

Refining proteins from green crops using lactic acid fermentation and obtaining feed products for animals

Mette Lübeck

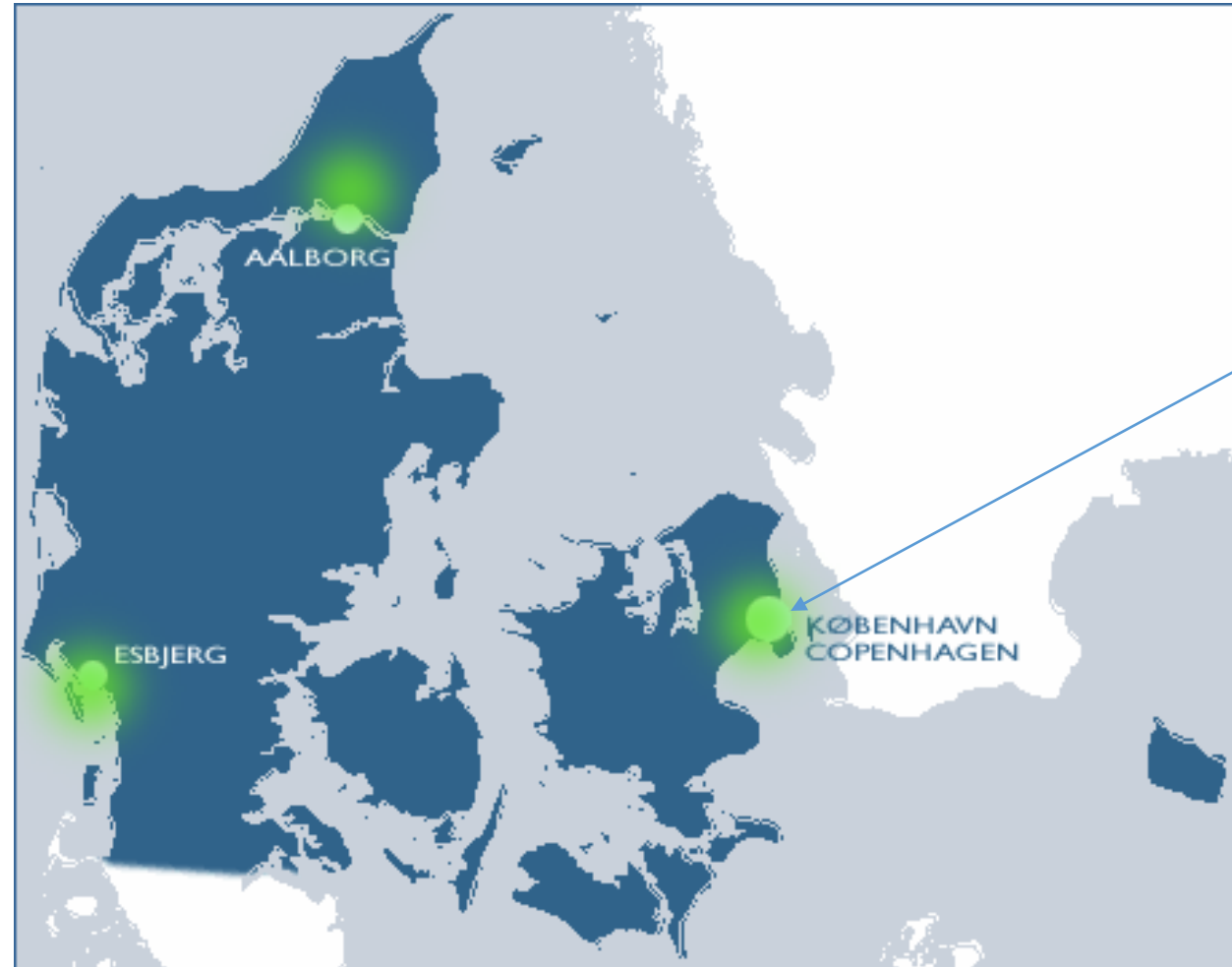
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AALBORG UNIVERSITY
DENMARK

