

# Kemi Gør Græsset Grønnere

Mads Koustrup og Kathrine Danner

# Extraction of protein from plant leaves

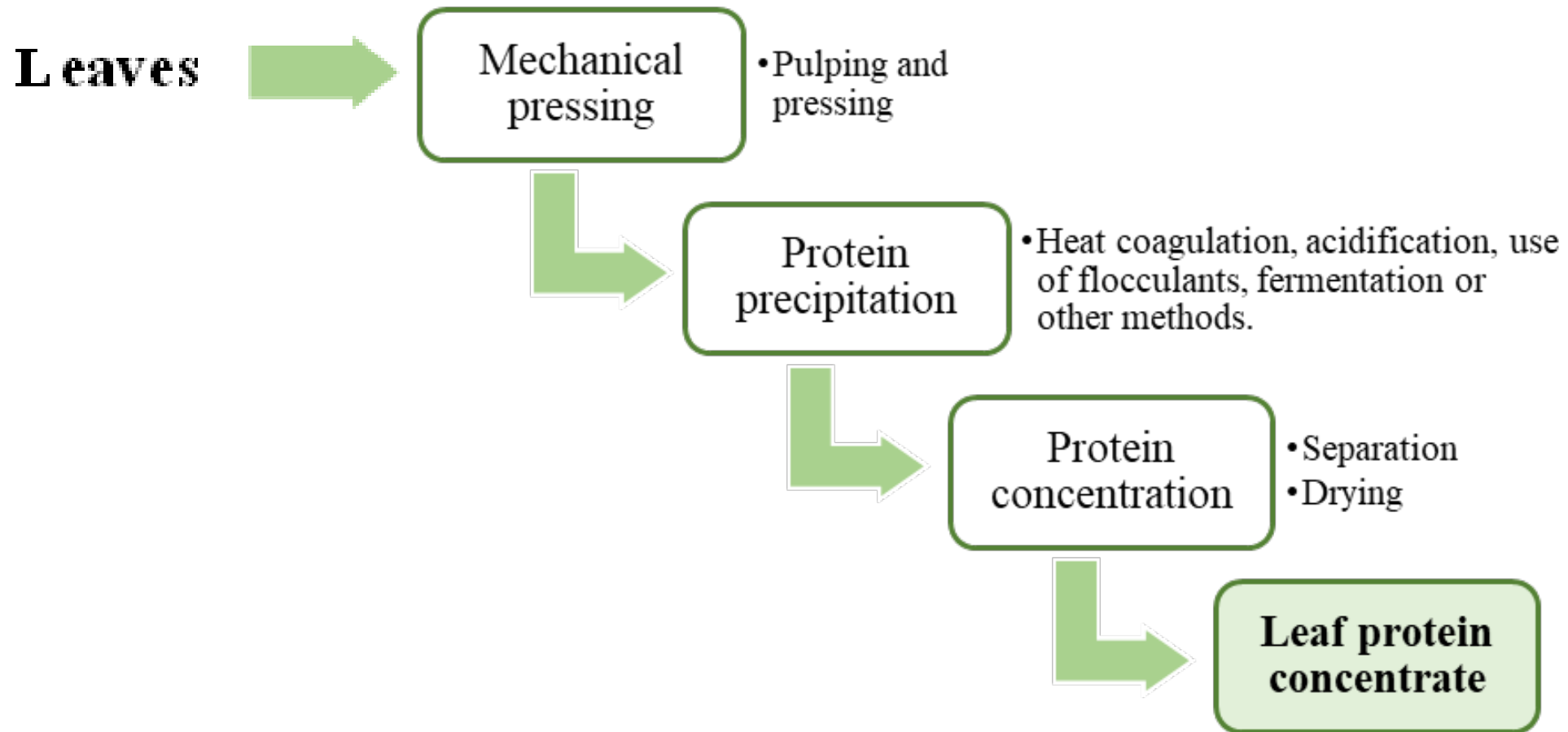
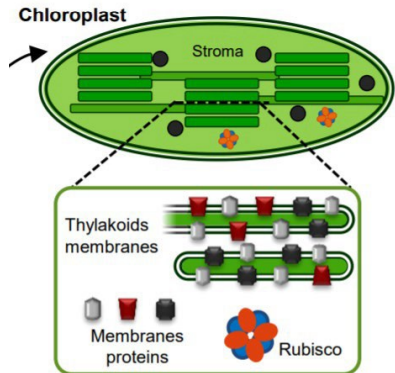


Figure: Santamaria-Fernandez & Lübeck 2020

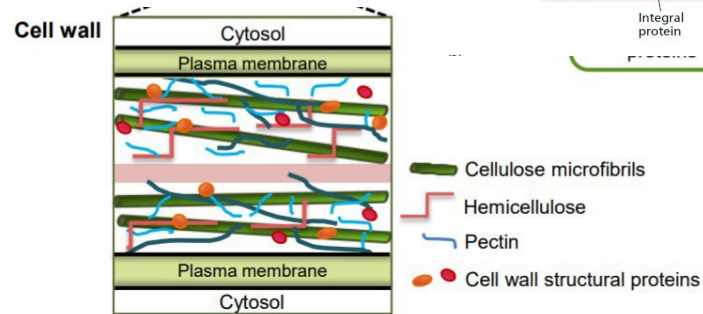
# Difference in feed and food quality of leaf proteins

## GREEN PROTEIN FRACTION

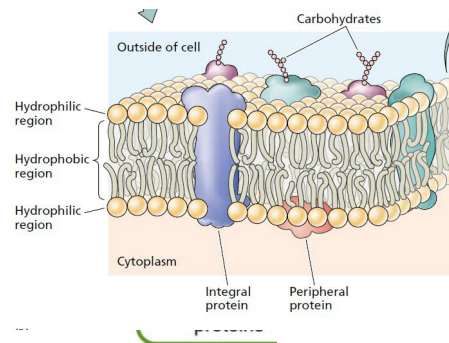
Proteins in photosynthesis complexes with pigments and co-factors



Proteins, that are bound to cell wall polysaccharides (fibre)



Membrane proteins

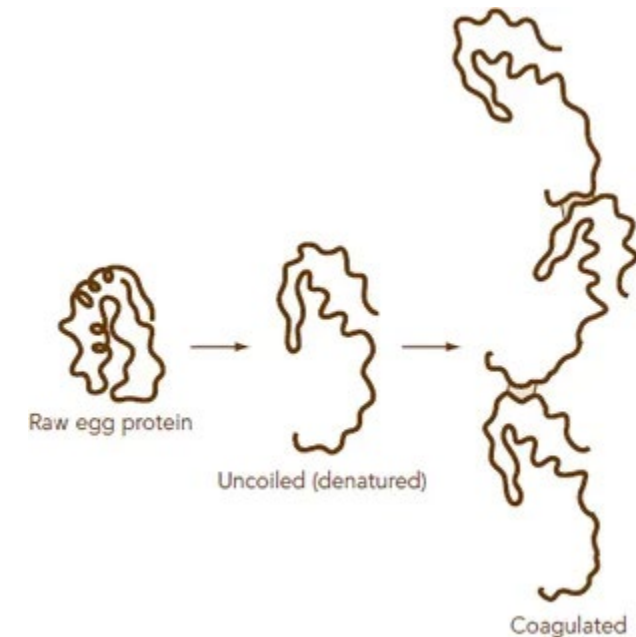
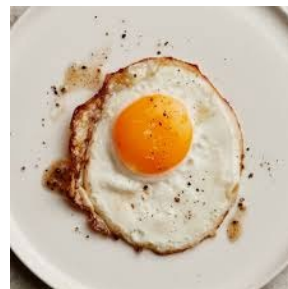
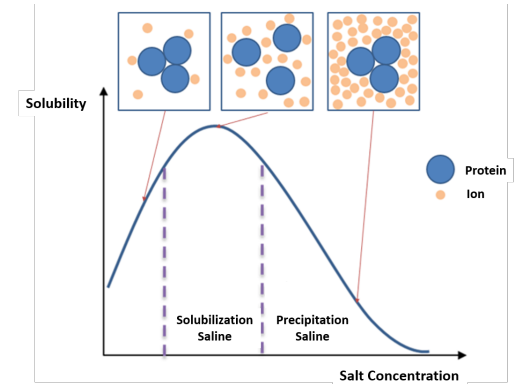
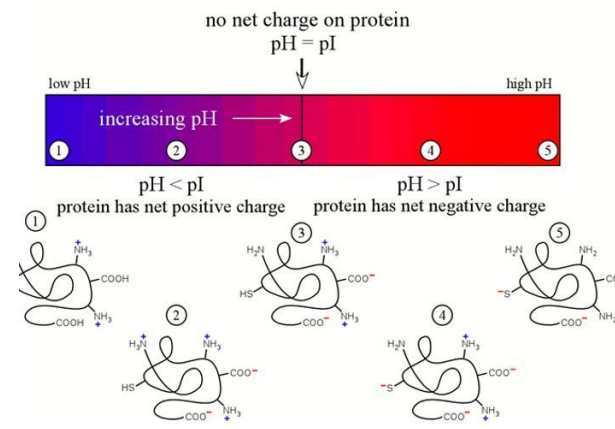


