EFFECT OF TEMPERATURE ON THE DEGRADATION OF RAPESEED CAKE PROTEIN

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Summary. Rapeseed cake is frequently used in the diets of high productive cows. Production conditions of rapeseed cake can be variable, affecting the quality of feed.

Objectives of the investigation was to study chemical composition and nutritive value of rapeseed cake produced by short-term heat treatment (HTRC) and cold-pressing (CPRC) of rapeseed. In addition, the effect of treatment temperature of rapeseed on protein degradability and ruminal kinetics was studied. Rapeseed was processed at 100°C for 15-20 minutes. In production of CPRC, temperature reached up to 60°C. Protein degradability of rapeseed cake was studied by the *in sacco* method.

Chemical composition and nutritive value of CPRC were significantly different from these of HTRC. In CPRC, the content of crude protein, crude fat, metabolizable energy, metabolizable protein in dry matter was 336 g/kg; 187 g/kg; 13.99 MJ/kg and 103 g/kg, respectively; ruminal balance was 174 g/kg. As to HTRC, these values were 349 g/kg, 111 g/kg, 12.96 MJ/kg, 161 g/kg and 105 g/kg, respectively. CPRC had significantly higher content of crude fat and metabolizable energy ($P<0.0001$); in HTRC, the content of metabolizable protein was significantly higher ($P<0.0001$). Ruminal degradability of HTRC protein was slow. Heat treatment of rapeseed decreased effective protein degradability by 35.8%. The content of metabolizable protein in rapeseed cake increased by 1.5 times (58g per kg dry matter).

The effective degradability of protein of CPRC was 89.5% and of HTRC was 53.7%.

Chemical composition of rapeseed cake was affected by production conditions and temperature. Heat treatment of rapeseed improved the protein quality of rapeseed cake.

Key words: rapeseed cake, heat treatment, cold-pressed, protein, degradability.

TEMPERATŪROS ĮTAKA RAPSŲ SĖKLŲ IŠSPAUDŲ PROTEINŲ SKAIDYMUISI

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Santrauka. Rapsų sėklų išspaudos dažnai naudojamos didelio produktyvumo karvių racionuose. Išspaudų gamybos sąlygos turi būti reguliuojamos veikiant pašaro kokybę.

Tyrimų tikslas – rapsų sėklų išspaudų cheminės sudėties bei pašarinės vertės nustatymas gaminant jas trumpalaikiu temperatūros poveikiu bei šaltu rapsų sėklų spaudimo būdu. Be to, buvo tiriama rapsų sėklų apdorojimo temperatūra įtaka proteinų skaidymuisi bei prieskrandžio kinetikai. Rapsų sėklos 15–20min. buvo veikiamos 100ºC temperatūra. Taikant šaltąjį rapsų sėklų spaudimo būdą, temperatūra pakildavo iki 60ºC. Rapsų išspaudų proteinų skaidymasis buvo tiriamas *in sacco* metodu.

Šaltai spaustų rapsų sėklų išspaudų pašarinė vertė labai skyrėsi nuo išspaudų, paveiktų karščiu. Šaltai spaustų rapsų sėklų išspaudose žalių proteinų, žalių riebalų, apykaitos energijos ir apykaitinių proteinų kiekis sausojoje medžiagoje buvo atitinkamai 336g/kg, 187g/kg, 13,99MJ/kg, ir 103g/kg; prieskrandžio balansas buvo 174 g/kg. Rapsų išspaudų, paveiktų aukšta temperatūra, šios vertės siekė atitinkamai 349 g/kg, 111 g/kg, 12,96 MJ/kg, 161 g/kg ir 105 g/kg. Šaltai spaustos rapsų išspaudos turėjo daug daugiau žalių riebalų bei apykaitos energijos ($p<0,0001$). Aukštos temperatūros poveikio rapsų išspaudos turėjo daug daugiau apykaitinio proteino ($p<0,0001$).

Aukštos temperatūros rapsų išspaudų proteinų skaidymasis prieskrandyje buvo lėtesnis.

Rapsų sėklų temperatūrinis poveikis efektyvų proteinų skaidymąsi sumažina iki 35,8 proc. Apykaitinių proteinų kiekis rapsų sėklų išspaudose padidėjo 1,5 karto (58 g kilogramui sausosios medžiagos).

