Production of local organic protein concentrates from grass- and forage crops to substitute soy import

DK DEMO





GO-GRASS

Grass-based circular business models
for rural agri-food value chains

AARHUS UNIVERSITY

Kjeldal

Food & Bio Cluster Denmark

CBIO
AARHUS UNIVERSITY CENTRE FOR CIRCULAR BIOECONOMY

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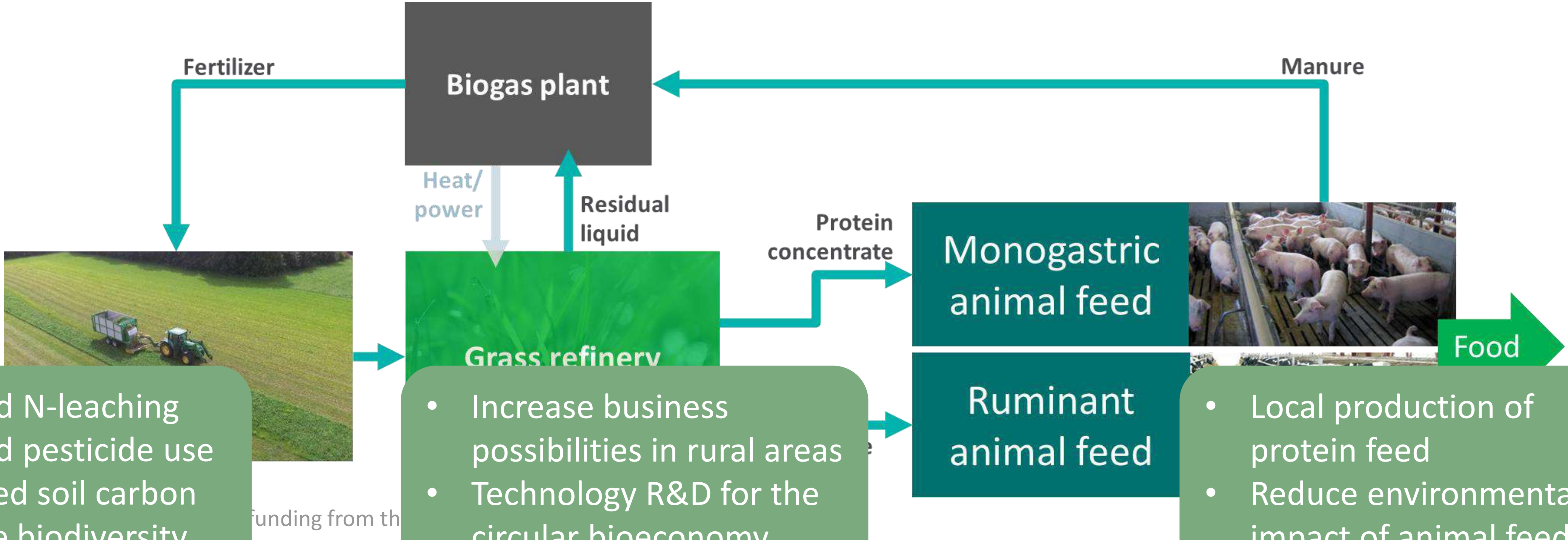
Motivation

Improve the ecological sustainability of agricultural production

→ Changing annual cropping systems to green perennials

- **Prevent nutrient leaching** (especially in nitrate sensitive areas)
- **Build up soil carbon** (especially in carbon depleted areas)
- **Reduce pesticide use** (especially close to groundwater reserves)
- **Increase photosynthetic productivity** (extending the growth season)
- **Potentially improve on biodiversity**



- Reduced N-leaching
- Reduced pesticide use
- Increased soil carbon
- Improve biodiversity

- Increase business possibilities in rural areas
- Technology R&D for the circular bioeconomy

- Local production of protein feed
- Reduce environmental impact of animal feed

Challenges

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- How to make a profitable business case for a rural green biorefinery?
    - Many possibilities but which routes to choose?

- Achieve constant high yields of the main product; the leaf protein concentrate (LPC)

- Secure high quality raw materials during the entire growth season (May to November)

- Create efficient and practical harvest and logistics for production during the entire growth season (May to November)

- Create enough value from the side streams to support a good business case

This project has received funding from the European Union's Horizon 2020 research and

Focus areas of GO-GRASS DK Demo

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Base case value chain:

Focus on simplicity, practicality and bulk applications

- **General process optimisation in Demo-scale**
    - E.g. Yield optimization
- **Test of grassland biomass from paludiculture areas**
    - E.g. Tall fescue and Reed canary grass
- **Test of harvest methods and logistics**
    - E.g. Time from harvest to processing
- **Protein concentrate feed trials with pigs testing the digestibility of different protein product qualities**
- **Press cake fibre feed trial with dairy cows and milk production on farm scale**

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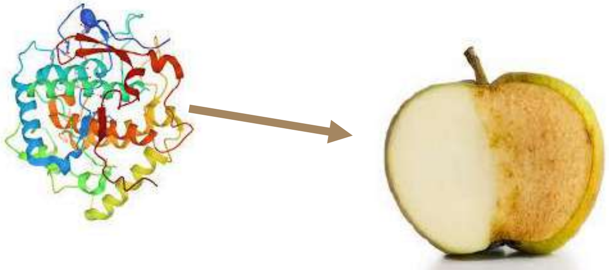
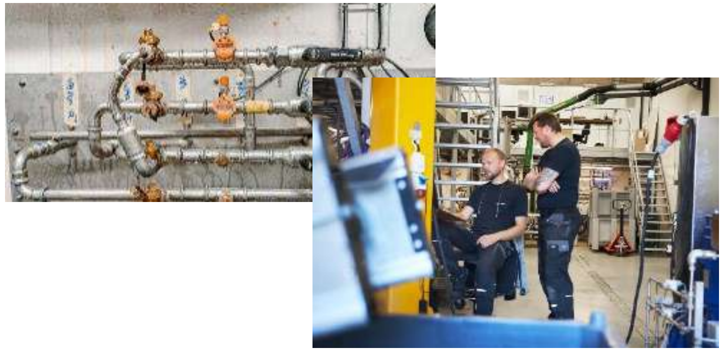
Three important factors for achieving high yields

- **The biomass is important**, its protein content and especially the distribution of soluble and fiber-bound protein.

