

Tech Protein Strategy 2035



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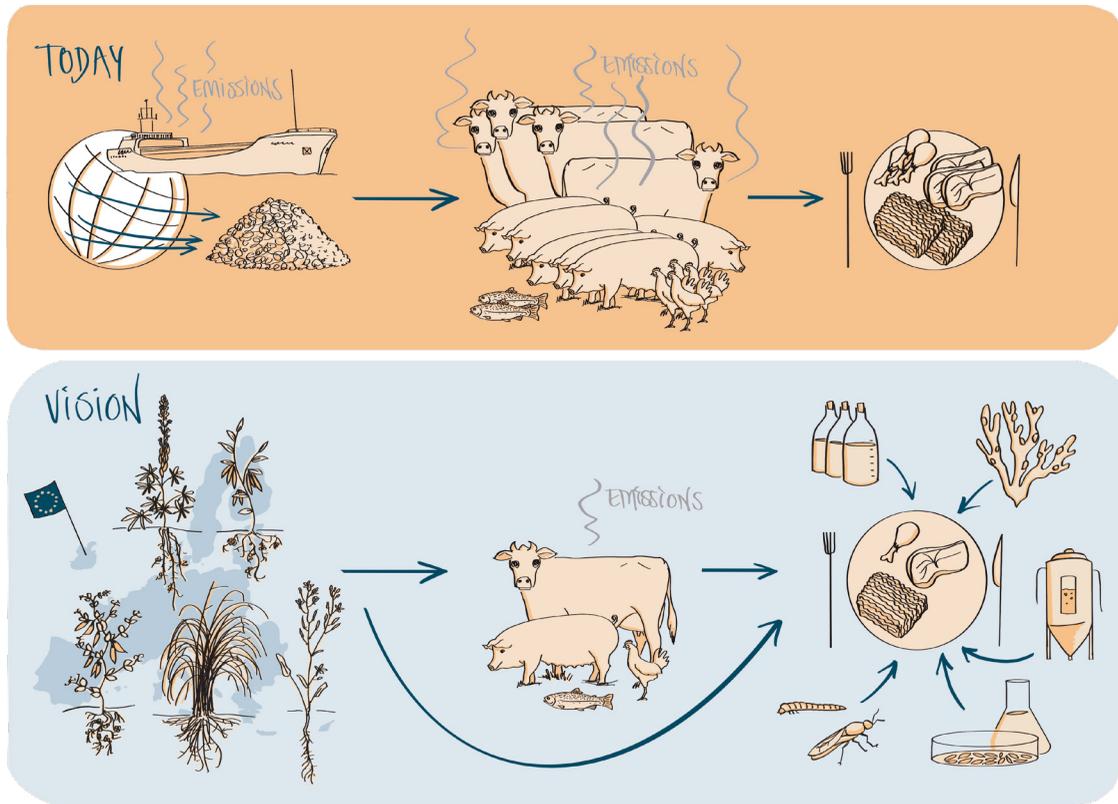
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The challenge



The global food system is unsustainable in most aspects and in need of transformation. Food production and consumption must feed the growing population in the world while reducing greenhouse gas emissions and respecting planet boundaries. This is a challenge and calls for a major transition. The transition must consider profitability across the value chain, cost, climate, environment, and resilience while increasing consumer acceptance for novel foods and improving the current nutritional value and accessibility of food.

Currently EU is dependent on import of large amounts of protein crops for feed from third countries, in order to produce animals for consumption. This calls for a two-dimensional transformation: EU's protein crop

production must be increased, as the dependency poses risks related to food security and is highly unsustainable. Additionally, there is a need to identify protein alternatives that can serve as substitutes for animal proteins. These alternatives must have low climate and environmental impact, high nutritional value, and equitable accessibility.

Faculty of Technical Sciences at Aarhus University (Tech) therefore strives to provide excellent research that will facilitate the agro-industrial transformation needed to make Denmark and EU self-sustainable and resilient in protein production for food and feed, while improving climate, biodiversity and environment and respecting planetary boundaries.

