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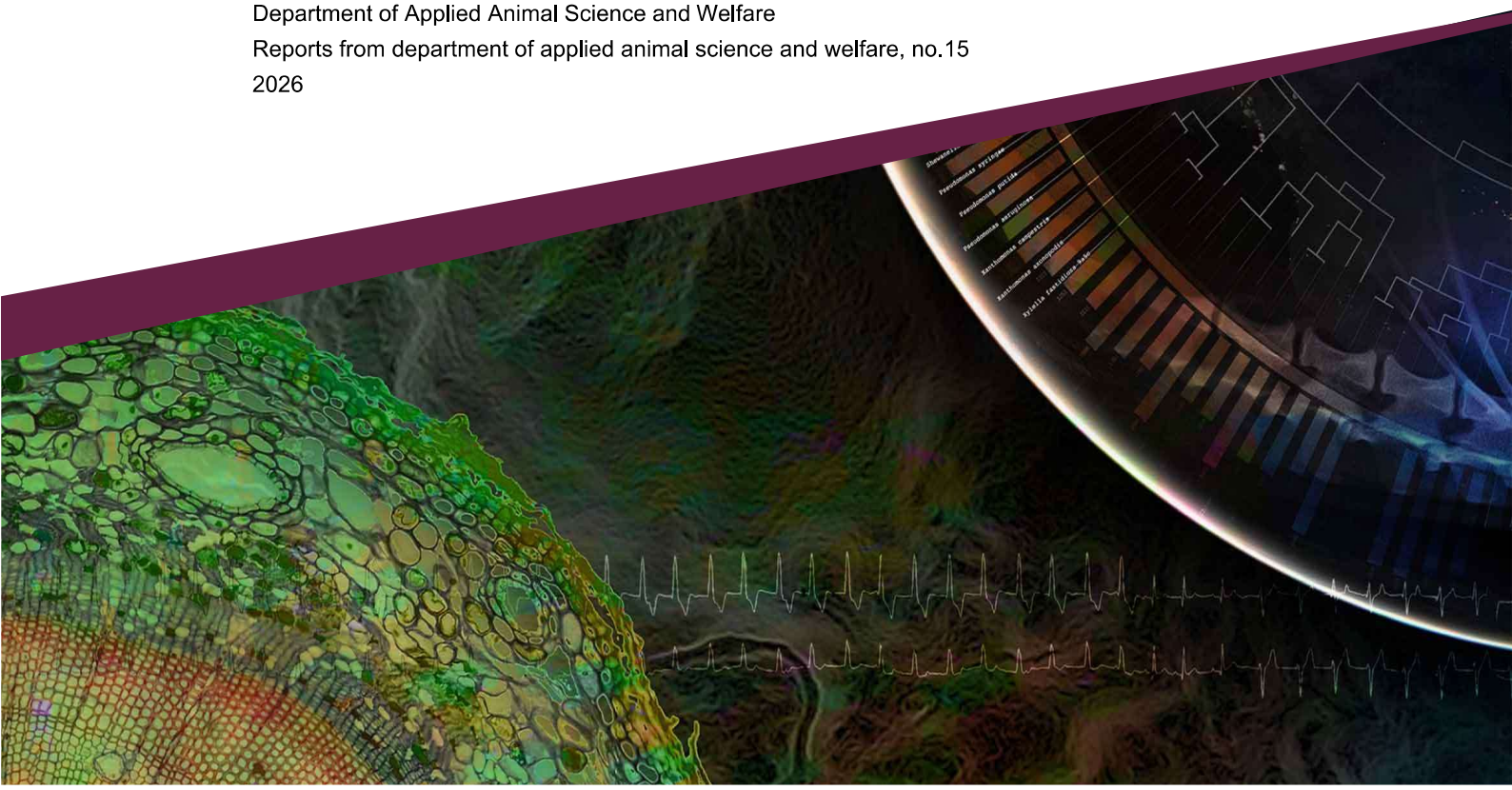

The effect of processing protein feedstuffs to increase AAT in dairy cow diets in the NorFor system– a meta study focusing on milk production responses

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Introduction

Processing of protein sources, for example through heat treatment or controlled Maillard reactions, aims to reduce ruminal protein degradation while maintaining a high degree of intestinal amino acid digestibility (Reynal and Broderick, 2003). Moreover, in light of increasing focus on precision feeding, reduced protein overfeeding, and stricter environmental sustainability requirements, reduced protein degradability without decreased amino acid availability may improve nitrogen efficiency and reduce N loss. However, processing of protein to reduce the rumen degradable protein (RDP) fraction represents an increased cost. The objective of this study was to conduct a meta-analysis of feeding trials comparing unprocessed and heat- or chemical treated protein feedstuffs to quantify effects on milk production.

