy is considered to be a protein source with a high climate and environmental impact. Alternative protein sources to feed are defined as other sources with the same levels of protein, the same feed quality in terms of amino acid composition, and therefore constitute a competitive alternative.

For food
Alternative protein sources to food are defined as protein sources that can replace conventional animal protein sources (such as meat, milk and eggs). In general, alternative protein sources for food are associated with being more sustainable, such as in the form of having a lower climate footprint than conventional protein sources.

Source: University of Copenhagen, 2023

the agricultural sector of 4 October 2021. These should be seen in relation to each other: the Danish Action Plan for Plantbased Foods, Strategy for organic farming, Strategy for the Technical Reduction Potentials, Strategy for Green Jobs in Agriculture and Related Industries, the Dan-ish National Bioeconomy Panel and a Task force for vertical farming. As a whole, all initiatives serve the common purpose of strengthening the gre-en transformation of the agri-food sector and of reducing the sector's greenhouse gas emissions.

The strategy's efforts centres around three overall focus areas, each of which is estimated to contribute to increased green proteins production in Denmark in the future: 1) green biorefining; 2) legumes and other proteinrich crops; and 3) new pro-tein sources, including better utilisation of residual and side streams (see Figure 1). The potentials, barriers and initiatives for developing a number of green proteins are described for each focus area. The three focus areas are followed by a section on internationalisation and exports.

The strategy for green proteins is linked to the European Commission's Farm to Fork Strategy of May 2020, which aims to promote healthy and sustainable food. The Farm to Fork Strategy sets the course for how the European food system can help reach the target of a climateneutral Europe by 2050, while providing more robust and resili-ent food systems. In 2018, the Commission pub-lished a report on the development of plantbased protein in the EU. More recently, the European Parliament called on the Commission to draw up an EU protein strategy. The Danish government generally supports the preparation of an EU pro-tein strategy and will work to ensure that Danish priorities are included.

Figure 1
The three focus areas of the protein strategy



Biorefining of green crops
Clover grass, alfalfa etc.



Protein-rich crops
Legumes such as peas, faba beans etc.

Focus areas



New protein sources
Insects, single-cell, marine sources, residual and side streams such as potato protein etc.

Proteins in brief

Proteins have a number of vital functions in all living organisms and are made up of amino acids. While plants can produce all the necessary amino acids for themselves, animals and humans lack certain enzymes to form all essential amino acids and therefore need to obtain these amino acids through their diet. Proteins in feed and foods containing the essential amino acids we need are therefore particularly sought after.

When comparing the protein content of different protein sources, it is often done based on dry matter content. Certain protein sources, such as grass or spent grain, contain large amounts of fresh water, which has a lower content of protein per unit weight if dry matter content is not taken into account. This is also called crude protein – i.e. the part of the raw material that is pure protein. An example could be a tonne of soy bean meal, which has a protein content of 45 percent. This would be equivalent to 450 kg of crude protein.

Denmark's current protein supply

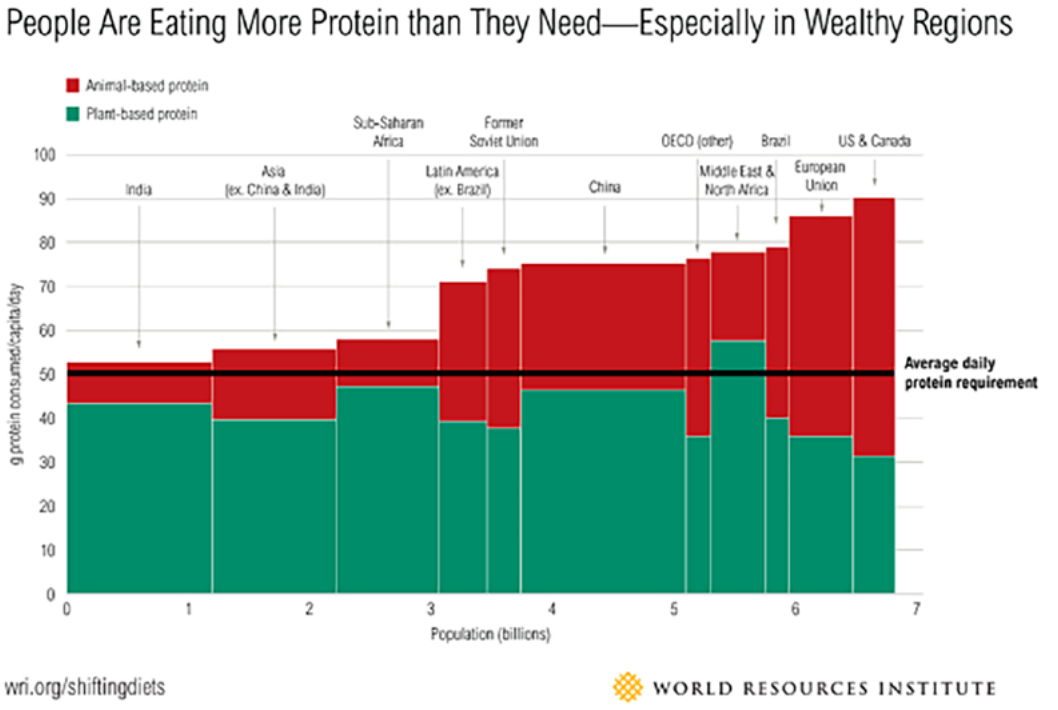
We are becoming increasingly aware that sustainable protein production is the way forward, not only at a national level, but also on a European and global level. Figures from the Food and Agriculture Organization of the United Nations (FAO) show that there is a growing demand for proteins globally, which is due to an increasing intake of proteins per capita, especially from animal sources. In addition, the world's population is growing rapidly.

Meanwhile, it is a wellknown fact that a large part of the total greenhouse gas emis-sions from agriculture can be attributed to animal production. This includes in particular the amount of methane and nitrous oxide from the digestion and manure of animals, as these greenhouse gases are particularly potent. Additionally, the cultivation of feed, which occupies large areas of agricultural land, contributes to these emissions. In Denmark, approximately 70 percent of the total Danish agricultural area is used to produce feed.

Feed

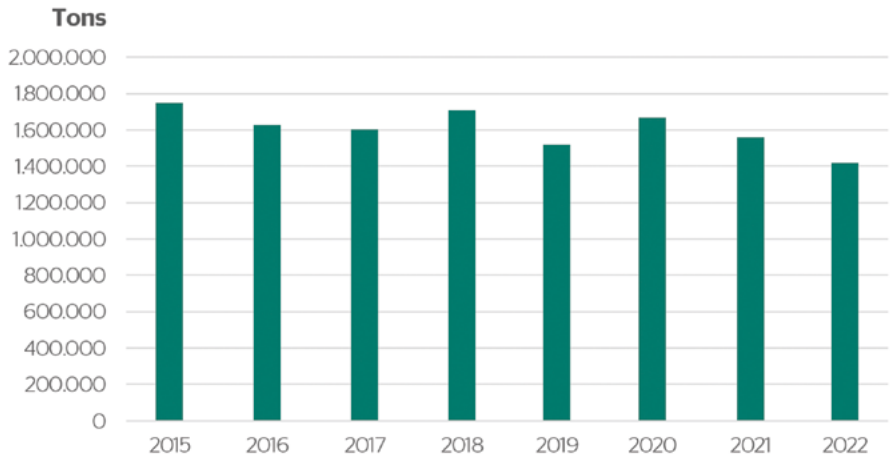
According to IFRO, the three largest sources of feed protein in Denmark are grains, grass and green fodder and oilcakes (including soy). The protein supply for feed alone in 2021 was around 2.7 million tonnes of crude protein, of which almost 69 percent was produced in Denmark. The remaining need for proteins for feed is met through imports. Denmark imports around 800,000-900,000 tonnes of crude protein per year, which mainly consists of soy from South America.