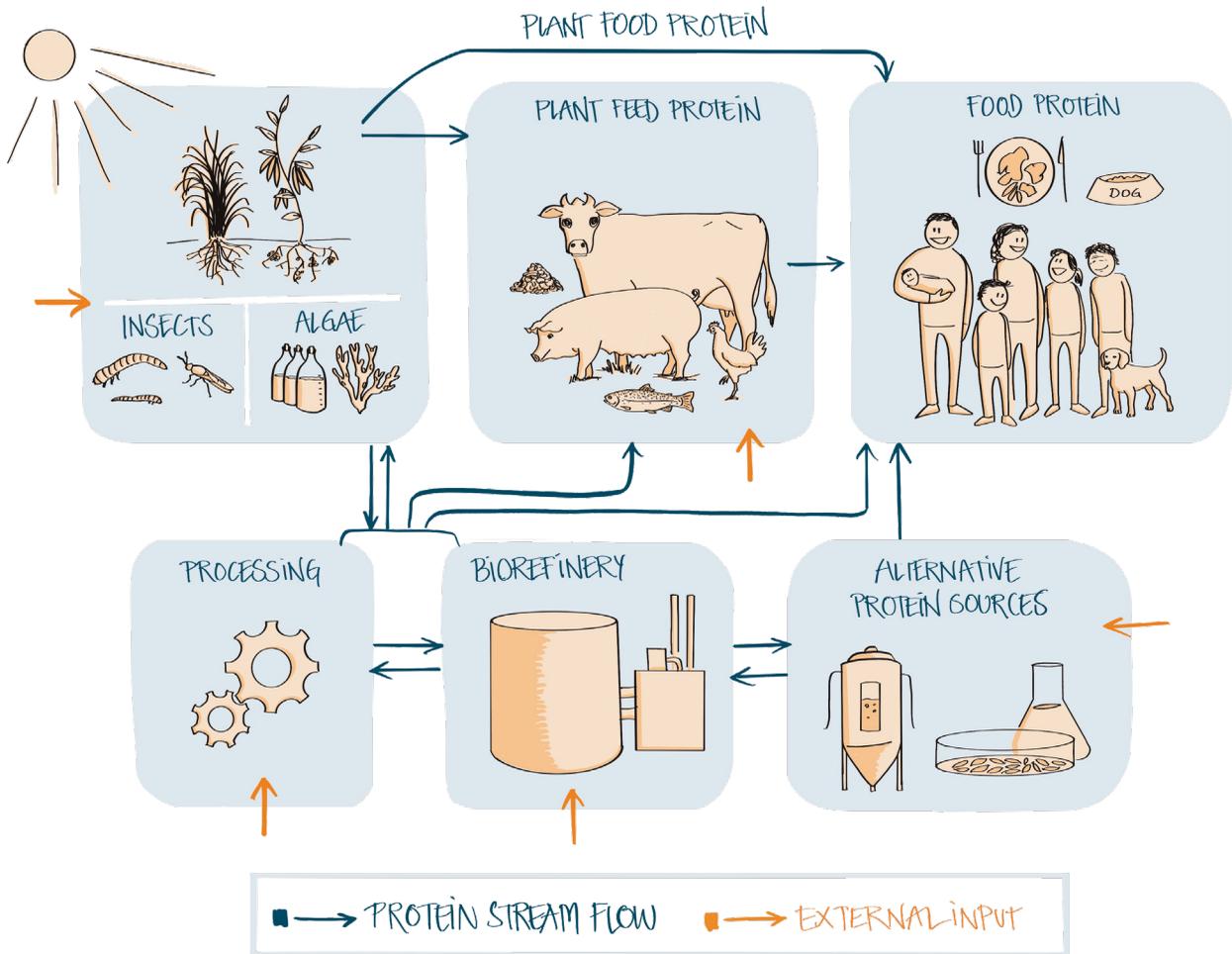
The missions

At Tech we take a systematic view to the production system. Therefore, our research within alternative protein sources is conducted across a wide spectrum of value chains where everything is connected. Aarhus University holds unique strengths by covering entire value chains and works across disciplines to create impact.

We research options in cyclic economy, side-stream valorization, upcycling of products and diversifying the availability of all protein sources: plant, animal, aquatic,

fermented and biotechnologically produced, in the context of future climate changes.