## "WHITE" PROTEIN FRACTION

- Soluble proteins
- **RUBISCO** (ribulose-1,5-bisphosphate carboxylase/oxygenase).  
**550 kDa protein complex with subunits:**  
8x large (53kDa) and 8x small (14kDa)
- Enzymes involved in synthesis of carbohydrates, fibre, fat, proteins mm.
- Free amino acid and small peptides

# How can proteins be recovered?

- Heat precipitation
- Acid precipitation
- Saline precipitation
- Membrane filtration



# What is a membrane?

- Heat precipitation
- Acid precipitation
- Membrane filtration

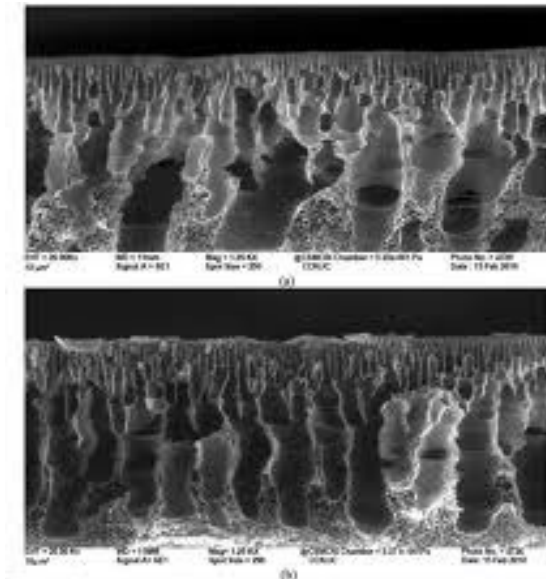
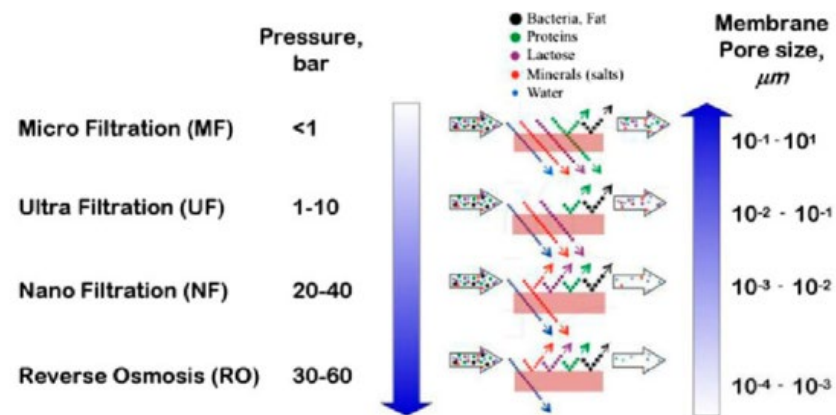
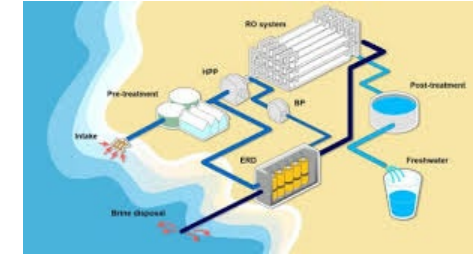


Figure 4: Cross-section morphology of asymmetric polyether terephthalates prepared (a) in water and (b) in aqueous solution of 1,3-phenylene diamine.

# Separation

- Heat precipitation
- Acid precipitation
- Membrane filtration

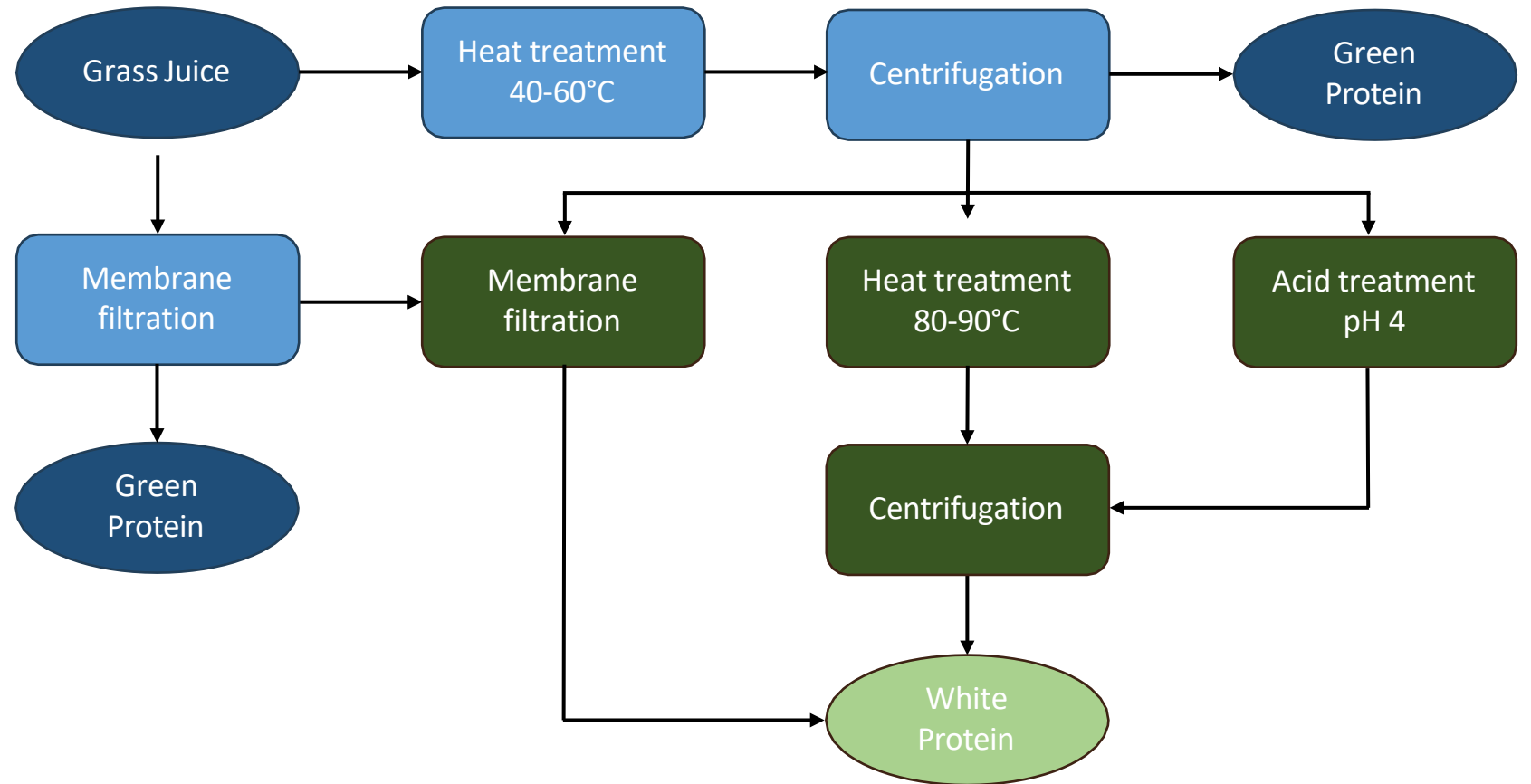
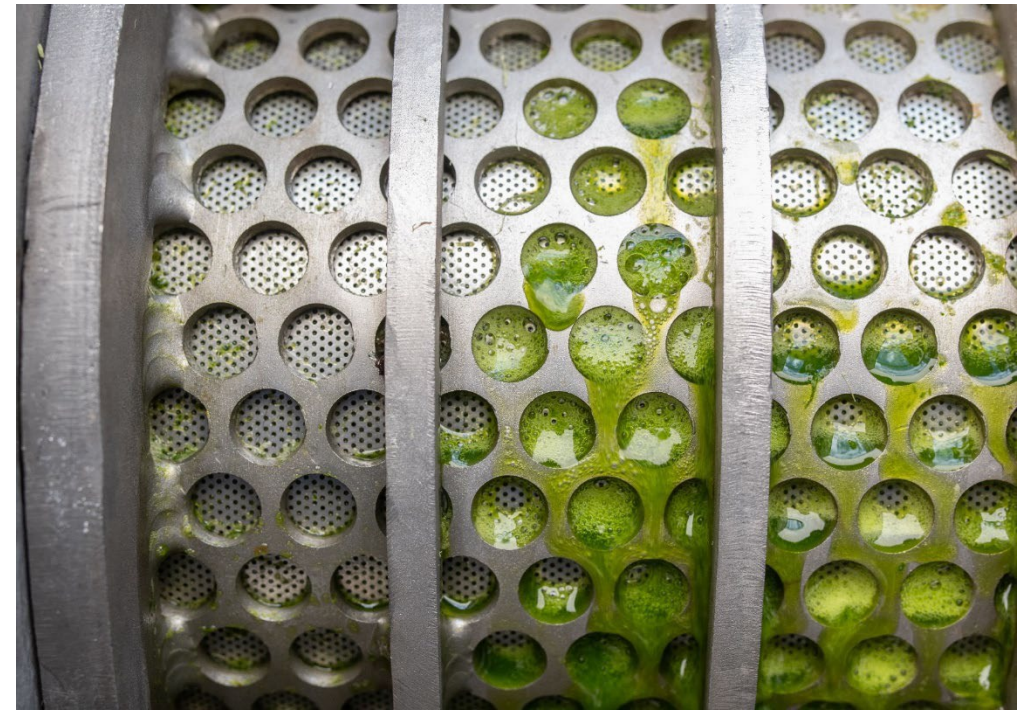