- **Biological activity** in the plant that starts immediately after harvest. In particular 1) enzymes that cross-link protein and cause browning 2) enzymes that break down protein into amino acids that cannot be precipitated and centrifuged



- **How we process** that biomass so that as much protein as possible is extracted from the plant, and as little protein as possible is cross-linked and broken down



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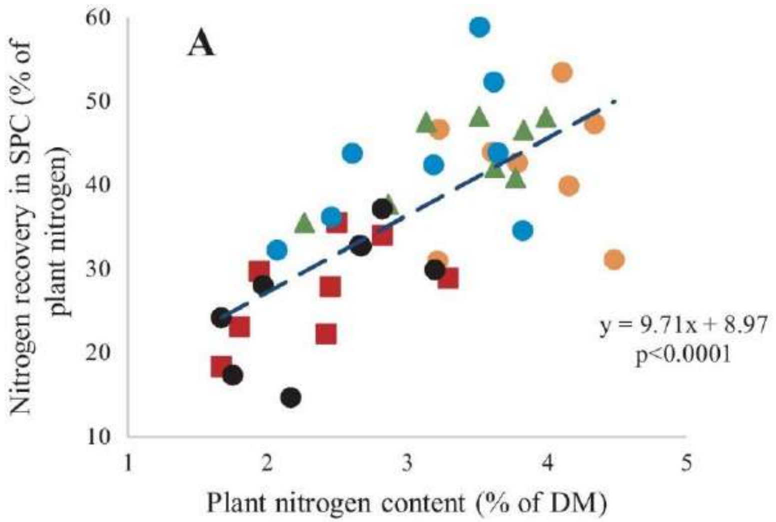
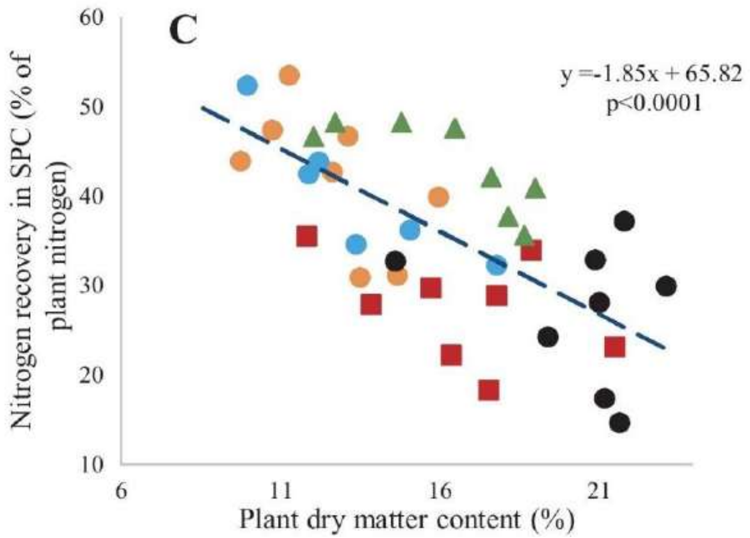
Importance of the biomass for reaching high yields of protein concentrate





- ✓ Yield increases with the plant nitrogen content
- ✓ Yield decreases with plant dry matter content
- ✓ Legumes result in higher yields of protein concentrate than grasses
- ❖ Processing of paludiculture crops in GO-GRASS resulted in very low yields of protein concentrates

Enhancing protein recovery in green biorefineries through selection of plant species and time of harvest
Stødkilde, Lene; Lashkari, Saman; Eriksen, Jørgen; Jensen, Søren Krogh; **ISSN:** 0377-8401 , 1873 2216; **DOI:** 10.1016/j.anifeedsci.2021.115016; Animal feed science and technology , 2021, Vol.278, p.115016

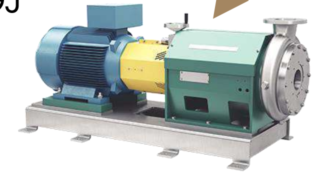
Optimization of protein concentrate yields