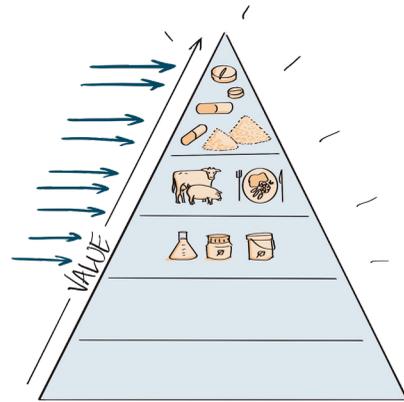
Our research ranges from land-based protein crop breeding and production, additive protein production from algae and insects, biotechnological protein production through single cell and precision fermentation and from carbon capture. Crude protein separation and purification for downstream food and feed processing and product development, all the way to markets.



To be the facilitator of the knowledge needed for the agricultural transformation, we have identified four mission objectives:



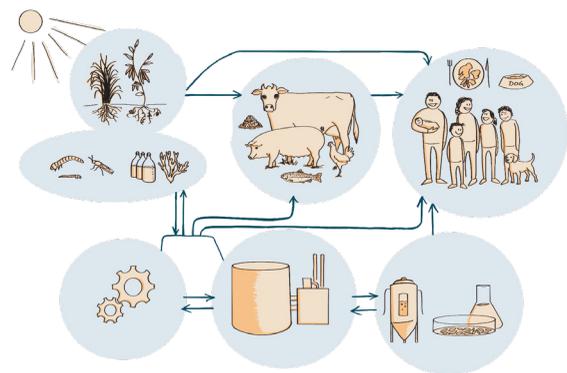
Provide tools for sustainable and resilient arable and aquatic protein crop farming in Denmark