Campus locations

Department of Chemistry and BioScience



Section for Sustainable
Biotechnology

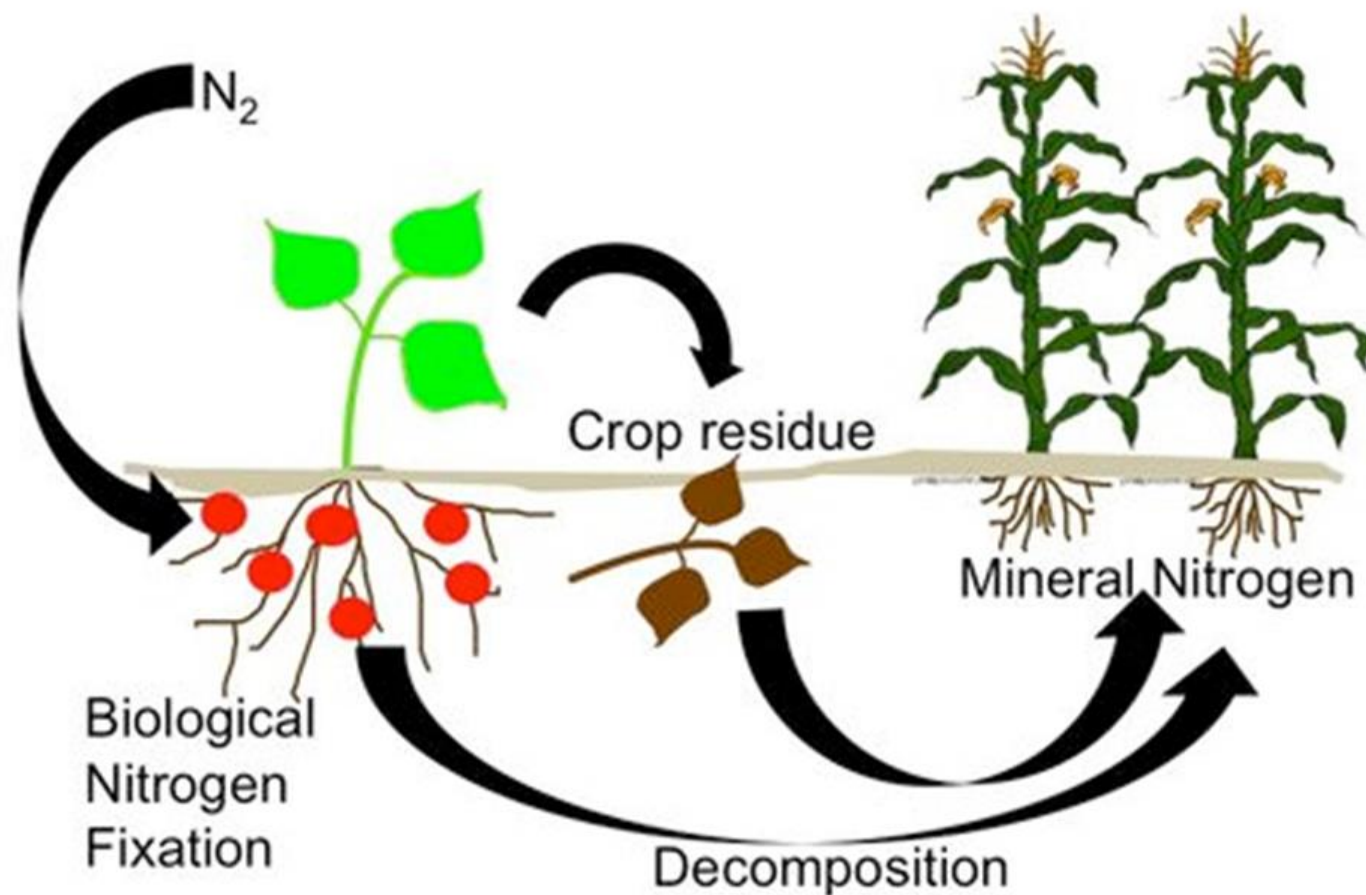


Introduction

- This research is based on the vision of developing **sustainable farming systems** based on **locally produced feeds**.
- This is especially important for the organic sector which has several key challenges:
 - **Increased demand** for organic products (20% increase in egg production/y)
 - Supply of **organic protein feed** for monogastric livestock (5% conventional)
 - Need for **organic fertilizers**
- Improved, climate-friendly, and robust **crop rotations** in areas with a low density of livestock.
 - Better efficiency of the nutrients, and **higher yields**.

Crop rotations important – especially in organic farming

Legume based cropping system



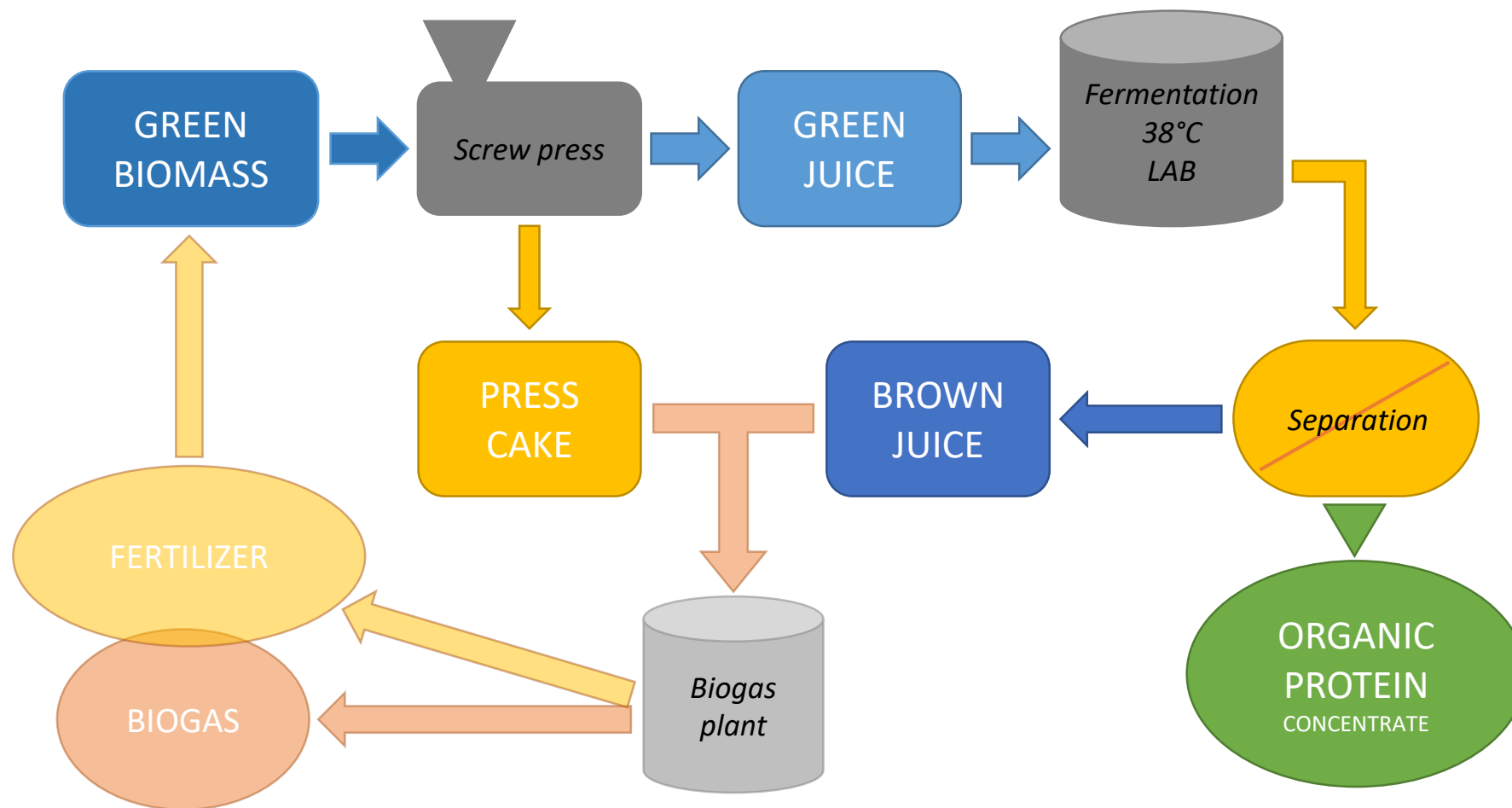
The farming system is based on "green crops"