Demoscale setup for more severe maceration

→ Increase extraction of intracellular protein to the green juice

Mixing tank with recirculated GJ

Rota-cutter



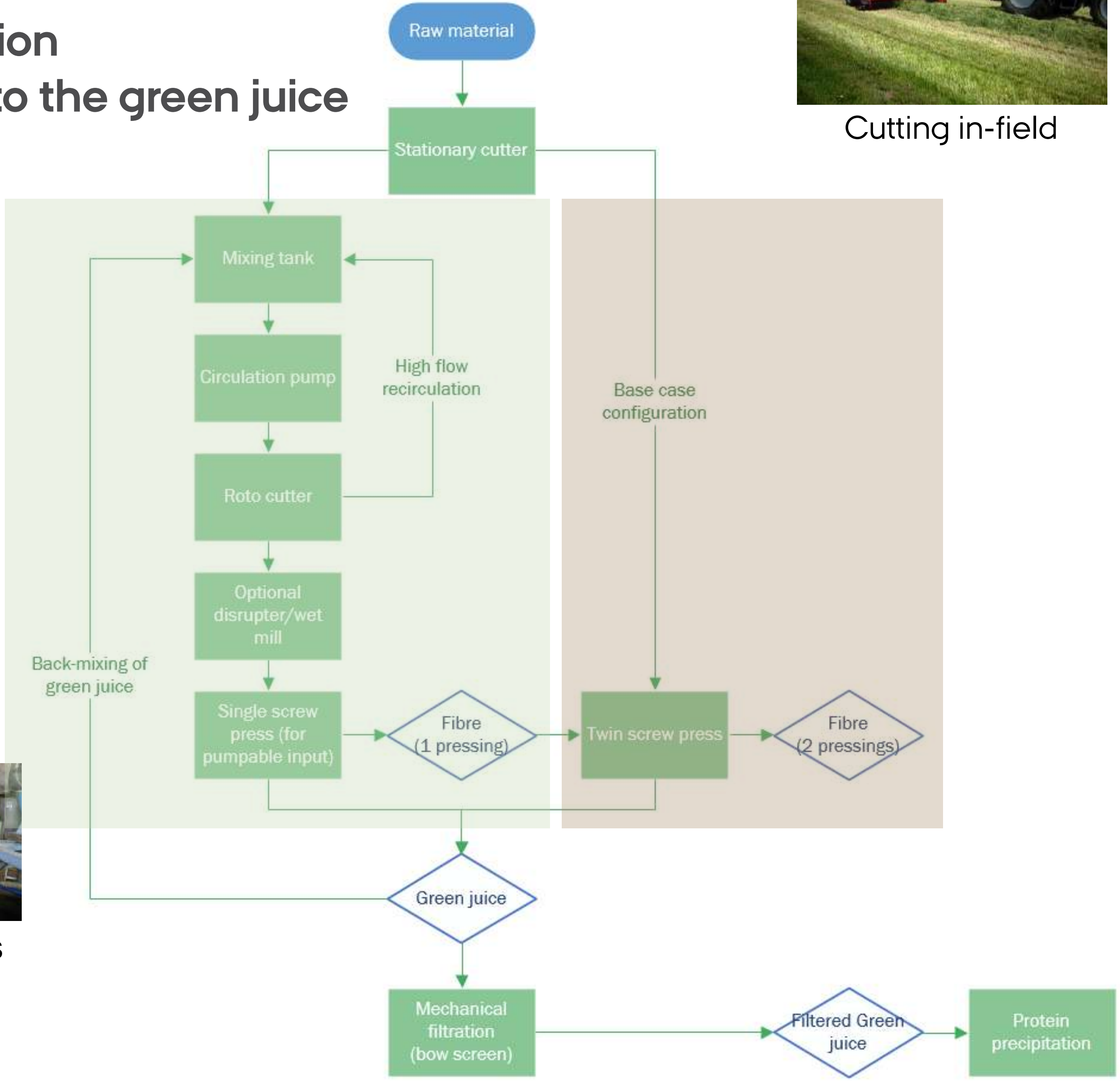
Deflaker

Disrupter

Dewatering (press)

Screwpres

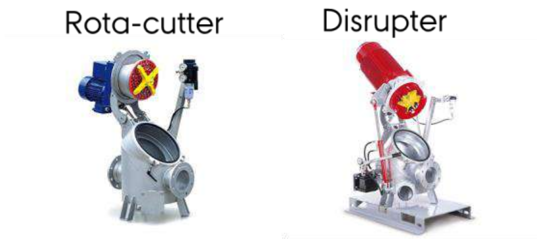
Cutting in-field



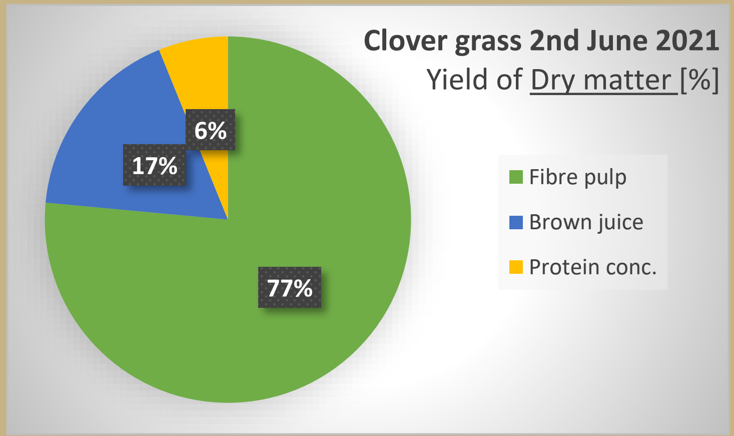
This project has received funding fror

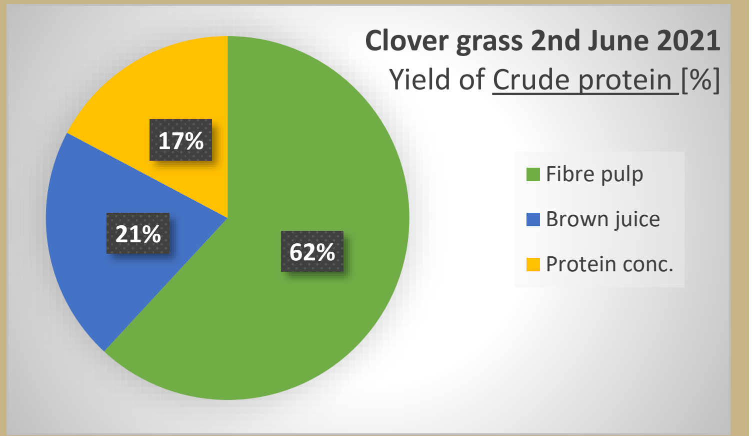
Yield improvement with severe maceration

- ✓ **Yield improvements of up to 2-3 times. Both for dry matter yield and for crude protein yield.**
- ❖ **However, the improvements are very depending on the raw material quality.**