Facilitate high value protein production from existing and new side streams



Establish sustainable and safe methods for novel protein (food) production

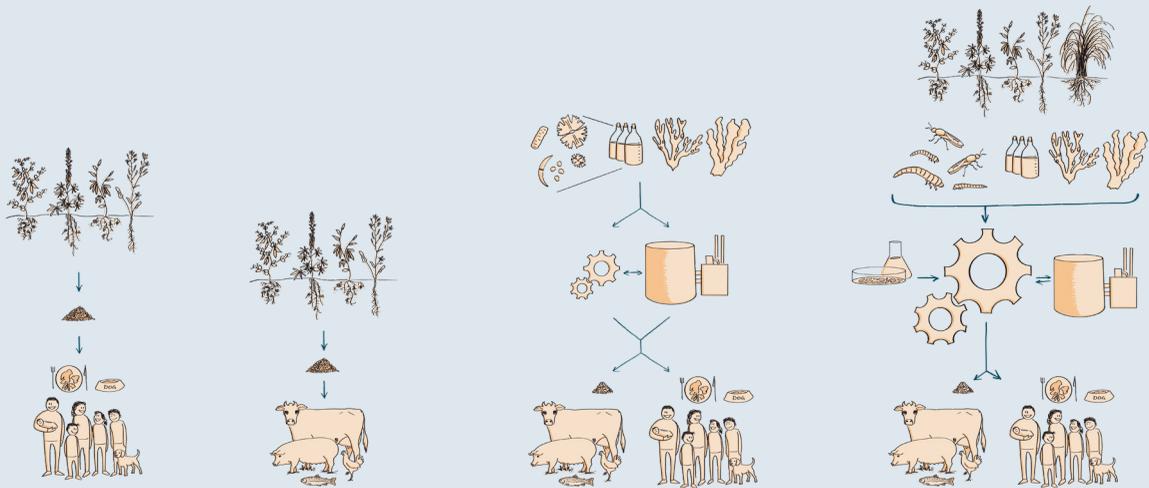


Demonstrate the value of cyclic food production and alternative protein as food

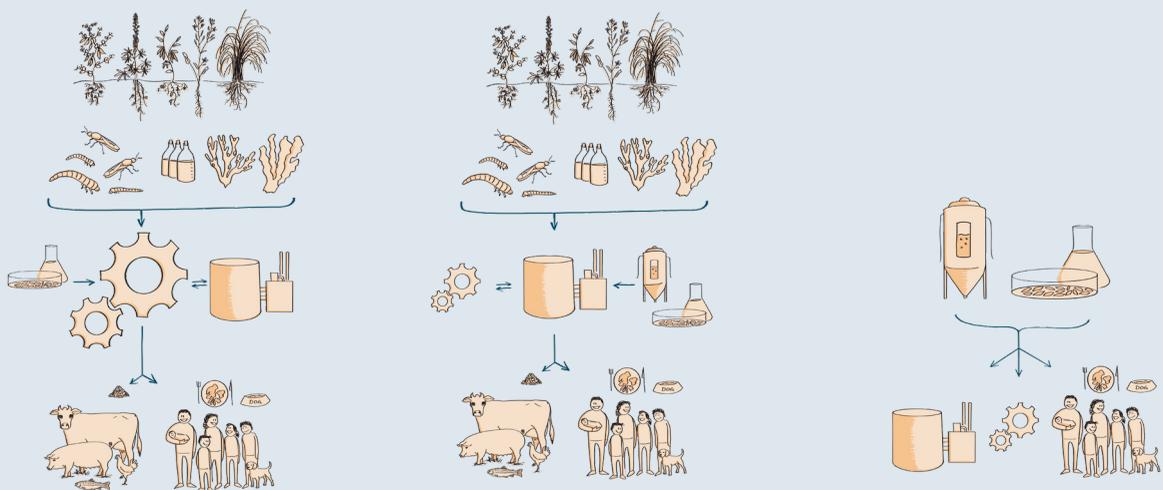
Future of protein research at Tech

The complexity of the challenge requires combining disciplines and sectors. Here we describe 7 interconnected protein streams, which rely on each other and together will transform the agro-industry in concert with a whole new agro-industrial biotechnology.

In the following, we describe the 7 interconnected protein streams. We describe the status, problem, overall need and how we want to address the challenges.



1: PLANTS TO FOOD 2: PLANTS TO FEED 3: INSECTS FOR FEED AND FOOD 4: ALGAE FOR FEED AND FOOD



5: PROCESSING

6: BIOREFINERY

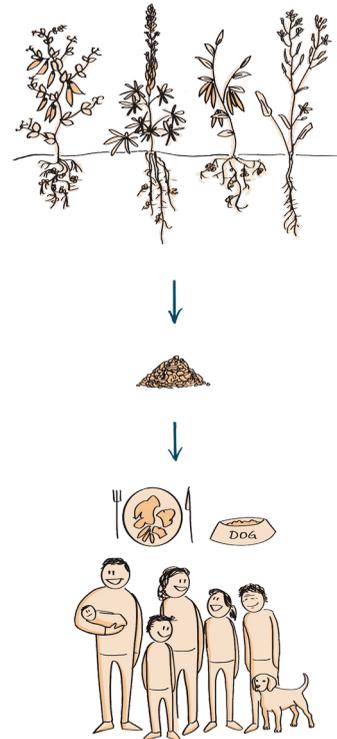
7: ALTERNATIVE PROTEIN

Protein stream 1:

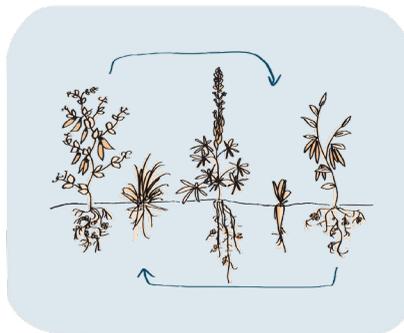
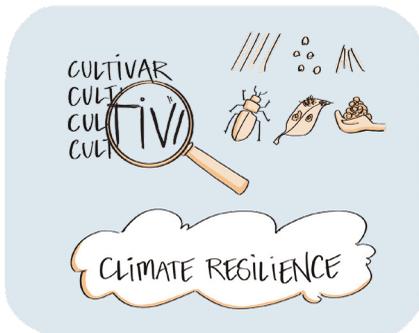
Production and development of cultivated plant protein sources for food

Status, problem and overall need in DK:

The existing supply chains of plant protein for food rely to a high degree of imported raw materials. The major obstacle for migration to Danish raw materials is the lack of local value chains and the absence of a home market for these products.