Figure 2
Global demand for protein for food



Source: Jensen, J. D., Haugsted, L. Í. H., & Dong, Y. (2022)

Figure 3
Danish imports of soy bean oil cakes from 2015 to 2022



Source: Statistics Denmark

The production of soy in Brazil, which is one of the largest exporters of soy, and other countries are sometimes linked to deforestation and cutting down other valuable natural resources. Clearing natural habitats and converting them to agriculture release significant amounts of CO2e, which would otherwise be stored as carbon in the trees. A large part of the climate footprint of imported soy comes from this release. The Danish Energy Agency has estimated the greenhouse gas emissions associated with the production of Denmark's imported soy bean meal in 2020 to be around four million tonnes of CO2e. Due to accounting methods adopted by the UN, the emissions associated with Denmark's imported soy are not included in the national climate accounts, but instead in the country in which the actual production takes place. So reducing soy imports will not only be included in the Danish climate accounts, but will have a global climate effect. Furthermore, production in other countries can lead to a number of other consequences for the local environment, such as loss of biodiversity, high consumption of pesticides and violations of indige-nous peoples' rights. There is, therefore, a strong reason for Denmark to ensure more sustainable supply chains for feed proteins for animal production.

Food

According to the Danish Council on Climate Change (the DCCC), Danes have one of the world's highest climate footprints from food per capita, which is mainly due to the large proportion of animal foods in our diet. The official dietary guidelines from the Danish Veterinary and Food Administration recommend eating a more plantrich diet with a limited intake of animal products, including animal protein. According to the DCCC, if the average Dane were to follow the Official Dietary Guidelines

Actions for responsible and deforestation-free soy

Political agreement has been reached on a new EU Deforestation Regulation (EUDR), which will come into force at the end of 2024. The Regulation imposes due diligence requirements on all companies that make available, export or place soy and a number of other agricultural products on the EU market to ensure that its cultivation has not contributed to deforestation or forest degradation. The Regulation's requirements for imported soy could lead to a price rise, which would make Danish proteins more competitive on price than today. Voluntary efforts include the Danish Alliance for Responsible Soy under the auspices of Ethical Trade Denmark, where companies, business organisations and NGOs come together over the common goal of promoting responsible and deforestationfree production and import of soy. The Ministry of Environment, the Ministry of Foreign Affairs and the Ministry of Food, Agriculture and Fisheries are supporting members and have joined the Alliance.

to a greater extent than currently, not only would the individual be healthier, they would also reduce the climate impact of their diet by 31-45 percent. The overall effect, according to the University of Copenhagen (University of Copenhagen IFRO report), would be a socio-economic gain in the region of DKK 12 billion annually.

The University of Copenhagen also states that Denmark's net import of proteinrich crops such as chickpeas, beans and lentils has been increasing over the past 30 years. A Coop analysis from 2022, which mapped the Danes' shopping habits, shows that sales of plantbased meat alternatives have increased tenfold since 2010, and sales of legumes have doubled. However, these figures need to be seen in the light of the fact that plantbased meat alternatives and plant drinks make up only 1-2 percent of the total food turnover in supermarkets. Demand is expected to increase. A 2020 survey conducted by SEGES and the Danish Agriculture & Food Council, mapped out the Danes' expectations for their future diet. Approximately half of adults surveyed indicated that they expected to use more plantbased foods in the future. The study also found an increasing demand for plant-based proteins, and that many consumers preferred the foods to come from Denmark.

Furthermore, there is a growing global demand for plantbased foods and protein sources. In the report entitled *Fremskrivning af markedsudviklingen for plante-baserede fødevarer i nærmarkeder* (Projection of the market development for plant-based foods in local markets) the University of Copenhagen reproduced results from a survey from 2021, which shows that 23 percent of the world's consumers expressed that they are trying to limit their meat consumption. The same report shows that the global consumption of alternative plantbased protein sources was estimated to be 13 million tonnes in 2020, which corresponds to around 2 percent of the animal protein market. The market is expected to increase sevenfold by 2035 with an annual growth rate of 14 percent. The growing global demand will provide a foundation for exports and contribute to the sector's economy and the de-velopment of new food and technological solutions. The opportunities for Danish farmers and companies to become part of this development are therefore consider-able.

Ingredients

Proteins are not only used as feed for livestock or as food for humans. The ingredients industry also has a great need for green proteins. Protein ingredients can be used in both food and feed products

Danish business is already up and running

The Danish business community is acutely aware of the need for a more sustainable production of proteins and more sustainable supply chains. Denmark has a large number of worldleading companies, start-ups and research institutions within the field. As such, in 2019 a number of companies, interest groups and knowledge institutions formed the network Danish Protein Innovation, which has since been working to boost research and development in Danish proteins. Another example is the Network for Plant Proteins of the Future, which began as a network project supported by the Green Development and Demonstration Programme. The network is working on strengthening the development of plant proteins for human consumption.

In 2021, the Danish Grain & Feed Industry Organisation (DAKOFO) presented the industry's proposal for a possible protein strategy, in which they pinpointed specific opportunities to increase the production of Danish proteins. The strate-gy presented an industry target to replace 320,000-370,000 tonnes of imported protein with locally produced protein by 2030, corresponding to about a third of current imports.

and have a number of different uses. They can be added to food and feed to boost protein content, thus increasing the nutritional value. They are also used as functional ingredients to provide texture, flavour and aroma, as well as preservatives.

Protein ingredients are defined as a processed protein source, such as a crop or a residue, into a high-protein end product that can be included as an ingredient. Protein powder is an example of a protein ingredient that is already gaining wide acceptance. This can be produced from several different protein sources such as peas and whey, the latter of which is a byproduct from cheese production. Denmark is the world leader in producing protein ingredients from whey, and this is a great example of how a residual product can be processed into a highvalue product.

According to the report Analyse af *'grønne' proteiner til fødevarer* from Aarhus University, the global market for protein ingredients is expected to grow from USD 72 billion in 2021 to USD 115 billion in 2030. Denmark has several large companies in the ingredients industry, so the potential for increased production and sales of Danish green protein ingredients is great.

Link to the bioeconomy

The development of new green proteins is closely linked to Denmark's bioeconomy. As mentioned, our current food production is a significant part of our bioeconomy, both in Denmark and abroad. The prospects of increasing the yield from our areas and improving the utilisation of the yield as much as possible are therefore considerable. The production of a number of new and promising protein sources can contribute to this.

In the Danish National Bioeconomy Panel's latest recommendations to the government from September 2022, the panel highlights the potential for increasing the bioresource yield from Danish areas, while at the same time dedicating areas to clean nature and biodiversity purposes. Denmark's area is limited, which means that our bioresource base is limited. As such, the panel recommends that Denmark becomes better at utilising photosynthesis on our areas for a larger part of the year, so that we can increase the subsequent yield. This is achieved by e.g. cultivating a larger area of legumes and perennial crops such as grassland crops. In addition to high yields, perennial crops can also contribute with positive environmental and climate effects such as reduced leaching of nutrients and increased storage of carbon in the soil.

The Danish National Bioeconomy Panel recommends that Denmark becomes better at getting the most out of our bioresources. We can do this by e.g. refining our bioresources so that we get more products from our crops, or by making better use of our residual and side streams. The principle of cascading utilisation is key here as it seeks to optimise the utilisation of all parts of our resources. Moreover, there is significant potential to produce proteins for both animals and human consumption based on residual and side streams from the agri-food sector.



4.0
Promising sources of Danish protein

According to the University of Copenhagen, future Danish protein production is expected to come from a wide range of different sources. Some of the protein sources are well known to us and will therefore be easy to scale up in a matter of years. Other protein sources are based on new technologies and processes that still require significant research and development, or where regulation constitutes a barrier to achieving the technology's full potential. The size of the production potential of each indi-vidual protein source will differ in Denmark, as will the expected value of the products. Generally, however, we can expect the largest volumes to be for feed purposes in the short-erm, whereas proteins for human consumption and ingredients will often be produced in smaller quantities but will be of higher value (Figure 4). Additionally, there is already significant potential for exporting technology, which is likely to increase as the demand for proteins increases globally.

The different uses for Danish produced proteins also mean that competition may arise for biomass and other relevant areas, which further supports our need to use our resources efficiently. General research can promote proteins for both feed and food, such as breeding or logistics for protein-rich crops. In general, it would be preferable to use proteins for food rather than feed where possible, as not all proteins can be used for food.