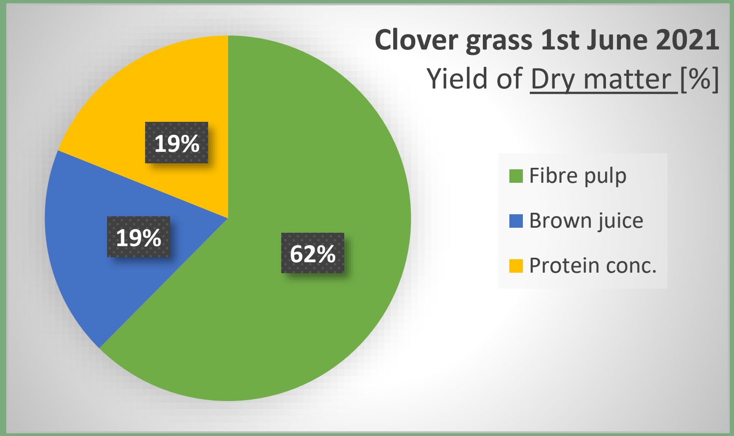


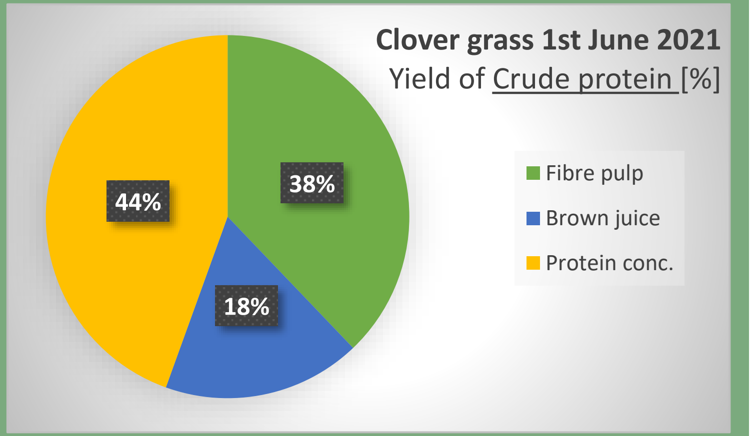
Without severe maceration (only stationary cutter)





With severe maceration (rotocutter + disrupter)





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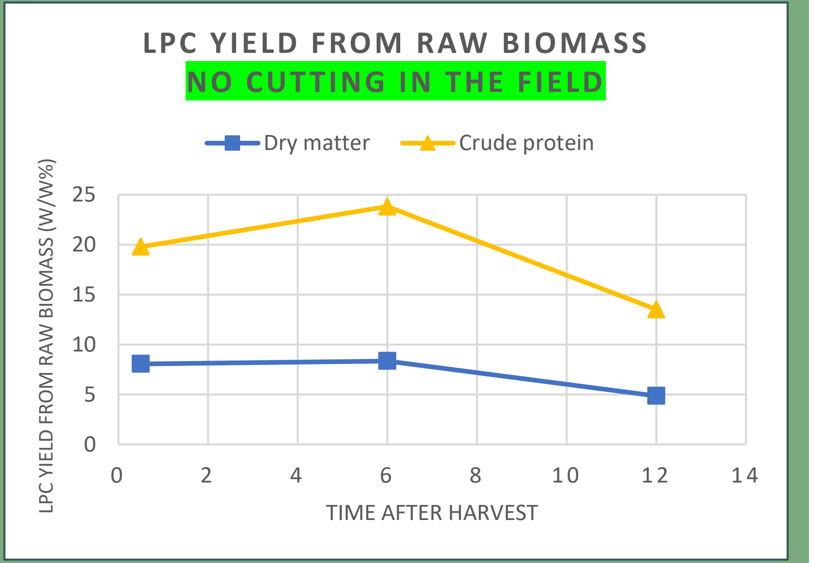
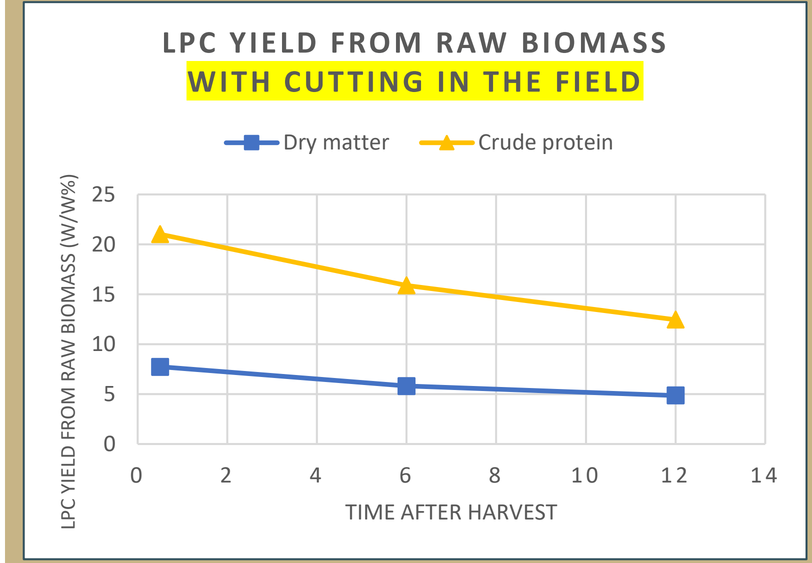
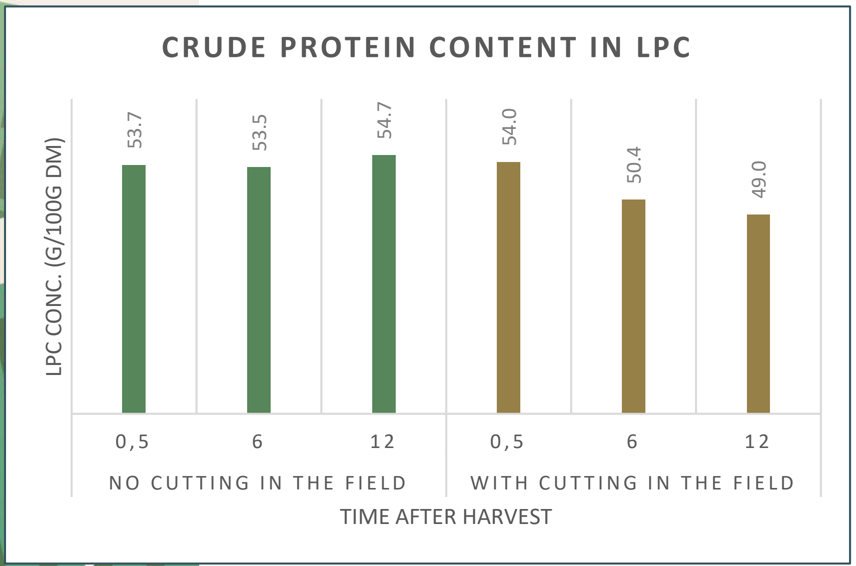
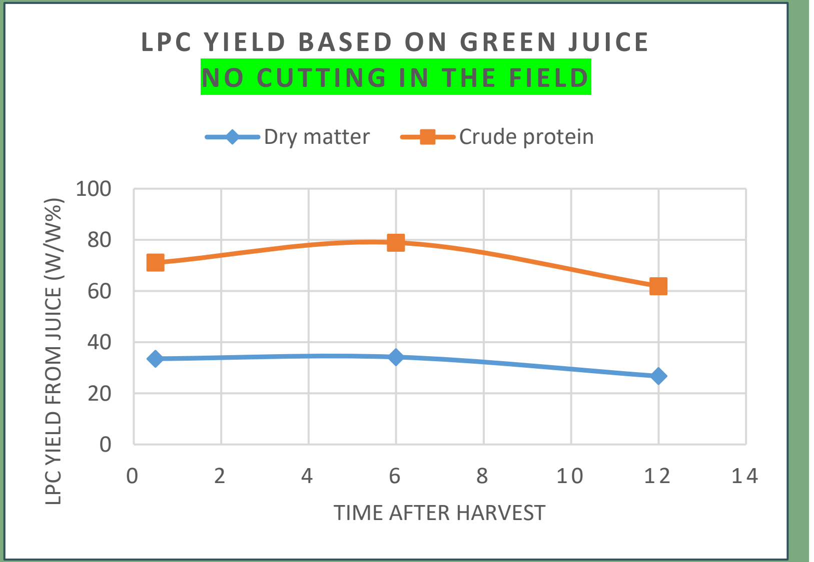
Harvest and time experiment