- Alfalfa
- Red clover
- White clover
- Clover grass
- Brassica species

Harvest 3-4 times/year



The process developed in the "OrganoFinery" project



The process in small scale

Red Clover



Clover Grass



Alfalfa

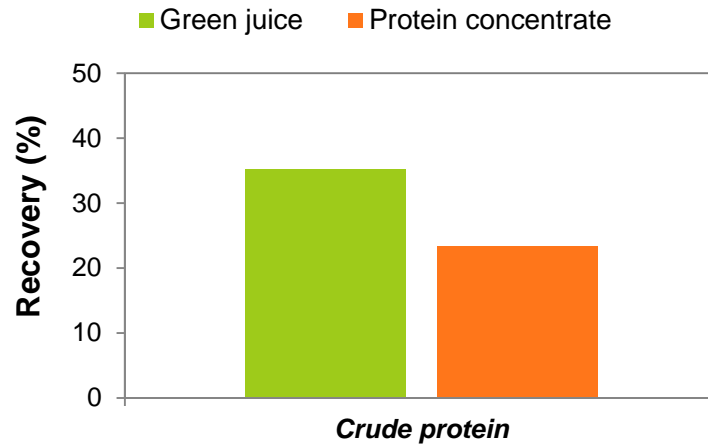


Oilseed Radish

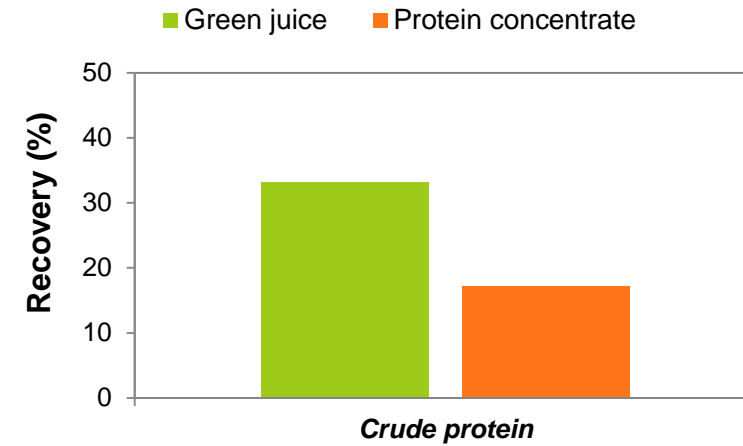


Protein recoveries at small scale

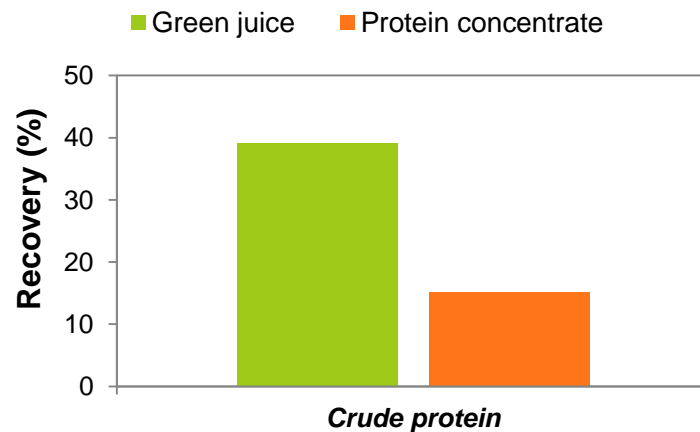
Red clover



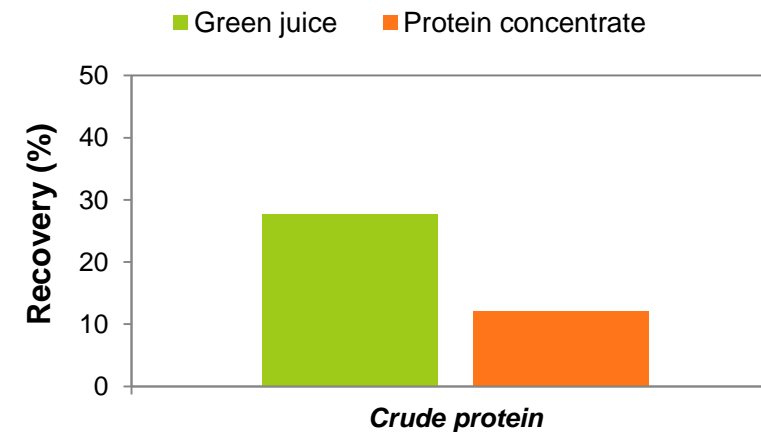
Clover grass



Alfalfa



Oilseed radish



Amino acid in the dry protein concentrate

<i>Essential amino acid for poultry</i>											
g/kg DM	Arg	Cys	His	Ile	Leu	Lys	Met	Phe	Thr	Val	Total
<i>Soy bean^a</i>	31.4	5.8	10.1	18.5	29.3	26.2	5.2	19.7	15.6	18	179.8
<i>Red clover</i>	26.8	2.5	10.8	23.5	39.4	26.8	8.5	26.5	20.1	28.2	213.1
<i>Clover grass</i>	22.9	2.4	9.1	20.9	34.3	23.9	8.2	23	17.7	24.8	187.2
<i>Alfalfa</i>	20.1	3.4	9	21.8	35.4	21.5	7.8	25.5	17.6	24	186.1
<i>Oil seed radish</i>	23.4	4.7	10.1	21.7	37.3	25.4	9.1	25.3	19.2	26	202.2

^aSteenfeldt and Hammershøj, 2015.