Figure 4
Illustration of the volume-value relationship



Source: Trine Kastrup Dalsgaard, AU

In a recent analysis carried out for the Ministry of Food, Agriculture and Fisheries, IFRO at the University of Copenhagen highlighted a number of significant barriers to the development of green proteins and those protein sources that would have the greatest potential in Denmark by 2030.

IFRO highlights three major barriers that currently inhibit the development of green proteins:

- Consumer acceptance: Products with new protein sources have not yet become the norm. Nor do they have the right quality in terms of texture and taste, which is a barrier to increased demand.

- Legislation: EU regulation for e.g. novel foods or bans on feeding organic waste to insects are cited as examples of regulation that may limit development and innovation.

- Financial obstacles: The conventional alternatives (soy and animal products) remain cheaper than the green alternatives. And in many cases, the cost of production currently exceeds the sales value.

The analysis identifies legumes, grass and insects as the protein sources with the greatest potential for Denmark going towards 2030. Both legumes and grass have a lower protein content than other protein sources, but when processed, the concentration of protein in legumes and grass increases significantly. The market is also considered to be mature for these two protein sources. The production of insect pro-tein in Denmark is still minimal, but according to the analysis, there is great potential in promoting the production. Nevertheless, IFRO also argues that - according to the Danish National Bioeconomy Panel – it would be better to develop a wide range of alternative green protein sources to increase the crop base. The protein content of a number of protein sources for feed is shown in Table 1. IFRO's assessment of which protein sources have the greatest potential is in line with the Danish National Bioe-conomy Panel's recommendations on "Proteins for the future" from 2018 and the Forum for Future Ingredients' recommendations on green proteins from 2023.

The following chapters detail each of the strategy's focus areas, highlighting the potentials and barriers to developing a number of different green proteins. Each focus area contains initiatives that promote the development and production of green proteins in Denmark.

Table 1
Overview of protein content and climate footprint for protein sources used for animal feed

Category	Protein source	Protein content of dry matter (percentages)	Climate footprint including LUC (in CO2e/kg)
Imported soy meal		45	5,67
Green biorefining	Grasses and leg-umes in grassland	40	0,66
Legumes	Legumes: peas, lupins and faba beans	23-45	0,69
New proteins	Seaweed	47	No data
	Starfish	70	No data
	Mussels	57	0,22
	Rapeseed meal	35	0,70
	Potato pulp	77	1,98
	Spent grain (fresh)	20-30	0,05
	Dairy products (mainly whey)	29-90	No data
	Insects	65	2,3-2,7
	Microalgae	65	No data
	Single-cell bacte-ria	72	0,66

Note: LUC: Land use change
Source: IFRO, 2023



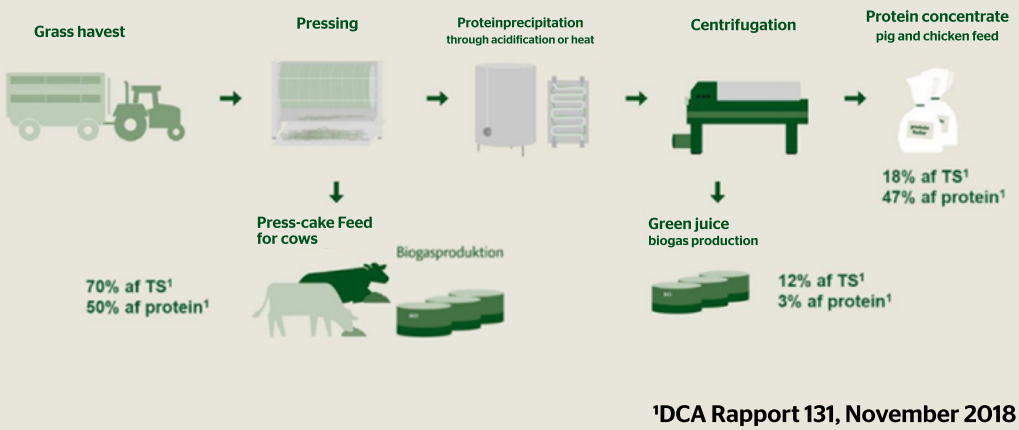
5.0
Green biorefining

When most Danes hear the word 'grass', they probably think of a freshly mowed lawn or a football field. However grass is also an important crop in agriculture. In Denmark, we have about 480,000 hectares of grassland, which is used for e.g. feed. Grass, clover and alfalfa are proteinrich crops, which is why they are already important sources of feed. Until now, however, the use of grass has primarily been lim-ited to feed for multigastric animals such as cattle, sheep and goats. In recent years, work has been done to develop biorefining processes that extract a protein concentrate from grass, so that it also becomes available to monogastric animals such as pigs, poultry and humans.

Green biorefining is a good example of how bioresources can be used for multiple purposes. In green biorefining, high-value protein is first extracted from clover grass or similar crops. The various residues from the refining process can then be used for other purposes such as feed for cows, materials and energy (see Figure 5).

Biorefining green biomass such as clover grass and alfalfa is a great potential future source of Danish-produced protein. This is partly due to the fact that grass generally has a high protein content as well as a high yield. In the right conditions, it is possi-ble to harvest around 1.5 tonnes of crude

Figure 5
Illustration of green biorefining of grass



Source:
SEGES Innovation

protein per hectare of grass per year. And compared to annual crops such as grains or maize, grassland cultivation has the added benefit of storing more carbon in the soil. It also requires less pesticides and reduced leaching of nitrogen, despite a high nitrogen requirement. Due to its high protein content and beneficial amino acid composition, grass protein for feed would make a good soy substitute. In one example, Aarhus University has estimated that converting 200,000 hectares of agricultural land to produce crops for green biorefining could produce 200,000-400,000 tonnes of feed protein, i.e. around 23-46 percent of the imported feed protein. However, converting to grass that is suitable for biorefining will depend on the farmer's incentive to grow this instead of other crops. The biggest potential is currently in organic production, where grass protein is able to better compete with soy on price compared to conventional farming, where soy prices are likely to continue to beat Danish alternatives. Green biorefining may also be relevant for other crops or crop residues such as catch crops and leafy greens in the form of sugar beet tops.

The development and application of green biorefining in Denmark is still at a relatively early stage, which means that there is still a way to go before a complete value chain can be established. Initiatives in the fields of research and development, processing, support for the establishment of plants and synergy effects with other links in multiple applications are essential to the ongoing development. The following section highlights a number of initiatives that support green biorefining.

Initiatives that support the development of green biorefining

Research and development in grass protein

The development of green biorefining in Denmark is the result of a collaborations between the industry, research institutions and public support. In 2013, the first grass protein projects were supported through *the Green Development and Demonstration Program* (GUDP) and in 2018, the Danish National Bioeconomy Panel recommended that further efforts be made to develop green biorefining. In 2018 to 2019, a total of DKK 39 million was allocated to a number of funds under GUDP to promote green biorefining, partly as part of the government's 2018 action plan for new sustainable proteins and to follow-up on the panel's recommendations. Over the past ten years, GUDP has supported projects focusing on grass protein with more than DKK 140 million for feed and food. The projects demonstrate that as the value chain for green biorefining is relatively undeveloped, there are still a number of challenges associated with scaling up production. This applies to both the content and quality of the protein and to the profitability of the production facilities. There may also be logistical challenges associated with the transport of grass, which has a high water content.

With further research and development of the technology, green biorefining could eventually help convert green proteins for human consumption. However, we are still a long way from being able to do that. Aarhus University has estimated that up to 10 percent of the grass protein from green biorefining could potentially be used for food in the future, i.e. up to 40,000 tonnes of grass protein. Nevertheless, this estimate is subject to significant uncertainty due to the technology's infancy and the general lack of research. By comparison, according to Aarhus University Danes consume around 180,000 tonnes of protein a year. There is still a lack of knowledge around the functional properties of grass protein, nutrient content and possible challenges with allergens. Furthermore, the development of processing technolo-gies and processes that solve the issue of the green colour and taste of the grass is pending. The very method of purifying protein from green crops into food is also still under development, and GUDP will continue to fund this. There is, however, an opportunity to share many of the early development costs between different purposes. For example, the biorefining technology could be applied to turning feed protein to food protein in the future.

