Extracts of green biomass as source of protein for pigs

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Abstract
The world-wide increasing demand for protein has lead to intensive search for sustainable alternative protein sources for monogastrics. Protein extracted from grass and forage legumes have the potential to become such source. However, the nutritional quality may depend on plant source, harvest- and processing conditions. Two studies with ileal-cannulated pigs fed concentrates with crude protein (CP) contents of 33-38 % of DM separated from perennial ryegrass (PRG), red clover (RC), and lucerne (LU) had standardized ileal digestibilities of indispensable amino acids of 62-81, except Cys which ranged 13-37 %; lower than of reference soybean meal (SBM). Higher CP content of the concentrates by improved harvest and processing technology may increase the nutritional quality. Such optimization is required for green biomass to be both environmentally and economically competitive as feed protein.

Keywords: biorefinery, protein quality, monogastric, amino acids, digestibility

Introduction
There is a demand for alternative sustainable protein sources for feed to cover the global needs. In temperate climate such as Northern Europe, grass and forage legumes are possible alternatives due to their high yields of dry matter and protein, and balanced amino acid composition. However, the protein needs to be separated from the fibres and other antinutritional factors in order to be used for monogastric farm animals. This can be done in a screw press that separates the biomass into a fibre-rich pulp and a juice from which the protein is precipitated either by acid or heat. The amino acid digestibility of the feed sources, which may depend on plant species, harvest-, and processing, is important for the use in monogastric animals.

Materials and methods
Protein concentrates from PRG and RC were produced in a pilot plant by extraction in a single screw press with or without the use of cell-wall degrading enzymes. PRG was precipitated in a heat exchanger reaching 70°C and RC precipitated by lactic acid fermentation by heating the juice to 38°C and let it naturally ferment until pH was below 4 (Trial 1). A second batch of concentrates were produced from PRG, RC, and LU using lactic acid fermentation and compared to soybean meal (SBM). The standardized ileal digestibility (SID) of N and amino acids was determined in two trials with ileum-cannulated growing pigs. In each trial, 5 barrows were fed 5 diets in 5 periods. An N-free diet was used to correct for basal endogenous N and amino acid losses. Each period lasted 7 days, and pigs were fed 80 g/kg$^{0.75}$/d divided into 2 meals. Ileal digesta were collected for 8 consecutive hours on day 5 and 7. Data were analysed using a Mixed model in SAS.

Results and discussion
The concentrates produced from green biomass had CP contents of 33-38 % of DM and an amino acid composition comparable to SBM. Except for Met in Trial 1, SID of CP and amino acids were not affected by source, processing, or use of cell wall degrading enzymes. For all green biomasses, SID was in the range 62-81 % except for Cys, which had a SID of 13-37 %,

which may indicate cross-linking and polyphenoloxidase-induced complexing of protein. The SID of CP and amino acids of the concentrates were all lower than of SBM, which in part may be due to the relatively low CP content.

Table 1. Crude protein content and standardized ileal digestibility (SID) of CP and indispensable amino acids in pigs fed protein concentrates from perennial rye grass (PRG), red clover (RC), and lucerne (LU) compared to soy bean meal (SBM)[1].

	Trial 1						Trial 2					
	PRG		RC		SEM	P	PRG	RC	LU	SBM	SEM	P
Enz[2]	-	+	-	+								
CP[3]	33	33	33	34			36	33	38	55		
SID												
CP	61	62	55	63	6.2	0.17	58^{b}	64^{b}	59^{b}	78^{a}	4.3	0.0006
Arg	78	80	72	80	6.0	0.12	75^{b}	78^{b}	77^{b}	87^{a}	4.5	0.0227
Cys	29	37	22	26	5.3	0.23	13^{b}	22^{b}	20^{b}	76^{a}	4.0	<0.0001
His	70	73	67	70	2.3	0.25	65^{b}	70^{b}	66^{b}	85^{a}	2.2	<0.0001
Ile	74	78	71	75	1.9	0.18	68^{b}	72^{b}	69^{b}	84^{a}	2.5	0.0004
Leu	77	81	74	76	1.9	0.17	71^{b}	75^{b}	72^{b}	84^{a}	2.3	0.0011
Lys	74	77	72	71	1.8	0.07	69^{b}	72^{b}	70^{b}	84^{a}	2.2	0.0003
Met	76^{ab}	81^{a}	74^{b}	75^{ab}	1.7	0.04	72^{b}	76^{b}	73^{b}	86^{a}	2.4	0.0006
Phe	76	80	73	75	2.0	0.19	71^{b}	75^{b}	71^{b}	84^{a}	2.0	0.0003
Thr	70	72	66	70	2.7	0.41	65^{b}	69^{b}	62^{b}	78^{a}	2.3	0.0003
Trp	69	73	67	69	2.5	0.25	63^{b}	68^{b}	62^{b}	83^{a}	2.7	<0.0001
Val	73	76	70	73	2.0	0.26	68^{b}	72^{b}	69	82^{a}	2.4	0.0004

[1]Values are least squares means with standard error of mean (SEM), n = 5 per treatment. For each trial, values with different superscripts are significantly different, P<0.05; [2]Enz, extraction with (+) or without (-) use of cell-wall degrading enzymes; [3]CP, crude protein content (% of DM) calculated as N x 6.25.

Previous studies in rats (Stødkilde *et al.* 2018, 2019) point towards the protein content as a key factor for the protein digestibility. Improved technology has recently lead to products with higher CP content (49-54 %) and reduced NPN and ash content. SID of this product has not been evaluated, but an ongoing growth trial with pigs indicates good performance with partial or full replacement of SBM. In conclusion, green biomass from grass and forage legumes have the potential to become a sustainable alternative protein source, but further optimization is required to obtain a high quality source of feed protein that is both environmentally and economically competitive.

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