Santamaria-Fernandez *et al.* 2017

Overall biorefining results – pr. HA (10-11 tons TS)

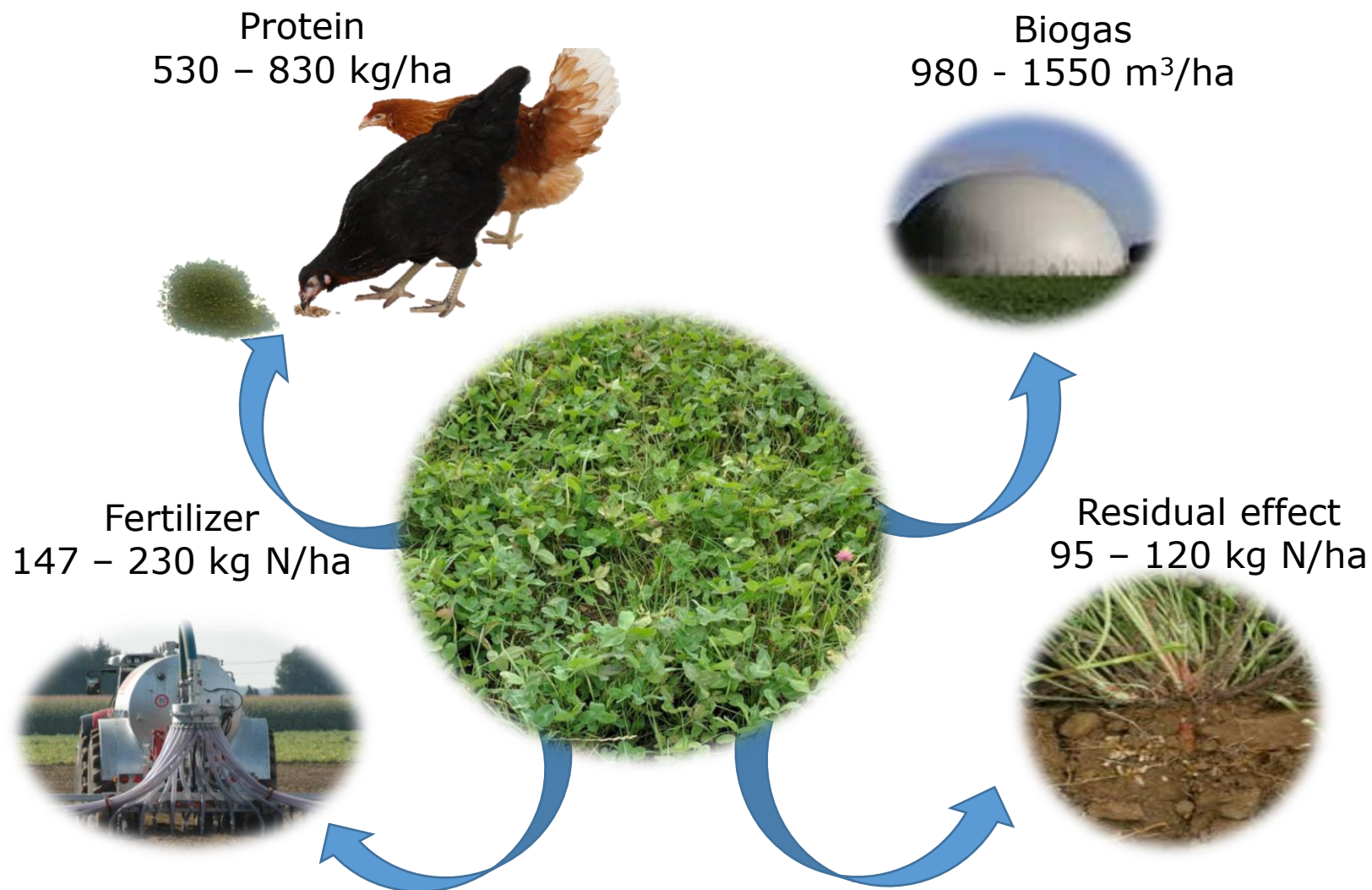


Figure: Nanna K. Ytting

Process in demo-scale – protein feed production at a production facility for green feed pellets (Nybro-Tørreri)

In collaboration with
Aalborg University
Aarhus University
Nybro Tørreri
KMC
Runi
Bounum Maskinstation
SEGES

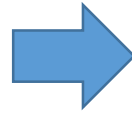


Freshly harvested organic clover grass (within few hours)



Process overview – from harvest to green juice

fresh biomass



screw pressing



Process overview – fermentation of green juice

Fermentation



Transport to separation of proteins



Process overview – separation of protein concentrate

Separation of
protein and
drying (KMC)



Pelletizing of
wet paste
(Vestjysk Andel)



