Recommendations from the National Bioeconomy Panel

Proteins for the future

The Danish National
BIOECONOMY
Panel

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Introduction

Global population will increase from today's 7 billion to around 10 billion in 2050; along with this, the global middle classes increase by 3 billion, which will lead to a growing demand for healthy and tasty food produced in an environmentally and climate-friendly way.

UN Sustainable Development Goals

Perspectives for bio-economy

Since the industrial revolution the world's companies have produced according to linear thinking. We extract raw materials, produce, consume, and discard. This has created considerable prosperity in the world, but has also resulted in a massive pressure on the resources of the planet. Three planets would be required, if everybody were to live the way we do in Denmark. Consequently, we have to rethink our production and consumption. The present linear economy must be transformed into a circular economy. We must utilise our biological resources in a new way that fits production conditions of the future. What used to be waste must in the future be a valuable input in new products.

Bioeconomy comprises the production of renewable biological resources and the conversion of these resources and their waste streams into products with an added value, such as food, feed, bio-based products, and bioenergy. Bioeconomy can lead to increased production of sustainable biomass, in which the total pressure on the environment and climate can be reduced. Concurrently, bioeconomy must promote the resource efficient use of biomass for feed, food, biomaterials, and bioenergy.

In other words, we get more out of the biomass and less wastage of what we grow, harvest, produce, and eat – and we become better at recycling our resources. At the international level developments are already ongoing to promote bioeconomy. Bioeconomic thinking is gaining ground globally – and it is crucial that Denmark is at the cutting edge.

"We must utilise our biological resources in a new way that fits production conditions of the future."

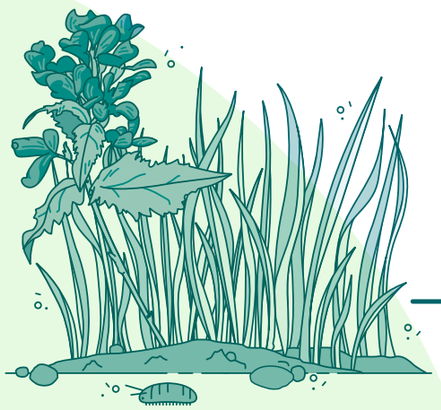
Bioeconomy can contribute to continued economic growth and prosperity in a way that the Earth can cope. The UN Global Goals for Sustainable Development adopted in 2015 are to take the world in a more sustainable direction, and bioeconomy is part of the solution to attain the Global Goals. It will sustain Denmark's Global Goals Action Plan and create awareness among companies about new business opportunities and their customers' higher expectations for local and global sustainability.

Bioeconomy also plays a key role in attaining the international climate goals from Paris in 2015 (COP21): bioeconomy can contribute by creating solutions for a fossil-free future through the development of new biomaterials, climate-friendly types of feed and food, production of bioenergy, and by promoting more sustainable consumption in general. The coming COP process should focus not only on bioenergy, but also on incentives for attaining an increased and sustainable yield from the biological resources, and a better utilisation of what is harvested, grown, or caught. It must create a new strong driver for sustainable bioeconomy and thus also promote the attainment of the goals of the climate agreement.

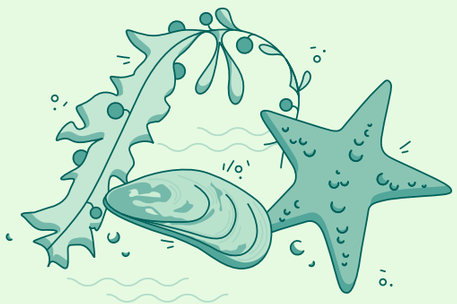
Danish biotechnology companies are at the cutting edge in a broad spectrum of biotechnology. We see examples in the use of microorganisms and enzymes in the production of food, pharmaceuticals, chemicals, and within plant improvement. Although we have a strong starting position in the form of professional research environments and a world-class industry, developments in countries around us are rapid, not only in Europe, but also in countries such as USA, China, and Brazil. In order for Denmark to keep its frontrunner position it is important to dedicate serious and focused efforts in modern biotechnology – a central issue for the development of bioeconomy in Denmark.

One of the fields in which Denmark has the opportunity to create a competitive lead within bioeconomy, is the development of protein value chains. New protein value chains means the development of new proteins (such as grass or insects), new processing technologies, and new products in the range of feed and food.

New protein value chains



New proteins from land



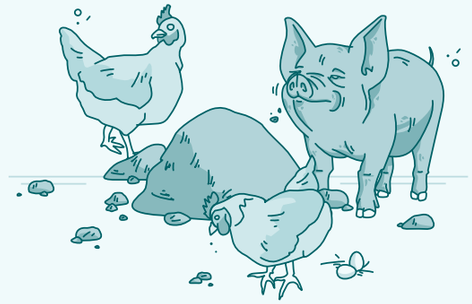
New proteins from sea

New proteins from residual and secondary flows

Raw materials

Processing and technology
(such as biorefining)

Food
(such as ingredients for food production and insects)



Feed
(such as protein additives to feed mixtures)

Other products
(such as pharma-ceuticals and fertiliser)

Market

Overview of recommendations

The National Bioeconomy Panel recommends:

1

A national bioeconomy strategy with clear political targets is prepared.

2

A forum is established for the coordination of bioeconomy measures within relevant public appropriations bodies focusing on a prioritisation of funds for research and development in this field.

3

More funds are set aside for research, development, and establishment of new bioeconomy value chains in Denmark, including support for pilot and demonstration facilities within biorefining.

4

Knowledge and value chain partnerships are established for the development of new sustainable bioeconomy value chains, and business incubation and acceleration environments for start-ups are strengthened.

5

Capital injection and public funding of bioeconomy projects are increased by activating venture capital.

6

Skills and competences within new bioeconomy value chains are strengthened.

7

Research and development measures to promote the supply of sustainable raw materials for new protein value chains are implemented.

8

Environmentally and climate-friendly production of biomass is acknowledged as an instrument in national regulation, such as targets within the aquatic environment and climate. Environmental impacts across sectors are calculated and incorporated into future political initiatives.

9

EU framework conditions for new, more sustainably produced proteins are promoted.

10

An enhanced national focus on bioeconomy is accelerated through stronger coordination and common knowledge about biorefining between universities, approved technological service providers, the business community, and other stakeholders in view of promoting the development of an innovative Danish biorefining industry.

11

Research, development, and establishment of first-of-its-kind biorefining for promising, sustainably produced protein-rich biomass are supported.

12

Basic knowledge about which types of proteins are in demand on the market is gathered.

13

Existing and new knowledge about environmental and climate footprints in different protein products is gathered, organised, and used to inform companies and consumers about products in the new protein value chains.

14

A fund for financing of specific nutritional and toxicological studies and surveys of functional properties of concrete protein sources is established.

15

Traceability within new protein products is promoted in view of securing that existing traceability systems are adequate for handling new protein products for food and feed.

Case

Example of partnership: Insect network under INBIOM

Insects are a new field within feed and food with great potential. A network of stakeholders - Danish Insect Network - has been established under INBIOM (Innovation Network for Biomass) for companies and researchers in the field. Participation in the network is open for all and free of charge.

After just below two years of existence, the network has now 188 members from 144 unique organisations. Focus of the network is knowledge sharing, input from researchers and other knowledge institutions, inspiration from abroad through international speakers, and contact to funding institutions.

A sustainable bioeconomy in Denmark

Cross-sectoral thinking is important when it comes to the realisation of the potentials of bioeconomy. Therefore, partnerships, access to financing, and good coordination of research and development are the key cornerstones of the National Bioeconomy Panel's recommendations for the Government.