We will:



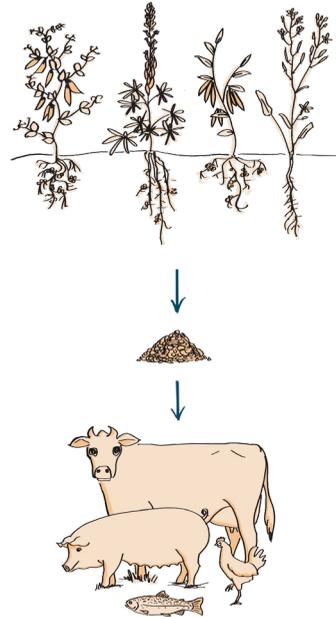
- identify the best cultivars and optimize crop management practices, considering climate resilience.
- improve cultivation techniques for food-grade legumes.
- engage with research outside technical sciences to work on societal engagement.

Protein stream 2:

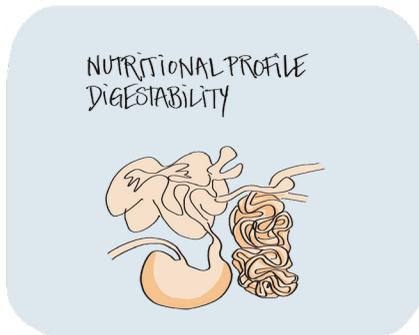
Development of protein sources from plants as feed to animal-based protein

Status, problem and overall need in DK:

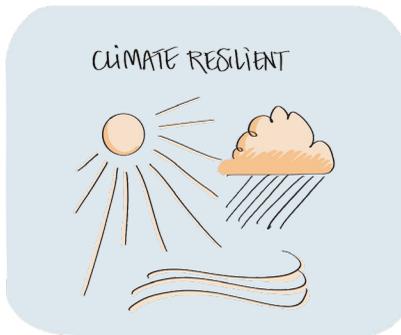
The current dependency on soy imports as feed protein can be greatly reduced if the quantity and quality of local protein crops can be improved. Sourcing protein ingredients from local crops is associated with challenges in obtaining a suitable profile of amino acids and good protein digestibility when fed to monogastric animals, such as pigs and poultry. Reduction of carbon footprint of feed sources holds a major potential for reducing climate impact of animal protein production.



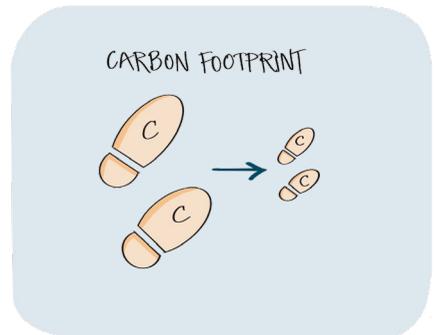
We will:



- improve digestibility and nutrient availability.



- identify a diverse set of climate resilient crops.



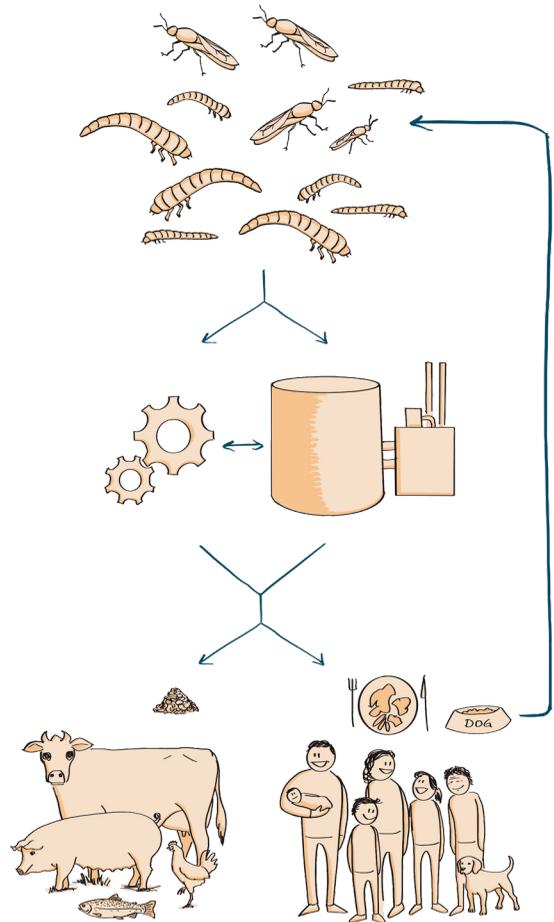
- reduce the carbon footprint in animal feed production.