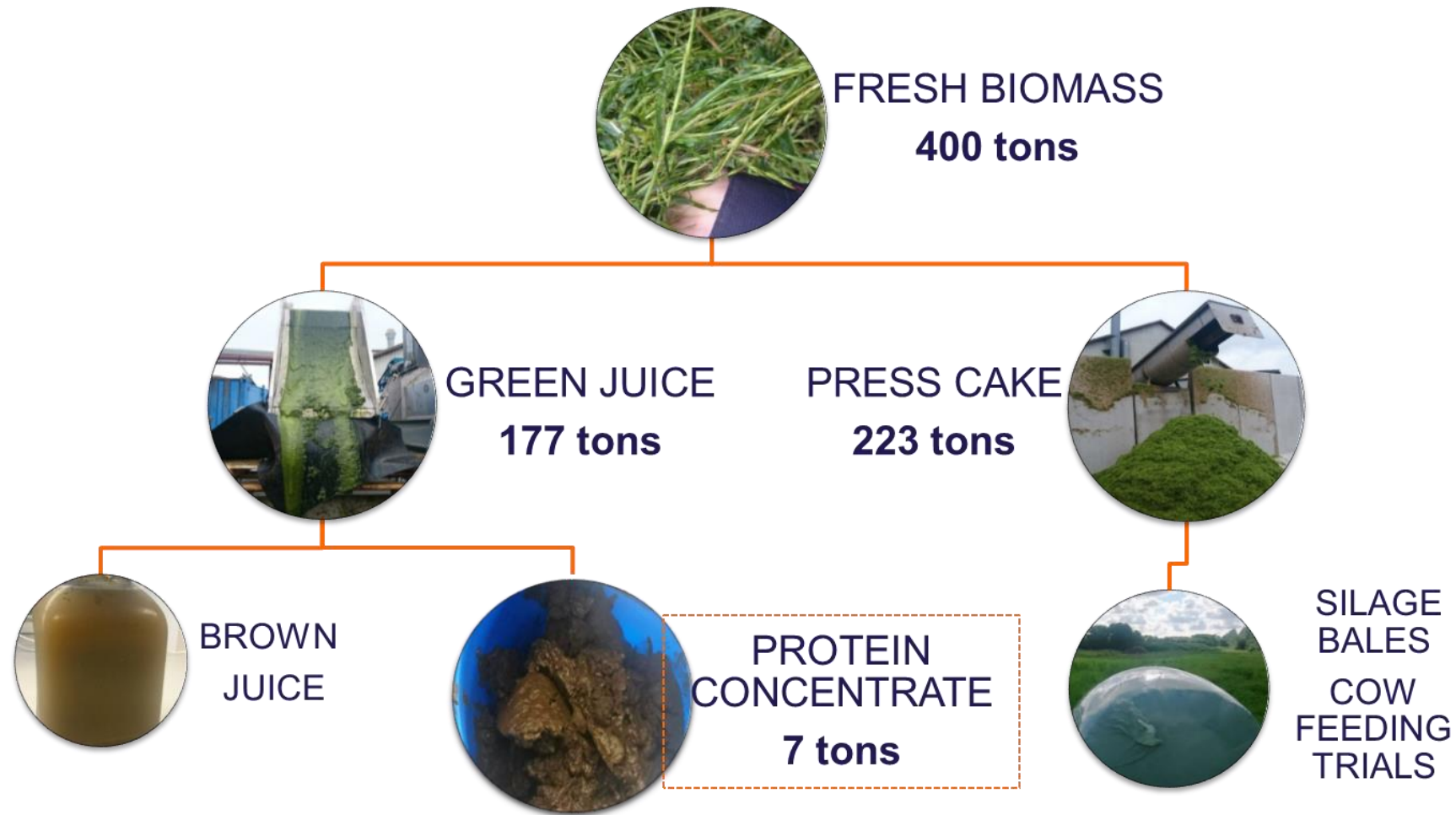
Process overview – preparation of silage bags of press-residue

Preparation of silage bales of the press-residue



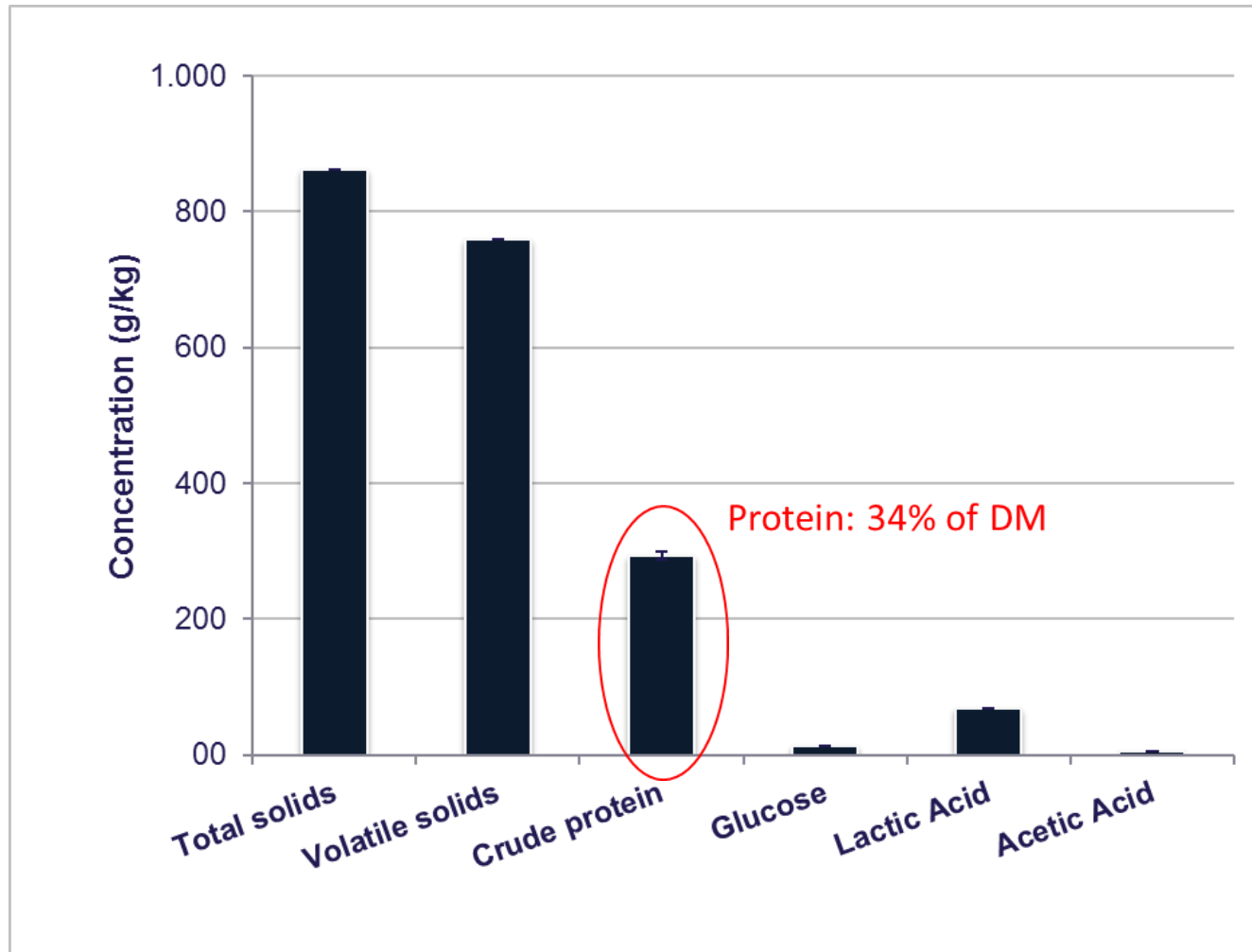
Overall process numbers from Nybro-feed production