To exploit the Danish potential for the development of new bioeconomy value chains – with sale of technology, knowhow, and bio-based products on a growing global market – it is important with even stronger partnerships with the participation of all relevant players throughout the value chain. Bioeconomy must be a natural part of our society's thinking from education and research to financing, policy development, and regulation.

In the field of education we need to have focus on the entire system – from upper secondary education and vocational training to university education. The development of strong graduate and research education will be the answer to companies' demand for candidates.

In order to create a Danish bioeconomic growth adventure it is necessary to identify and match new and existing resources with accessible plant capacity and the development in demand for new proteins for various purposes. System integration and digitalisation are some of the tools for attaining full exploitation of the opportunities within bioeconomy and linking the new value chains for, e.g., feed to biomaterials, biochemicals, and bioenergy.

In Denmark, we have a tradition for strong partnerships within the food value chains, particularly in the fields where ownership coincides vertically in the value chain; these partnerships may give inspiration to partnerships in other value chains (such as blue biomass).
The potential to be gained from an enhanced cooperation throughout the protein value chain is large, since partnerships may create coherence from one link in the chain to the next, ensuring that the potential for development of new protein value chains is enhanced and focused on a commercial market. There is a specific potential in long-term innovative partnerships between companies, universities, and public authorities. Whenever expedient, partnerships can be coupled to international initiatives in the EU, the Nordic countries, or beyond Europe.

If Denmark is to harvest the highest possible yield from bioeconomy in the future, and if Danish companies' competiveness and leading position are to be secured, we must focus intensely on research in the bioeconomy field. There is a potential for creating higher societal value by giving research a cross-sectoral aim and ensuring that it works in broad partnerships with the participation of industry, along with a focus on dissemination of knowledge, broad dialogue, and sustainability.

This will reduce the risks of investments in the transition to new technologies and products.
An accelerated development of competitive feed and food products of high quality may be ensured by creating a visionary and focused cooperation between primary plant production (such as plant improvement and plant production), processing industries (such as upgrading of secondary flows), animal production, as well as the feed and food ingredient industries. The potential found in the synergy between animal and plant production is pivotal to market development.

The development of a competitive bioeconomy requires both private and public investments and must show the good business cases in the longer-term perspective. Simpler access to financing of a bioeconomic venture will mean that promising projects are realised through sufficient financing. The opportunities for investing venture capital and attracting private investments may be improved by better activation of venture capital and a reduction of risks in connection with fixed asset investments and market maturing. This may be promoted through focused public business promotion measures. This also applies to the EU structural funds and focused and coordinated research and innovation efforts. The benefits to be harvested through the support of an efficient capital injection will be that projects accelerate, thereby creating profit, environmental and societal value, as well as jobs.

"The development of a competitive bioeconomy requires both private and public investments and must show the good business cases in the longer-term perspective."

By reducing regulation and market risks and improving the framework for and supply of venture capital it is possible to promote scaling and commercialisation of plants and new business models from demonstration/pilot scale to full scale. At the same time, a larger supply of special venture capital and reduction of risks may contribute to the promotion of a wealth of SMEs inspiring and feeding into, among others, the larger companies' continuous innovation.

There is a large potential in bioeconomy with the wealth of Danish SMEs and entrepreneurs that are considered to constitute a substantial part of the future Danish "ecosystem" within new protein value chains. This applies both to their capacity as stand-alone units with a special capital need and to their feeding into larger companies' continuous innovation and investments in, e.g., increasing the value of secondary flows.

Challenges facing bioeconomy in Denmark

There is a need for further partnerships with the participation of all links in new bioeconomy value chains – all the way from raw material producers over processing companies, the retail sector, consumers, and the recycling industries up to knowledge institutions.

Partnerships have been called for at many different levels. It is a challenge to get sufficient information across the value chain, in order that, e.g., plant producers can work to improve plants targeted at what is in demand. Another challenge is to secure sufficient cooperation on technical solutions across, e.g., different types of biomass or technologies, in order that solutions become sufficiently efficient for reaching a commercial stage. There are further practical and concrete challenges, such as storage of proteins that may be solved through inspiration from technology suppliers that do not necessarily work in the food or feed industries. Finally, it is a challenge to exploit the knowhow that is available internationally. In the EU, focus has for several years been on bioeconomy and partnerships in the research field. In 2014, EU Member States launched a major public-private partnership (Bio-Based Industries Joint Undertaking, BBI-JU), and there are other smaller partnerships with the primary purpose of coordinating research and innovation efforts in the EU Member States. It is crucial that Denmark utilises these initiatives along with other initiatives that are launched at the international level.

Denmark has strong bioeconomic research environments that over time have had great success in the EU framework programmes for research and development. In Denmark, the research financing system has had focus on biotechnological options within food, feed, and the use of bioresources for non-food. In Denmark, business-related research is mainly supported through Innovation Fund Denmark, the technology development and demonstration programmes, and regional business promotion initiatives. There is a request for a more coherent strategy coordinating the Danish efforts and integrating research and innovation initiatives in the EU context. Measures in this field should be incorporated in the future business promotion system.

New protein value chains hold an enormous global potential that should attract more and new types of investors. Also, there is a need for major long-term investments in the entire protein value chain to allow for the establishment of technologies and processing methods, and to launch new protein products.

Financial players by tradition have low knowledge of potentials and business opportunities within bioeconomy, since this agenda is new and the technical complexity is high, involving uncertainties for facilities and sale of the produced proteins. An overall comprehensive narrative to be used by investors as a strategic benchmark is called for in their assessment of risks.

It is also a challenge that many links in the protein value chain and especially the technological solutions constituting the bioeconomic business models are immature from a technical point of view. They require dedicated public financing in order to develop and become profitable, thus supporting the transition from idea over pilot plant to full-scale technology. Therefore, there is a need for public funds that may be used to achieve socially beneficial purposes through biorefining. At the same time, the initial investments in, among others, pilot and demonstration plants are relative large and the product fields are in many cases new, thereby requiring the creation of entirely new markets.

The start-up of new protein value chains, in other words, may mean initial low income, relatively large investments and high risks in the short-term perspective, before the value chains are fully established in the markets, the investors see a suitable return, and the companies have gone through the so-called "valley of death". This is a key barrier. One of the key challenges is to create larger cohesion and coordination between the different investment channels, all the way from different types of public financing and lending opportunities, over venture capital, pension funds, private investors, and industrial players to banks – thereby securing the adequate gearing of efforts. Another specific challenge is to exploit the many options available in the EU and in the Danish established innovation system.

Finally, it is a challenge that the access to establishment and lending opportunities is unclear; companies call for further information and support in connection with new options for access to capital, such as new EU lending opportunities. Also, application processes for new and immature technologies are seen as heavy, in particular for SMEs. Thus, there is a need for enhanced incubation and acceleration environments within Danish bioeconomy promoting the transition from research to commercialisation, especially for SMEs.

Example of system integration:

There are many aspects to be considered in an overall optimisation of the value chains.

Grass is an example of a crop that is grown today almost exclusively for cattle feed. Through biorefining it is possible to divide grass into several fractions, each contributing to an added value of the crop. The biorefining process divides grass into three fractions:

- A protein concentrate that can be used for monogastric animals such as pigs and poultry.
- A fibre fraction that can be used for cattle feed and, in a longer-term perspective, can be refined into prebiotic feed for monogastric animals.
- A residual juice that can be used in biogas facilities, thus ensuring the recirculation of nutrients.

Perennial grasses have positive impacts on the environment and climate: there is very low nitrogen leaching from grass areas, a high soil carbon sequestration, and a very low use of pesticides. Biorefining, thereby, creates new income opportunities in this industry, and the positive environmental and climate impacts may contribute to solving some of the challenges that agriculture is facing.

