Nitrogen degradability and intestinal digestibility of rumen undegraded protein in rapeseed, rapeseed meal and extracted rapeseed meal

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ABSTRACT: In this study, nutritive values of rapeseed (R), rapeseed meal-expeller A (RM-A), rapeseed meal-expeller B (RM-B) and extracted rapeseed meal (ERM) were compared. The trials were performed using the *in sacco* method with three steers of the Czech Fleckvieh breed, which were fitted with a permanent ruminal cannula. Nylon bags with samples were incubated in the rumen for 2, 4, 8, 16, 24 and 48 hours. The effective degradability (ED) of crude protein (CP) was calculated at 0.08, 0.06 and 0.04 1/h of rumen particulate outflow rates (k), and the obtained ED values were 65.4, 70.8 and 77.4% for R, 86.7, 88.1 and 89.7% for RM-A, 82.2, 84.4 and 87.0% for RM-B and 56.3, 62.1 and 69.6% for ERM, respectively. The ED values significantly differed between feeds ($P < 0.05$) for all rumen particulate outflow rates. Disappearances of amino acids (AA) after 16 hours of incubation in the rumen of R, RM-A, RM-B and ERM were determined. In all cases, the concentrations of AA in the feeds determined after incubation in rumen were lower than in the original feeds. A mobile bag technique was used to determine intestinal digestibility. In the experiment, three dry cows fitted with permanent large ruminal cannula and the T-piece cannula in the proximal duodenum were used. The intestinal digestibilities of rumen undegraded CP (DSI) were estimated 30.0% in R, 15.4% in RM-A, 27.6% in RM-B and 65.3% in ERM. The DSI values significantly differ between the feeds ($P < 0.05$), except for the difference between R and RM-B.

Keywords: rapeseed; rapeseed meal; extracted rapeseed meal; ruminant; protein; amino acids; degradability; intestinal digestibility

Rapeseed is one of the most important oilseeds grown in the Czech Republic. Its acreage accounts for approximately 80% of the total area under oilseeds. In 2005, rapeseed was harvested from 271 000 ha, which is about 10% of the country's total arable land area. Since the early 1990s, rapeseed has been used in the food industry, and besides, the oil obtained by cold pressing has been processed into methyl ester to be alternatively used as a biodiesel fuel.

Extracted rapeseed meal, rapeseed meal and expeller are by-products of industrial processing of rapeseed. These products are used as a source of valuable proteins and energy in ruminants, pigs and poultry. A 10% content of rapeseed cake is available as a part of calf starter diet (Göpfert et al., 2006). According to commonly used technological processes of oil production from rapeseed, the following products are distinguished: extracted rapeseed meal – a by-product of chemical extraction of fat (the lowest fat content) and rapeseed meal (expeller) – a by-product from the cold and hot pressing of seeds.

It is important to accentuate that nutrient content and above all fat content, fat to crude protein ratios and the resulting nutritional values are different for rapeseed, extracted rapeseed meal and

Supported by the Czech Science Foundation (Grant No. 523/02/0164) and the Ministry of Agriculture of the Czech Republic (Project No. MZe No. 0002701403).

rapeseed meal (expeller). The method of rapeseed (industrial physical or chemical) processing affects the degradability (solubility) of crude protein (CP) and other nutrients in the rumen of ruminants and their further digestibility in the intestine. With respect to the higher fat content in rapeseed meal (expeller) compared to extracted rapeseed meal, the former contains more energy. The relatively high fat content in a feed mixture containing rapeseed, rapeseed cakes and rapeseed oil did not negatively influence either yield traits (milk yield, yield of milk fat, milk protein and lactose) or the content of basic milk constituents, including total solids (total lipid, total protein, lactose and calcium) (Komprda et al., 2005).