Figure by PhD student Anders Kjær Jørgensen, AAU

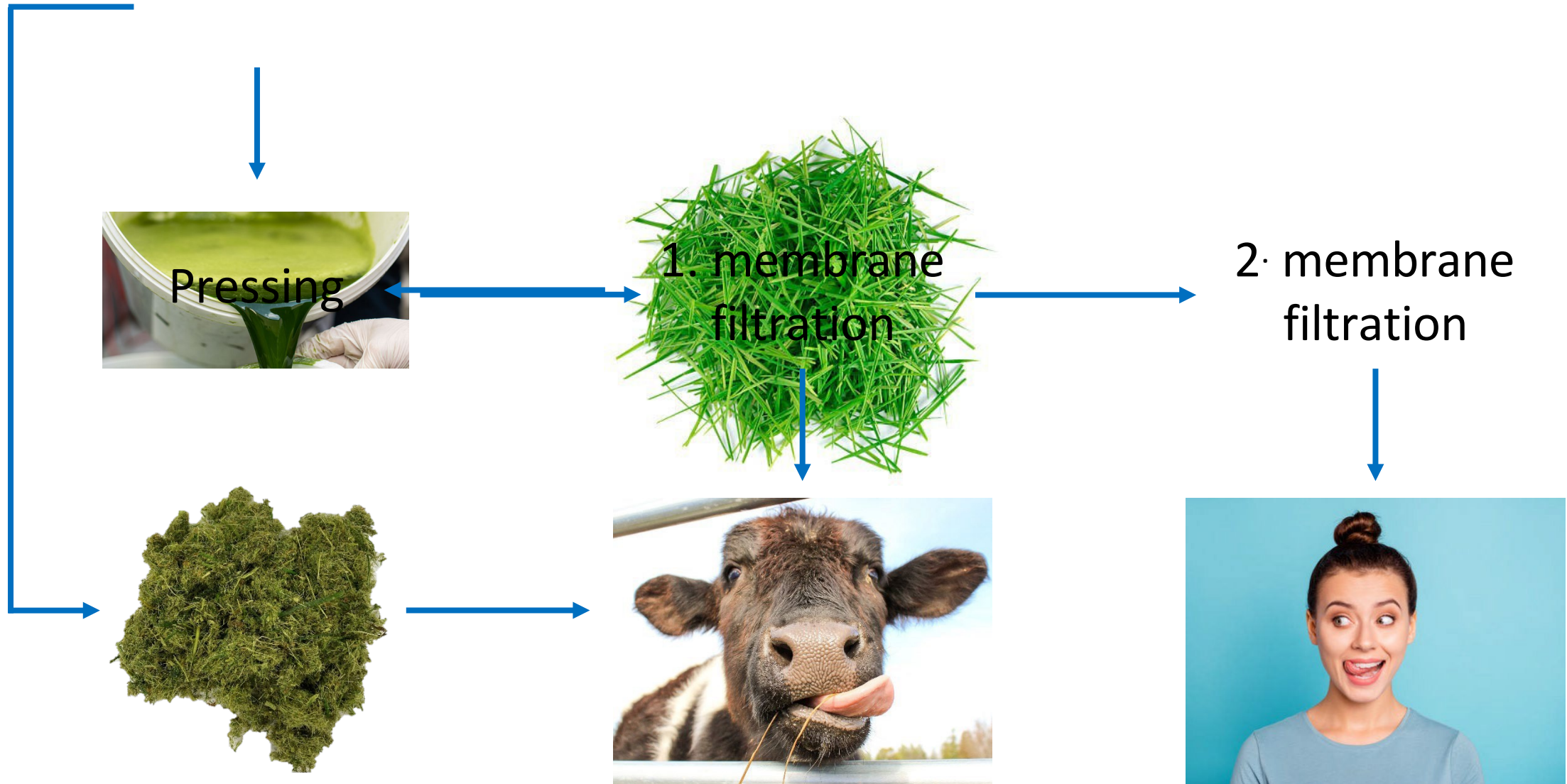
# Grass4Food project



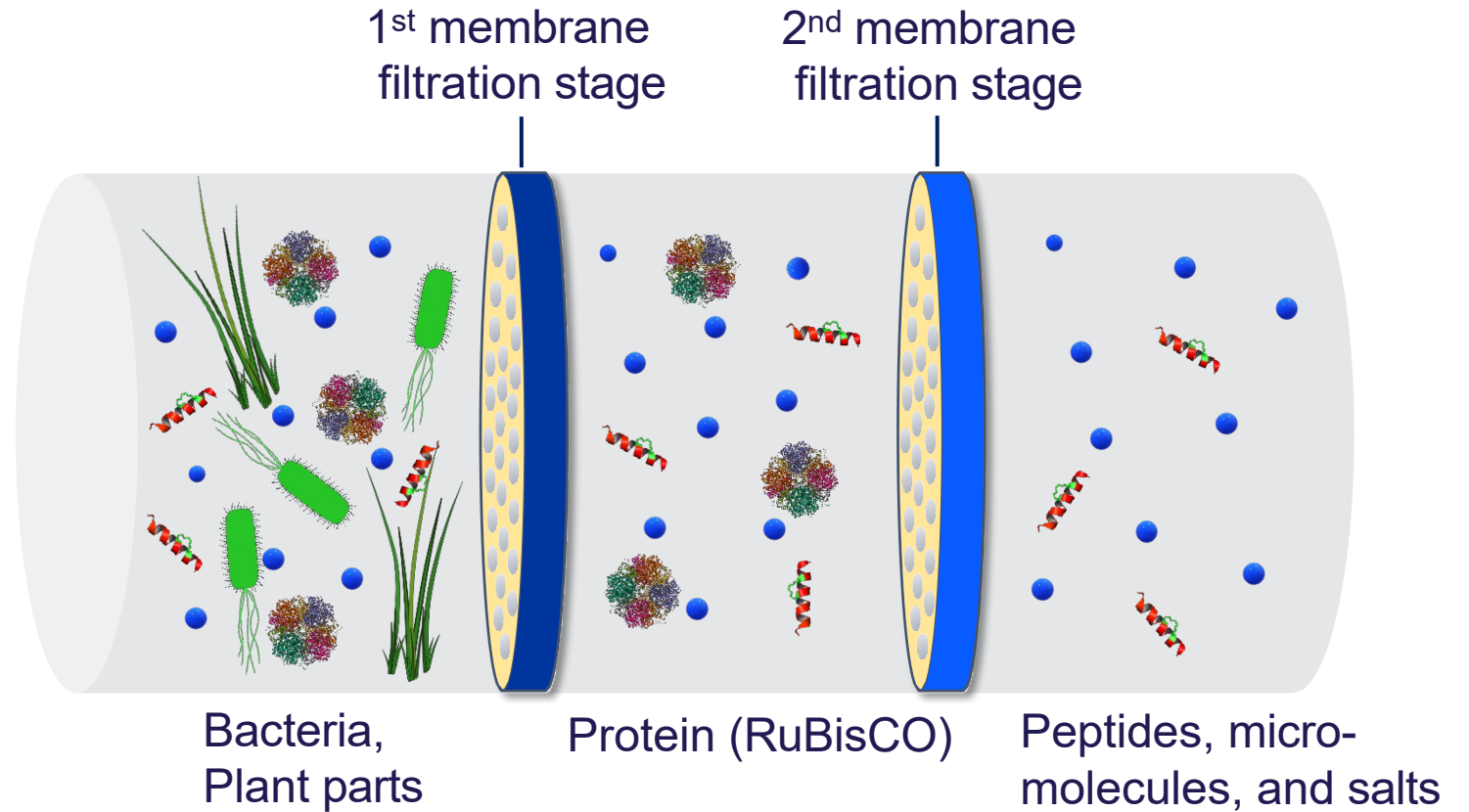
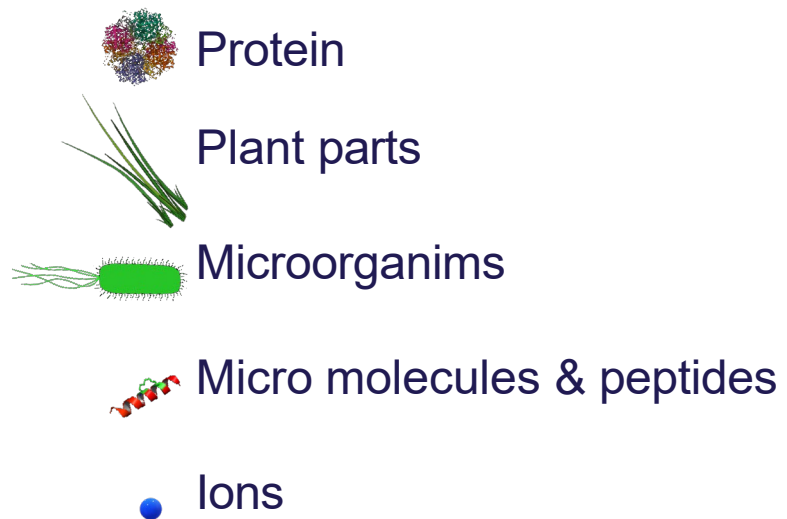
- ▶ The standard grass protein production focuses on heat precipitation
  - Grass taste and smell is not suitable for food
  - Loss of solubility and functionality
- ▶ We developed a membrane filtration process for production of feed and food protein products
- ▶ Pilot process in GreenLab Skive



