Quality requirements and nutritional value of protein products for feed from biorefined biomass

Søren Krogh Jensen, Department of Animal Science, AU-Foulum

Lab scale



Pilot-scale

Semi-production-scale



Lab analyses



Biobase BI



Feeding experiments









Why a Danish protein production?

- Large import of soya protein
 - Sustainability and carbon footprint is questioned
- Grass and forage legumes has a high protein content
 - Environmental friendly production (nitrate, pesticides, carbon in soil)
 - High yield

Perspectives in relation to biorefining

- Protein for mono gastrics
- Protein/fiber for ruminants
- Sidestreams for bioenergy / materials

Increasing income increase meat consumption

OECD-FAO expect 70 % increase in meat consumption over the next decade

Meat consumption, kg per capita per year

	1964-1966	1997-1999	2030 (estimated)
World	24.2	36.4	45.3
Developing countries	10.2	25.5	36.7
Developed countries	61.5	88.2	100



Increasing population decrease the arable area per capita



Towards 9.000.000.000



If we continue as today we will need 3 globes



Why green biomass?

Relative Sun insolation

30 % af sun energy

70 % of sun energy can be utilized by grain and seed legumes

20 16 12 8 4 0 Warch October Mat August September April Ine MUI

100 % can be utilized by clover, grasses and lucerne

Protein and amino acid yield under Danish growing conditions

	Yield	Protein	Protein	Lysine	Methionine	N
	DM ton/ha	%	kg/ha	kg/ha	kg/ha	leaching
Soya		35	700	43	0	Large
Rapeseed	5	20	1000	60	20	Large
Wheat	9	11	1000	30	16	Large
Faba beans	6	25	1500	92	11	Large
Peas	6	22	1300	92	13	Large
Corn silage		ð	1000	27	14	Large
grass clover	13	20	2600	200	90	Small
Lucerne	12	21	2600	200	90	Small
Potato	14	9	1300	90	27	Small





Cultivation of forages

- Challenges and perspectives
 - Cultivation is easy
 - Yield is high
 - Growing season is long
 - Environmental impact is low
 - Optimizing harvest in relation to maximal protein content
- Challenges are
 - Logistic
 - Persistence of the harvested biomass
 - The low dry matter content

Biorefining - Processing







Main products from processing line

• Pulp (60-70 % of DM)

- Cattle feed
- Fiber for energy production (Biogas, Biochar, etc)
- Fiber for lignin production
- Fiber for insulation
- Fiber for production of oligosaccharides
- Precipitated protein (20-30 % of DM)
 - Protein concentrate as feed for monogastrics
 - White protein concentrate for food purposes
- Brown juice (10-20 % of DM)
 - Inorganic salts / fertilizer
 - Organic matter for biogas production
 - Speciality compounds

(vitamins, phytoestrogens, saponins etc)





Biorefining

- Protein yield depends on
 - Effective screw pressing
 - Effective precipitation of protein from the juice
 - adequate separation of protein and fiber

Challenges:

- Maintain the nutritional quality of the protein
- avoid oxidation and crossbinding between proteins
 - Cause decreased digestibility
- Avoid hydrolysis of the proteins with proteases before protein precipitation
 - Cause too little protein yield

Chemical composition of pulp

	Protein % in DM	Ash % in DM	NDF % in DM	ADF % in DM	CEL + Lignin % in DM	CP in NDF % in DM
White clover	26.8	7.2	52.9	32.5	8.0	19.3
Red clover	19.8	6.6	58.9	37.9	8.2	14.8
Rye grass	16.4	5.1	69.4	34.1	3.3	11.1
Lucerne	18.4	5.8	56.9	40.6	9.5	8.2

NDF = Neutral Detergent Fibre ADF = Acid Detergent Fibre (Hemicellulose) CEL + Lignin = Cellulose + Lignin CP = Crude Protein

Pulp for cows

- 36 Danish Holstein cows
- Incomplete Latin square design
- 4 periods of 3 weeks each





Pulp for cows

400 tonnes of grass clover was processed over 5 days

This huge production experiment was a cooperation with OrganoFinery, Biovalue and Biobase



Composition of pulp and clover grass silage

	Pulp silage	Clover grass silage
DM (%)	28	52
Protein (% af DM)	18	16
Ash (% af DM)	9,3	9,4
NDF (% af DM)	45	39
Sugar (% af DM)	0	8,7
<i>In-vitro digestibility</i> (% of Organic matter)	70	72