Protein supplements are an essential part of diets for high-yielding dairy cows. In connection with the BSE (bovine spongiform encephalopathy) disease in cattle, Czech and EU legislation (Commission Dec. 2001/25/EC) prohibits the feeding of animal proteins. These limitations disqualified time-proven sources of animal protein. The advantage of animal protein was in its lower degradability ensuring its sufficient supply to the small intestine. More attention is therefore paid to the sources of vegetable proteins. Traditional sources of energy and protein are used most frequently in order to improve the nutritive value of the diet for high-performance cows (Strusinska et al., 2006).

A precise feed quality evaluation is one of the main assumptions of milk production in dairy cows and of the efficient utilisation of feeds. Protein supplements are an essential part of the diet for high-yielding dairy cows. Protein evaluation systems determine the organism's requirements for amino acid (AA) intake according to the quantity of protein actually entering the small intestine. All these systems are based on the same principles:

(1) Separate evaluation of protein used by a host animal and by microorganisms in the rumen
(2) The use of protein degradability (the most important criterion) and intestinal digestibility of rumen undegraded protein

The PDI system (Protein Digestible in the Intestine) used in the Czech Republic has been taken over from the French PDI system – Protéines vraies réellement Digestibles dans l'Intestin (Verité et al., 1988). To determine PDI units, it is necessary to know CP content, digestibility of organic matter, degradability of protein in the rumen and the intestinal digestibility of protein undegradable in the rumen.

The objectives of the study were to determine the protein degradability by the *in sacco* method and the intestinal digestibility of rumen undegraded protein by the mobile bag method in rapeseed, rapeseed meal (expeller) and extracted rapeseed meal.

MATERIAL AND METHODS

Feeds

Rapeseed (*Brassica napus* L.) of the low-erucic, low-glucosinolate ("00") variety:

(a) Rapeseed (R), full fat, ground to pass through a 2-mm screen.
(b) Rapeseed meal – expeller A (RM-A). By-product of the production of rapeseed oil, obtained by mechanical extraction (hot pressing) of rapeseeds.
(c) Rapeseed meal – expeller B (RM-B). By-product of the production of rapeseed oil, obtained by mechanical extraction of rapeseeds.
(d) Extracted rapeseed meal (ERM). By-product of the production of rapeseed oil, obtained by the solvent extraction of rapeseeds.

The chemical compositions and gross energy contents of individual feed samples are given in Table 1.

Crude protein and amino acid degradability

Experiments on crude protein (CP) and amino acid (AA) degradability were performed using an *in sacco* method (Ørskov and McDonald, 1979) in three steers of the Czech Fleckvieh breed. The animals were fitted with large, permanent, ruminal cannulas (120 mm in inside diameter). The steers were fed twice a day and their daily feed rations consisted of meadow hay (5 kg), maize silage (5 kg), lucerne and clover silage (7 kg), barley (0.5 kg), wheat (0.5 kg), mineral – vitamin supplements and barley straw *ad libitum*. Two-gram samples were weighed into bags 5 × 15 cm of 42 μm pore size (Uhelon 130 T, Silk and Progress Moravská Chrastová). The weight of 15 mg dry matter (DM) of the feed sample corresponded to 1 cm^2 of the active surface area of the bag. The bags with feed were attached to a cylindrical carrier (Třináctý et al., 1996) and incubated for 0, 2, 4, 8, 16, 24 and 48 h in the rumen. Six bags were tested for each

Table 1. Chemical compositions and gross energy values of the feeds (n = 2)