Protein stream 3:

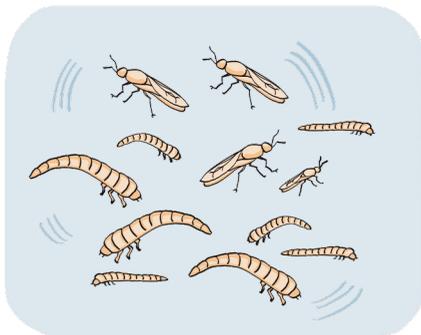
Development of protein from insect production

Status, problem and overall need in DK:

Insect farming for sustainable food and feed protein is a rapidly growing industry internationally because of great production potential and high value. Insects are increasingly seen as a solution in the transition to greener and cyclic food production, using side streams as feed. However, in Denmark there are still only few production sites of which most are small scale delivering niche food products. For feed ingredients, fractionation of lipids and protein provides increasing exploitation potential.



We will:



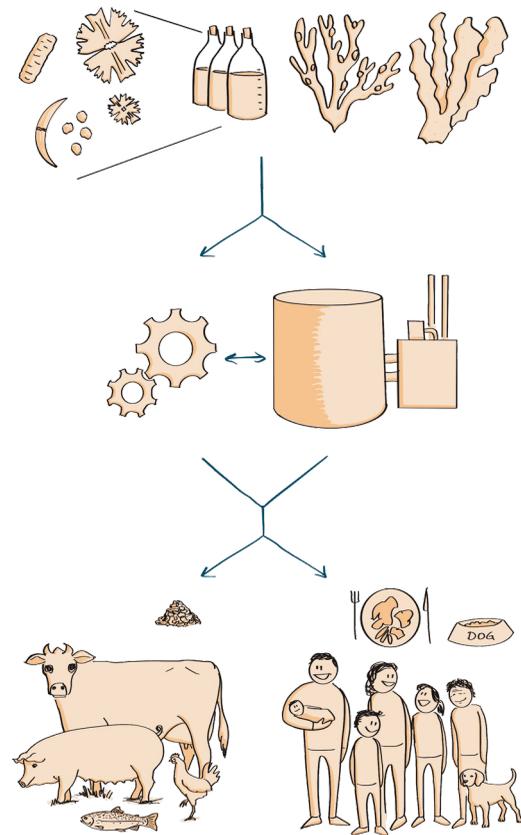
- improve efficiency and scalability of insect production.
- create market-ready sustainable feed and food products.
- build demand and trust in insect-based products through interdisciplinary collaborations and high food safety.

Protein stream 4:

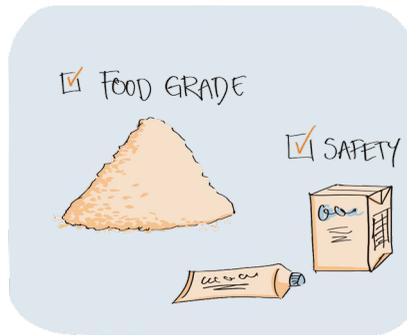
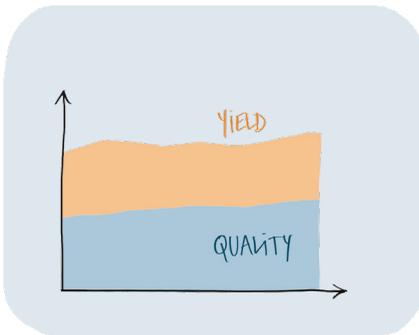
Development of protein from micro- and macroalgae

Status, problem and overall need in DK:

Micro- and macroalgae for food and feed are of increasing interest due to good amino acid composition, ability to be grown with a high degree of control of biomass production and quality, with no or low use of land, and by using captured emissions of carbon and nutrients from other productions. Production sites are few and small scale and market is not developed. The extraction and purification of proteins from algal biomass for food quality proteins is in progress.