Efektyvus šaltai spaustų rapsų išspaudų proteinų skaidymasis siekė 89,5 proc., o aukštos temperatūros poveikio – 53,7 proc. Rapsų išspaudų cheminė sudėtis priklausė nuo gamybos sąlygų ir temperatūros. Temperatūra pagerino rapsų sėklų išspaudų kokybę.

Raktažodžiai: temperatūros poveikis, šaltai spaustos rapsų sėklų išspaudos, proteinai.

Introduction. Protein is considered to be the second important nutritive factor besides energy. Feed protein consists of protein and non-protein nitrogen. Feed protein is broken down by ruminal microflora and -fauna into peptides, amino acids and ammonia which in turn are used by micro-organisms for the synthesis of their body proteins (Broderick et al., 1991).

Ruminal protein degradation is affected by various factors; the most important of them is chemical composition of protein. Protein degradability is generally affected by the proportion of non-protein nitrogen in total protein and the amount and proportion of different protein

fractions in feed (Wadhwa et al., 1993; Nolan, 1993). The average ruminal degradability of feed protein is 60 to 80%; non-protein nitrogen is rapidly and almost totally degraded (Chalupa, Sniffen, 2002). The following important factors affect proteolysis: ruminal environment as pH, ammonia concentration, composition of microflora etc. (Ørskov, 1992, Nolan, 1993); ruminal motorics (Kaufmann, 1979), ruminal passage rate of feed particles (Ørskov, 1994, Cottrill, 1996); structure and composition of feed ration (Kärt, 1996), and intake (Zhao et al., 1993, Huhtanen, Kukkonen, 1995).

Chase (2002) suggests that the ration of high productive cows should contain 60 to 65% ruminally degraded protein (RDP) and 35 to 40% ruminally undegraded protein (RUP) in total protein. Degradability of silage, the basic feed in the diet, is high – the average effective degradability of protein is 80 to 85%. Consequently, in order to improve the use of protein in cows, their diets should be supplemented with feeds with slow degradability (Syrjala-Qwist et al., 1982). With higher production the ruminal degradability of feed protein should be reduced as in high productive dairy cows the amount of ruminally synthesized microbial protein is not sufficient to cover the amount of amino acids necessary for the synthesis of milk protein. In order to increase the amount of ruminally undegraded protein, it is recommendable to add rumen-protected proteins into the diet. Rumen- protected proteins are protein-containing feeds that have been treated or processed in ways to decrease ruminal protein degradability and increase the content of digestible ruminally undegraded feed protein. Most research has been focused on oilseeds. Rumen-protected proteins, as well as protein supplements that have an inherent high rate of ruminal escape, are important in dairy cattle nutrition because of the low content of digestible RUP in most feedstuffs. Thus, protein supplementation should be limited in high RUP-containing feedstuffs to avoid large excesses of RDP.

Many methods have been investigated to decrease the rate and extent of ruminal protein degradation. Most methods have involved the use of heat, chemical agents, or a combination of heat and chemical agents (Satter, 1986; Broderick et al., 1991; Schwab, 1995). Heat processing decreases rumen protein degradability by denaturation of proteins (Van Soest, 1994).

Careful control of heating conditions is required to optimize the content of digestible RUP (Schwab, 1995). Under-heating results in only a small increase in digestible RUP. Optimal conditions of heat processing are generally considered to be those which significantly decrease ruminal protein degradability without adverse effects on postruminal digestion or significant losses of amino acids (Schroeder et al., 1996).

Objective of the investigation was to study the chemical composition and nutritive value of rapeseed cake produced by short-term heat treatment and cold-pressing of rapeseed. The effect of treatment temperature of rapeseed on protein degradability and ruminal kinetics was studied.

Material and methods. The studied rapeseed cake originated from two different Estonian feed factory. The first feed factory used heat treatment for processing rapeseed: purified and crushed oilseed was treated at 100°C for 20 to 25 minutes and oil was mechanically extracted by pressing. In the other feed factory were using cold-pressing: purified oilseeds were directed into the press where the temperature shortly increased up to 50-60 °C.