Materials and Methods

Data were collected by searching published literature from protein feeding trials where the difference between the rations was due to treatment of the protein source at similar crude protein levels. Seven references included 10 comparisons of unprocessed and processed soybean meal, rapeseed meal and faba beans. Iso-energetic and iso-nitrogenous rations where protein sources were either unprocessed or partially/fully replaced by processed protein sources to reduce ruminal degradability and increase amino acid supply to the small intestine from feed protein were compared. Processed protein sources were expeller and xylose-treated soybean meal, micronized rapeseed meal and heat treated faba beans. Forages were corn silage, grass silage, alfalfa hay or silage, grass clover silage, barley silage or a mixture of these. Cows were from 100 to 200 DIM, with an average of 130 DIM. Data was analyzed with proc mixed in SAS (SAS Institute) with treatment (unprocessed; processed) as the main effect. The feed composition variables NDF, starch, crude fat, PBV (all g/kg DM) and NEL (MJ/kg DM) and their second-order polynomials were included in the model, and backward elimination was used to eliminate non-significant ($P \leq 0.05$) variables. Models were fitted using weighted regression, including study as a random effect to account for between-study heterogeneity, and weights defined as the inverse of the variance in milk yield.

Results and Discussion

Across the dataset (n = 20), cows exhibited a high and variable production level, with an average dry matter intake (DMI) of 24.4 kg/day (range: 18.7–27.1 kg/day). Crude protein concentration was the same within treatments (unprocessed/processed) and averaged 170 g/kg DM among trials, spanning from 140 to 198 g/kg DM, indicating that the experiments covered diets from marginally to clearly adequate protein supply. Mean absorbable amino acids in the small intestine (AAT) supply was 2,335 g/day, corresponding to 96 g AAT/kg DM and 16.0 g

AAT per MJ NEL, reflecting diets designed to meet or exceed metabolizable protein requirements. Positive protein balance in the rumen was indicated by a mean PBV value of 28 g/kg DM, although substantial variation was observed (range: 4–57 g/kg DM).

Table 1 Response in milk production from unprocessed and processed protein sources, and NorFor feed characteristics.

	Unprocessed	Processed	SE	P
ECM, kg/day	35.4	35.2	0.51	0.68
Milk protein yield, g/day	1181	1186	8.85	0.63

Feed characteristics	Unprocessed		Processed	
	Mean	Std Dev	Mean	Std Dev
DMI, kg/day	24.5	2.52	24.2	2.37
NEL, MJ/kg DM	6.68	0.38	6.67	0.39
AAT, g/kg DM	94	9	97	6
PBV, g/kg DM	30	14	25	16
Microbial protein production, g/day	2307	236	2258	217
Rumen undegraded feed protein, g/day	1313	397	1456	325
Dietary AA from feed protein to small the intestine, g/day	766	336	858	260
AAT, g/MJ NEL	15.7	2.8	16.3	2.3
N utilization for milk, %	28.4	3.4	28.6	3.5

The present results show that replacing unprocessed with processed protein sources had no significant effects on ECM and milk protein yield (Table 1). Energy-corrected milk averaged 35.4 and 35.2 kg/day and milk protein yield 1181 and 1186 g/day for unprocessed and processed diets respectively.

Dry matter intake (DMI) was slightly lower for cows fed a processed protein diet compared with an unprocessed protein diet (24.2 vs. 24.5 kg/day. Increased protein protection may slightly reduce intake, possibly due to altered ruminal fermentation patterns or palatability (Olmos Colmenero and Broderick, 2006). Despite this numerical reduction in intake, NorFor calculated higher AAT per kg DM, AAT per MJ NEL, and an increased AAT supply of 93 g/day from feed protein in the processed protein diet compared with the unprocessed diet. Moreover, microbial crude protein synthesis was numerically lower with the processed (2258 vs. 2307 g/day) than the unprocessed diet.

Reynal and Broderick (2003) demonstrated that substituting solvent-extracted soybean meal with expeller soybean meal altered ruminal protein degradability and increased duodenal flow of undegraded protein but also resulted in limited responses in milk yield and milk protein yield. Similarly, Olmos Colmenero and Broderick (2006) reported that increasing rumen undegradable protein (RUP) supply via expeller soybean meal had minimal effects on milk production, while nitrogen efficiency declined when crude protein supply exceeded requirements. The absence of production responses in the current dataset therefore supports the conclusion that increasing dietary RUP does not provide additional benefits when microbial protein synthesis is not limited. The tendency toward numerically lower microbial crude protein synthesis observed with processed protein is also mechanistically plausible. Reducing ruminal protein degradability lowers ammonia availability for microbial growth, which may slightly depress microbial protein synthesis if RDP supply approaches the lower margin of adequacy (Mutsvangwa et al., 2016). The balance between microbial protein and dietary RUP

has also been described by Savari et al. (2018), who showed that shifting protein digestion post-ruminally alters nitrogen partitioning without necessarily improving productive performance.
From an environmental and efficiency perspective, the lack of production response combined with higher AAT supply suggests limited scope for performance gains from replacing unprocessed protein with processed protein under the conditions represented in the dataset. These findings align with Hansen et al. (2021), who reported that improving protein quality rather than quantity can reduce nitrogen losses but does not necessarily increase milk yield in diets already supplying adequate ruminal nitrogen. Nitrogen utilization efficiency for milk production was calculated to 28.4 and 28.6 for unprocessed and processed protein diets respectively, and values below 30 are considered low (Lavery and Ferris, 2021). This may indicate an inefficient utilization of dietary nitrogen for both unprocessed and processed protein diets, and the results suggest that increasing AAT supply beyond the NorFor recommendation of 15 g AAT per MJ NEL is unlikely to improve nitrogen utilization or milk protein synthesis.

Conclusions

The results indicate that processing of protein increased calculated AAT flow, but this increase did not provide any benefit in terms of improved milk production.

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