(NOT an optimized process)



Protein content in concentrate 30-32% - which was lower than in small scale
- feed for trials in broilers, laying hens and pigs

Protein concentrate



Feeding trials with laying hens

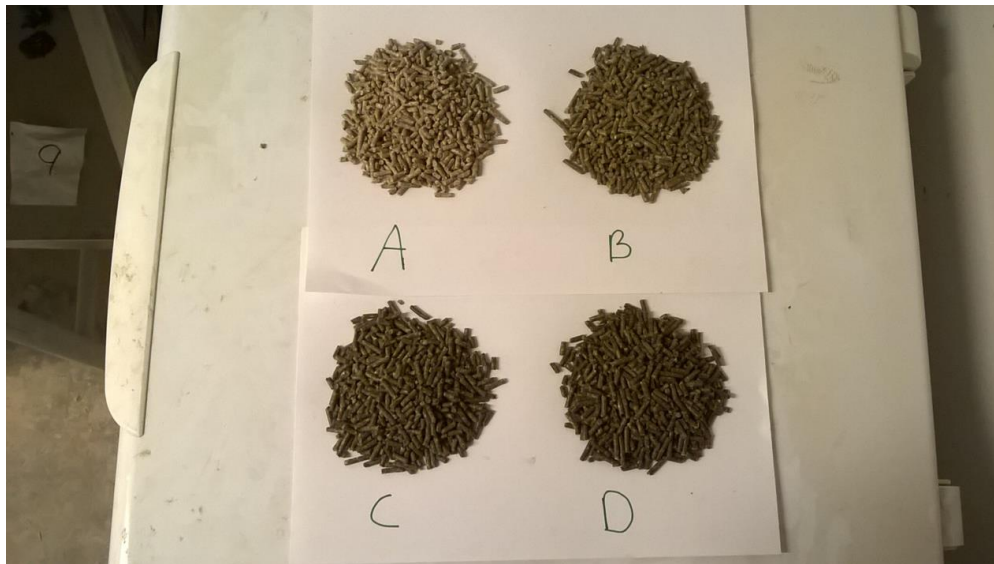
- Three inclusion levels of the protein concentrate (CPC) in the diets were evaluated and compared with control diet:

A: Diet including 0% CPC (Control)

B: Diet including 4% CPC

C: Diet including 8% CPC

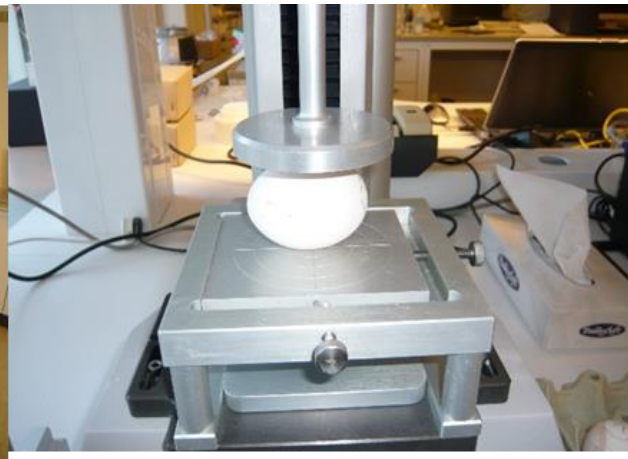
D: Diet including 12% CPC



Khanal, Tanka and Steinfeldt, Sanna (2017) Effect of Clover grass protein concentrate on performance, digestibility and egg quality of laying hens fed 100% organic diet. Organic Eprints (OrganoFinery)

Performance parameters

- Egg production, % (number of eggs)
- Egg weight, g
- Egg quality
- Feed intake (g/h/d)
- Kg Feed/kg Egg (FCR)
- Plumage quality
- Mortality



Main conclusions from feeding trials with laying hens

- Clover grass protein concentrate (CPC) - a promising substitute for organic soybean
- Partial replacement of organic soybean with CPC (4, 8, and 12 %) did not influence the egg production
- Total digestibility of dry matter was not influenced,
 - However, the digestibility of methionine and lysine decreased with higher inclusion amount.
- The yellowness of the yolk increased significantly with CPC in the diet.