General recommendations

The Panel attaches importance to presenting general recommendations across all the themes that the Panel expects to be discussing over the next years:

1

A bioeconomy strategy with clear political targets is prepared.

Among others it should contain a strategy for the development of new protein value chains. The objective is to make Denmark a frontrunner within sustainable bioeconomy.

The strategy should contain:

- A vision and clear targets for bioeconomy in Denmark as well as identification of relevant indicators for continuous follow-up.
- Benchmarks for a long-term development of new protein sources with plant improvement, biomass production utilising the resources of the sun, water, and nutrients more efficiently, innovative harvesting and logistics, utilisation of residual and secondary flows, and new technologies being the key elements.
- Initiatives focusing, among others, on future needs for sustainable and ample protein sources.
- A clear cohesion with the EU bioeconomy strategy, the coming EU protein strategy, and the Nordic bioeconomy programme.

A bioeconomy summit is organised once a year with the participation of all relevant players (authorities, universities, approved technological service providers, key companies, NGOs, and other organisations) in order to ensure progress, information, and focused coordination during the implementation of the bioeconomy strategy.

2

A joint forum is established with representatives of all relevant public appropriations bodies with the task of optimising the societal resources used for research and development efforts in the bioeconomy field.

This is ensured by coordinating and preparing recommendations for priorities for the different appropriations boards.

3

More funds are set aside for research, development, and establishment of new bioeconomy value chains in Denmark, including support for pilot and demonstration facilities within biorefining.

4

Cohesion in the protein value chains is strengthened by:

Establishing the frames for knowledge and value chain partnerships on the development of new sustainable bioeconomy value chains with participation of key business stakeholders, having concrete targets for the development of new products. These partnerships must cover the entire value chain and may consist, among others, of raw material suppliers, technology owners, processing companies, and asset managers. The partnership will focus on the creation of knowledge about bioeconomic business opportunities.

Promoting a national incubation and acceleration environment for start-ups by having the public subsidy system creating larger economic incentives for a closer cooperation between small and large companies, in order that more large companies are motivated to enter eligible partnerships with small companies, taking upon them the role of incubator.

5

Capital injection and public funding of bioeconomy projects are increased by:

Activating private venture capital, in particular for small companies, by having public cooperation with the financial sector on the development of a number of mixed financing products (in which the public side can provide, e.g., security or similar) in order to limit the risks entailed by private investors. This may be done, e.g., by allowing the Danish Green Investment Fund to offer equity capital and security, and generally increase loans thereby increasing the access to venture capital.

Establishing matchmaking between capital and the growth layer of potential SMEs by organising pitch sessions with relevant investors (e.g. through innovation networks such as INBIOM).

Increasing information for Danish companies about the opportunities for financing in the Horizon2020 programme, the upcoming investment/lending platform under EIB, and other financing sources.

6

Skills and competences within new bioeconomy value chains are strengthened by:

Launching cooperation between universities, approved technological service providers, and vocational courses in biorefining and development of new bioeconomy value chains. Companies participate actively in the development of educational curricula at universities, vocational training institutes etc. as

well as by teaching at focused courses, workshops, etc.

Proteins for the future

Bioeconomy is under rapid change. There used to be a major focus on the production of bio-fuels. Today we can do so much more.

Actually, we can produce a number of products and in the end exploit the energy contained in the residues. Such a cascading use can and must be developed further.

One of the most important constituents of biomass is proteins, which are crucial in feeding the world. The Panel has worked to identify the business potentials for a number of protein value chains and to draw up concrete and ambitious recommendations for how to realise these potentials in order that a sustainable development in Denmark is promoted with a positive impact on the environment and climate.

Denmark has strong competences when it comes to the production and development of feed, food, and other products based on proteins. All these product groups see a surge in demand at the local and global levels. Potentials for growth and export are seen for new land and marine-based protein sources and from a better exploitation of residual and secondary flows from industry. The low-value proteins of the residual flows may in some cases be utilised for high-value ingredients for feed and food use. The National Bioeconomy Panel estimates a need for a broad range of new bioresources, processing technologies, and protein products. Thus, there will not be one protein source, but a large number of different new protein sources on the markets of the future.

If we are to realise the large potentials in the protein field, everybody must do their bit to promote the agenda. This includes Government. For we have a number of challenges in all links in the chains. Many Danish stakeholders hold knowledge, technological knowhow, and not least the will to go for the potentials of the new protein sources, but it is a long haul.

It takes time to make the transition to new protein sources capable of competing with existing well-developed sources, and it takes a multitude of permits, dialogue with producers and buyers, approvals, etc. If Denmark is to be a first-mover in some of these new value chains, an active effort is called for.

Global and European demand for proteins on the increase

The global need for proteins will increase steeply along with population growth, economic growth, and higher purchasing power, along with higher focus on health and lifestyle. It is assessed that total global consumption of animal proteins from 2007 to 2030 may increase by around 70 percent[1]; an increase in the demand for plant-based proteins for food is also expected.

70 pct.

Total global consumption of animal proteins from 2007 to 2030 may increase by around 70 percent; an increase in the demand for plant-based proteins for food is also expected.

Proteins for feed are today a global commodity, and the price follows largely the world market price of soy proteins. The future market for new proteins for feed, therefore, must be able to compete in price and quality with soy. There is a trend that the ethical, environmental, and climate footprints of feed proteins increasingly are a competitive parameter in global trade. For example, several major European dairy plants today opt out of genetically modified soy proteins, demanding near-produced non-GMO feed proteins. In the EU, there is no balance between the production and consumption of proteins. This means, among others, that every year we import around 27 million tonnes of soy, which is primarily used for feed. Only just below 5 percent of soy used in Europe is produced in Europe. To secure a higher degree of self-sufficiency within the EU, the EU Commission has decided to prepare an EU protein plan, expected to be adopted by late 2018.

China, India, and USA are the world's largest producers of organic soy beans, but only around 0.3 percent of the world's total soy production is organic. An increasing demand for organic soy is expected. Several European countries, such as Germany, Austria, and Switzerland, wish to become independent from imports of, in particular, overseas organic soy. Also, in a number of EU Member States there is a growing wish to become less dependent on imported conventional GM soy. Here, the excess price of non-GM soy products is seen as an opportunity to launch a national production of soy.

Denmark – considerable imports of proteins

In Denmark, annual imports amount to some 1 million tonnes of protein for feed; soy products make up 64 percent, while extracted sunflower seeds/cakes, extracted rake seeds/cakes, and fish meal constitute the second largest part of imported feed protein. Costs of total imports in 2016 amounted to approximately DKK 5.9 billion. Total consumption of protein for feed in

[1] Westhoek, H, Rood, T, van den Berg, M, Janse, J, Nijdam, D, Reudink, M, Stehfest, E. 2011. The Protein Puzzle – the consumption and production of meat, dairy and fish in the European Union. PLB Netherlands Environmental Agency 218 pp

Around 1 million tonnes of protein

In Denmark, annual imports amount to some 1 million tonnes of protein for feed of which soy products make up 64 percent.

Denmark amounted to around 3 million tonnes of protein. Thereby, the feed industry is the largest buyer of the total protein raw material base, also when it comes to new protein sources. It is also interesting and essential to take a look at developments in plant-based and animal proteins for human nutrition; volumes are much lower, but potentially a considerably higher settling price for the proteins can be achieved. For example, the markets for food ingredients may turn out to be interesting specialty market for new protein sources.

