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COMPARISON OF MAIZE SILAGE-BASED DIETS FOR DAIRY COWS CONTAINING EXTRUDED RAPESEED CAKE OR EXTRUDED FULL-FAT SOYBEAN AS MAJOR PROTEIN SOURCES

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Abstract

TŘINÁCTÝ JIŘÍ, RICHTER MICHAL, KŘÍŽOVÁ LUDMILA. 2016. Comparison of Maize Silage-based Diets for Dairy Cows Containing Extruded Rapeseed Cake or Extruded Full-fat Soybean as Major Protein Sources. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis,* 64(3): 901–909.

The trial was carried out on four Holstein cows with initial milk yield of 27.3 ± 1.7 kg.day^{-1}. Cows were divided into two groups – the first was fed a diet based on extruded rapeseed cake (D-ERC), the second one was fed a diet based on extruded full-fat soybean (D-EFFS), both diets contained maize silage and meadow hay. The experiment was divided into 4 periods of 42 days. Intake of dry matter, crude protein and NEL was not affected by the treatment ($P > 0.05$) while the intake of PDIA, PDIN and PDIE was lower in D-ERC than in D-EFFS ($P<0.05$). Milk yield in D-ERC (22.6 kg.d^{-1}) was lower than in D-EFFS (24.7 kg.d^{-1}, $P < 0.001$) while concentration of milk fat and protein were reverse ($P < 0.05$). Smaller portion of essential AADI in crude protein intake (CPI) in D-ERC resulted in lower efficiency of CPI utilization for milk protein synthesis in comparison to D-EFFS being 313 and 327 g.kg^{-1}, respectively ($P < 0.01$). Concentration of AA in blood plasma was not affected by the type of diet except of His and Ile that were higher in D-EFFS ($P < 0.01$).

Keywords: dairy cows, rapeseed cake, soybean, extrusion, protein degradability, amino acids

INTRODUCTION

In the European Union the turn towards renewable energy sources has increased the production of biodiesel from rapeseed oil leaving considerable amounts of valuable by-products as, for example, rapeseed cakes. This product can be fed in its original form or in particular as a solvent-extracted rapeseed meal which is more uniform (fat content). Rapeseed meal is currently used in dairy cows' diets and can fully replace soybean meal without considering differences in yield of milk and milk components (Schmidely *et al.*, 2004; Brito and Broderick, 2007). In the case of rapeseed feeding components heat treatment is associated with palatability improvement, anti-nutritional factors decrease (Jensen *et al.*, 1995) and with increase of ruminally undegradable protein content in range of ruminants nutrition (Lund *et al.*, 2008). In the case of heat-treated rapeseed cakes (RC) only several studies have made direct comparisons with other commonly used protein sources (rapeseed meal (RM) and soybean meal (SM)) in dairy cows diet (Ahvenjärvi *et al.*, 1999; Rinne *et al.*, 1999; Shingfield *et al.*, 2003).

The aim of the study was to compare isonitrogenous and isoenergetic diets differing in protein supplements (extruded rapeseed cake vs. extruded full-fat soybean) for dairy cows given maize silage-based diets.

MATERIALS AND METHODS

The present work is an extension of a previous study in which four lactating dairy cows were used in the experiment to study the effect of dietary soybean-derived phytoestrogens on milk yield and composition and transfer of phytoestrogens from feed into milk (Třináctý *et al.*, 2009) and on the activity of sex hormones during the oestrous cycle (Watzková *et al.*, 2010).

Animals, Experimental Design, Evaluated Feeds and Diets

The experimental design has been described previously (Třináctý *et al.*, 2009; Watzková *et al.*, 2010). Briefly, four lactating Holstein cows with initial body weight of 618 ± 54 kg and milk yield of 27.3 ± 1.7 kg.day^{-1} (lactation 3–4, 183 ± 55 days in milk) were used in the experiment. Cows were divided into two groups – control, fed a diet based on extruded rapeseed cake (D-ERC) and experimental, fed a diet based on extruded full-fat soybean (D-EFFS). Both of diets contained maize silage and meadow hay. Isonitrogenous and isoenergetic diets were optimised using INRA 2007 system (Agabriel *et al.*, 2007). Cows were fed individually twice daily (6.30 and 16.30 h). Maize silage was offered ad libitum to ensure proportionately between 5 and 10% refusals. Meadow hay and concentrates were offered at a rate of 1.8 kg and 10.5 kg (on an air-dry basis), respectively. The experiment was carried out in the form of replicated Latin square in double reversal design (Tempelman, 2004) and was divided into 4 periods of 42 days (21d preliminary period, 21d experimental period).

Mean composition of concentrates is given in Tab. I. Extruded rapeseed cake (ERC) used in concentrate (C-ERC) was from 00-varieties and was extruded at 125 °C (dry extrusion), extruded full-fat soybeans (EFFS) used in concentrate (C-EFFS) was extruded at 135 °C (dry extrusion). Both supplements were commercially available. Detailed nutritional value of mentioned protein supplements is given in Tab. II.