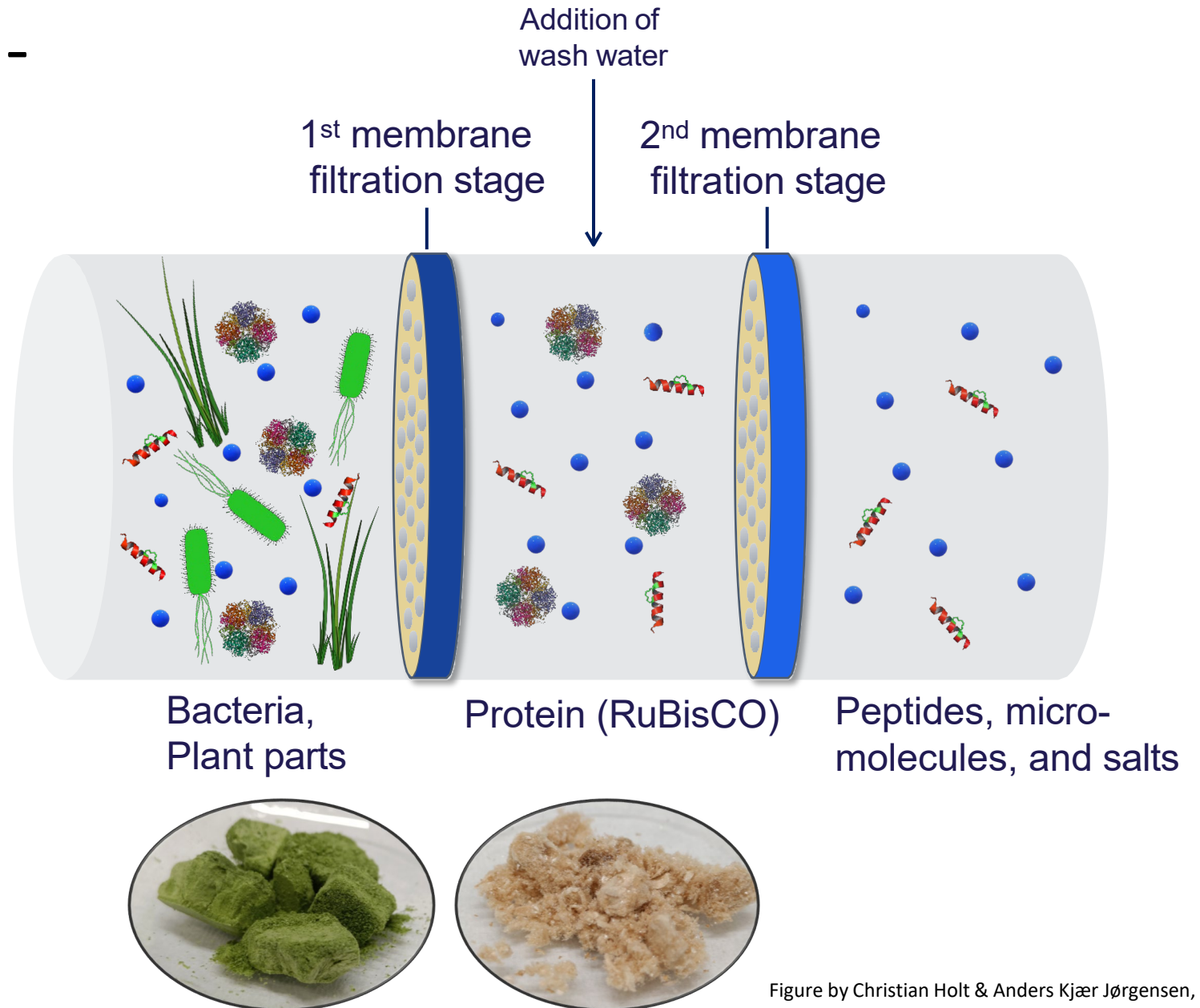
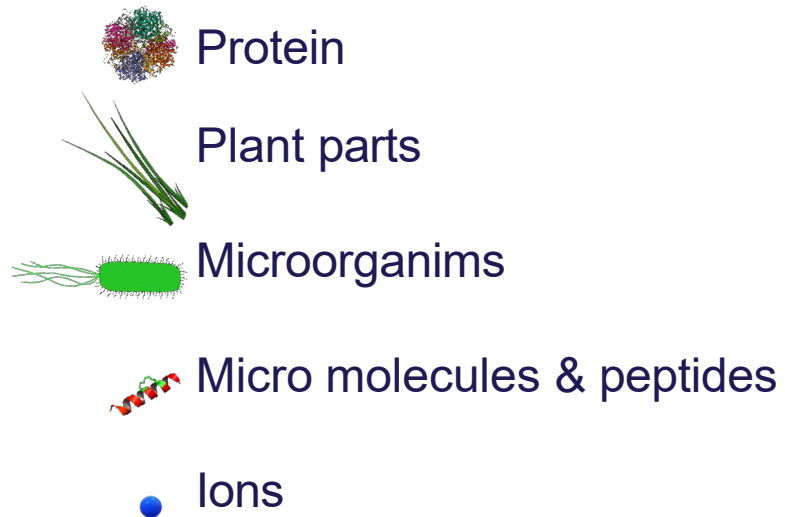