In Denmark there is an increasing demand for milk for which no GM products have been used in the cattle feed. This may be conventional non-GM milk or organic products. Both conventional non-GM soy and organic soy come at an excess price that must be covered in the sale of the finished product. In Denmark, our northern location means that the production of soy beans at present is not relevant. Therefore, work is being done in the development of other protein crops and new value chains for the production of protein in replacement of soy protein for feed.

Organic production of milk, beef, and pigmeat sees a limited supply of proteins for feed. Organic farmers demand near-produced and organic protein sources with a positive environmental and climate profile. There is a potential for a substantially increased production of protein in Denmark, concurrently reducing our total environmental and climate impacts, which vary from one crop to another and in relation to the cropping system they are part of.

The market for new proteins for food is a relatively niche-type market, closer linked with the consumer level, while the market for proteins for feed is a business-to-business relation. New proteins for food, such as plant-based proteins, are in demand from a growing group of consumers opting out of animal protein, in total or in part. In several European countries, we see an annual reduction in the sale of meat of up to 2 percent, and several supermarket chains report on annual growth rates of around 100 percent for, e.g., plant-based alternatives to meat. Another market for food proteins is expected to emerge within protein-enriched food for people with a reduced appetite, or to cover other needs for a specific diet.

Environmental impacts

Environmental impacts associated with the production of the new protein sources are partly linked to local conditions, partly to global impacts. Environmental impacts in Denmark may, among others, be lower nitrogen leaching to the aquatic environment from cultivation of new crops on land. The cultivation of mussels and seaweed in marine areas gives the opportunity to collect "lost" nutrients emitted to the marine environment. For the residual and secondary flows it is possible to secure a more resource-efficient use of available resources, lower emissions to the environment, all while increasing the value added.

Global impacts are in particular associated with the total yield of biomass, since with a larger production of biomass for feed in Denmark there is a lower need for imports of feed. In general, the lower pressure on conversion of nature or grazing land into areas under crops means reduced emissions of greenhouse gases and a lower pressure on biodiversity. However, it is important to include total environmental and climate impacts from a conversion to alternative protein sources and to include which protein sources are displaced. If, for instance, the new Danish protein sources produced do not contain oils, and the Danish protein production leads to lower demand for soy, it may create an imbalance between supply and demand for oils, since soy contains vegetable oils. This may lead to increased production of palm oils – a very cheap vegetable oil, whose production may cause considerable negative environmental and climate impacts. Life-cycle analyses may contribute to assessing the consequences in a larger context.

Vision and targets for proteins in Denmark

The National Bioeconomy Panel has set up an overarching vision for new protein value chains: "Within five years alternative Danish protein products with a better environmental and climate footprint can match existing protein products regarding price and quality in key market fields within feed and food".

It is a precondition that the recommendations from the National Bioeconomy Panel are followed. In order to operationalise the vision, specific targets have been set up for selected fields.

Specific targets

- Within five years a commercial production of sustainable protein-rich raw materials from landbased production, aquatic sources, and from industrial residual and secondary flows has been established for both feed and food purposes, having a better environmental and climate footprint than existing products.
- In a relatively short number of years, close to one third of Denmark's imports of feed proteins has been replaced by feed proteins based on Danish protein sources. Danish produced protein sources must be economically and environmentally sustainable, and the functionality of the products must be at least equal to that of existing products.
- Danish companies have established solid business cases for biorefining of protein-rich land and marine-based biomass and of industrial secondary flows.
- The Danish market for new protein products for feed and food has increased by more than 50 percent annually, knowledge is available on environmental and climate footprints, and there is transparent traceability[2].
- There is an ambitious political orientation towards a sustainable bioeconomy in Denmark. Strong partnerships exist for biorefining, among others, and companies have easy access to 13 public and private capital.

[2] Monitored through qualitative interviews with key stakeholders within the feed and food industry (including the retail trade)

A solid raw material base is the foundation of a future increase in the protein production in Denmark. Raw material base is to be seen in broad terms: it covers both cultivated protein crops on agricultural land, raw materials from the sea, cultivated single-cell proteins, and raw materials from residual and secondary flows in industry.

Raw materials

By having a broad focus on the raw material base the best preconditions for utilising and expanding the value chain for protein production are secured. It is a prerequisite that we get more focus on how to produce and utilise the many types of biomass more expediently, thereby reaping the economic and environmental benefits from a sustainable biomass production.

Potentials – Raw materials

The raw material supply to global food production is seeing massive changes. While there is an increasing demand for food, higher requirements are set for the way in which raw materials are produced. For example, the demand for proteins for feed that are not genetically modified is on the increase. There is a need for new protein products in Denmark, and a better utilisation of existing biomass and residual and secondary flows may contribute to an increase in the protein raw material base, while the total environmental and climate burden is reduced. We do not expect to see one type of raw material base solving this matter; instead, we need a long range of different, niche-type protein value chains.

Which crops for biorefining need to be cultivated or harvested, as well as on which areas their cultivation is most expedient depend on the concrete demand from industry and consumers. It also depends on the way in which farmers or other primary producers may be credited for the positive environmental impacts associated with this production.

Denmark is in a good position to become the frontrunner in identifying and realising the potentials of different new raw materials useable for protein products. Three raw material spheres are in play for new protein products.

The first raw material sphere is from sources produced on land. This may be crops such as grasses, clover, lucerne, broad bean, or other legumes with a high content of proteins. There are potentials for an increased protein yield per hectare, an improvement of the quality of the products (digestibility etc.), an improvement of the operating economy, and retention/creation of new jobs (first and foremost in the rural areas); all this may go hand in hand with a reduced need for imports of protein-rich raw materials. However, it should be considered that protein crops cultivated on agricultural land require arable land; this is one of the most essential factors when it comes to climate accounts and biodiversity.

Denmark has a strong starting position when it comes to exploiting the potential of plant improvement, since we have highly specialised and valuable competences among companies and knowledge institutions, a broadly based international cooperation, and a tradition for public-private partnerships, among others through the coordination taking place in Crop Innovation Denmark (CID). This means that knowledge can quickly be turned into products and production. The Danish plant improvement industry has the competences allowing for the production of new high-yield robust varieties of,

New protein sources with large potential

Within few years a substantial production potential can be realised for perennial grasses. A conversion of 100,000 hectares from a combination of existing grass, cereal, and corn areas to perennial grasses and grass field legumes will yield some additional 50-100,000 tonnes of protein in Denmark (corresponding to the protein content of 105,000-210,000 tonnes of soy cake meal).

The cultivation of grass instead of cereals reduces nitrate leaching from agricultural land substantially (30-50 kg N / ha). A conversion of 100,000 hectares will mean a reduction of nitrate leaching of between 3,000 and 5,000 tonnes of nitrogen from the root zone, along with reduced consumption of pesticides. In addition, emissions of greenhouse gases will be reduced by 1-2 tonnes of CO_2 eq per hectare, if changes in soil carbon stock are included. The potential for nitrogen reduction may be far larger in cases where the conversion affects corn, since the nitrogen reduction here is substantially larger (up to 70-80 kg N/ha). There may also be a further potential in having grass on the most environmentally vulnerable lands.

If the production of broad bean increases by around 100,000 hectares, the net increase in proteins will attain some 110,000 tonnes. It is possible to increase production in the short term, depending on plant improvement efforts. Finally, there is a potential for upgrading substantial volumes of residual and secondary flows from, i.a., rape production from feed to food.

Source: IFRO and Aarhus University 2018

for instance, grass crops and legumes with a focus on high protein contents and quality along with a high yield, yield stability in relation to inter-annual climate variations, and a good disease resistance. This is a crucial precondition for the efforts through plant improvement measures to be successful in new protein value chains.