	Rapeseed	Rapeseed meal		Extracted rapeseed meal
		expeller A	expeller B	
Dry matter (g/kg)	934.5	912.2	910.0	878.8
Crude protein (g/kg DM)	212.2	318.7	314.3	386.6
Ether extract (g/kg DM)	462.3	179.8	109.9	39.3
Crude fibre (g/kg DM)	201.2	111.8	93.4	115.0
Nitrogen-free extract (g/kg DM)	82.8	325.4	397.8	384.9
Organic matter (g/kg DM)	958.5	935.7	915.4	925.8
Gross energy (MJ/kg DM)	29.3	23.3	21.3	20.5
Starch (g/kg DM)	24.8	16.6	61.1	53.5
Glucosinolate (mmol/g)	9.0	14.0	22.1	4.2
Cystine (g/kg DM)	14.6	22.6	23.3	28.0
Methionine (g/kg DM)	9.2	14.0	13.8	17.4
Aspartic acid (g/kg DM)	9.0	13.3	13.6	16.7
Threonine (g/kg DM)	34.0	49.9	47.1	62.8
Serine (g/kg DM)	11.3	17.6	18.4	22.5
Glutamic acid (g/kg DM)	10.1	15.2	15.0	19.2
Proline (g/kg DM)	8.7	13.1	13.3	16.7
Glycine (g/kg DM)	4.9	8.1	7.8	8.9
Alanine (g/kg DM)	10.1	15.2	14.8	19.1
Valine (g/kg DM)	4.2	7.1	7.0	8.1
Isoleucine (g/kg DM)	8.3	12.5	11.0	16.0
Leucine (g/kg DM)	13.9	21.4	20.8	26.8
Tyrosine (g/kg DM)	6.4	10.1	8.9	12.4
Phenylalanine (g/kg DM)	8.5	12.3	12.4	16.7
Histidine (g/kg DM)	6.0	9.3	8.8	11.3
Lysine (g/kg DM)	11.9	19.0	18.1	21.7
Arginine (g/kg DM)	13.9	22.0	22.1	26.4

time period and feed. Two cylindrical carriers were placed in the rumen of each of the three cannulated steers. For the zero incubation interval the bags were immersed into warm water for ten minutes. After rumen incubation, except for the zero incubation interval, all bags were rinsed in water to remove the coarse content of the rumen from the bag surface, and subsequently washed three times in a washing machine (without the spinning programme). The CP disappearance was determined on the basis of six values obtained for each treatment. After drying at 60°C, the matter in each bag was analysed to determine the CP content. For the analysis of AA, six bags were incubated for 16 h in the rumen, but only two samples for each interval were analysed. Each of them was made by mixing three bags from this time.

The disappearance means and standard deviations (SD) of CP and AA were subsequently calculated for all incubation intervals. Statgraphics software, version 6.1 (Manugistics, Statgraphics, Inc. Rockville, Maryland, USA) was used for calculations. The effective degradability (ED) was calculated as described by Ørskov and McDonald (1979) with rumen particulate outflow rates (k) of 0.08, 0.06 and 0.04 h. No corrections for microbial contamination were made.

Intestinal digestibility of rumen undegraded protein

The mobile bag technique (Frydrych, 1992; Homolka et al., 1996) was used on three dry cows

fitted with permanent large ruminal cannulas (120 mm in inside diameter) and T-piece cannula in the proximal duodenum in order to determine intestinal digestibility. This method included three steps:

(1) Feed incubation in the rumen of three cows to obtain undegraded feed residues. Feeds were weighed directly and without adjustments. The bags (15 × 5 cm, pore size 42 μm) containing feed samples were incubated for 16 h in the rumen. Then the bags were washed in water for 30 min and dried for 24 h at 50°C.
(2) The residues of the incubated feed were weighed into 30 nylon bags (4 × 4.6 cm, pore size 42 μm). The bags were sealed and incubated in a solution of pepsin and 0.01N hydrochloric acid for 2.5 h at 39°C.
(3) The bags were inserted throughout the cannula into the cow's duodenum (30 bags; 10 bags per cow per 1 h). The bags found within 24 h in the faeces were washed in water and subsequently freeze-dried. Intestinal digestibility was calculated according to the following formula:

$$(A - B)/A \times 100$$

where:

A = amount of CP (in DM) entering into the intestine
B = CP residues (in DM) after the passage through the intestine