Over the years, GUDP has generally supported the development of new proteins, including grass, with almost DKK 500 million, and is continuing to invest in this area. GUDP's new strategy for 2023 to 2027 has selected proteins and food ingredi-ents as a focus area. This focus area includes the development of new alternative proteins and food ingredients for feed, and for tasty and nutritious foods that could increase consumer acceptance (highlighted by IFRO as a key barrier to developing new green proteins). New proteins include proteins from agricultural crops such as grass, clover and legumes, or protein extracted from e.g. mussels, insects and sea-weed.

Green biorefining at Ausumgaard

Ausumgaard farm has launched a new form of grass protein production to produce plant proteins from, among other things, clover grass. In 2020, the project received DKK 14 million in funding from GUDP to build test and demonstration facilities for grass protein production. This type of facility is the country's first farm facility. The grass protein from Ausumgaard is used for e.g. compound feed for pigs, and contributes to a larger proportion of locally produced feed protein.

Funds

Agricultural funds can also go towards gaining a deeper understanding of grass proteins. For green biorefining, *Frøafgiftsfonden* (the seed levy fund) is particularly relevant. One of the fund's main objectives is to support projects within the prebreeding of grassland legumes and grasses. The Fund only supports research and development activities that benefit the entire sector, and in 2022 it awarded DKK 10.6 million towards research and experiments.

At the request of the agricultural industry, a production levy fund for plants has been set up to help boost Denmark's position within crop production, and support the green transition of agriculture. The fund will provide grants for areas such as research and development activities related to all plant production, including feed for animals. The production levy fund will thus have a broader purpose than the Plantbased Food Grant. The production levy fund is financed by a production levy on the areas on which the crop producer is entitled to receive the basic payment (agricultural aid) for the year in question and on which crop production takes place. The levy is expected to generate an annual income of approx. DKK 35 million, which the fund can dispose of.

Genome techniques

Recent years have seen a number of new genomic techniques (NGT), such as the "gene scissors" CRISPR, being developed, which can cause targeted genetic changes in plants and other organisms. According to a study carried out by the Commission, the current GMO regulation is not suitable for dealing with all of these new genomic techniques. The government agrees with the Commission that there should be separate legislation for NGT, so that this type of plant breeding is no longer cov-ered by the GMO rules. Future regulation must ensure a high level of safety while providing greater value to both society and the environment. In July 2023, the Commission proposed a regulation for plants generated by certain new genomic techniques and their use for food and feed. The proposal, if adopted, will introduce a new regulation for a number of new genomic techniques that are considered com-parable to traditional breeding methods and can thus be authorised for cultivation and marketing in the EU. Denmark also wants to look at the possibilities of similar separate legislation for micro-organisms produced by NGT. The Danish Veterinary and Food Administration and the Danish Agricultural Agency are the bodies that advise Danish companies on the NGT rules.

Grant schemes

The *Agreement on a green transition of the agricultural sector* of 4 October 2021 (also called the 'agricultural agreement') has spurred developments, as the parties behind the agreement allocated DKK 260 million to support green biorefining. The grants are implemented through two independent subsidy schemes at the Danish Agricultural Agency: *Project maturation of plants for green biorefining and Establishment of facilities for green biorefining*. The purpose of the schemes is to support the development of biorefining plants focusing on protein production for feed from green biomass such as grass, clover or alfalfa.

It is essential that there is enough biomass available for future biorefining facilities. This will depend on e.g. whether enough land is converted to grass suitable for biorefining, which in turn depends on the farmers' incentives to grow it. With the new Danish strategy for implementing the CAP (Common Agricultural Policy) 2023 to 2027, a number of eco-schemes have been established. The ecoschemes are voluntary, one-year green support schemes. Under *the climate and environment friendly grass ecoscheme*, farmers can apply for funding from the third year in which a grassland is not tilled. This ecoscheme delivers an environmental impact as well as an estimated climate effect of approx. 0.11 tonnes of CO2e per hectare per year. The scheme can also provide an increased incentive for Danish farmers to grow green biomass, which can potentially be refined into protein-containing feed and, in the long term, into food. However, it is still uncertain to what extent the scheme will lead to a larger total area of grassland in Denmark, and whether the protein content of the grass is sufficient for use in biorefining or other purposes. A total of DKK 297 million has been allocated annually for the period 2023 to 2027.

Partnerships

Knowledge sharing through partnerships, alliances, and networks is highlighted by the University of Copenhagen as an effective tool for addressing complex issues, achieving greater clarity around common challenges and coming up with possible solutions, such as developing new value chains for green proteins. Food & Bio Cluster Denmark is the cluster organisation for food and bioresources in Denmark, and is currently working on innovating and strengthening entrepreneurship throughout the value chain. DKK 160 million was allocated annually for the period 2021 to 2024 to the national knowledge and business clusters. Food & Bio Cluster Denmark promotes knowledge-sharing by e.g. facilitating the Green Protein Network, which brings together companies and universities to develop new green proteins.

How the government plans to support green biorefining in Denmark

- The government will continue to support research and development of green biorefining through the research-based government service and the Green Development and Demonstration Programme (GUDP), where the proteins of the future are included as a focus area in GUDP's new strategy for 2023 to 2027.
- The agricultural funds, and especially *Frøafgiftsfonden*, support further research into grass and green biorefining. In 2022, *Frøafgiftsfonden* awarded DKK 10.6 million towards research and experiments.
- The Agricultural agreement allocated a total of DKK 260 million to developing green biorefining in Denmark. The funds are implemented through two grant schemes:
  - Project maturation of facilities: DKK 15 million in 2023 and 2024
  - Establishment of facilities: DKK 245 million in 2023, 2024 and 2025
- The government has allocated DKK 297 million annually for the period 2023 to 2027 to the climate and environment friendly grass ecoscheme under the EU's CAP (the Danish CAP plan from 2023 to 2027). This scheme will increase the production of grass for green biorefining.
- In collaboration with the industry, a production levy fund has been set up for plants, financed through the industry's production taxes. The fund's an-nual income is expected to be approximately DKK 35 million.
- The government is supporting separate legislation for new genomic tech-niques (NGT) at EU level, which support developments and maintain a high level of safety. The Danish Veterinary and Food Administration and the Danish Agricultural Agency advise Danish companies on the NGT rules.
- DKK 160 million has been allocated annually for the period 2021 to 2024 for national knowledge and business clusters, including Food & Bio Cluster Denmark, which is working on green proteins, among others.



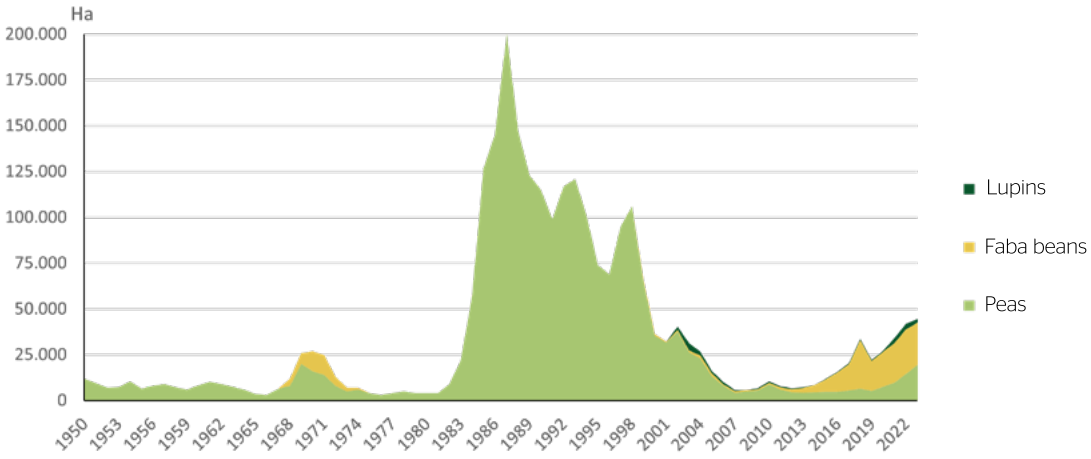
6.0
Legumes and other protein-rich crops

Proteinrich crops such as beans, peas and lentils are not core components of the average Dane's diet. But this is changing as more and more people start choosing legumes as a protein source. The Official Dietary Guidelines from 2021, which address both health and climate, also recommend we eat a plantrich diet with less meat and more legumes. In other parts of the world, on the other hand, legumes have been a staple part of people's diets for thousands of years. It is with good reason that proteinrich crops such as legumes are gaining ground in Denmark as a protein source for both feed and food. Partly because legumes have a significantly lower climate footprint than e.g. meat and dairy products, and partly because they require less nitrogen fertiliser as legumes are nitrogen-fixing. This means that the crops, along with bacteria, are able to fix nitrogen from the atmosphere and make it availa-ble to the plants. This also makes legumes particularly beneficial in organic production. Other protein-rich crops such as quinoa, amaranth and oats are not able to fix atmospheric nitrogen, but are still make good protein-rich food crops.

