Evaluation of the Quality and Degradability of Rapeseed Cake Protein

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INTRODUCTION

The area under rapeseed cultivation has more than doubled in the last six years in Estonia. This has meant that more rapeseed cake is available for dairy farmers to use as a protein source for highly productive cows. For higher production, the diet should contain ruminally undegradable protein feeds, which are digested in the postruminal digestive tract, and supply the cow with additional amino acids originating from feed rather than from ruminal microbes.
In high-productive dairy cows the amount of ruminally synthesized microbial protein is not sufficient to cover the requirement for amino acids needed for milk protein synthesis. If the amount of undegradable protein in the ration is insufficient, the amount of amino acids in the blood in also insufficient, and the synthesis of milk protein decreases. According to Tuori at al. (1996), the daily ration of a high-productive cow should contain 33% undegradable and 67% degradable protein. Ruminal degradation of protein is affected by several factors such as diet composition, intake level, passage rate of feed particles, rumen pH, the type of feed protein and technology used in feed production (Ørskov, 1994; Dakowski et al., 1996; Goelema et al., 1999).
The processing temperature of the seeds is one factor which may affect the rumen-degradability of protein; overheating may overprotect the protein to a degree where it is neither fermented in the rumen nor digested in the intestine. As the determination of the effective degradability of protein (EPD) by the in sacco method is labour-intensive, simpler methods for protein evaluation have been studied.
The objective of this experiment was to evaluate the quality of rapeseed cake, as a by-product from the cold pressing and heat treatment of rapeseed, from the viewpoint of the nutrition of highly productive cows, and to predict EPD.

MATERIALS AND METHODS

The feed samples were collected during 2009-2010. Chemical compositions of locally-produced heat-treated rapeseed cake (n=10) and cold-pressed (n=12) rapeseed cake were evaluated. Cold-pressed rapeseed cake (CPRC) was produced at a temperature of 60-70°C and the heat-treated rapeseed cake (HTRC) was processed at 100°C for 20-25 minutes. Ground rapeseed cake samples were analysed for dry matter, crude protein, crude ash, crude fibre and crude fat contents. To determine crude ash concentration, samples were reduced to ash at 550°C for six hours. Crude protein was analysed by the Kjeldahl method with a Kjeltec 2300 analyser, crude fat by the Soxtec 2043 System and crude fibre using the Fibretec System.
Effective degradability of rapeseed cake protein was determined by the in sacco method using two fistulated cows. The cows were fed the same basal ration, providing a stable ruminal environment. To determine degradability, the samples were milled, weighed, and 4 g of feed, on a dry matter basis, were placed in a polyester bag (PES 28/7; SAATI, Italy). The polyester bags (100 x 160 mm) had a pore size of 28 µm and an open surface area of 17%.
Feed samples were incubated in the rumen for 2, 4, 8, 16, 32 or 64 hours. Nutrient solubility was determined by rinsing the bags in cold water for 15 minutes. The 4 g of rapeseed cake were weighed into bags for five parallel tests. The sample bags were soaked in lukewarm water (39°C) for 30 minutes before solubility was determined.

Effective degradability of feed nutrients was calculated using the formula described by Ørskov and McDonald (1979): $p = a + b (1- e^{-ct})$,

where p = effective degradability, %,
a = soluble fraction, %,
b = degradable fraction, %,
c = degradation rate of degradable fraction, $\%h^{-1}$,
t = time of incubation, h.

Passage rate of feed particles was assumed to be 8% per hour. Results were analysed statistically using computer programmes MS Excel and SAS (SAS Institute, 2004).

RESULTS AND DISCUSSION

The chemical composition of the rapeseed cakes are shown (Table 1). Significant differences between the cakes were found for: dry matter, crude protein, crude fat and N-free extracts. There was a significant difference between minimum and maximum values for metabolizable protein. The metabolizable energy contents were relatively constant.

Table 1. Chemical composition and nutritive value of rapeseed cakes

Items	CPRC		HTRC	
	$\bar{x}$	s	$\bar{x}$	s
Dry matter, %	90.8	2.3	92.7	4.4
In dry matter, g/kg				
crude protein	351	2.7	364	1.1
crude ash	64	0.5	71	0.6
crude fibre	126	1.0	133	1.1
crude fat	135	2.5	111	1.2
N-free extracs	324	3.4	321	2.4
Metabolizable energy, MJ/kg	13.6	0.3	13.1	0.2
Metabolizable protein, g/kg	109.7	31.1	172.5	11.0

The mean ruminal protein degradability of cold-pressed rapeseed cakes was 90%, and 54% for heat-treated rapeseed cakes. Heat treatment had a significant effect on crude fat content ($P<0.001$). The strongest relationships between parameters were related to the EPD. The higher treatment temperature of the seeds resulted in reduced, and slower, ruminal degradability of rapeseed cake protein. This indicates that, based on chemical composition and solubility values, the EPD of rapeseed cake can be predicted. There was a strong correlation between EPD and protein solubility ($R^2=0.906$). Including two characteristics to predict EPD gave a significant R^2 value between protein solubility and crude protein content ($R^2=0.920$). It is therefore possible to use the chemical composition and solubility parameters in laboratory conditions to evaluate the quality of rapeseed cake for dairy cows.
Table 3 shows relationships between the different characteristics. The weakest relationship was found between crude fat content and the other characteristics. This result confirms that, due to the high variability of crude fat in rapeseed cakes, crude fat cannot be used as a basis for predicting effective protein degradability. The strongest relationships between characteristics were related to effective protein degradability.