Chemical analyses

Analytically evaluating dry matter (DM), CP, ether extract, crude fibre, ash and individual AA contents were carried out according to AOAC (1984). CP was determined by the Kjeldahl method (Kjeltec System 1002 Distilling Unit). Nitrogen-free extract (NFE) was calculated as follows:

NFE = DM – (CP + ether extract + crude fibre + ash)

Gross energy was determined using an adiabatic calorimeter (IKA C5000 control). Cystine and methionine were oxidized on methionine sulphoxide and cysteic acid and then with the remaining AA they were hydrolysed by acidolysis (6M HCl). OSTION LG ANB ionex was used for the partitioning of AA after acidolysis.

pH = 2.95; 0.3M Na^+ t = 55°C; 37 min
pH = 4.25; 0.3M Na^+ t = 55°C; 19 min
pH = 7.9; 0.3M Na^+ t = 65°C; 44 min

For the assessment of AA containing sulphur, ionex pH = 2.95 was used; 0.3M Na^+; t = 55°C; 35 minutes. The assessment was performed by the T 339 Analyzer of amino acids.

Statistical analyses

The statistical analysis was conducted using the SPSS software (SPSS, 2000). A one-way analysis of variance (ANOVA) was applied and multiple comparisons (Scheffe test) were used to compare differences in the disappearances of feeds at individual incubation intervals, a, b and c parameters and effective degradability values at outflow rate k = 0.08, 0.06 and 0.04 h.

RESULTS AND DISCUSSION

The content of DM, CP, ether extract, crude fibre, ash, gross energy, starch and contents of individual AA of R, RM-A, RM-B and ERM (Table 1) are in agreement with the characteristics of these feeds reported by several authors (Boila and Ingalls, 1994; Zeman et al., 1995; Zedník, 1999; Sauvant et al., 2004).

Disappearance of amino acids

Disappearances of AA (%) in R, RM-A, RM-B and ERM after 16 hours of incubation in the rumen are shown in Table 2. In all cases, the concentrations of AA in feeds determined after incubation in the rumen were lower than in original feeds. Boila and Ingalls (1992) found a higher content of amino acids after incubation than before incubation in some samples of rapeseed meal, in the following sequence: tyrosine (+27%), phenylalanine (+24%), valine (+20%), isoleucine (+17%), threonine (+17%), leucine (+10%) and methionine (+6%). The results of this study showed that the high concentration of easily degradable glutamic acid of the original diet apparently increased the content of other amino acids that were recovered from undegraded residues.

According to Dakowski et al. (1996), the disappearances of cystine (Cys), methionine (Met), aspartic acid (Asp), threonine (Thr), serine (Ser), glutamic acid (Glu), proline (Pro), glycine (Gly), alanine (Ala), valine (Val), isoleucine (Ile), leucine (Leu),

Table 2. Disappearances of amino acids (%) after a 16-h incubation in the rumen (n = 2)

	Rapeseed	Rapeseed meal		Extracted rapeseed meal
		expeller A	expeller B	
Cystine	86.9	96.1	94.2	80.2
Methionine	82.2	96.4	93.9	74.9
Aspartic acid	82.5	94.7	91.6	73.3
Threonine	79.0	93.7	90.5	72.8
Serine	80.2	94.1	90.8	72.0
Glutamic acid	84.7	97.2	94.7	81.1
Proline	81.7	93.5	90.9	76.9
Glycine	81.5	95.0	92.1	75.9
Alanine	80.8	95.7	93.0	73.8
Valine	79.9	94.5	90.9	73.7
Isoleucine	82.5	94.9	91.0	70.7
Leucine	83.7	96.4	93.4	75.4
Tyrosine	86.7	95.9	92.7	70.9
Phenylalanine	83.7	95.4	92.1	70.2
Histidine	80.5	93.8	89.1	69.5
Lysine	83.2	95.4	93.5	79.1
Arginine	81.3	96.4	94.4	78.1