# Membrane Filtration



# Membrane Filtration - Diafiltration

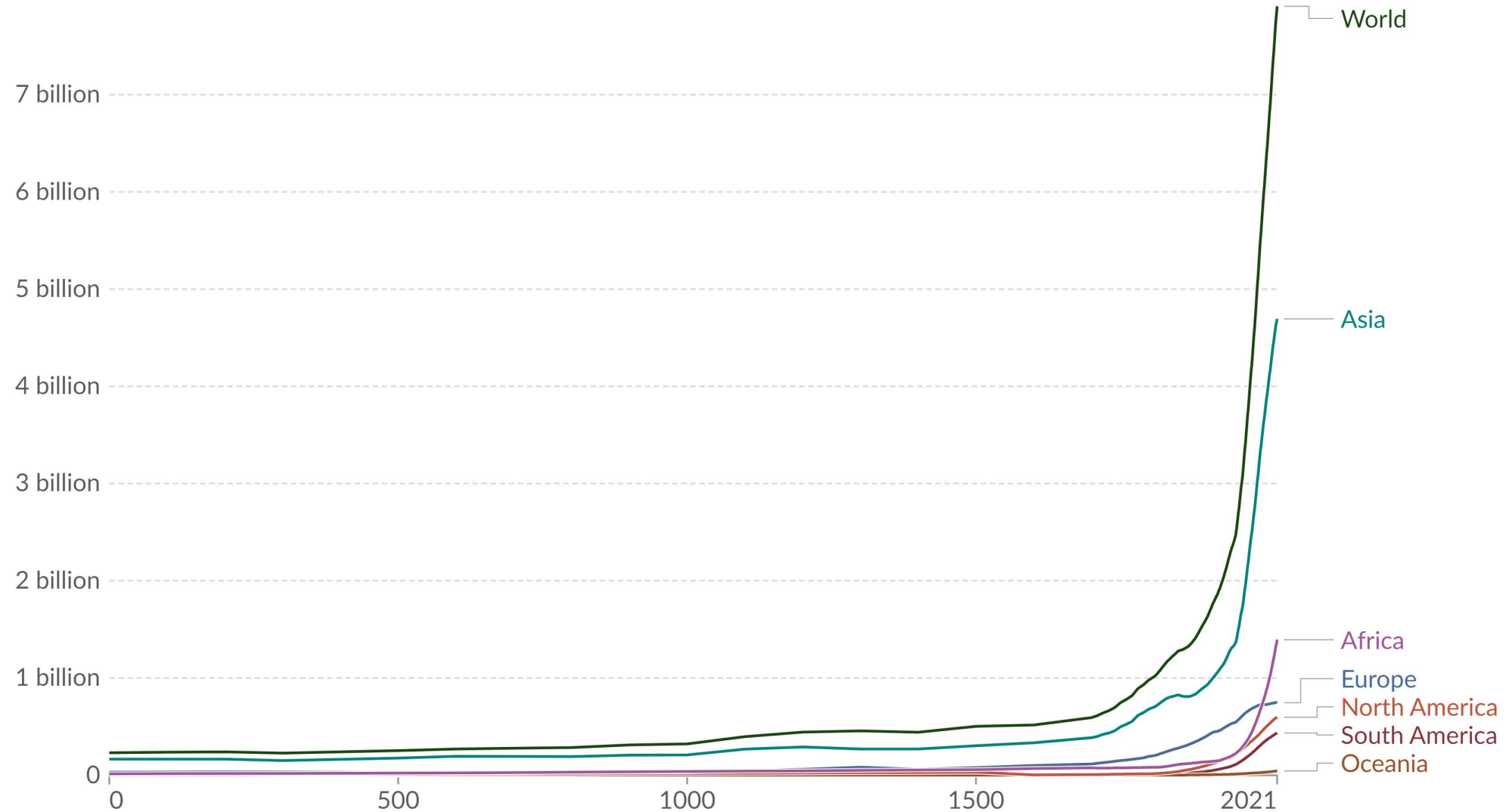


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# Population, 0 to 2021

Population by country, available from 10,000 BCE to 2100, based on data and estimates from different sources.



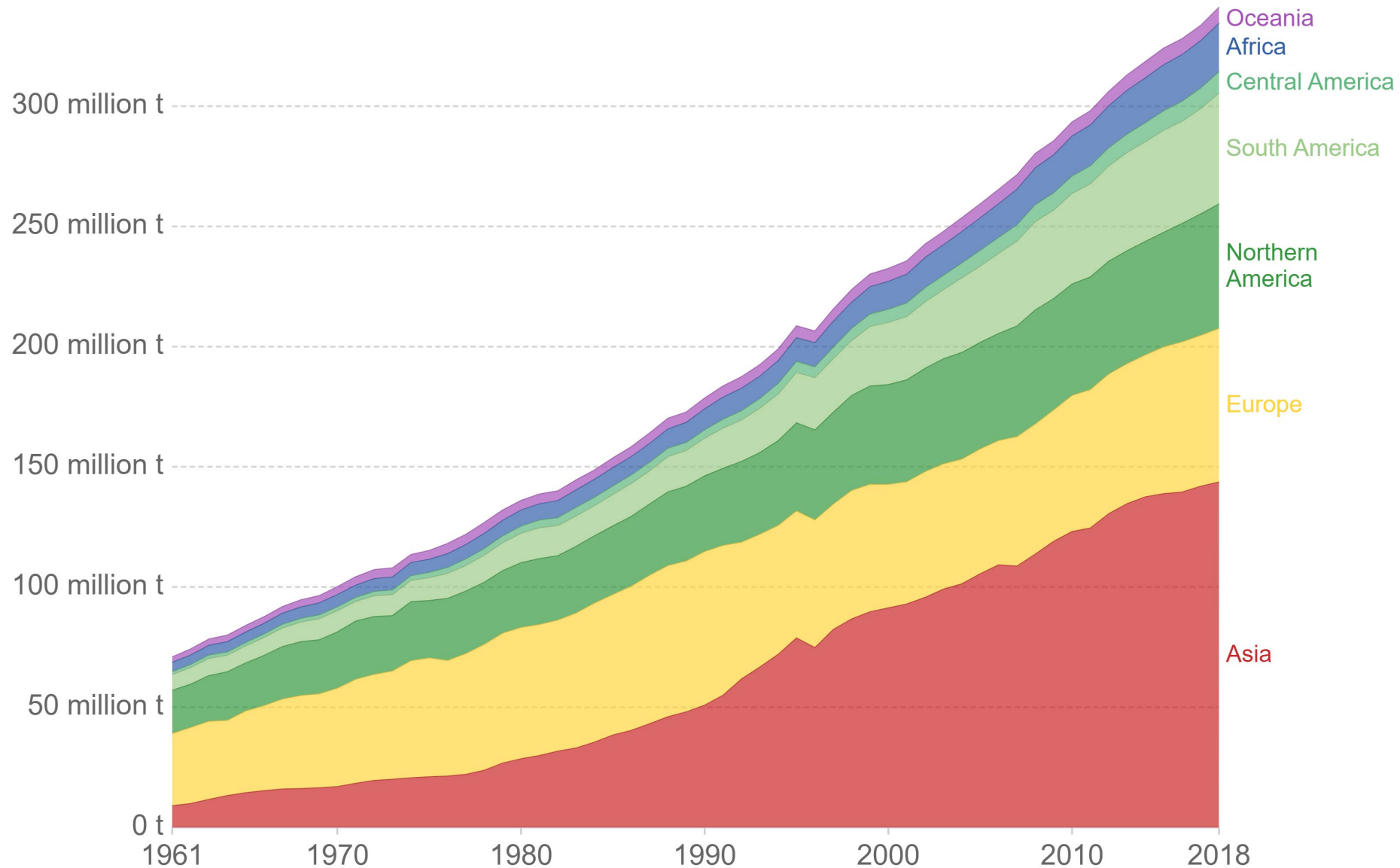
Data source: HYDE (2017); Gapminder (2022); UN (2022)

Note: Historical country data is shown based on today's geographical borders.

[OurWorldInData.org/population-growth](https://OurWorldInData.org/population-growth) | CC BY