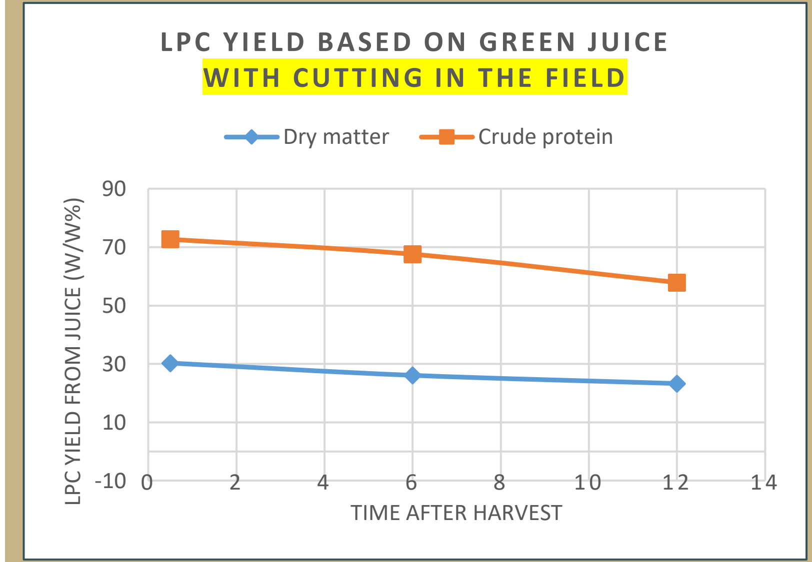
- Protein extraction yields for with- and without chopping in the field and processed at different times after harvest (0.5, 6,12 hr)
- 30-31. august 2021
- Outside temperature: 15-21°C
- One out of several harvest and time experiments…