tyrosine (Tyr), phenylalanine (Phe), histidine (His), lysine (Lys) and arginine (Arg) in rapeseed meal for the Danish (sample a) and Polish product (sample b) after 16 hours of rumen incubation were: 79.3, 75.0, 72.4, 68.9, 69.9, 81.9, 73.6, 74.2, 73.0, 70.4, 70.8, 72.0, 66.7, 69.9, 75.7, 71.7 and 76.9% (sample a), and 74.7, 66.6, 63.4, 61.1, 62.3, 75.7, 65.9, 66.7, 64.1, 61.3, 63.0, 64.9, 56.5, 62.3, 69.5, 65.4 and 69.6% (sample b), respectively. The values of AA disappearances determined in our study are in agreement with the above-mentioned values of sample a (Dakowski et al., 1996).

Moshtaghi Nia and Ingalls (1995) found the disappearances of AA 27.4, 50.8, 63.8 and 80.3% in canola meal within rumen incubation intervals of 1, 8, 16, and 24 h, respectively. However, compared to this study, our results for the corresponding incubation intervals were higher.

The disappearances (after 12 h of rumen incubation of canola meal) of Cys, Met, Asp, Thr, Ser, Glu, Pro, Gly, Ala, Val, Ile, Leu, Tyr, Phe, His, Lys and Arg were 72.9, 63.3, 56.6, 57.7, 58.2, 79.0, 70.4, 62.2, 58.2, 55.7, 54.6, 59.5, 51.6, 56.6, 67, 64.1 and 66.2%, respectively (Boila and Ingalls, 1994).

Table 3. The effective degradability of crude protein (%) calculated at outflow rates (k) of 0.08, 0.06 and 0.04 h

	Rapeseed	Rapeseed meal		Extracted rapeseed meal
		expeller A	expeller B	
Disappearance parameters				
Soluble fraction a (%)	21.9[a]	61.6[b]	53.6[c]	14.7[d]
Potentially degradable fraction b (%)	74.9[a]	32.2[b]	40.1[c]	78.6[d]
Rate of degradation c (h)	0.13[a]	0.22[b]	0.19[b]	0.10[a]
Lag time d (h)	0.7	0	0	0.6
Effective degradability (%)				
k = 0.08 h	65.4[a]	86.7[b]	82.2[c]	56.3[d]
k = 0.06 h	70.8[a]	88.1[b]	84.4[c]	62.1[d]
k = 0.04 h	77.4[a]	89.7[b]	87.0[c]	69.6[d]

[a,b,c,d]Means in a row with different superscript letters are significantly different ($P < 0.05$)

Degradability of crude protein

Effective degradabilities of CP in R, RM-A, RM-B and ERM were calculated at rumen particulate outflow rates (k) of 0.08, 0.06 and 0.04 h (Table 3). The highest degradability of protein calculated at an outflow rate of 0.06 h was found in RM-A (88.1%), closely followed by RM-B (84.4%). A slower degradability of protein was observed in R (70.8%), while the slowest was in ERM (62.1%). The ED values significantly differed between feeds ($P < 0.05$) for all rumen particulate outflow rates. The disappearance parameters a (soluble fraction) and b (potentially degradable fraction) were significantly different ($P < 0.05$) between all the investigated rapeseed feeds. Lag time d (h) was determined 0.7 h and 0.6 h for R and ERM, respectively. The zero value was obtained for RM-A and RM-B. It suggests that the soluble fraction disappears immediately and the insoluble fraction starts to disappear immediately (Ørskov, 1992).