Eggs from diets with 0, 4, 8 and 12 % CPC

Sanna Steenfeldt, Aarhus University

Evaluation in broilers

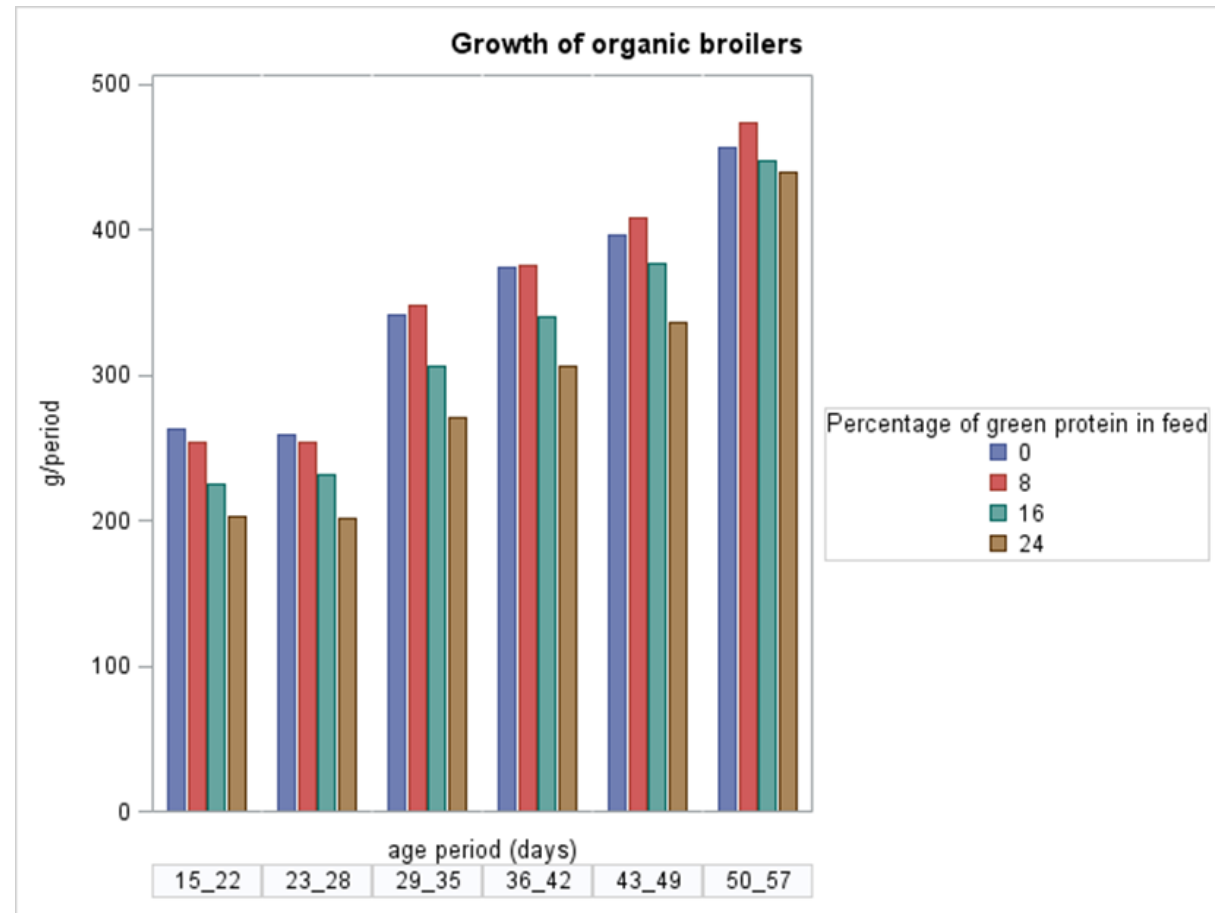
- Three inclusion levels of the protein concentrate (CPC) in the diets were evaluated:

A: Diet including 0% CPC (Control)