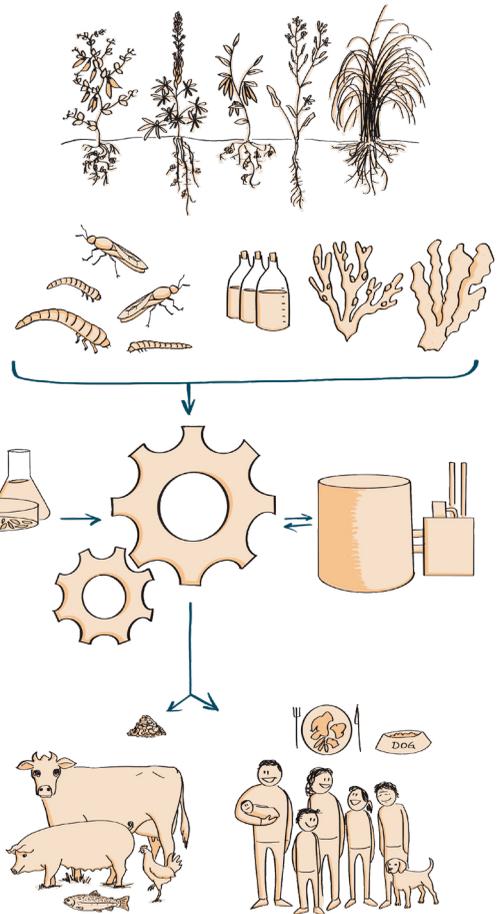
We will:



- enhance algae production systems for consistent yield and quality.
- develop efficient methods for isolating food-grade proteins and create innovative food products of high safety using algal proteins.

Protein stream 5:

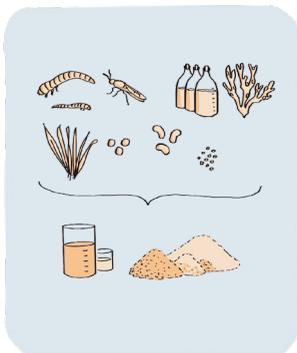
Processing and development of proteins



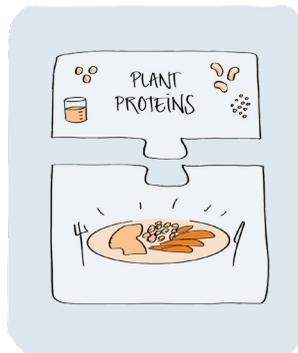
Status, problem and overall need in DK:

The processing of protein concentrates and isolates can be performed in multiple ways, where the aim typically is to gain high protein content, high purity, and single protein products. This may require many processing steps and processes of various physical and chemical methods to isolate and extract the protein from other components such as oils, sugars, and fibers.

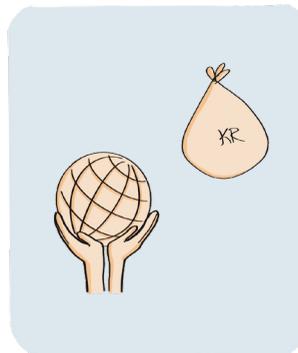
We will:



- optimize methods for producing protein concentrates and isolates



- enhance the usability of plant proteins in attractive food applications.