Table 2. Solubility and degradability parameters of rapeseed cakes

	CPRC		HTRC	
Item	$\bar{x}$	s	$\bar{x}$	s
Dry matter solubility, %	51.9	9.2	37.0	2.3
Dry matter ED, %	69.2	7.6	52.8	2.9
Protein solubility, %	56.8	17.8	27.3	5.3
Protein ED, %	90.6	12.9	53.5	4.5

Table 3. Relationships between characteristics; correlations of coefficients and probabilities

	CF	CP	DMS	DM ED	PS	EPD
Crude fat	1	0.074	0.001	0.001	0.001	0.001
Crude protein	-0.389	1	0.188	0.027	0.168	0.051
DM solubility	0.706	-0.292	1	0.001	0.001	0.001
DM ED	0.710	-0.470	0.937	1	0.001	0.001
Protein solubility	0.730	-0.305	0.976	0.933	1	0.001
EPD	0.711	-0.420	0.935	0.988	0.952	1

CF – crude fat; CP – crude protein; DMS – dry matter solubility; DM ED – dry matter effective degradability; PS – protein solubility; EPD – effective protein degradability

Figure 1 illustrates the relationships between effective degradability of protein and crude protein and dry matter solubility. There are strong R^2 values between protein solubility and EPD (R^2=0.906) and between dry matter solubility and EPD (R^2=0.874). Both regression lines show that rapeseed cakes are divided into clusters, which indicate that the rapeseed cakes were produced with different methods. The clusters are of different processing temperatures; increased temperature was associated with decreased solubility.

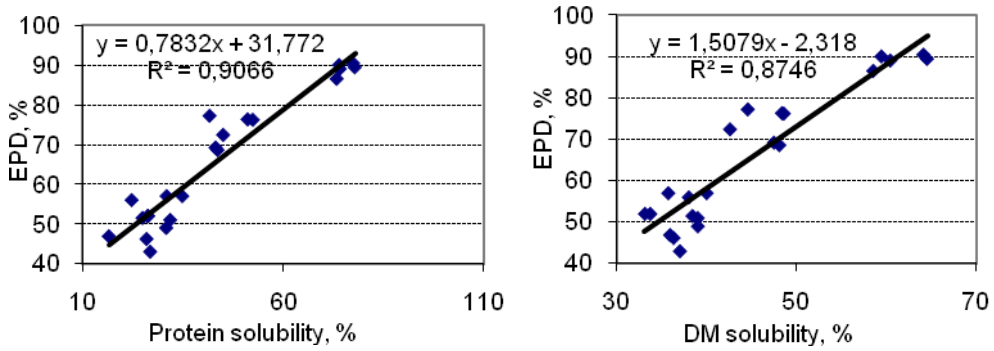

Figure 1. Comparison of protein degradability and crude protein and dry matter solubility

Correlations between crude fat content with effective protein degradability and protein solubility were significant, but these correlations were not as significant as those between effective protein degradability and protein and dry matter solubility. Once again, these results show that crude fat content is not a good indicator of protein degradation. Predicting EPD using protein and dry matter solubility data gave a 0.1% better correlation than using any individual characteristic.
To predict EPD two characteristics were included in the model (Table 4). Predicting effective protein degradability using protein solubility and crude protein content was significant (R^2=0.920).

Table 4. Prediction of EPD using protein solubility and crude protein data

	Coefficients	Standard Error	t Stat	P-value
Intercept	66.73	19.69	3.39	0.003
Protein solubility, %	0.75	0.06	13.29	0.001
Crude protein, %	-0.94	0.52	-1.79	0.089

Effective degradability of rapeseed protein can be predicted from its dry matter and crude protein solubility.

CONCLUSION

The chemical composition of rapeseed cake is significantly affected by production temperature. With increased crude fat content of rapeseed cake other nutrients contents decreased. Compared to heat-treated rapeseed cakes, cold-pressed rapeseed cakes had significantly higher ($P < 0.001$) crude fat contents. Compared to heat-treated rapeseed cake, the metabolizable protein content of cold-pressed cake was lower. Differences in production method had the greatest effect on the solubility and ruminal degradability of the rapeseed cake protein. A higher treatment temperature of the seeds resulted in lower, and slower, ruminal degradability of the rapeseed cake protein. It is known that heat treatment of rapeseed improves the protein quality of rapeseed cake (Kaldmäe et al. 2010). Therefore, heat-treated rapeseed cake is of higher quality for the provision of the required amino acids to the high-producing dairy cows.

Correlations between protein solubility and effective degradability and between dry matter solubility and effective degradability were significant. Predicting effective protein degradability using protein solubility and crude protein content was reliable. These two characteristics showed the best results for the prediction of effective degradability of protein of rapeseed cake.

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