# Den globale kødproduktion 1961-2018

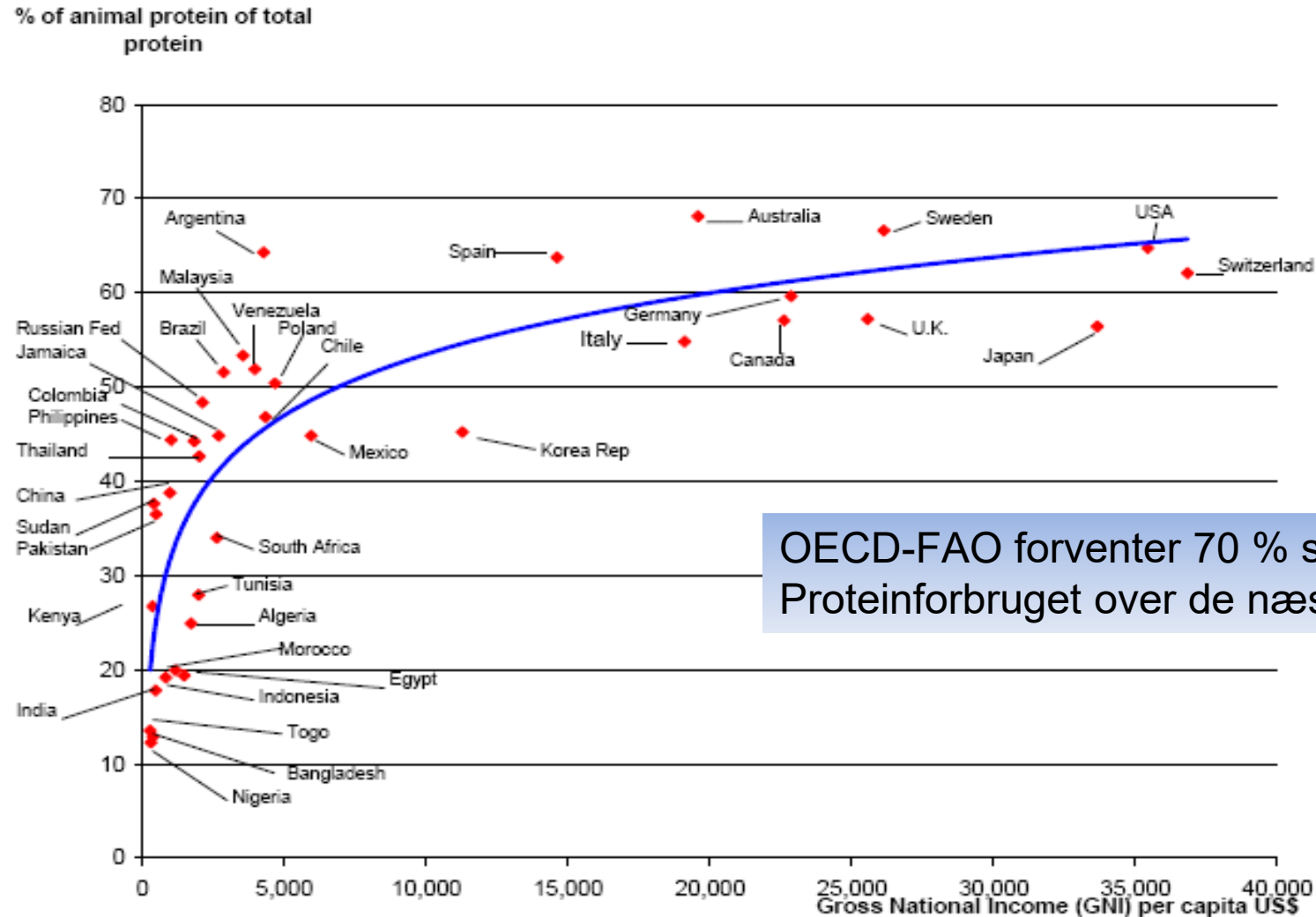
Our World  
in Data



Source: UN Food and Agriculture Organization (FAO)

OurWorldInData.org/meat-production • CC BY

# Stigende indkomst øger forbruget af animalsk protein



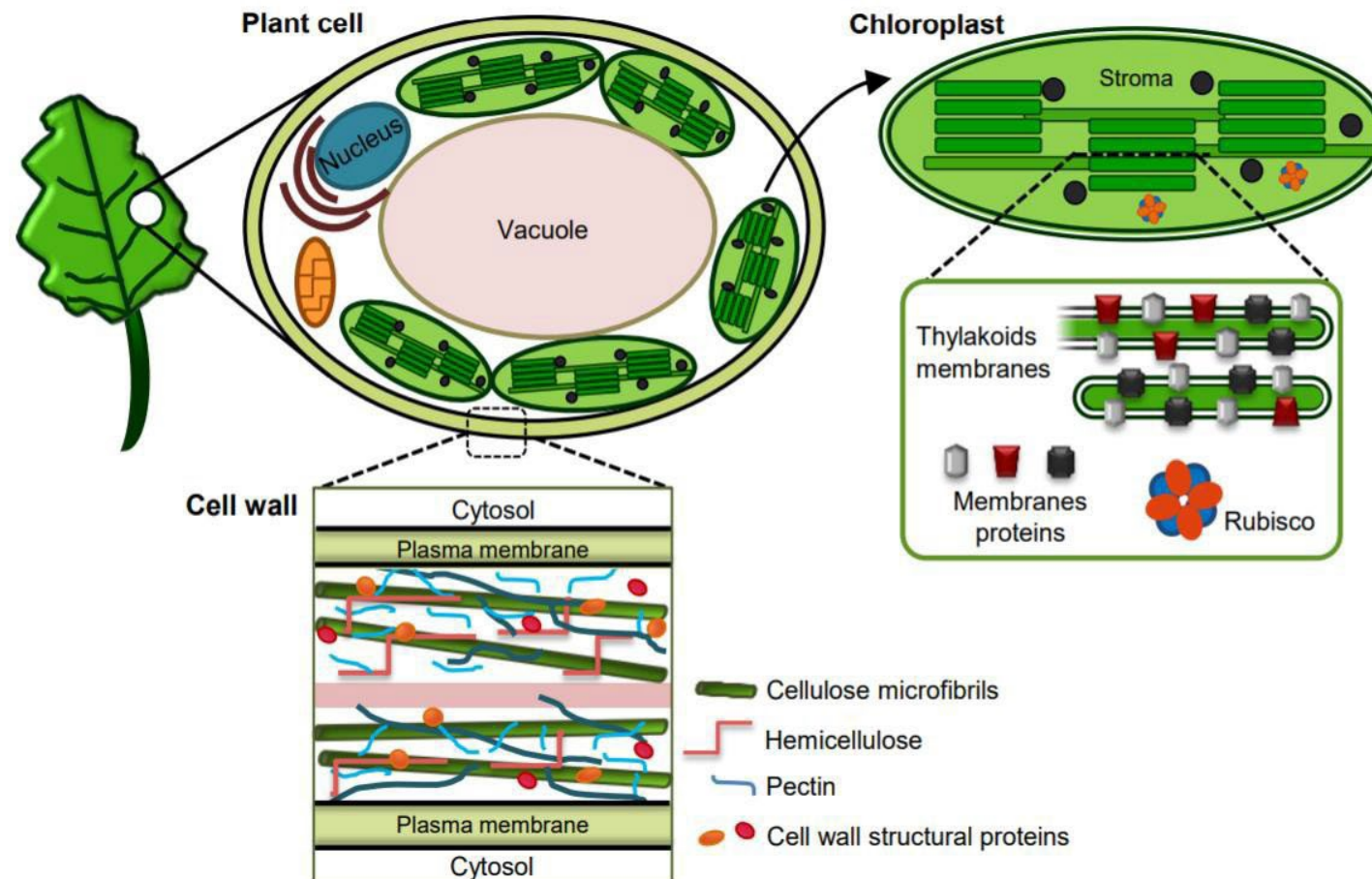
Source: Based on data through 2002 from FAO and World Bank.

# Alternative proteinkilder

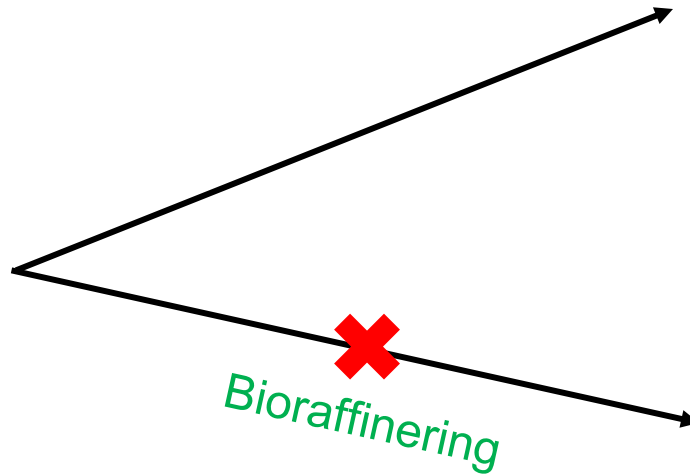


Hvorfor spiser vi ikke den største  
proteinkilde i verden?

Grønne blade: Kilde til fibre, proteiner, lipider, mineraler, vitaminer, pigmenter...