Focused plant improvement in this field may strengthen Danish competitiveness within farming and associated industries; it may contribute to exports and farm economy, and it may support local/regional/Danish sustainable protein production. The improvement efforts must also focus on the potentials in intercropping, and on varieties for use in environmentally vulnerable areas.

Such protein value chains must contribute positively to the environment, for instance through reduced nitrogen leaching and the potential for increased soil carbon sequestration, thereby contributing to an improvement of the cultivation properties of the soil.

The other opportunity is to extract proteins from the sea. This is done through the rearing and cultivation of, e.g., mussels and seaweed, but in some cases also through the harvesting of wild organisms that are not exploited commercially today. The exploitation of wild organisms, however, must take place only with the utmost regard to any adverse effects on the ecosystem from which they are harvested. Mussels, seaweed, and starfish are examples of organisms with a known potential for protein production, but other examples may be of relevance. Mussels feed on algae, so rearing takes place without the addition of feed. Thereby, mussel rearing has the potential to remove nitrogen from the aquatic environment, since algae contain nitrogen. The development of seaweed processing production in Denmark has the potential to make Denmark the European centre for seaweed processing. Here, the National Bioeconomy Panel sees major opportunities for a future production of seaweed off the Faroe Islands and Greenland in cooperation with the local self-governments and companies.

Cases

New broad bean varieties for Danish production of protein

Broad bean has a huge potential as a protein crop, and under the project NORFAB researchers together with Danish plant improvers will now generate new varieties of broad bean in Denmark. This is to optimise the cultivation of broad bean, primarily for animal feed.

The beans should make it economically profitable to produce broad bean protein locally, instead of importing soy bean protein. In Denmark, a first goal is to cultivate broad bean on 100,000 hectares, corresponding to some 140,000 soccer fields; this is estimated to hold a value of DKK 1.5 billion.

Source: Innovation Fund Denmark

Perennial grasses – an efficient utilisation of arable land

New research at Aarhus University shows that it is possible potentially to double the dry matter production per hectare by converting to grass crops. The agricultural co-operative Vestjyllands Andel has just launched a pilot project with the aim, in addition to the production of starfish meal at its facilities, to produce protein based on grass in a longer-term perspective.

DLF seeds company also notes that the improvement of grasses so far has focused on feed and seeds, and in the light of this there is basis for further improvement of grass varieties intended for protein production.

Cases

Proteins from slaughterhouse secondary flows

Danish Crown Ingredients is a young company established to utilise secondary flows from Danish Crown's slaughterhouses. The raw material base amounts to some 350-400,000 tonnes of raw materials a year; it derives from slaughtering of pigs and cattle. Today, the raw materials are used in a broad range of industries - many of which are approved for food purposes. The protein content is in the range of some 15-18 percent of total weight.

In the field of protein-enriched food, in particular, there is a huge potential in Denmark and abroad. The high quality of the meat proteins makes them suitable for nutritional purposes. The products are readily digestible and broadly applicable in food intended for persons and situations with special protein needs. Proteins derived from meat have a natural taste of umami, and they can be used as an ingredient in meals needing protein enhancement. Also, it will be possible to develop completely new taste alternatives to existing protein supplements that are generally made in the form of dairy products or bars.

Insects as sustainable protein source

Insects are highly suitable for converting organic waste and by-products from food industries to protein, oil, and fertiliser. Therefore, the company ENORM Biofactory A/S is now establishing an industrial production of Black Soldier Fly larvae for fish feed and food; the facility is located at a former chicken farm in Western Denmark (City of Horsens).

Larvae are fed with low-value biomass that cannot be used for food, and only to a modest extent can be used directly as feed for other domestic animals. The larvae are harvested after 16 days - here they have the optimum composition of nutrients.

Then they are processed into feed and food ingredients. The company's vision is to replace parts of the protein sources used today in feed and food, and having larger adverse environmental and climate impacts, with protein from insects. The production of 1 kilogram of protein from insects emits around 100 times less greenhouse gases compared with the production of 1 kilogram of protein from beef. Along with this, water consumption is around 1,500 times lower. The input of 100 kilograms of feed turns into 6-7 kilograms of cow or 16-17 kilograms of pig, while it results in almost 60 kilograms of insect.

A third option is to extract proteins from residual and secondary flows from, e.g., the food industry or other companies with large quantities of plant-based or animal residual and secondary flows. The residual and secondary flows from slaughterhouses may, for instance, be reprocessed into special high-value protein ingredients for feed and food use. Another example is the upgrading of feathers and pigs' bristles from the slaughterhouse industry into products of a higher value. The National Bioeconomy Panel sees major potentials for further added value of residual and secondary flows.

The production of insects for feed and food use has also a substantial potential in terms of economy, volume, and environmental impacts. With the adequate efforts, Denmark may take a leading position in Europe in the years to come. The potential for the production of microbial biomass (single-cell proteins) and microalgae is yet to be surveyed, but it may turn out to be of a major scale.

Finally, the EU has decided that organic waste must be collected separately as from 2023. This means that organic material will become more accessible and that this biomass must be managed in a way that resources such as nutrients contained in organic waste are utilised along with a recovery of the energy contained in it.

Challenges – Raw materials

A number of existing protein sources are being criticised for not being produced in a sustainable manner. For example, many fish stocks decrease globally and there is therefore a potential to be found in looking for alternative proteins to replace fish meal in fish feed. The conventional and rapidly expanding soy production in South America is being criticised, among others, for leading to deforestation, a substantial pesticide load, and loss of other natural areas with high biodiversity, causing i.a. major greenhouse gas emissions.

Some challenges affect all sources of raw materials of which proteins are to be extracted.

"Environmental impacts in agriculture have not been valued for the farmers, and there is a lack of incentives for cultivating crops with low environmental and climate impacts."

One of these challenges consists in clarifying what is in demand in the market, in order that the adequate products are being supplied. There is a major need for more dialogue between all links in the value chain – from raw material producers over processing industries to the end consumer.

This may contribute to a better understanding throughout the chain of the development of market demands – thereby sending clear signals to plant improvers, producers of new proteins, and processing companies.

Challenges are also found in connection with harvesting, storage, processing, and logistics of the new raw materials. Potentially, this may entail substantial costs and thereby have a major impact on whether a business case is positive. Therefore, the appropriation of prioritised funds for research and development in connection with practical challenges is called for – as a precondition for attaining the potential.

When it comes to feed, in particular, changes in EU legislation are of importance, if the potentials for exploiting alternative animal protein sources such as insect meal and kitchen/food waste are to be exploited fully.

Today, legislation contains barriers to the effect that fish meal and starfish meal cannot be used as cattle feed. In addition, consumer acceptance of the new products such as grass proteins or proteins from slaughterhouse residual flows is uncertain, also when it comes to taste. The barriers for raw materials from sources cultivated on agricultural land consist of several elements.

First, there are issues relating to the use of agricultural land associated with efficient operation and environmental impact. Environmental impacts in agriculture have not been valued for the farmers, and there is a lack of incentives for cultivating crops with low environmental and climate impacts. At the moment, this is only seen in relation to catch crops, while perennial grasses, for instance, are not recognised as an environmental instrument.

Second, plant improvement is a research-intensive process; the development of specific properties is time-consuming and in many cases specialised knowledge, equipment, and technologies are needed. Persistent efforts are a prerequisite and they must be long-lasting – preferably with a solid base in a broad public-private partnership that may promote an interplay between key stakeholders.

In the public research and innovation system, the time frame of subsidy schemes is often too short for this process and too inflexible in relation to co-financing. This is a substantial barrier for more long-term research and innovation efforts.