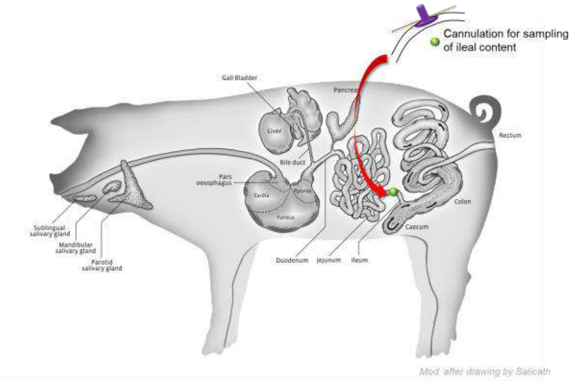


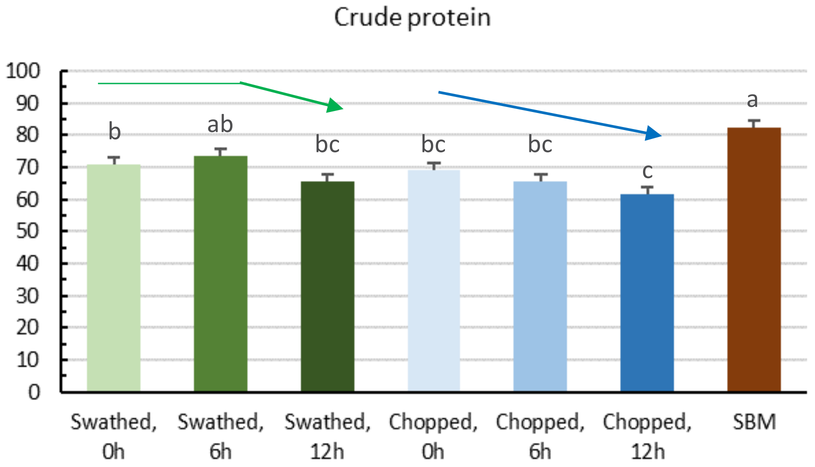


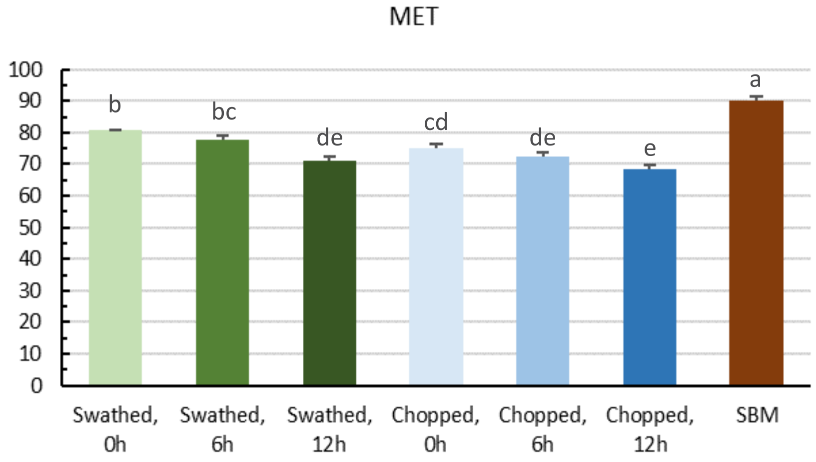


Feed quality of protein concentrates

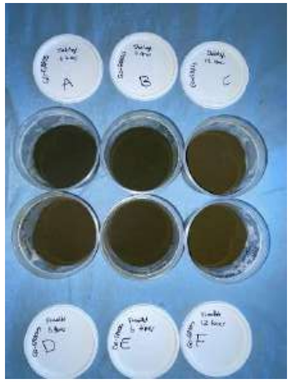
Standardized ileal digestibility (SID), %

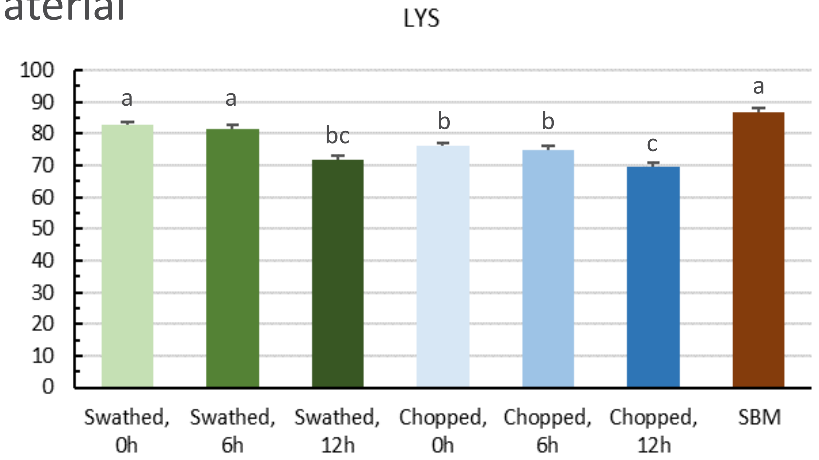


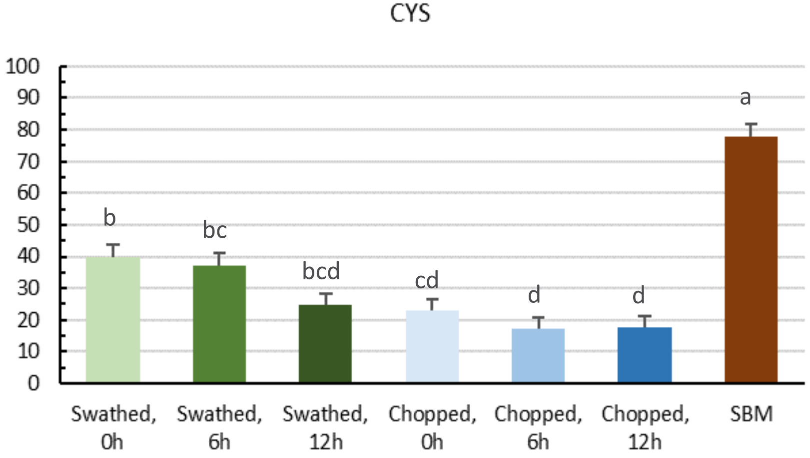




Intake - ileal output = digested material







$$\text{Standardized ileal digestibility (\%)} = \frac{\text{Digested*}}{\text{Intake}} \times 100$$

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* Corrected for endogenous loss of CP or AA

Example of economics in a production scenario

NOTE! numbers can vary depending on **how** and **where** we make the refinery and the value chain

Capacity assumptions:

- 40 ton fresh biomass/hour
- 21.600 t dry matter/year
- 3000 operational hours/year
- In combination with existing biogas

Production		
Protein concentrate	3.643*	t DM/yr
Fiber pulp	15.034*	t DM/yr
Rest juice	2.924*	t DM/yr