Like soy, most legumes can also be consumed by animals and therefore used as feed. There is great potential in Danish legumes being able to replace part of our imported feed protein in the future. Legumes such as peas, faba beans and lentils can be grown in Danish conditions, and there are currently a considerable number of fields that have been converted to growing protein-rich crops due to greater demand for both human consumption and feed. It is generally expected that these proteinrich crops will replace more starchy crops in the fields. Increased prices for fertilisers also make the cultivation of legumes more attractive.

There is great potential to rapidly scale up the production of a number of high-protein crops. Faba beans and peas are highlighted in several sources as crops that could, within a relatively short number of years, comprise a much larger share of our protein supply than today. Partly because these are well-known crops and culti-vation methods, where we in Denmark, for example, have previously produced significantly more peas than we do today (see Figure 6), and partly because there is an increasing demand for Danish-produced legumes. Aarhus University has pointed out that there is a potential for further production of faba beans at the expense of grains in the region of 100,000 hectares with a net gain of up to 110,000 tonnes of crude protein. AU expects faba beans and peas to replace grain, which will typically result in higher protein productiion, but slightly lower biomass and energy produc-tion. In addition, a smaller emission corresponding to 1.5-2.0 tonnes of CO2e per hectare of faba beans is expected. Other legumes such as chickpeas and lupins are also being increasingly grown.

Figure 6
Denmark's area of legumes



Source:
SEGES Innovation

There is already a value chain for Danish legumes today, but all stages of production need to become stronger, from variety development to demand and export. This is a further objective of the Danish Action Plan for Plant-based Foods.

Initiatives to boost growth and consumption of legumes and other protein-rich crops in Denmark

Variety development and breeding

Developing new crops and new varieties within known crops is essential for agricultural development and opportunities to meet the changing demands, including more varieties for plant-based foods and new protein sources for animals and humans. For many years now, Danish agriculture has specialised in producing crops for feed purposes. This has also influenced varietal development of e.g. legumes, which have been optimised mainly for animal feed. However, further varietal de-velopment is required for protein-rich crops that are to be used for both feed and food. When using protein-rich crops for feed, further varietal development is need-ed to increase feed efficiency in livestock so that the largest possible proportion of the protein is absorbed. With the increasing demand for more Danish legumes for human consumption, we need to see further varietal development and increased cultivation, both in terms of protein content, nutritional quality and flavour. We also need to ensure we maintain a high protein content in Danish grains and rapeseed, which still constitute a large share of Danish protein supplies. Knowledge of the functionality of proteins in relation to how they can be used in products and nutri-tional conditions is sorely lacking.

The purpose of the 2019 *national strategy for plant genetic resources in agriculture* is to ensure the long-term, continuous and binding efforts to preserve plant genetic resources so that we can use diverse plant genetic material, to e.g. develop and adapt food for human nutrition and feed for animal production. DKK 1.1 million is allocated annually to the Danish Agricultural Agency's work on plant genetic re-sources. Alongside the strategy for agricultural plant genetic resources, there are a number of opportunities to obtain grants for varietal development, including through GUDP, the Plantbased Food Grant and several agricultural funds. The Nordic public-private partnership (PPP) on pre-plant breeding is also a source of funding.

Furthermore, Innovation Fund Denmark can help fun research and development of green proteins. Every year, a significant number of funds are allocated to Innovation Fund Denmark, which is an independent body that allocates money to research and development, including targeted support for the green transition, also in agriculture. Innovation Fund Denmark has, among other things, granted approx. DKK 200 million to a missiondriven partnership effort called AgriFoodTure, which will support the realisation of one of the four green missions launched

in continuation of the green research strategy (September 2020). AgriFoodTure supports projects that generate new knowledge and new solutions for the agrifood sector. An example of a project under AgriFoodTure is AQRIFood, which aims to investigate and test different varieties of oats, faba beans and peas for food quality. The projects under Agri-FoodTure can thus help boost demand and thus competitiveness for Danish-produced legumes by, for example, identifying varieties with better nutritional con-tent or taste.

With Agreements on the distribution of the research reserve etc. in 2023 and Agreements on the distribution of the research reserve etc. in 2024, funds have been allocated for sustainable proteins. In 2023, DKK 300.3 million was allocated to the four green missions and in 2024, an additional DKK 318.3 million. In 2023, DKK 321.4 million was allocated for broader thematic calls for proposals within green research, technology development and innovation in seven areas, and in 2024 a further DKK 338.2 million will be allocated. The seven areas are part of the green research strategy. One of the areas is 'Agriculture and food production', where sustainable proteins are specifically mentioned as a possible focus area for research efforts. In 2024, DKK 75 million will be allocated for research into the climate-friendly foods of the future, including plantbased foods and alternative proteins. Funding has also been allocated for transnational research collaboration under the auspices of the Horizon Europe partnership Sustainable Food Systems.

Grant schemes

A greater variety of crops in Danish fields can lead to positive environmental and climate effects. The agricultural agreement provides for the establishment of the eco scheme for *diversified crop production* under the CAP. The scheme provides a subsidy to holdings that apply increased crop diversification and grow a minimum of certain crops on their rotational area. These are crops that today make up a smaller proportion of the total agricultural area, mainly crops that can be included for human consumption and certain protein crops. Subsidies can be obtained for areas cultivated with these crops, which includes legumes, and the scheme thus provides an increased incentive for Danish farmers to grow legumes. DKK 116 million has been allocated to this scheme annually for the period 2023-27 under the CAP.

However, the roll-out of protein-rich crops on Danish fields must take into account proper crop rotation, as there is a risk of developing pathogens and diseases in the soil when growing legumes. Even if a five-year break in crop rotation is taken into account, there is theoretically still room for more than 400,000 hectares of seed legumes in Denmark, from which the protein yield would correspond to approxi-mately half of Denmark's imported soy protein.

To further accelerate the cultivation of high-protein crops for both feed and food, the government will explore the possibilities of further supporting the growth of a number of protein crops within the framework of the CAP. It should be noted that any changes in the organisation of the CAP must be approved by the conciliation group behind the agricultural agreement and by the Commission. It is important to ensure that none of the measures have any negative environmental and climate impact, and that there is demand within the industry.

Processing

An increased production of legumes in Denmark depends to a large extent on demand. An analysis conducted by Aalborg University and the University of Copen-hagen highlights a continued increasing demand for plant-based products, including Danish-produced plant protein. There are already a number of Danish companies that process legumes of both Danish and foreign origin, as well as companies that sell Danish-produced, dried legumes directly to consumers. At present, Danish-produced legumes are also processed in other countries such as Norway, where they are converted into protein-rich flour and then shipped back to Denmark to be used in food products, e.g. as meat substitutes. There is also a rising global demand for plantbased foods, including protein-rich products based on legumes. Figures from Statistics Denmark show that between 2017 and 2021, exports of legumes grew by 179 percent. The government's action plan for plant-based foods provides more information on government measures to boost demand for plant-based foods and increase exports. The action plan includes initiatives targeted at public kitchens and educational institutions.