To give an example: today, there are not sufficient incentives in plant improvement to optimise protein contents and quality in crops such as grasses, clover, and grain legumes. This is due to the fact that improvement properties are determined from requirements where yield and feed quality are the most important improvement parameters. Another example is the need for developing and exploiting new more focused tools in plant improvement in order to enhance the efficiency of improvement processes, attaining faster development of new robust and productive varieties and crops that may enter new protein value chains. For plant improvement, a clarification at EU level of the framework for use of these new precision plant improvement technologies is pending, and this situation is a barrier to the use of new methods. Such methods may accelerate the improvement progress and thus bring new products (with the requested new properties) faster on the market.

Finally, it is not clear to plant improvers what is in demand on the market. While today improvements are made to increase yield and feeding value, focus must now also be directed at properties for biorefining. This creates completely other needs, and it calls for a prioritised improvement towards other properties than the usual ones – along with cooperation in the entire chain.

71 pct.

The oceans cover 71 percent of the Earth's surface, and when the pressure on land-based resources increases we evidently look to the sea in our search for new protein sources.

The oceans cover 71 percent of the Earth's surface, and when the pressure on land-based resources increases we evidently look to the sea in our search for new protein sources.

It is very important that we learn from the experience we have gained in the utilisation of land-based resources. In the harvesting of species that are not subject to commercial use today we must ensure that only minimal impacts affect the ecosystems from where these organisms are removed.

Today, established world fisheries are under pressure. Despite increasing fishing pressure the volume of wild-caught fish has not gone up during the last decade. Growing human populations lead to an increasing need for food, so the use of fish meal for animal feed has come under pressure. All growth in recent years in the harvesting of fish and other edible marine resources has therefore in reality taken place in connection with aquaculture, i.e. a controlled production of resources. However, also this practice is coming under increasing pressure, since it often leads to pollution of the region of production, changes in local ecosystems, and the destruction of habitats. It is therefore crucial in the establishment of production facilities that emissions (organic material, medicines, etc.) to the sea are minimised and that the local nature is respected.

There are also challenges associated with the harvesting, transportation, and storage of biomass. Traffic in the fields is, for example, a limiting factor on yield in grass fields, and harvesting more than three to five times a year entails considerable costs. Robots are expected to be useable for harvesting areas on a continuous basis, avoiding soil compaction, costs will be reduced and quality will be optimised, since fresh leaves have a better protein content. The storage of grass for the winter season is another significant challenge that is closely linked to the needs of processing plants for high and stable supply.

Danish companies and research institutions have for several years had a close dialogue with the authorities on the framework for development and production of insects for feed and food. The overall framework is relatively clear in relation to, e.g., requirements for registration, approval according to EU rules for new food and food ingredients, requirements for feed, for insects as feed, etc. The Danish Veterinary and Food Administration has published a guideline with a total outline of rules regarding insects for feed and food. The largest barrier to exploiting the full potential within the production of insects is found in the requirements for feed and food safety given in EU legislation for, i.a., animal byproducts, domestic animal diseases, and marketing. The EU rules constitute a limiting factor for which plant-based or animal feed sources are fed to the insects and which animal species can be fed with processed insects. Insects or other reared animals, for instance, cannot be fed with kitchen and food waste or animal manure.

Documentation for the safe use and traceability can be used as a lever for an adjustment of EU rules in order that low-value products can be used for feeding of insects that again can be used for feeding of animals that are not intended for food (such as animals bred for fur). New knowledge can furthermore be used as a lever for other adjustments of EU law in this field if it turns out that the use of insects or new feed types for insects does not carry a risk for human or animal health.

Recommendations for Raw materials

The National Bioeconomy Panel recommends:

7

Research and development measures to promote the supply of sustainable raw materials for new protein value chains are implemented, including:

- Digestibility, nutritional value, health, and composition of new protein sources.
- Plant improvement of grass and legumes in view of optimising them to enter into biorefining processes.
- Efficient methods for careful harvesting of biomass, logistics, and storage.
- Optimisation of residual and secondary flows in the production of new proteins from insects, mushrooms, algae (micro and macro), and bacteria in view of exploiting the resources and increasing their value.
- Clarification of potentials and business cases for catch and production of new aquatic protein sources, including seaweed and algae.
- Clarification of the potentials in production of proteins from new conversion technologies such as cultivation of insects, new microbial biomass (single-cell proteins), and microalgae.

8

Environmentally and climate-friendly production of biomass is acknowledged as an instrument in national regulation, for instance in relation to targets within the aquatic environment and climate.

Environmental impacts across sectors should be calculated and incorporated thoroughly into future political initiatives. Environmental and climate benefits of new production types should be quantified and incorporated in environmental and climate regulation, and incentives should be created for primary producers opting for these types of cultivation. This may be done, for example, with the following means:

Environmental and climate footprints of various protein sources are clarified in order to value and recognise the environmental impacts as an instrument in different national regulations.

Conversion from, for instance, corn to biomass crop with lower nitrogen leaching and climate impacts must be quantified and used as an instrument in future regulation.

The incentive for producing protein-rich biomass must be enhanced by ensuring that those sectors that supply biomass, thus contributing to a reduction of greenhouse gases, are credited for this in environmental and climate accounts, at company, sector, and society level.

9

Denmark must actively seek to promote EU framework conditions for the enhancement of new, more sustainably produced proteins, and we must actively exploit existing opportunities.

Production of sustainably produced proteins must be actively addressed in the new CAP reform, which may be done, i.a., in the following ways:

European agricultural policy should create to a higher extent the opportunities for subsidising the production of biomass with positive environmental and climate impacts.

Possibilities for exemption from the rule that grass areas must be made permanent after five years are introduced.

The Danish implementation of EU green requirements are adapted in a way that it becomes possible to cultivate a number of protein crops on these lands – among others broad bean and grass/clover/lucerne for green biorefining and in respect of Danish environmental regulation.

The recommendations from the future EU protein plan must be translated into concrete policy measures, for instance the CAP.

EU regulation is made smoother in order that new innovative protein sources based on, for instance, animal residual products can be used as feed sources to a higher extent.

Denmark engages actively in the wording of the future revision of the Nordic and the EU bioeconomy strategies as well as other relevant initiatives in the bioeconomy field.

Denmark works to ensure that bioeconomy, including the protein field, gets a key position in the next EU Framework Programme for Research and Development (FP9) – this should include a continuation of the large public-private partnership on bio-based innovation (Bio-Based Industries Joint Undertaking).

It is a precondition for the development of new protein value chains that cost-effective technologies are available for upgrading relevant biomasses and residual and secondary flows from competitive protein sources.

Processing and technology

A successful upscaling within processes and products along with knowledge about quality and market potentials are crucial if these new value chains are to find success. The Panel assesses that the requested resources are available among Danish players, and there is keen interest in cooperating across sectors. However, there is a need for an overarching national coordination and facilitation of the hitherto dispersed initiatives into a comprehensive effort.

Potentials – Processing and technology

Every day large quantities of protein-rich products are processed in Danish companies, from plant-based as well as animal protein sources. The food and ingredients industries have a turnover of billions of kroner, and the business cases are known and robust. The processing of new protein sources takes place in a strong food cluster holding much knowledge about processing technologies and ingredient properties along with a tradition for thinking in cross-sectoral terms (such as feed, food, and bioenergy).
A good example is found in perennial grasses that have the potential to reduce environmental and climate impacts from production compared with, for instance, corn and wheat, while grass proteins also have a good feeding value, and research shows a potential for using grass for human consumption.

Seaweed is found in large quantities in Danish waters and may be harvested in the sea or collected on the beaches. There is a potential for biorefining of seaweed with the purpose of extracting proteins for feed and food. Seaweed varieties also contain other substances than proteins, such as certain carbohydrates that may have positive health properties and a broad application potential in the food industry.