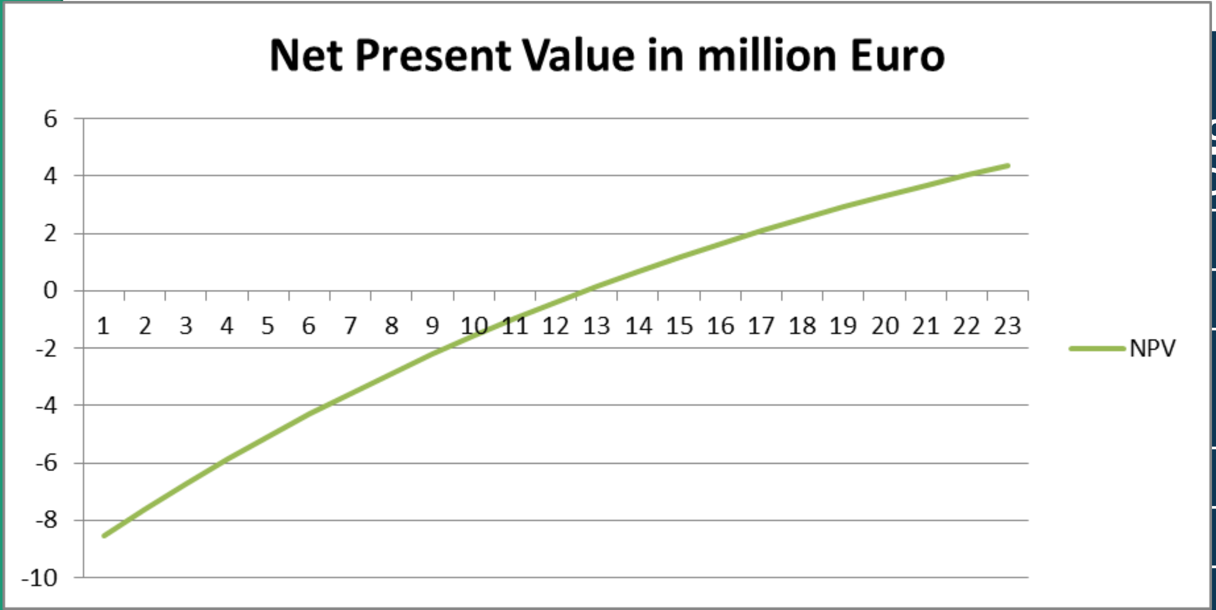
* Based on assumed production efficiencies

Economic assumptions:

- Biorefinery CAPEX : 3.36 mio EUR
- Depreciation time: 15 year
- 5% Interest rate , 5% Maintenance

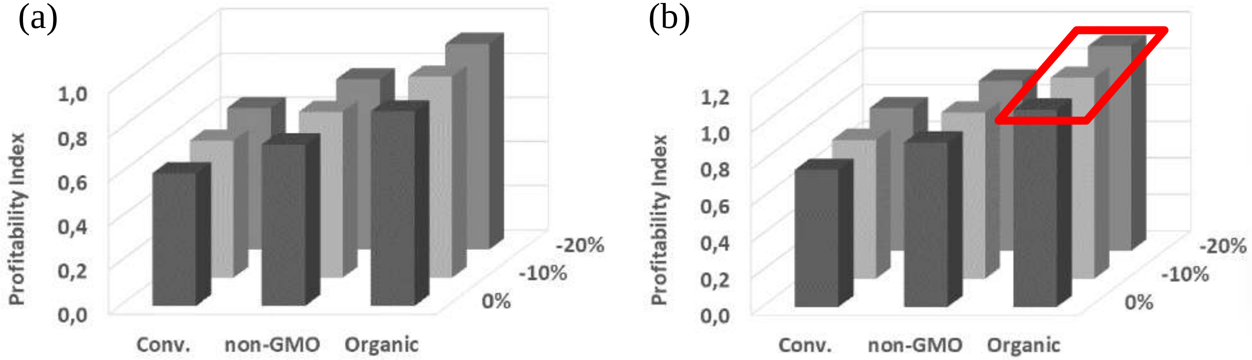
- Grass price
- Organic: 0.15 EUR/kg
- Conventional: 0.13 EUR/kg
- Protein price
- Organic: 0.67 EUR/kg
- Conventional: 0.34 EUR/kg
- Fiber pulp price
- Identical to grass price

- Residue juice is not given either any cost or value - It is used for internal energy production at the biogas plant.

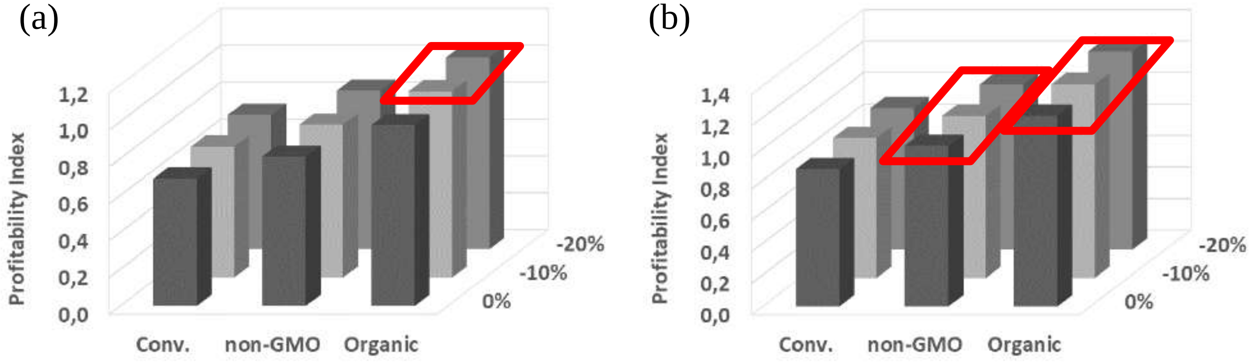


		Conventional
		Mio. EUR
		3.25
		2.90
		0.19
Maintenance	0.17	0.17
Depreciation and interests	0.32	0.32
Result	**0.66**	**-0.34**