# Grøn bioraffinering gør planteproteiner til virkelighed!



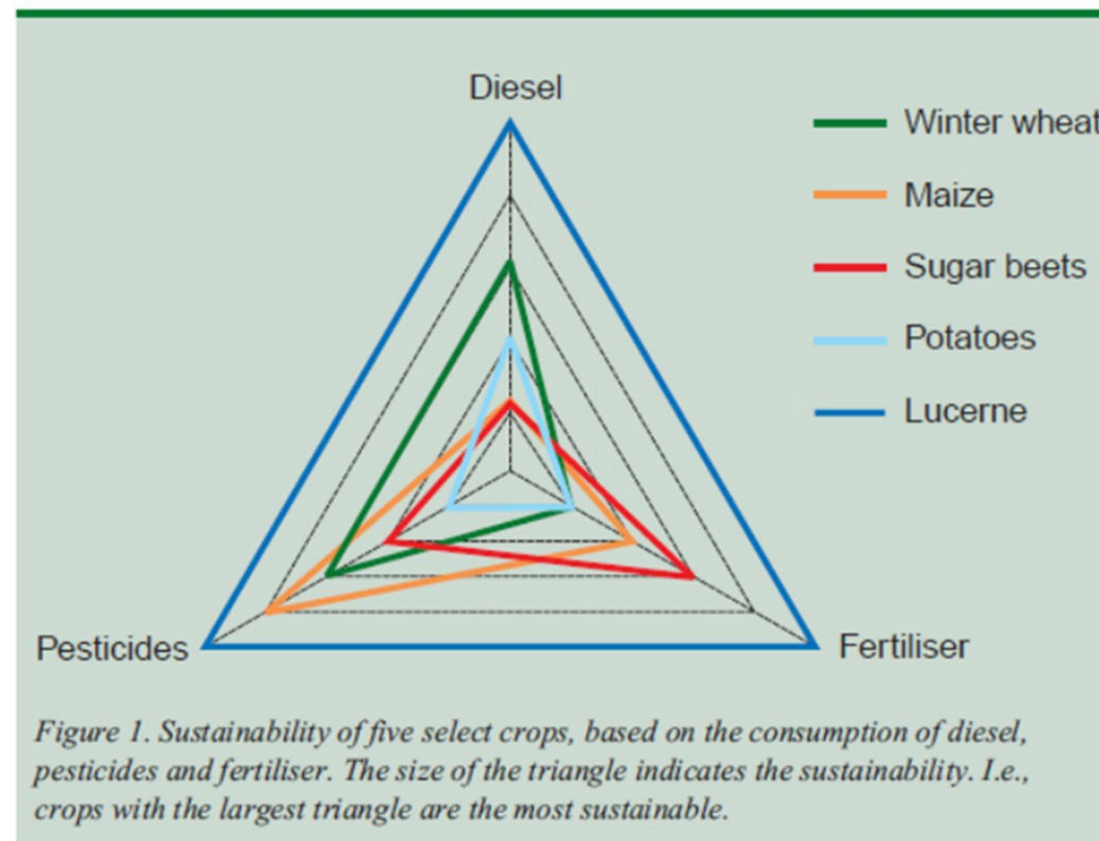
# Hvorfor kløver-græs?

- ▶ Udbredt – dækker ~70% af verdenens landareal
- ▶ Gror godt i tempereret klima
- ▶ Græs proteiner kan bruges både til dyre og menneske føde
- ▶ Græs har 6-26% protein i tørstof
- ▶ **Høj dansk prioritet – Den Grønne trepart**



# Kløver-græs som afgrøde

- ▶ Kulstof-binding – især i rødder
- ▶ Nitrogen fiksering via bælgplanter
- ▶ Mindsker pesticid og gødning
- ▶ Afgørende i sædskifte for den specifikke landmand



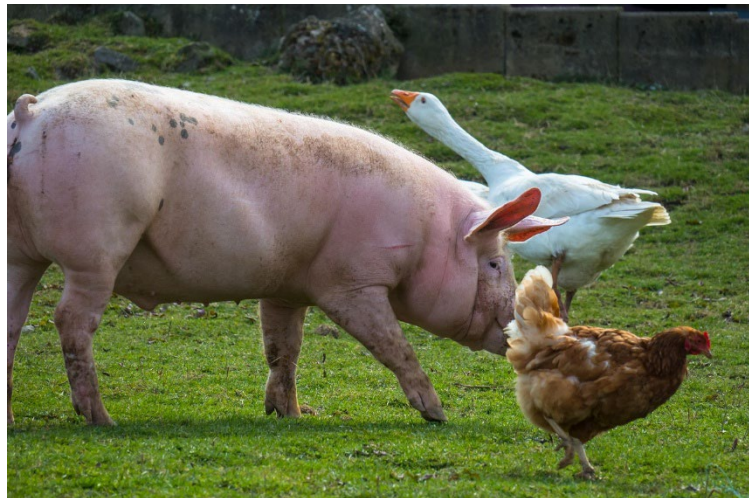
# Udbytter og nitrogenudvaskning i forskellige kultiveringssystemer

|                | Udbytte<br>TS ton/ha | Protein<br>% | Protein<br>kg/ha | Lysin<br>kg/ha | Methionin<br>kg/ha | N<br>Udvask |
|----------------|----------------------|--------------|------------------|----------------|--------------------|-------------|
| Soja           | 2                    | 35           | 700              | 43             | 9                  | Stor        |
| Raps           | 5                    | 20           | 1000             | 60             | 20                 | Stor        |
| Hvede          | 9                    | 11           | 1000             | 30             | 16                 | Stor        |
| Hestebønner    | 6                    | 25           | 1500             | 92             | 11                 | Stor        |
| Ærter          | 6                    | 22           | 1300             | 92             | 13                 | Stor        |
| Kløvergræs     | 13                   | 20           | 2600             | 200            | 90                 | Lille       |
| Lucerne        | 12                   | 21           | 2600             | 200            | 90                 | Lille       |
| Ekstensiv græs | 3                    | 12           | 350              | 25             | 12                 | Lille       |



# Hvad kan proteinerne bruges til?

Grønne proteiner

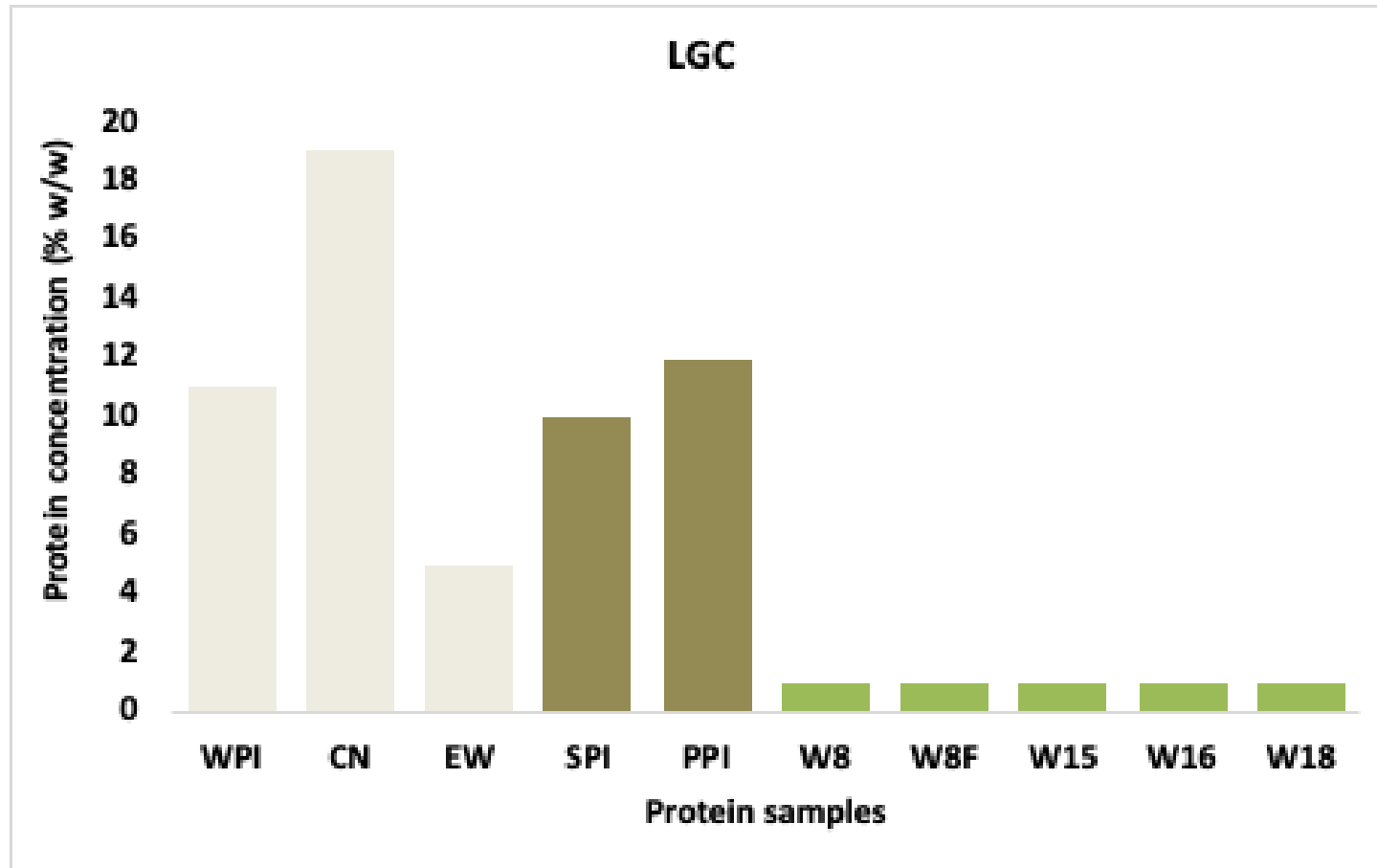


“Hvide” proteiner



Proteinprodukter og funktionel ingredients

# Minimal geleringskoncentration (lgc)



WPI: Valle protein

CN: Mælkeprotein (casein)