Denmark has a long tradition for cross-sectoral cooperation. This is also reflected within new protein value chains: a large number of research projects and innovation networks take place in cooperation between knowledge institutions, approved technological service providers, and companies. In addition, several purely commercial initiatives on processing are found within new protein value chains. We see, for instance, facilities for the production of feed based on starfish, plants for the production of bacterial biomass (single-cell protein), and facilities for the cultivation of insects and mushrooms.

In addition, Danish companies are strong within the development of technological solutions, including "soft technologies" such as measuring devices. Therefore, there may be large potentials for systems export of technologically sophisticated biorefining plants along with the associated knowhow and equipment.

However, there are substantial potentials in cooperating further by thinking in far more cross-sectoral terms among key stakeholders. This could be, for instance, by promoting exchange of ideas on processing and technology development and by applying existing processes to new protein value chains.

This would contribute to bringing early innovation from the pilot scale to large scale and "proof of concept". It could also be by establishing clusters of companies creating synergies by sharing secondary flows and establishing new value chains.

System integration and a better market for residual flows from, e.g., agricultural crops and industrial residues for feed, food, and bioenergy has the potential to improve the economy among farmers and companies, to retain and create jobs (primarily in rural areas), and to increase exports of products and technology. In order to create new protein value chains products must have a functionality comparable or superior to those already available, and their economic potential must be attractive.

Challenges – Processing and technology

Processing and development of new technologies for the utilisation of new protein sources – in line with other kinds of development – often face a number of "teething troubles". Typically, they come in the form of security of supply and costs of the raw materials used in the production, along with uncertainty in relation to efficiency and precision of processing methods and technologies. Often, new technologies are to be applied, or various types of known technologies have to co-work for the first time.

Finally, health and quality are key issues when working with food and feed. There are strict requirements for product development entailing, among others, that the food or feed quality and functionality of new products must be tested and documented. This may be, for example, knowledge and documentation of how a feed protein is digested by animals, or how the protein affects the texture and shelf-life of food. Producing such documentation and knowledge is very cost-intensive.

There are a number of concrete fields with challenges in relation to attaining an efficient processing of new protein sources. There is a lack of practical and theoretical assistance for solving problems in connection with technology development within the processing of several of the new protein sources, in particular in connection with the upscaling from pilot to full-scale plants. In addition, there is a lack of analyses of various scenarios for biomass input. This may be the composition of the biomass and how product flows may be planned in the optimum way, as well as knowledge about storage and pre-treatment of biomass.

The state-of-the-art of biorefining plants as yet is not sufficiently high to ensure an efficient fractioning of the biomass in, e.g., a protein fraction and a fibre fraction, along with an isolation of the different protein flows in view of securing optimum added value in the process.

It is a challenge to ensure a coherent set-up in connection with the different plants, as the entire value chain must work as efficiently as possible. For example, it may be a challenge to establish decentralised biorefining plants combined with central plants for the processing of protein concentrate and thickening of the residual juice.

Various initiatives are ongoing within the processing of new protein sources, but there is no overarching coordination of efforts. In addition, it is a challenge to share the knowledge produced in research and development, including the knowhow found in companies. All this calls for a need to support increased cooperation and more networking across sectors (universities, approved technological service providers, and companies).

Cases

New opportunities in proteins from potatoes

KMC is one of the world's leading companies within potato-based ingredients for the food industry. KMC turns over more than 1 million tonnes of starch potatoes cultivated on 26,000 hectares of agricultural land. The potatoes contain 75 percent of juice that first and foremost contains starch, but also proteins.

The protein fraction is found in the juice that is refined into a feed product with a much-coveted composition of essential amino acids. Together with other potato flour companies KMC has worked continuously to optimise the protein processing. This took place, among others, under the Green technology development and demonstration programme project InnoPro that had the objective of extracting functional proteins from the juice. The results from this project are now being used in the proPOTATO project under Innovation Fund Denmark.

Residues from cheese production becoming valuable protein products

Whey is a secondary flow from cheese production. Traditionally, whey was seen as a residual product spread on land or used as feed.

Today, Arla Food Ingredients P/S (AFI) has developed a refining of whey into high-value protein products and lactose in a separate production branch handling approximately 6.5 tonnes of whey. One tonne of whey contains 95% water and 5% dry matter. The dry matter fraction consists of 74% lactose, 14% minerals, and 12% proteins. The protein fraction is refined into protein products such as ingredients for breast-milk substitute, sports nutrition, and ingredients for the food and pharmaceutical industries.

Arla is now so advanced in the biorefining process that it is profitable to import whey from cheese production abroad. Along with this, the value of the whey proteins is now higher than the fraction of the proteins that is used in the cheese production, which is why AFI has now started looking for ways to get the proteins directly from the milk instead of going via the cheese production. AFI's turnover in 2017 amounted to DKK 5.3 billion. The company has seen an average annual growth rate of 12% since 1993. The highest growth is found in the production of ingredients for breast-milk substitute and food for medical consumption, respectively.

Recommendations for Processing and technology

The National Bioeconomy Panel recommends:

10

An enhanced national focus on bioeconomy is accelerated through stronger coordination and joint knowledge about biorefining between universities, approved technological service providers, the business community, and other stakeholders in view of promoting the development of an innovative Danish biorefining industry.

This may be done by boosting existing and new activities among groups and centres at universities, technological service providers, and innovation networks in Denmark. Clusters and networks must be strengthened, and new focused partnerships within protein value chains must be launched.

For example, there may be focus on efficient matchmaking between companies and research groups, in which companies can be assisted in solving concrete challenges in relation to, among others, added value for residual and secondary flows, and where new technologies from SMEs can come into play

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Research, development, and establishment of "first-of-its-kind" biorefining for promising, sustainably produced protein-rich biomass are supported.

There must be focus on protein products and ingredients for feed and food, as well as promising processes, in particular in terms of expected volume, but also possible added value, technological and commercial maturity, positive environmental and climate impacts, along with market needs and export opportunities.

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Key areas for effort for research, development, and establishment of biorefining for promising, sustainably produced protein-rich biomass.

- Technologies for separating, processing, and ensuring storage stability of biomasses as cost-effectively as possible (e.g. deshelling of mussels, careful harvest methods for grass and clover, and preservation of the desired protein qualities).
- Establishment of biorefineries based on the new protein sources, contributing to a reduction of nitrogen emissions to the aquatic environment, protecting the groundwater from pesticides, and having focus in the refining process on an overall value optimisation for the entire production chain, including all secondary flows through a so-called cascading use of the biomass.
- New processes for full utilisation of biomass based on the cascading use and high-value products. The objective is an overall value optimisation – also for those secondary flows that do not contain proteins, but that may be decisive for the competitiveness of the entire process.
- Promotion of recirculation of nutrients from the biomasses.

Introduction to Market

New protein products may have benefits relating to the environment, climate, health, and nutrition, and they will be able to compete with established protein products, if these positive impacts are recognised and used as a competitive parameter towards consumers and between companies.

Market

New protein value chains must not be supported by subsidy schemes, blending requirements, or procurement policies. The development and establishment of new protein value chains is market-driven. The recommendations of the Panel emphasise that impacts are documented and that the products can be traced back in the value chain.

Potentials – Market

At the global level, a greater market is expected in many years ahead, for both animal and plant-based protein products. This applies to feed and food alike. There is a trend in the market for all protein products indicating keener interest in protein products' footprints on the environment, climate, and nature. Already today this is reflected in increasing demands for protein products that are nearproduced (locally, nationally, or EU-wide), preferably non-GM or organic, as well as plant-based protein products replacing protein products of animal origin. The Panel has noted that in Denmark there is a broad and growing market interest in new protein products. This applies to feed that is not based on soy proteins, as well as to new types of food, such as protein-enriched diets for people with a low appetite or new types of plant-based food partly replacing animal-based food.