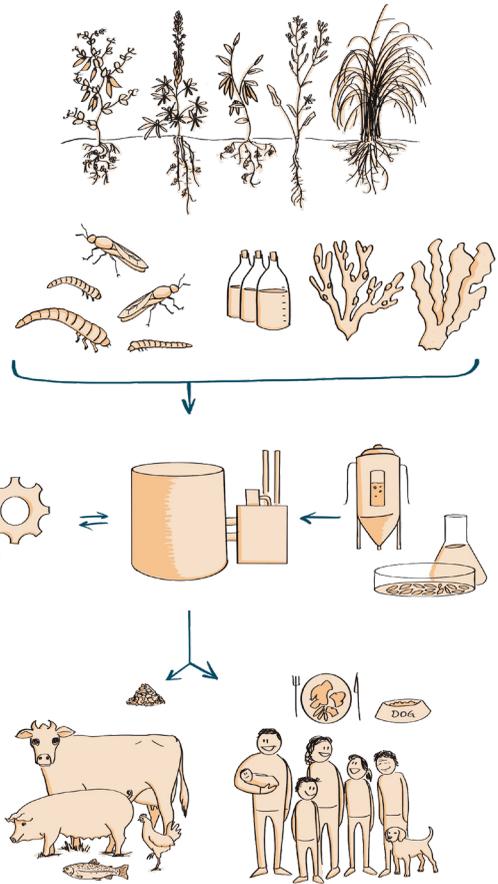
- minimize environmental impact and processing costs.



- build research infrastructure for research in protein processing.

Protein stream 6:

Development of alternative protein sources via biorefining



Status, problem and overall need in DK:

The Danish protein and forage crops have the potential of obtaining higher nutritional and commercial value by the use of physical, chemical, and biological processing. Other protein sources also hold potential to obtain increased value by fractionation. The resulting sustainable protein holds a high potential for usage in Denmark. Further, biorefining holds great potential for a cyclic feed and food production, where tons of carbon can be cycled, with zero waste.

We will:

- ensure consistent quality and suitability of crops for biorefining.

- advance biorefining technologies for scalable and efficient processing.

- research in upcycling of waste and side streams.

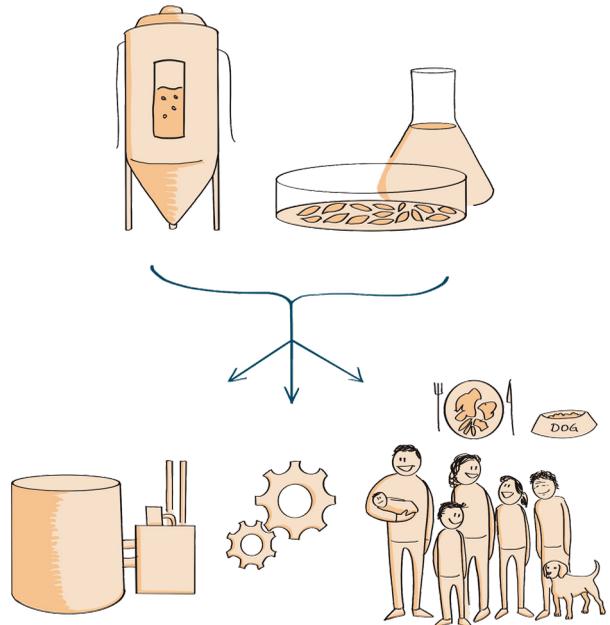
- explore high-value compounds from biorefinery side streams of the algae protein production.

Protein stream 7:

Biotechnological production of alternative protein sources

Status, problem and overall need in DK:

This area covers protein production via microbial single-cell and precision fermentation, with captured CO₂ as carbon source, and animal cell-based protein production of more complex meat and milk proteins. These alternative protein solutions are of increasing academic and commercial interest with significant climate potential. They are, however, emerging research areas facing several technical, nutritional and consumer-related challenges. In addition, production is still small-scale and costs are thus very high.



We will:

☑ RESILIENT

- Establish resilient biological systems for protein production.

☑ SUSTAINABLE

☑ EFFECT

- Create sustainable and cost-effective growth environments.

☑ FOOD SAFETY

- Scale up production with efficient bioreactor systems while ensuring high food safety.

- Work interdisciplinary to measure and influence the societal readiness to cell-based foods.

Concluding remarks

The transformation is a complex task, and technical solutions cannot transform the agro-industry alone. The transformation of the agro-system requires strong partnerships and collaboration to develop the value chains and create the impact needed.

Tech is open to collaboration with everybody in the food/feed value chain. Tech works at all technological and societal readiness levels, from the most fundamental discoveries to the products ready to be put on the market.

We measure our success in actual impact and our goal is to help transform the global food system to achieve sustainability and resilience at all levels.





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