We still need to develop and learn more about processing, drying, storing and refining legumes for food and ingredient purposes. Here, help can be found in the *Environment and Climate Technology Scheme*, which is a project support scheme offered in 2023 to 2027 under the CAP. Until now, the scheme has subsidised crop production and horticulture, which may in future also encourage the cultivation of protein-rich crops. The Danish Agricultural Agency is investigating whether the scheme could also subsidise processing. A total of DKK 570 million was allocated for the scheme in

2023. DKK 60 million will be allocated annually in 2025, 2026 and 2027.

As a result of the agricultural agreement, a plant-based food grant has been established. *The Plant-based Food Grant (The Plant Grant)* was established in 1 March 2023 with the purpose of supporting the development of plant-based foods for human consumption. The Plant Foundation is able to support several purposes such as consultancy, research and development. The above covers everything from variety development, cultivation, processing, promotion, education and knowledge dis-semination. As such, the Foundation's funds can go towards helping eliminate a number of major obstacles that currently stand in the way of green protein production. As long as the projects only concern crop production for human consumption, the Foundation can support protein sources under all three focus areas of this strategy. A total of DKK 675 million has been allocated for the period until 2030. The aim is to earmark at least half of the Foundation's resources for organic farming.

How the government plans to boost the use of legumes and other protein-rich crops in Denmark

- The government will continue to support varietal development and the cultivation of protein-rich crops through the Strategy for Agricultural Plant Genetic Resources, GUDP, agricultural funds and the Nordic public-private partnership (PPP) on pre-plant cultivation.
- nnovation Fund Denmark promotes research and development of protein-rich crops and other new protein sources. Innovation Fund Denmark has previously granted approx. DKK 200 million to the mission-driven partnership AgriFoodTure.
- With the Agreement on the distribution of the research reserve, etc. in 2023 and 2024, funds have been allocated for plant-based protein-rich crops. In 2023 and 2024, an additional DKK 300.3 million and DKK 31.8 million respectively were allocated to the four green missions, including AgriFoodTure. A further DKK 319.8 million and DKK 338.2 million re-spectively were allocated in 2023 and 2024 for seven thematic calls for proposals where sustainable proteins are a key focus area under the theme 'Agriculture and food production'. In 2024, DKK 75 million will also be al-located to research into climate-friendly foods, including plant-based foods and alternative proteins.
- The government is pushing the production of protein-rich crops such as legumes through the Varied Plant Production eco-scheme under the CAP (the Danish CAP from 2023 to 2027). A total of DKK 116 million has been allocated annually for the period 2023 to 2027.
- The environmental and climate technology scheme under the CAP is able to promote the development of protein-rich crops. The Danish Agricultur-al Agency is investigating to what extent the scheme can provide subsidies for processing. A total of DKK 380 million was allocated to the scheme in 2023. DKK 60 million will be allocated annually from 2025 to 2027.
- The government wishes to explore the possibilities of further supporting protein crop production within the CAP.
- With the agricultural agreement, the government has established the Plant-based Food Grant, which has a total budget of DKK 675 million for the period 2023 to 2030. The Plant-based Food Grant is set up to support projects within the entire value chain of plant-based foods, including protein-rich crops.



7.0
New protein sources

Denmark's future protein supply is not only to be found in the fields. New proteins can come from a variety of sources. Seaweed, algae, insects, fermented protein, single-cell proteins and cultured meat are all possible alternative sources of protein that we do not exploit much of today, if at all. What several of these types of protein sources have in common is that they do not need to be grown in fields and so do not take up nearly as much space as traditional animal proteins. This is a benefit as these sources do not compete for space with other agricultural production or other land uses such as energy production, recreational areas or nature.

Food production generates residual and side streams that have the potential to be used to extract protein with a high nutritional value, which can be added to food or included in livestock feed. It is also possible to use residual and side streams as a cultivation medium for protein sources such as fungi or insects. For example, it may not be possible to use all parts of the crops directly for food. These might include green beet tops or excess blood from slaughterhouses. In Denmark, we are already good at exploiting our residual and side streams, but there is potential to utilise them further for new products with a higher value or new properties for food, ingredients or pharma. Exploring such potential would follow the bioeconomy principles of making the best use of our resources. There may also be an opportunity to export highvalue products and technology, as this is an area where Danish businesses are leading the way, and currently, any potential of side streams is barely utilised even globally.

A promising source of protein is insect protein. Protein from insects is a potential ingredient for both food and animal feed. The insects' high content of protein, good amino acid composition and umami taste could make them a popular ingredient in food products. Furthermore, according to IFRO, the production of insect protein is expected to increase throughout the EU, including Denmark, by at least 65 percent from 2019 to 2028. There are currently only a small number of insect productions for human consumption in Denmark, including several small-scale productions of mealworms and a few producers of larvae of black soldier fly.

Another promising source of alternative proteins is precision fermentation, which can support both the production of animal food proteins, but also serve as flavouring agents for plantbased products or, for example, growth factors for use in the pro-duction of cultured meat. In the long term, Aarhus University expects to see such protein used in both traditional products, hybrid products and brand new products. Denmark has extensive experience of precision fermentation with worldleading companies.

Other examples of protein sources based on residual and side streams are potato protein, spent grain, proteins from slaughterhouse waste, fungi or proteins grown on methane. These products are already in use today, but there is a potential for better and more efficient use. Potato protein is a side stream from the potato flour factories, which produce 20,000 tonnes of potato protein annually. In 2021, starch potatoes were grown on an area of approx. 35,000 hectares in Denmark, which

corresponds to an increase of 49 percent since 2015. Aarhus University sees a potential for increasing potato protein production. The climate footprint of potatoes ranks as one of the lowest for crops per kilogram of food produced, but involves a relatively high consumption of pesticides. The potato protein has several uses. Potato proteins can be used in animal feed. When it comes to food, the potato protein can partly be used as a functional ingredient e.g. for adding texture or as a binder, or it can be used in protein-rich foods.

Because protein from residual and side streams is a by-product, the production potential is often limited by the demand for the primary product. An example could be rapeseed cake, which is a byproduct of oil production for e.g. food or biodiesel. Rapeseed production is a wellestablished industry in Denmark with up to 900,000 tonnes of rapeseed harvested annually. Furthermore, rapeseed cakes have a high protein content and a particularly good amino acid composition, hence why they are used for animal feed. Rapeseed cakes have the potential to become a protein source for human consumption in future, but would require further research and devel-opment to eliminate unwanted substances that may be unhealthy if consumed in large quantities.

AU estimates that it will take more than ten years before protein sources such as microalgae or proteins from precision fermentation will have a significant, established production in Denmark. While the production potential may be significant in the long term, it is hard to estimate currently, and the production costs are also high presently. In the early stages of development, funds for research and development are essential to increasing production and improving economic competitiveness in the long term. There are also a number of regulatory challenges associated with a more efficient use of residual and side streams.

Initiatives to support the development of new proteins

Biosolutions

Biotechnical solutions (biosolutions) is a rapidly growing area for Danish companies, which are using enzymes, algae and bacterial cultures to produce new green solutions. This is an area that has the potential to make a significant contribution to the global green transition. Overall, biosolutions is an umbrella term for biotech green solutions within e.g. food and materials. The production of innovative protein products and ingredients is often based on biotech solutions such as various forms of fermentation. Innovative companies and excellent interaction with the research community put Denmark in a strong position in this field. Precision fermentation is a good example.

In the long term, the potential for producing proteins in industrial plants, such as single-cell proteins, is impressive. These single-celled organisms generally have a high protein content. Furthermore, there are a number of benefits to production in closed systems such as high productivity, low land use and low or no leaching of nutrients. Microalgae, yeast cells, bacteria, and mycoprotein are all examples of single-cell proteins. Mycoprotein is derived from fungi. The development of myco-protein in Denmark is currently being funded by GUDP as part an ongoing project that seeks to produce mycoprotein from oyster mushrooms using residues from the sugar industry. The project was granted DKK 6.9 million for the period 2020 to 2023.