Demarquilly et al. (1989) reported higher values of ED (k = 0.06 h) in rapeseed (90%) and in rapeseed meal (71%) in comparison with our results (70.8 and 62.1%, respectively). Zeman et al. (1995) also found higher ED (k = 0.06 h) in rapeseed (90%) and in rapeseed meal (69%), and lower values in rapeseed meal – expeller A (70%) and in rapeseed meal – expeller B (70%), in comparison with our results (88.1 and 84.4%, respectively). Similarly, Vencl et al. (1991) reported the ED of extracted rapeseed meal at 69% with an outflow rate of 0.06 h. Boila and Ingalls (1992) found the ED of CP 67.3% for canola meal incubated in the rumen for 0, 1, 4, 8, 12 and 36 h at an outflow rate of 0.05 h. The degradation parameters of Boila and Ingalls (1992) were as follows: soluble fraction 28.2%, non-soluble potentially degradable fraction 68.4%, lag time 0.1 h. In our study, we found the following degradation parameters: soluble fraction 14.7%, non-soluble but potentially degradable fraction 78.6%, lag time 0.6 h. Our results are in accordance with Harazim et al. (2002), who found the ED of CP for extracted rapeseed meal 68.1%. On the other hand, Masoero et al. (1994) reported lower values of ED of two rapeseed meal samples (48.35% and 57.69%, respectively) in comparison with our results. These discrepancies could be caused by various outflow rates and by different feed particle sizes. The degradation profile can also be affected by feed processing as a higher temperature could increase the amount of nitrogen permanently bound to the fibre in feeds of plant origin, which decreases the content of available nitrogen for rumen microorganisms (Kendall et al., 1991). In their experiments, the previously mentioned authors used the incubation intervals 0, 4, 8, 12, 16 and 30 h at an outflow rate of 0.05 h and determined the ED of CP in five

Table 4. The disappearance of crude protein (%) determined after rumen incubation at intervals of 0, 2, 4, 8, 16, 24 and 48 h (n = 6)

Time of incubation (h)		Rapeseed	Rapeseed meal		Extracted rapeseed meal
			expeller A	expeller B	
0	$\bar{x}$	21.9[a]	61.6[b]	53.5[c]	14.7[d]
	SD	0.4	2.9	0.2	0.5
2	$\bar{x}$	36.6[a]	76.8[b]	68.4[c]	26.2[d]
	SD	4.1	5.1	4.8	2.4
4	$\bar{x}$	43.1[a]	81.1[b]	73.0[c]	34.3[d]
	SD	1.1	0.8	1.3	1.5
8	$\bar{x}$	66.0[a]	90.2[b]	87.4[b]	58.3[c]
	SD	1.0	1.9	2.7	7.9
16	$\bar{x}$	90.5[a]	92.7[a]	91.0[a]	76.0[b]
	SD	1.8	0.5	0.4	6.5
24	$\bar{x}$	93.8[a]	93.5[a]	92.9[a]	85.1[b]
	SD	0.2	0.1	0.1	1.5
48	$\bar{x}$	94.1[a]	93.8[a]	93.8[a]	93.1[b]
	SD	0.1	0.2	0.2	0.5

[a,b,c,d]Means in a row with different superscript letters are significantly different ($P < 0.05$)

canola meal samples ranging from 44.3 to 59.0%. In this case, the average ED was 51.5%, a lower value than we found out (62.1%). The correction for the microbial contamination made by the authors could be grounds for the lower detected degradability.

Some authors present only the disappearances of CP in individual incubation intervals instead of ED values. The disappearances of CP (%) after incubation intervals of 0, 2, 4, 8, 16, 24 and 48 h (n = 6) in rumen and statistical analyses are given in Table 4. We found significant differences ($P < 0.05$) between RM-B and ERM for all rumen incubation intervals. The disappearances of CP (%) after incubation intervals of 0, 2 and 4 h were significantly different ($P < 0.05$) between all the investigated rapeseed feeds. Rooke (1985) determined a CP disappearance of 40% in rapeseed meal at an 8-h incubation interval, which is less in comparison with our result (58.3%). A fairly low value (63.4%) of CP disappearance after a 12-h rumen incubation interval was found for canola meal by Boila and Ingalls (1994). The figure shown in the present paper is 67.2% as the average of two values obtained within 8- and 16-h incubation intervals. Kudrna and Marounek (2006) suggested a high degradability of crude protein in a diet with rapeseed cake in comparison with the extruded soybean diet.