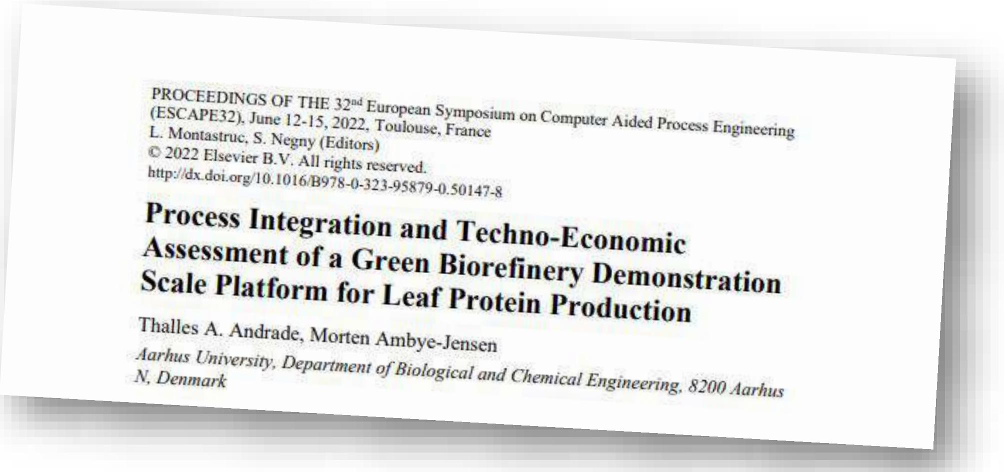
Further analysis and sensitivity



(a) 6 and (b) 12 months per year



(a) 6 and (b) 12 months per year; 20 % cheaper biomass cost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Process Integration and Techno-Economic Assessment of a Green Biorefinery Demonstration Scale Platform for Leaf Protein Production

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Aarhus University, Department of Biological and Chemical Engineering, 8200 Aarhus N, Denmark

LPC at conventional prices: PI < 1 for all cases

LPC at non-GMO prices: PI > 1 if annual production and 20 % cheaper biomass

LPC at organic prices: PI > 1 for different scenarios

Annual production, organic price: 5-6 years payout return

This project has received funding from the European Union's Horizon 2020 research and

LCA and Carbon footprint

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	Sweden	Denmark	Germany	Netherlands
Thermal Energy savings (kg CO_2eq/ Kg product)	-0.10	**-1.03**	-0.14	-1.87
Soil Carbon sequestration (kg CO_2eq/ Kg product)	-0.37	**-1.35**	-1.29	-0.30
Biomass production (kg CO_2eq/ Kg product)	0.28	**1.02**	N/A	N/A
Electricity use (kg CO_2eq/ Kg product)	-0.021	**0.051**	0.419	0.241
C-footprint (kg CO_2eq/ Kg product)	2.36 (RCG for dairy)	**-1.12**	-4.54	0.025

Substituting imported soy with grass clover LPC can reduce the carbon footprint of Danish pig production with up to 25% per kg, (incl. soil carbon and iLUC)

Local protein sources for growing-finishing pigs and their effects on pig performance, sensory quality and climate impact of the produced pork
November 2022, Livestock Science 267:105128, DOI: 10.1016/j.livsci.2022.105128

This project has received funding from the European Union's Horizon 2020 research and

TRL and technology deployment

The base case green biorefining technology is around TRL 8

The basic technology works! But improvements are still very welcome

Commercialization already started in DK (two facilities in operation and several more to come…) also commercial activities in the Netherlands and in France

The business case is not great, and the large-scale implementation needs support and a clear regulatory framework.

This project has received funding from the European Union's Horizon 2020 research and

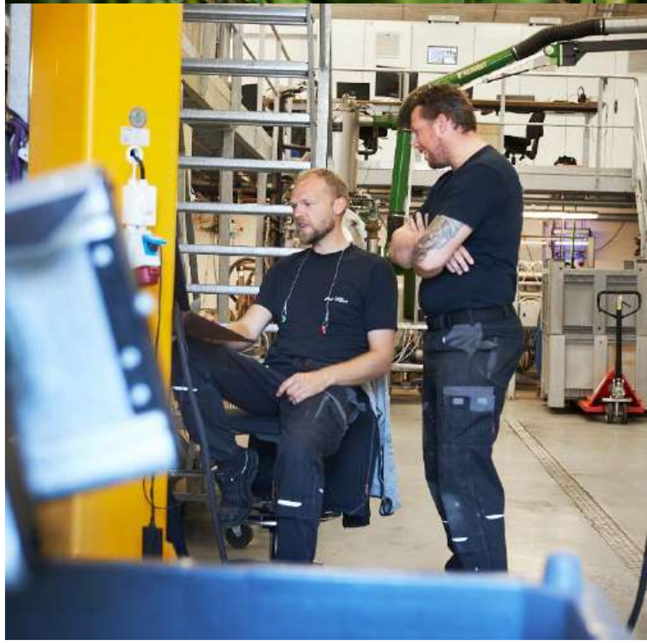
Outlook for the Green Biorefinery

Green Biorefineries has huge potential for both agriculture and rural development!

There´s so many ways to improve the busyness case and to combine LPC production with other grass-based products from the side streams

Several EU/national projects are looking into further developments of green biorefineries

The business case is not great, and the implementation needs support and a clear regulatory framework.



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