A large number of parties in Region Zealand have joined forces on *Business Light-house Biosolutions Zealand,* including knowledge institutions, companies, munic-ipalities and regions. Biosolutions Zealand is one of eight business lighthouses that the government has supported with a total of DKK 1 billion in 2022-25. So far, ap-proximately DKK 98 million has been spent on developing the biosolutions sector through the business lighthouse. The aim of the collaboration is for Zealand and Denmark to become a major global operator in biosolutions. Business Lighthouse Biosolutions Zealand specifically supports the development of alternative proteins by supporting the construction of testing, demonstration and development facilities for biorefining and biofermentation, which together will support the development of new technologies, solutions and companies within biosolutions all the way from research to market (TRL levels 1 to 9). The project can thus help address a major challenge for innovation and development of new, green proteins. The government has also entered into a partnership agreement with the consortium behind the lighthouse to create a framework for strategic and coordinated development of the biosolutions sector in the short and long term. Here, work is also being done to address regulatory barriers and strengthen the framework conditions for new technologies and products within biosolutions to enter the market.

Through agreements on the allocation of the research reserve, etc. in 2024, DKK 45 million has also been allocated for research and technology development within biosolutions, which is expected to support the development of new, green proteins. The funds will be implemented in 2024.

New consortium focusing on fermentation

The Novo Nordisk Foundation and the Bill & Melinda Gates Foundation have joined forces to support a new consortium that will use CO2 to produce alterna-tive proteins. The consortium includes the companies Novozymes A/S and Top-soe A/S as well as Washington University in St. Louis, USA, and the Novo Nordisk Foundation CO2 Research Center at Aarhus University. The proteins will be produced by converting CO2 into vinegar, which can subsequently be fermented into proteins that can be included in food. The technology has great sustainability potential, as the use of CO2 to produce food does not require the use of farmland. The total funding budget is up to DKK 200 million over a two-year period.

Microalgae project at the Danish Technological Institute

The ReMapp project is supported by the Innovation Fund Denmark, and is about utli-lising microalgae for feed protein production by using residues from the biogas industry. The project has a total budget of DKK 26 million and in-volves the construction of test fields with algae grown in tubular bags. An 800 square-metre facility will be added to GF Nature Energy's bioplant in Holsted and is expected to produce 4,700 tonnes of algae protein annually.

Research and development

Developing new protein sources is currently a significant growth area, but a common challenge for several of the above-mentioned protein sources is lack of knowledge about use, nutrient content, regulatory conditions and protein quality, toxicology and consumer acceptance. For example, the taste and colour of proteins may limit potential uses of food and consumer acceptance. This issue could be solved during protein extraction, but further research and development of this process is needed. Also, common to the majority of new protein sources is that they are based on technologies and infrastructures that are still only in the early stages of development. For example, using protein sources from side streams for food will often require a purification of the protein to raise the protein content or remove unwanted components, a process that is both cost- and energy-intensive. Life cycle assessments are therefore essential so that products' environmental and climate footprint can be duly assessed.

Projects on new proteins can be supported by government research and development funds implemented through Development and Demonstration Programs and Innovation Fund Denmark, as well as by Approved Technological Service institutes ("Godkendt Teknologisk Service" in Danish, abbreviated "GTS"). These are private knowledge institutions that facilitate knowledge-sharing and provide extra skills for the Danish business community. The Danish Technological Institute is an example of a GTS institute that participates in a number of projects focusing on increased development and research within both green biorefining, protein-rich crops and innovative proteins.

Innovation and the development of promising technologies and solutions often de-pend on access to risk capital. At the beginning of 2023, the three state funds, the Danish Growth Fund, Denmark's Export Credit Agency (EKF) and the Danish Green Investment Fund (DGIF), merged under the name the *Export and Investment Fund Denmark* (EIFO). The new fund aims to 1) promote growth and renewal in Danish business, 2) promote Danish business opportunities for export and internationalisation, participation in the global value chain and growth of new markets, and 3) contribute to a sustainable and green transition. Green food production and agrifood are thus a relevant investment for EIFO and a market with great potential.

Another source of further research and development activities could be international research funding, including the EU's Horizon Europe and the

Circular Bio-based Europe Joint Undertaking (CBE JU). Horizon Europe is the EU's main funding programme for research and innovation, where sustainable food production is a cornerstone. It is, for example, possible to apply for funding for research and inno-vation projects for foods that are "novel food-based" to support the development of taste and texture in new proteins. IFRO has highlighted texture and taste as significant barriers to increasing consumer acceptance and demand for new protein sources. CBE JU is also an EU initiative to promote the circular bioeconomy in Eu-rope, which provides support for research and development on the use of residual and side streams, and the development of new proteins.

The University of Copenhagen estimates that a number of marine protein sources can contribute positively to Denmark's future protein production, but with a more limited potential than e.g. legumes and grass. The potential in exploiting aquatic environments to produce marine protein sources is considered strong. This is partly because production does not compete for space on farmland, and partly because harvesting seaweed and other marine protein sources can have positive effects on the aquatic environment by helping remove nutrients, which in turn can help re-store the aquatic environment. However, several of these protein sources can also be produced on land in socalled aquaculture facilities, where there is potential to ex-ploit the nutrient-rich side streams such as cultivating sea lettuce as a side stream of fish farming. Other examples of marine protein sources are mussels and starfish, which are currently harvested to a much lesser extent than they could be.

Aarhus University estimates that less than 20 tonnes of seaweed are currently pro-duced annually in Denmark, but that the potential is significantly greater. This is particularly true of sea lettuce, where up to 11,000 tonnes are expected to be har-vested annually by 2030. The protein content of seaweed varies from species to spe-cies, but can be up to 47 percent of the dry matter content. However, if seaweed is to be included as a significant part of the human diet, it needs to be further refined to make it easier to digest. Seaweed production in Denmark also faces other significant barriers, such as high production costs, lack of development of biorefining and pro-cessing, and lack of permits for cultivation, which limits the potential. With the aim of supporting the development of Danish aquaculture, in March 2021, the govern-ment allocated funds to two initiatives through the *Agreement on the Maritime, Fisheries and Aquaculture Programme 2021-2023,*

Danish company about to launch a large-scale production of soldier fly larvae.

In 2023, the company Enorm Biofactory built a new plant for producing insect protein on a large scale. The financing behind the Nordic region's largest commercial insect production comes from the Danish Green Investment Fund, Nykredit Bank and DLG, among others. Enorm produces soldier fly larvae on a large scale for animal feed, including chicken and fish feed. The larvae in the plant utilise residues from food production for feed, and new proteins are there-by produced from residual products, while the production's waste products will serve as fertiliser. With this production facility, Enorm estimates that they can produce up to 11,000 tonnes of insect protein annually.

which has also been continued in the Finance Act for 2024. DKK 64.4 million has been allocated for develop-ment projects for the period 2021 to 2027, including the development of low-trophic aquaculture, such as mussel farming, and DKK 11.9 million has been allo-cated for the development of commercial seaweed production in Denmark.

Regulatory challenges

Regulations comprise significant barriers to developing new protein sources, often due to the necessary considerations that need to be made for feed and food safety as well as animal health. An example of this is insect protein, where the rules around feed and food use constitute a significant barrier. For animal feed it is the TSE regu-lation and the Animal byproducts regulation that regulate which animal compo-nents can be used in feed, including the approval of insect species. This poses a challenge partly to feed supply for insect production and partly to the insect pro-tein's use as feed.

With the need to follow existing food safety in mind, the Ministry of Food, Agriculture and Fisheries is actively working in the EU to relax the rules for animal feed bans, and to increase the supply of animal components that can be used as sustain-able feed for farmed animals, where this is justifiable. This is one of the regulatory barriers mentioned by IFRO. In the food area, a number of insect species have been approved in the EU, but if the products are to be further processed, new food ap-provals will be essential.

The previous government's ingredients strategy was adopted in 2019 with the aim of supporting the development of the Danish ingredients industry within the feed and food area. One of the areas where the ingredients strategy has contributed positively to new proteins is by strengthening the guidance on legislation in the area and working to remove legal barriers to developing new, sustainable ingredients. As part of the strategy, the Danish Veterinary and Food Administration established a *Forum for Future Ingredients,* a discussion forum for the development of the Danish ingredients industry. This effort has resulted in a number of recommendations to the government, which also specifically cover green proteins.