Intestinal digestibility of rumen undegraded protein

The intestinal digestibility of rumen undegraded protein (DSI) determined by the mobile bag technique in cows with rumen and duodenal cannulas (Table 5) was 30.0, 15.4, 27.6 and 65.3% for R, RM-A, RM-B and ERM, respectively. The DSI values significantly ($P < 0.05$) differ between feeds, except for the difference between R and RM-B. ERM with the highest DSI (65.3%) showed the lowest ED of CP (62.1%, calculated at k = 0.06 h). The highest ED of CP (88.1%, calculated at k = 0.06 h) was found for RM-A with the lowest DSI (15.4%). When we rank the rapeseed feeds according to their DSI values in descending order, according to their ED values in ascending order, we obtain the identical order of feeds: ERM, R, RM-B and RM-A. The higher intestinal digestibility of rapeseed feeds with low degradability showed that the substances undegraded in the rumen were utilized in the small intestine.

Demarquilly et al. (1989) reported higher values of DSI in rapeseed (60%) and in rapeseed meal (80%) in comparison with our results (30.0 and 65.3%, respectively). Zeman et al. (1995) also found higher values of DSI in rapeseed (65%), rapeseed meal-expeller (76%) and in rapeseed meal (75%). Harazim et al. (2002) reported DSI for rapeseed meal 65.9%, which is consistent with our result. Dakowski et al. (1996) found for rapeseed meal DSI 70.2% in sample a, and 74.1% in sample b. The authors used bags with a porosity of 9 μm and an active surface area 6 × 6 cm. Rooke (1985) used 2.5 × 6 cm bags with a porosity of 10 μm and reported DSI of rapeseed meal 75.6%. The weight/surface ratio and the porosity of the bag are known to influence degradability measurements. However, it is questionable whether different results obtained by Rooke (1985) and Dakowski et al. (1996) in comparison with our results could be attributed only to the above-mentioned conditions. Masoero et al. (1994) recorded higher values of intestinal digestibility of two rapeseed meal samples 78.04 and 78.09% while in our case it was only 65.3%. Boila and Ingalls (1994) determined DSI 90% in canola meal. However, incubation in the rumen was performed for a 12-h interval.

It is known that different technological processes (mechanical, thermic, chemical etc.) influence the degradability of protein in the rumen and the digestibility of protein in the intestine. As the results of DSI for RM-A and RM-B were lower in comparison with other authors, we repeated the determination under similar experimental conditions but at a dif-

Table 5. Values of intestinal digestibility of rumen undegraded crude protein (%)

	Rapeseed	Rapeseed meal		Extracted rapeseed meal
		expeller A	expeller B	
Intestinal digestibility	30.0[a]	15.4[b]	27.6[a]	65.3[c]
Number of bags	25	25	22	26
Standard deviation	2.2	3.5	3.6	5.3

[a,b,c]Means in a row with different superscript letters are significantly different ($P < 0.05$)

ferent research institute (The Central Institute for Supervising and Testing in Agriculture in Opava) with similar results.

CONCLUSION

The ED of CP of rapeseed feeds (R, RM-A, RM-B, ERM) and the disappearances of individual AA and DSI of ERM agree with the cited literature data. However, the determined DSI values of R, RM-A and RM-B were lower than is generally reported by most authors. These findings should provide the improved nutritional information necessary for determining the effects of the processing method on CP and AA metabolism of ruminants.

Acknowledgement

The authors would like to express gratefully acknowledgements to V. Hladká, V. Koukolová, O. Mašata and A. Vymětal for their technical assistance in this study.

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Received: 2005–08–26
Accepted after corrections: 2007–07–23

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