The Panel expects that in future there will be different markets for proteins depending on whether the intended use is as feed or food.

The Panel assesses that Danish companies are in a fine position to increase their market shares in Denmark as well as on the export markets for new protein products for feed and food. This is due to a strong cooperation between research and development with university environments opting for development of the protein raw materials of the future, among others through their research into the ways in which resources are exploited to the optimum extent. This may be done by using plants whose properties through improvement may become richer in protein, or by improving the protein composition. A sustainable bioeconomy may lead to a positive health impact on humans and animals, since research and development can be conducted in feed and food with good nutritive properties and higher contents of health-enhancing substances as well as biomaterials with lower health risks than present-day products.

Bacteria, mussels, and seaweed as well as residual and secondary flows from industry etc. may be applied in new ways. Experience is available with the development of methods for biorefining, and product development is ongoing in relation to more types of raw materials.
In Denmark we have a strong tradition for food safety and control as well as a well-working traceability system and cooperation across the entire value chain. The Panel believes that new protein products for feed and food in a not so distant future may be able to compete in some markets with existing protein products and on equal terms.

This is due to the fact that the new protein products have a number of properties for which it is assessed that the market is willing to pay a higher price than for traditional protein products. Within proteins for feed the price spread for non-GMO soy has been generally on the increase over the last years. The same is even more true for organic feed proteins.

New proteins for food are expected to be the preferred option for consumers to the extent that they are tasty and healthy, they have a documented superior environmental and climate footprint, and – not least – they can be produced at a price that consumers are willing to pay.

Challenges – Market

It is difficult to sell new products if they do not have well-documented, recognised, and approved functional properties, particularly if the new products are more expensive than existing products on the market. The higher the value of a product, the higher are the requirements for traceability and documentation, and the more cost-intensive is it to produce such data.

For buyers of feed for animal production it is also decisive that there is security of volume and supply. For buyers of new proteins for food there may be a major barrier when it comes to changing consumption habits, starting to eat food with a new origin, form, and colour. It may therefore, for example, be necessary to market plant-based products looking like the original product of animal origin. In this context, it is crucial that food safety is extremely high and that buyers feel confident that the new products will not make them sick. Last but not least, it is a challenge that knowledge about nutrition is generally poor; including knowledge about malnutrition, undernourishment, and over-nutrition. It is difficult for buyers of new protein products to be sure that they consume the correct quantity of proteins (not too many, not too few) and that the proteins have the correct amino acids composition.

If companies and consumers are to actively opt for new protein products from an environmental and climate point of view it is also a precondition that the total impacts are well-documented and communicable in a comprehensible way. Today, this documentation is often non-existent, and information between companies and to consumers is lacking.

The most important challenges in selling new protein products on the market are:

- Smoother approval procedures for feed and food products in EU context.
- More knowledge and consensus about environmental and climate footprints from different protein products to further enhance the market position of new protein products.
- Knowledge about new products' nutritional value for companies and consumers will further strengthen the market position of new protein products.
- Knowledge about specific nutrition facts/ functional properties of concrete proteins for feed and food.

Cases

New plant-based food booming

The company Naturli' Foods has been on the market for 100 percent plant-based food in Denmark since 1988. Naturli' Foods produces more than 50 different plant-based products: oat milk, protein bars, plant-based cold cuts, and minced plants as an alternative to minced meat.

In recent years the company has seen a boom within several categories, such as meat and dairy products. The interest from abroad is enormous, and the company's products are already on the shelves of several major supermarket chains abroad. The plant-based diet is here to stay according to Naturli', and the company still sees a large and increasing demand. Naturli' Foods has a keen interest in new Danish organic plant proteins that can be used in their production.

Consumers demand simple natural food

Arla Foods reports of a wave passing through the European dairy sector to the effect that industry opts out of GM soy from other continents, and the demand for other types of feed protein is on the increase.

Similar reports come from the organic farmers that see an urgent need for supplementing the import of organic protein from, among others, China and Italy with other competitive alternatives. Arla, Danish Crown, DLG, and DLF have joined forces to support the development of farm-produced proteins from grass.

Today, all milk and dairy products found on the shelves of supermarkets are free from GMO. Arla's target of reducing the use of GMO feed is a decision affecting farmers and having a large impact on what feed is used on the farms. To pave the way for the phasing out of GMO feed, Arla has paid a supplement of 1 eurocent per kilogram of conventional milk from those farmers that have changed the feed. Non26 GM rape, soy, and broad bean replace GMO protein crops in the feed.

Recommendations for Market

The National Bioeconomy Panel recommends:

12

Universities and approved technological service providers in cooperation with the feed and food industry must gather more basic knowledge about which types of proteins are in demand on the market, such as specific amino acids profiles and proteins with special properties. Which raw material base, quality, and composition are called for?

13

Existing and new knowledge about environmental and climate footprints in different protein products is gathered and organised, thus producing an overview of environmental and climate footprints from protein value chains.

This knowledge can inspire and support companies in their marketing efforts and contribute to turning the environment and climate into competitive parameters.

Furthermore, work should be done to create a larger international consensus about the description and marketing of environmental and climate impacts from food production, for instance under the auspices of the Product Environmental Footprint work (PEF). Solid knowledge about products is used to inform companies and consumers about products in the new protein value chains, in order that they can make informed choices.

14

A fund for financing of specific nutritional and toxicological studies and surveys of functional properties of concrete protein sources is established; companies may apply for subsidies from this fund to clarify issues such as feed weight gain ratio, food safety, Novel Food status, and potential in relation to food.

The fund may be administered under the Green Development and Demonstration Programme (GUDP) or under the current agreements on research-based consultancy services for the public sector. A proteins guideline for consumers may be prepared with the aim to inform about proteins' origin and quality/amino acids composition.

15

An explanatory document is prepared in view of securing that existing traceability systems are adequate for handling new protein products for food and feed.

Traceability is crucial for the new protein products to gain ground on the market. A system for traceability will increase both quality and confidence in the production of proteins, and it will open up export markets for Danish produced proteins.

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Henrik Wenzel, Professor, University of Southern Denmark
Charlotte Thy , Sustainability Director, Danish Crown
Michael Persson, Secretariat Leader, DI Bioenergi
Claus Crone Fuglsang, Senior Vice President, Novozymes
Kristine van het Erve Grunnet, Senior Consultant, Danish Energy
Lene Lange, Professor, Technical University of Denmark
Lars Visbech Sørensen, CEO, Agro Business Park
Niels Henriksen, Senior Advisor, Ørsted
Katherine Richardson, Professor, University of Copenhagen

A group of companies has been affiliated to the Panel's discussions of the subject of "new protein value chains".

This group has inspired and challenged the Panel in the process, while the National Bioeconomy Panel has ultimately decided on the direction of its recommendations. The group of companies consisted of:

Christian Sig Jensen, DLF
Steen Bitsch, Vestjyllands Andel
Ole Christensen, Biomar
Klaus Astrup Nielsen, Blå Biomasse A/S
Christian Ege, The Ecological Council
Nicolai Hansen, KMC
Esben Laulund, Chr. Hansen
Poul Pettersson, Arla
Klaus Jørgensen, Danish Agriculture & Food Council
Mette Skøt, Danish Green Investment Fund
Annette V. Vestergaard, Organic Denmark
Henrik Busch-Larsen, Unibio
Claus Crone Fuglsang, Novozymes
Charlotte Thy, Danish Crown

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