Grounded rapeseed cake samples were analysed for the content of dry matter, crude protein, crude ash, crude fibre and crude fat (AOAC, 1990). The concentration of crude ash was determined by incineration for 6 hours at 550°C. Crude protein was determined by Kjeldahl method using Kjeldec Auto 1030 analyser; crude ash by Soxtec system and crude fibre using Fibretec system. The concentrations of NDF and ADF were determined by ANKOM 220 analyser (Van Soest et al., 1991). For assessing undigestable protein, determination of acid-detergent insoluble nitrogen was used (Nakamura et al., 1994).

Effective degradability of rapeseed cake protein was determined by the *in sacco* method using two fistulated cows. The cows were fed the same ration, providing a stable ruminal environment. Feed samples were incubated in the rumen for 2, 4, 8, 16, 32 or 64 hours. Bags with the samples were put into the rumen at certain time and were removed simultaneously. Nutrient solubility was determined by washing the bags in cold water in a washing machine for 15 minutes. The sample bags were soaked in lukewarm water (35°C) for 30 minutes before putting them into the rumen and determination of solubility.

Effective degradability of feed nutrients was calculated using the formula elaborated 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 considered to be 8% per hour.

Results were analysed statisticly using computer programmes MS Excel and SAS.

Results and discussion. The nutrient content of HTRC was compared with CPRC. Table 1 represents the average chemical composition and nutritive value of both. Significant differences between the cakes are shown: for the content of crude fat ($P<0.0001$), crude ash ($P<0.001$), crude fibre ($P<0.01$), non-nitrogen extractives ($P<0.0001$), metabolizable protein ($P<0.0001$) and energy ($P<0.0001$). On the average, the content of crude fat in CPRC was by 76 g/kg higher and that of metabolizable energy by 1.03 MJ/kg higher. The contents of crude ash, crude protein and crude fibre in rapeseed cakes are mostly affected by species and quality of rapeseed (Pedak, 1997). Data about the chemical composition of CPRC were similar to those gained by Geier (2004) who showed that the content of crude protein was 306 g/kg and that of

crude fat 194 g/kg in dry matter. On the other hand, the data of Leming (2005) reveal that chemical composition of rapeseed cake depends on pressing technology and treatment temperature: the higher the amount of oil in the rapeseed cake is, the lower is the amount of other nutrients.

The content of metabolizable protein was by 1.5 times (161 g/kg) higher and ruminal protein balance by 69 g/kg lower in HTRC in comparison with CPRC. Consequently, processing conditions affected the protein quality of rapeseed cake.

Ruminal kinetics of protein degradability of various rapeseed cakes was studied. The chemical compositions of HTRC (n=3) and CPRC (n=3) are given in Table 2, protein solubility and degradability in Table 3. Assessing of protein degradability of rapeseed cake indicated that it was affected by the temperature used at pressing rapeseed. The ruminal degradability of CPRC protein was rapid: in two hours 82.9% of protein was degraded, for HTRC that value was 37.5%.

Table 1. **Chemical composition and nutritive value of cold-pressed and heat treated rapeseed cake**

Items	Cold-pressed rapeseed cake n=11		Heat treated rapeseed cake n=25	
	x	s	x	s
Dry matter, %	90.7	0.9	90.5	6.1
In dry matter, g/kg				
crude protein	336	2.7	349	2.3
crude ash	62	0.6	70**	0.3
crude fibre	137	1.8	151*	1.7
crude fat	187	4.7	111***	1.2
N-free extractives	278	2.2	319***	2.2
metabolizable protein	103	7.3	161***	2.2
ruminal protein balance	174	15.5	105***	12.7
metabolizable energy, MJ/kg	13.99	0.6	12.96***	0.1

Protein degradability of HTRC was significantly lower as seen in Figure 1. Protein solubility of rapeseed cake treated at 100°C (fraction A) was 28%, while that of rapeseed cake pressed at 60°C was 74.2%; effective degradability was 53.7% and 89.5%, respectively. Studies of ruminal degradation of protein of heat processed feedstuffs using *in sacco* approach indicate reductions in fraction A (soluble fraction), increases in fractions B (degradable fraction) and C (undegradable fraction), and decreases in the fractional rates of degradation of B fraction (Goelema et al. 1999; Prestløkken, 1999, Kaasik et al. 2002).