EW: Æggehvide

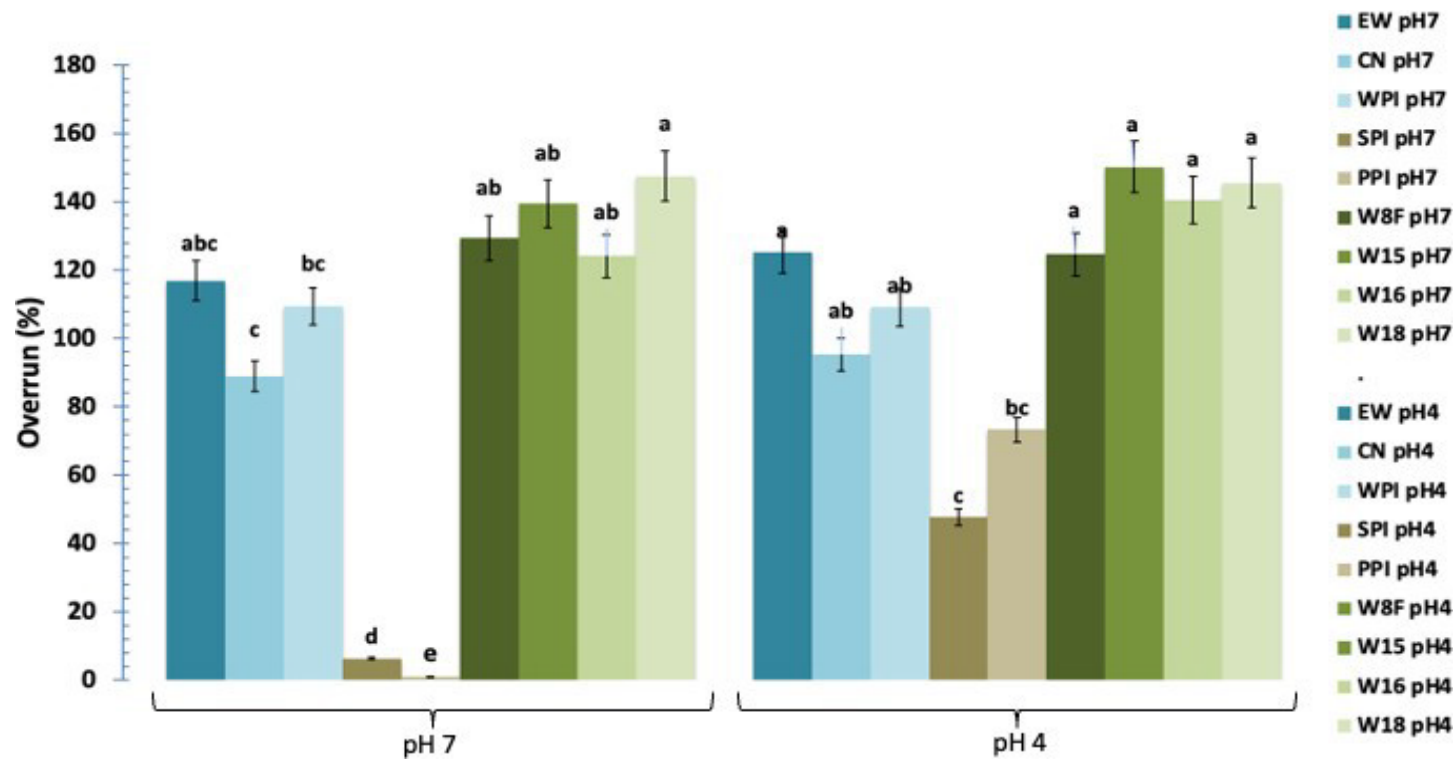
SPI: Soja protein isolate

PPI: Ærte protein isolate

W8-W18: Hvid protein fra forskellige

Hvid protein bedre gelation end andre proteiner

# Skumme egenskaber og kapacitet



WPI: Valle protein  
CN: Mælkeprotein (casein)  
EW: Æggehvide  
SPI: Soja protein isolate  
PPI: Ærte protein isolate  
W8-W18: Hvid protein fra forskellige

Hvid protein sammenligneligt med animalsk protein

# Sidestrømme

Pulp

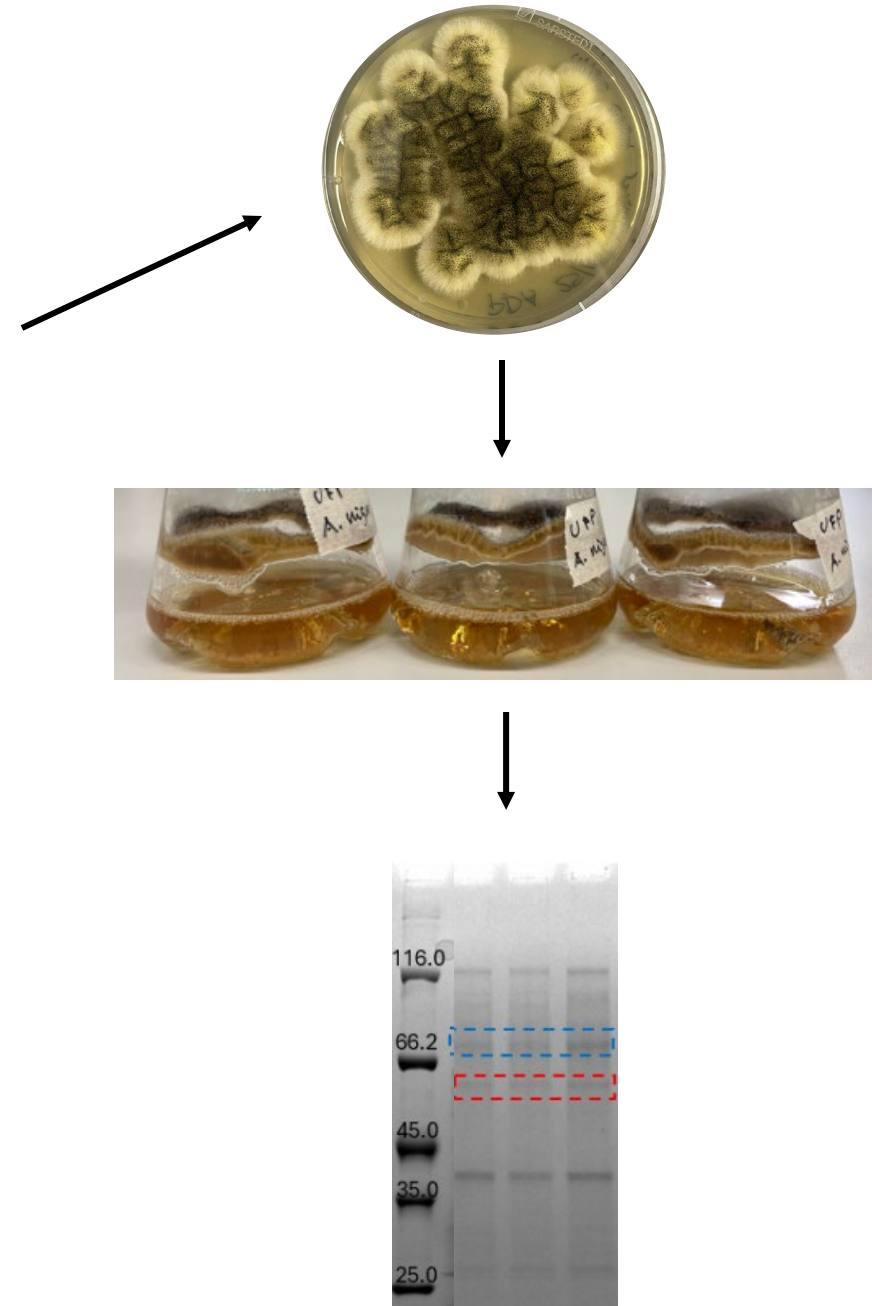


↓  
Ruminant fodder  
Biogas  
Byggematerialer  
Solid state fermentering

Residual juice



↓  
Genbrug vand og salt  
Gødning  
Submerged fermentering





Thanks to the following:

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