So far, many of the new protein sources have not been used to any significant extent for either food or feed. Before new, green proteins can be used in food in Denmark, they must be food approved, both in Denmark and in the EU. The approvals of novel foods are often time-consuming and costly, which is a significant barrier to many of the new green proteins mentioned in this strategy. The EU regulation on novel foods is particularly relevant in this context. Novel food is food that has not been consumed to any significant extent in the EU before 15 May 1997 and therefore, must be riskassessed and approved before being placed on the EU market. The Danish Veterinary and Food Administration is providing more guidance on the rules for novel food in line with the previous government's *ingredient strategy* from 2019. The increased focus has enabled small and mediumsized companies to better understand the rules and incorporate them at an early stage in the develop-ment process.

How the government plans to support the development of new protein sources

- The government has allocated DKK 1 billion to a number of business lighthouses for the period 2022 to 2025, including DKK 97.8 million for the public-private business lighthouse Biosolutions Zealand, which supports the development of new technologies and solutions within biosolutions.
- With agreements on the research reserve etc. in 2024, the government has allocated DKK 45 million to research and technology development within biosolutions, which also supports the development of new protein sources.
- The government has allocated approx. DKK 931 million for the period 2024 to 2026 to continue Approved Service Institutes (GTS), which, among other things, can support research and development into new pro-teins.
- EIFO is also able to invest in green food production and agrifood, and the government can support investments in the sector through the organisation.
- The government is supporting research and development of new proteins through Development and Demonstration Programs and Innovation Fund Denmark.
- Following the agreement on the Maritime, Fisheries and Aquaculture Programme 2021 to 2027, a total of DKK 64.4 million and DKK 11.9 million will be allocated to development projects, including mussel farming, and to commercial development of Danish seaweed production, respectively.
- The government will strive towards achieving innovation-friendly regulations in Denmark and the EU without compromising nature, environment, health, feed and food safety and animal health. This applies, among other things, to TSEs, by-products and novel food regulations in the EU.
- The government is supporting companies' innovation and development of new proteins through the Danish Veterinary and Food Administration's guidelines on novel food and other relevant regulations.
- Through the ingredient strategy and the Forum for Future Ingredients, the government has promoted the development of the Danish ingredients in-dustry, including new protein ingredients.



8.0 Internationalisation and export

Denmark's economy is small and open, which is why we must adopt an international mindset. We need to look abroad both when selling products, equipment and technologies, but also when it comes to attracting investments, new knowledge and entering into collaborations to develop and increase green protein production at home.

Export opportunities

The potential for exporting Danish technological solutions and products, e.g. within plant-based foods and biosolutions is vast. Not only because of a generally increas-ing demand for proteins globally, but also because more countries demand greener food and greener food production. The Danish biosolutions sector, for example, already has a solid foothold in international markets and exported an estimated DKK 27 billion in 2021, according to the consultancy HBS Economics. But the full potential won't be released by itself.

In September 2022, the previous government launched its action plan for food cluster exports. The action plan sets out a plan for the authorities' efforts and cooperation with the industry, including guidance on export opportunities for Danish companies. The action plan highlights the export potential of plantbased foods and proteins. As such, the Danish government is supporting food clusters' businesses by creating and maintaining market access and identifying customers and partners in priority markets. Among other activities, the Ministry of Food, Agriculture and Fisheries is supporting companies' access to exports by negotiating new and expanded market access with third countries and certifying the actual exports. Exports are also supported at the Danish representations abroad through The Trade Council, which helps Danish companies with market-oriented export promotion efforts, as well as valuable cooperation between authorities with the aim of increasing demand for the goods and solutions offered by Danish companies.

In 2022, the Danish food cluster's export forum set up a task force, which has come up with recommendations for stronger exports of biosolutions and food ingredients. The Forum has also set up a Task Force for plant-based foods. The task forces com-prises companies, organisations and authorities. The task forces completed their work at the start of 2023, and presented recommendations for initiatives that are followed up by the forum on a continuous basis.

An example of an initiative partly proposed by the task force, whereby Danish authorities collaborate with Danish companies abroad, is The Food & Bio Forum in America under the Ministry of Foreign Affairs' The Trade Council. The forum is an alliance made up of Danish companies in the biosolutions sector and business organisations. The purpose of the forum is to address opportunities and challenges facing the sector, and is aimed at official decision-makers in America in particular. An investigation of how commercial activities can be incorporated into the project is underway, and will in the long term support even more Danish small and medium-sized companies wanting to export to the US.

The export promotion efforts are also supported by Food Nation, which continuously markets the food cluster with white papers, participation at trade fairs and promotions and, not least, attendance at delegations from foreign stakeholders visiting Denmark. In 2021, Food Nation launched a white paper on ingredients, which partially addresses green ingredients for food production. Later in 2023, Food Nation launched a case catalogue on biosolutions, highlighting how the Danish biosolutions sector can contribute to greener food production globally.

Innovation, research and entrepreneurship

Innovation Centre Denmark (ICDK) is a collaboration between the Ministry of Foreign Affairs and the Ministry of Higher Education and Science will support these efforts through its innovation centres in South Korea, India, China, Israel, Germany and the US. Through its network of operators in international innovation ecosys-tems, ICDK creates access for Danish knowledge institutions, start-ups, scale-ups, large companies and authorities to technology, knowledge, partners, financing and help to test and adapt companies' solutions and business models in an international context.

ICDK can also contribute to strengthening Danish research and development within green proteins by bringing knowledge and best practices back to Denmark from markets that are further ahead in the field. The organisation can also help pave the way for research and innovation collaborations between Danish and international players.

A number of the innovation centres have specific activities centred on green pro-teins. In the US, the centre is studying alternative proteins as part of a biosolutions effort. In Korea, a collaboration is underway between Danish and Korean operators to develop and use seaweed in food and to see how foodtech can support its production. Finally, the centre in Israel is working on a project within AgriFoodTure concerning climate- and environmentally friendly food production with a focus on car-bon-reducing technologies, which could also be used in alternative protein production

The Global Innovation Network Programme (GINP) initiative was established under the Ministry of Higher Education and Science in 2022 to support an in-creased internationalisation of Danish research and innovation. The programme is designed to support networking activities outside the EU and the European Eco-nomic Area. An example of such cooperation is the DK-Korea Blue BioCluster Alliance, which has received support through GINP. The Alliance is studying the use of seaweed in food, feed and pharmaceuticals, as well as the climate benefits of using seaweed. The Global Innovation Network Programme has also supported a major initiative in which the University of Copenhagen together with a number of Danish partners, including knowledge institutions and companies, participated in the 'Future of Food' conference in California in March 2023, where plant-based foods were a major focus.

Invest in Denmark

Denmark needs to look abroad to attract foreign investment and to bring new knowledge, innovation and technology back home. Foreign companies can help make Denmark e a leader in the development of green proteins for the future. Attracting foreign investment will be achieved through Invest in Denmark, which will continue its focus on attracting foreign companies and investments in e.g. the Food & Feed area.

How the government plans to strengthen Danish export opportuni-ties for green proteins

- Support Danish companies' export opportunities within plantbased foods, biosolutions and ingredients, e.g. under the auspices of the Trade Council.
- Through the Forum for Food Cluster Exports, the government and business community will continue to support and boost export promotion efforts for Danish products and technologies.
- The government will promote and market the Danish food cluster, including green proteins, ingredients and plant-based foods through Food Nation.
- Through the Danish food cluster's export forum the government will continue to support Danish biosolutions companies in the US under the auspi-ces of 'The Food & Bio Forum' and in Germany under the auspices of 'Danish Biosolutions in Germany', e.g. by facilitating dialogue with relevant decision-makers and stakeholders at both government and company level.
- The government will continue to contribute actively to boosting Danish research, innovation and entrepreneurship in alternative proteins and biosolutions through the Danish innovation centres in the US, South Korea and Israel, among others.
- Through the Global Innovation Network Programme, the government is supporting an increased internationalisation of Danish research and inno-vation, e.g. through network-building activities outside the EU and the European Economic Area on new proteins.
- The government will continue to actively attract foreign companies and investments in the Food & Feed area, which also includes alternative proteins.





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