Table 2. **Chemical composition of rapeseed cake *in sacco* tests**

Items	Cold-pressed rapeseed cake	Heat-treated rapeseed cake
Dry matter, %	90.6	89.5
In dry matter, g/kg		
crude protein	356	365
crude ash	59	73
crude fat	159	126
crude fibre	125	145
NDF	301	338
ADF	229	243
N-free extractives	301	291

Earlier studies have also revealed that heat treatment of rapeseed can decrease effective ruminal degradability of rapeseed cake protein. Kass et al. (2005) have shown in their studies that at treatment temperature 98°C, the effective degradability of protein was 57% and at 112°C it was 43%, respectively.

In the diets of high productive cows it is recommendable that the effective degradability of rapeseed cake does not exceed 55%. Strudsholm et al. (1995) suggest that the effective degradability of rapeseed cake is 55%; by Tuori et al (1996) that value should be 65%.

The studied material was analysed for potentially undegradable protein – its average content in CPRC was 6.77% and in HTRC 6.80%. According to these data, heat treatment did not reduce protein assimilation. Experiments with swine (Leming 2005) reveal that protein digestibility of HTRC tends to increase – protein digestibility of HTRC and CPRC was 71.8% and 68.4%, respectively.

Treatment of rapeseed shortly at 100°C significantly decreases the effective degradability of rapeseed protein, increases the amount of by-pass protein and improves the usage of feed protein by ruminants.

Table 3. **Protein degradability (%) of rapeseed cake processed under different conditions**

Time of degradability, h	Cold-pressed rapeseed cake		Heat-treated rapeseed cake	
	x	s	x	s
2	82.9	0.2	37.5	0.1
4	86.1	0.7	43.0	0.8
8	90.8	0.5	44.5	0.5
16	93.3	0.3	67.7	1.1
32	94.2	0.1	77.1	0.6
64	94.4	0.1	87.1	0.3
Effective degradability, %	89.5	0.3	53.7	3.1
Solubility, %	74.2	0.8	28.0	0.2

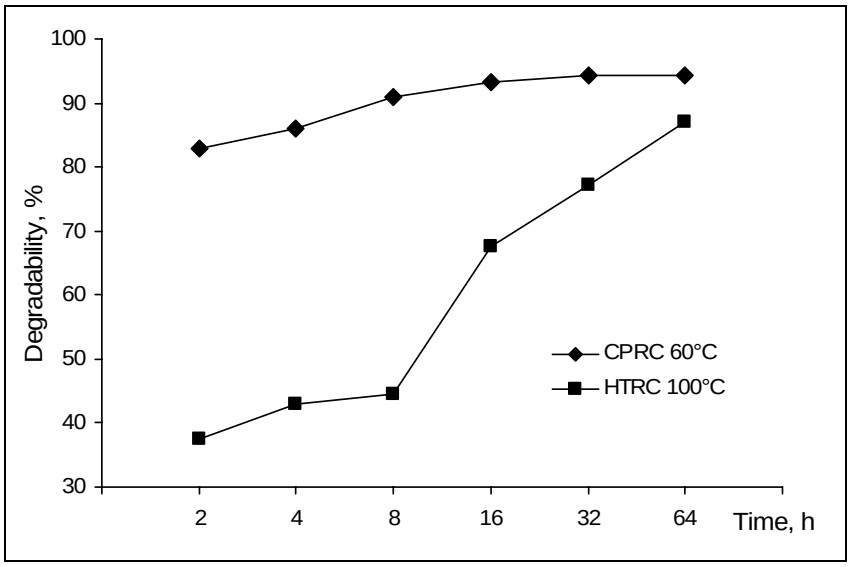

Figure 1. **Protein degradability of rapeseed cake at different temperatures.**

Conclusion. Chemical composition of rapeseed cake was affected by pressing technology and - temperature. The content of crude fat and metabolizable energy was higher in CPRC ($P<0.0001$), the content of metabolizable protein was higher in HTRC ($P<0.0001$).

The ruminal degradability of HTRC protein was slow. Heat treatment decreased the effective degradability of protein by 35.8%. Heat treatment rapeseed at 100°C increased the content of metabolizable protein of the rapeseed cake by 1.5 times (58 g per kg dry matter).

Heat treatment of rapeseed improved the protein quality of rapeseed cake.

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