Pulp experiment with dairy cows

	Pulp silage	Grass clover silage	Diffe- rence
DM intake, kg/day	23.0	22.7	No
ECM, kg/day	37.0	33.5	Yes
Dig. Organic matter, %	73	70	Yes
Dig. NDF, %	63	54	Yes
Dig. Protein, %	66	60	Yes

Pulp experiment with dairy cows

Screw pressing increased
 fiber and
 protein availability in the rumen
 Milk yield increased



Protein produced from grass clover in 2018 at Foulum Pilot Plant

Batch #	Wet amount, kg	Precipitation method	Ash % of DM	Protein % of DM
1	168	Fermentation	14.6	38.4
2	229	Fermentation	18.3	43.0
3	694	Heat	7.5	49.4
4	386	Heat	10.2	54.2
5	39	Fermentation	12.1	38.4





Relationship between protein content and protein digestibility



Feeding experimetn with green protein for organic broilers













Feeding experimetn with green protein for organic broilers

- "Nybro protein"
- Inclusion levels
 0, 8, 16, 24 % (w/w)
- Green protein substituted % of total protein: 0%, 13%, 26%, 39%



• Slaughtered at 57 days of age





Composition of green protein for the broiler experiment

Composition, g/kg DM	
Dry matter	968
Crude protein	362
Fat	138
Ash	88
Sugars ¹	0.3
Starch	-
Dietary fibers ²	324
T-NSP	103
S-NSP	20
I-NSP	83
Acid insoluble residue(lignin)	222
Fructans	0
Metabolisable energy (MJ/kg DM)	21.4
	Miljø- og Fødevareministeriet





Daily weight gain and feed utilization

Daily		Green protein, % of feed							
Weight gain	0	8	1	5	24		SI	M	P value
Day 16-57	49.8ª	50.2 ^a	45.	7 ^b	41.8	С	0.	56	<0.0001
Final weight, g	2367ª	2389ª	218	8 ^b	2017	7 C	2!	5.3	<.0001
Feed utilization									
d16-57	2.29) ^c 2.3	4 ^{bc}	2.	45 ^{ab}	2.	.55 ^a	0.03	<0.0001





Feeding experiment with organic slaughter pigs

• 48 Weaned piglets (7 weeks of age)









Feeding experiment with organic slaughter pigs

• Protein extracted from grass clover in 2018

Moisture	1.8 %
Protein	
(N*6 <i>,</i> 25)	47.0 %
Fat	11.3 %
Ash	12.3 %
EFOS svin	88.8 %
FEsv	1.08 pr kg





Amino acids, g/16 g N						
	Grass clover	Soya				
Lys	6.04	5,98				
Met	2.24	1,31				
Cys	0.70	1,43				
Thr	4.71	3,92				
Trp	2,17	1,36				
lle	5.19	4,91				
Leu	8.82	7,68				
His	2.26	2,61				
Phe	5.84	5,06				
Val	6.41	5,19				
Arg	6.02	7,23				
Glu	11.04	17,78				
Gly	5.45	4,22				
Ala	6.70	4,34				
Ser	4.38	4,97				
Asp	9.63	11,36				
Pro	4.68	5.54				

Feeding experiment with organic slaughter pigs

- 4 experimental groups
 - Control
 - 5% Grass clover protein
 - 10% Grass clover protein
 - 15% Grass clover protein
- Experimental period: from weaning to slaughter
- 3 different feed mixtures per groups



Feed mixtures

- Formulated by Vestjyllands Andel
- 100% organic
- Composition is realistic for practical feeding
- Main ingredients:
 - Barley
 - Wheat
 - Soybean cake, Chinesee
 - Peas
 - Faba beans
 - GRASS CLOVER PROTEIN



Feed mixtures

15% Group	Mix 1 Weaning – 30 kg	Mix 2 30 - 65 kg	Mix 3 65 - slaughter
FEsv	1.10	1.09	1.04
Protein %	21.4	19.5	17.6
Lysine, g/kg	10.5	9.2	8.4
Methionine, g/kg	3.5	2.9	2.7













Average daily weight gain





Average daily feed utilization





Average meat % at slaughter





Conclusion

- Pulp ensiled well and was palatable with a high feed consumption
- Pulp increased milk yield
- Protein concentrate with low protein content (35 %) was moderately acceptable as feed for monogastrics
- Protein concentrate with high protein content (47 %) is well suited for monogastrics
- Exact digestibilities is highly needed.



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