B: Diet including 8% CPC

C: Diet including 16% CPC

D: Diet including 24% CPC



Evaluation in broilers – color of the breast meat

Content of protein concentrate

0%



8%



16%



24%



Press residues as cow feed

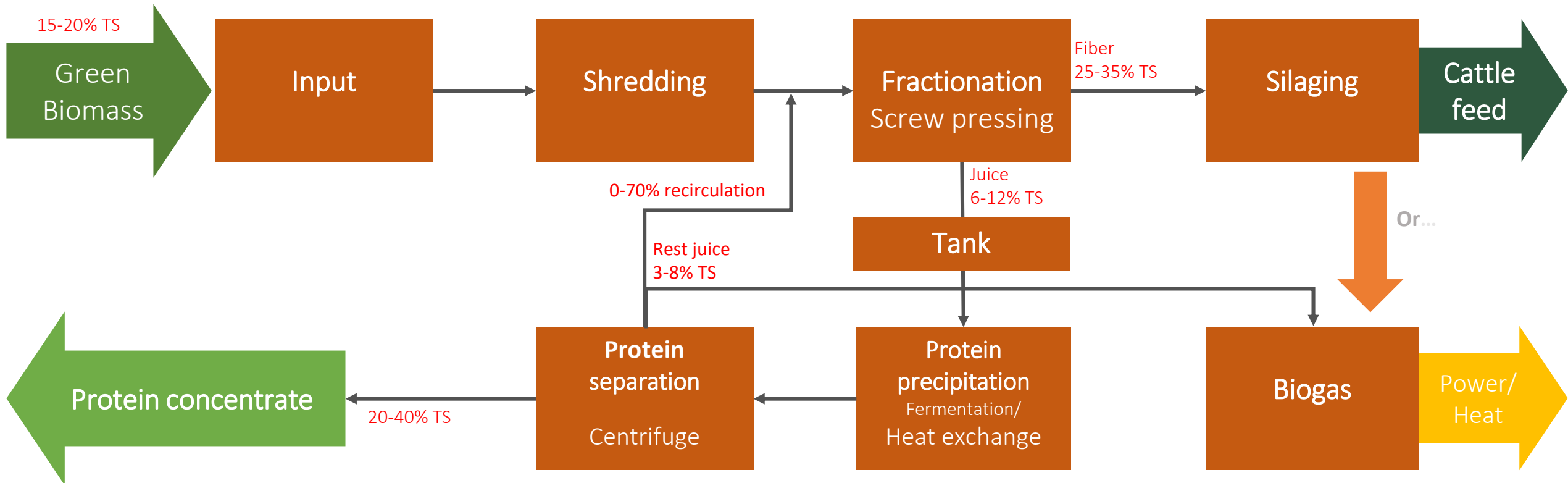
- Silage of press residues was compared with silage of grass clover from the same field as forage for dairy cows.
- Surprisingly, >5 % more milk was produced

	Press cake silage	Grass clover silage
In vitro digestibility	70.7 %	67.6 %
Crude protein concentration	16,8 %	13,6 %
Daily DM intake	23.1 (\pm 0.3) kg/d	22.6 (\pm 0.3) kg/d
Daily milk yield	37.4 (\pm 0.9) kg/d	34.6 (\pm 0.9) kg/d

V.K. Damborg, S.K. Jensen, M.R. Weisbjerg: Value of pulp from green protein extraction of grass clover as forage for dairy cows. 2017 ADSA Annual Meeting.



Pilot Plant at Aarhus University - flow diagram

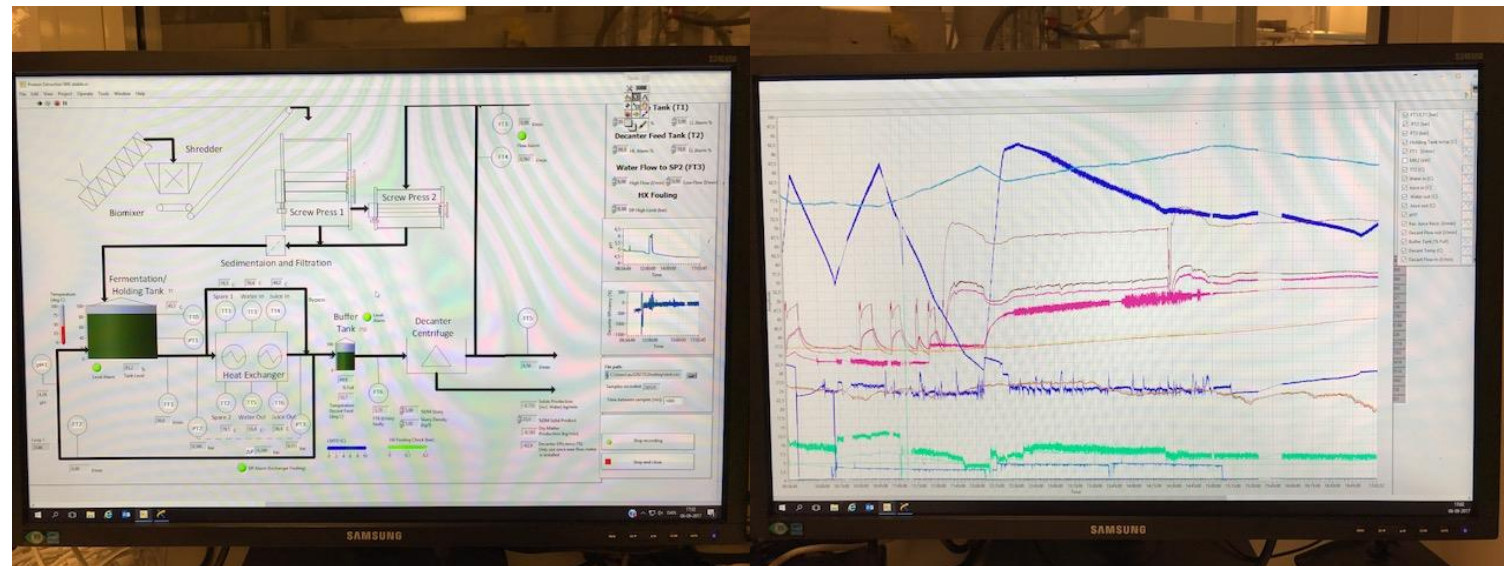




Results from pilot plant 2017

- Input capacity: **1-2 ton fresh biomass per hour**
- Protein concentrate yield: **5-15 % of input TS**
- Protein content: **30-55% of TS**
- Optimizing yield and quality is an ongoing process

Protein paste from centrifuging



Conclusions

- Protein concentrate can be extracted from fresh grass-clover juice.
 - Robust fermentation-centrifugation method → between **60-80% of the proteins in the green juice** can be concentrated
- Approximately 700 kg of crude protein/ha is realistic
 - Protein concentrate has a good level of **essential amino acids**
 - Protein concentrate contains **lactic acid as an extra product** from the process
 - May contain **probiotic lactic acid bacteria**
- More nitrogen in the rotation of crops is part of the benefits
- The concentrate can **substitute soy protein in the diet**
- Silage of grass press cake is a **valuable forage for dairy cows**
- Press cake and residual juice are valuable for biogas production
- A new company for commercialization of the process
 - BiomassProtein.com

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