I: *Composition of experimental diets and concentrates (g.kg^{-1} of dry matter)*

Diet	D-ERC[1]	D-EFFS[2]
Maize silage	465	484
Meadow hay	79	82
Concentrate	456	434
Concentrate	**C-ERC[3]**	**C-EFFS[4]**
Barley	267	296
Oats	267	296
Beet pulp (dried)	142	150
Extruded rapeseed cake	262	-
Extruded full fat soybean	-	207
Rapeseed oil	12	-
NaCl	6	6
DCP[5]	17	17
$CaCO_3$	17	17
$NaHCO_3$	1	1
MSP[6]	2	2
MgP[7]	2	2
Premix[8] (trace elements and vitamins)	6	6

[1]diet with extruded rapeseed cake, [2]diet with extruded full-fat soybean, [3]concentrate with extruded rapeseed cake, [4]concentrate with extruded full-fat soybean, [5]dicalcium phosphate, [6]monosodium phosphate, [7]magnesium phosphate, [8]content of trace metals (mg.kg^{-1}): Co (550), I (1250), Mn (70000), Cu (17500), Zn (75000), Se (250); content of vitamins (IU/g): vit. A (13500), vit. D_3 (2000); content of vitamins (mg/kg): vit. E (50000)

II: *Nutrient content (in dry matter), feeding values and essential amino acids composition and essential AADI values of protein supplements*

Item	Unit	ERC[1]	EFFS[2]
Dry matter	g.kg^{-1}	937	925
Crude protein	g.kg^{-1}	371	433
Ether extract	g.kg^{-1}	101	195
Crude fibre	g.kg^{-1}	172	60
NDF	g.kg^{-1}	299	122
ADF	g.kg^{-1}	259	97
ADL	g.kg^{-1}	119	15
PDIA[3]	g.kg^{-1}	98	186
PDIN[4]	g.kg^{-1}	248	319
PDIE[5]	g.kg^{-1}	153	227
NEL[6]	MJ.kg^{-1}	7.8	9.6
OMD[7]	%	76.8	88.9
deg[8]	%	73.1	58.1
dsi[9]	%	76.5	90.8
Arg (ArgDI)[10]	% TAA (%PDIE)	8.01 (5.47)	9.78 (6.32)
His (HisDI)	% TAA (%PDIE)	3.04 (2.36)	2.93 (2.44)
Ile (IleDI)	% TAA (%PDIE)	4.68 (5.15)	4.62 (5.00)
Leu (LeuDI)	% TAA (%PDIE)	8.08 (8.34)	8.00 (8.36)
Lys (LysDI)	% TAA (%PDIE)	6.84 (7.20)	7.06 (7.20)
Met (MetDI)	% TAA (%PDIE)	1.73 (1.73)	1.45 (1.47)
Phe (PheDI)	% TAA (%PDIE)	4.60 (4.72)	5.75 (5.49)
Thr (ThrDI)	% TAA (%PDIE)	4.89 (5.11)	3.74 (4.53)
Val (ValDI)	% TAA (%PDIE)	6.06 (5.86)	5.11 (5.34)
TAA[11]	(g.kg^{-1} DM)	313	415

[1]extruded rapeseed cake, [2]extruded full-fat soybean, [3]dietary protein undegraded in the rumen, [4]digestible protein in the intestine when N supply is limiting, [5]digestible protein in the intestine when energy supply is limiting, [6]net energy for lactation, [7]organic matter digestibility, [8]protein effective degradability, [9]protein true intestinal digestibility, [10]essential amino acids digestible in intestine, [11]total amino acids (value includes also following nonessential AA: Ala, Asp, Glu, Gly, Pro, Ser, Tyr)

Sampling and Analyses

During the experimental period feed intake and respective orts were monitored daily. Samples of individual dietary components and orts were taken two times a week and analysed for dry matter (DM), ash, crude protein (CP), ether extract (EE) and crude fibre (CF) according to Commission Regulation (2009). NDF (neutral detergent fibre, with α-amylase without sulfite, ash corrected), ADF (acid detergent fibre) and ADL (acid detergent lignin) were estimated according to Van Soest *et al.* (1991). The pepsin-cellulase digestibility of ERC, EFFS and dietary components was determined according to Aufrère (1982). AA composition of feeds was determined on Automatic Aminoanalyser AAA 400 (Ingos, Praha, Czech Republic).

Value of deg of ERC and EFFS was determined using an *in situ* method (Michalet-Doreau *et al*., 1987) on three dry Holstein dairy cows fitted with large ruminal cannulas and fed twice daily with diet containing (in g.kg^{-1} of DM): maize silage (375), lucerne hay (375) and concentrate (250). Two-gram samples ground at 2 mm were weighed into the nylon bags (5×10 cm, 42 µm pore size), that were than fixed to a cylindrical carrier (Třináctý *et al*., 1996) and incubated for 0, 2, 4, 8, 16, 24 and 48 h in the rumen. After the incubation bags were washed three times (4 min) in a washing machine (without a spinning programme), dried for 48 h at 55 °C and analysed for total nitrogen (Commission Regulation, 2009).

Cows were milked twice daily (7.00 and 16.35 h). Milk yield was recorded at each milking. During the experimental period, samples of milk were taken three times a week at each milking, conserved by 2-bromo-2-nitropropane-1.3-diol (Bronopol; D & F Control Systems, Inc. USA) and analysed by infrared analyser (Bentley Instruments 2000, Bentley Instruments Inc., USA) for basic constituents.

In each experimental period blood samples (10 mL) were taken from the jugular vein into heparinised tubs, 3 times a week (Mon, Wed, Fri) after morning milking (between 7.30 and 8.30 h). Immediately after obtaining blood, the samples were centrifuged for 15 min at 1500 g. For the determination of AA profile the heparinised blood plasma was deproteinised with sulfosalicylic acid and centrifuged for 10 min at 3000 g. The supernatant was stored at –80 °C until the AA profile was determined on Automatic Aminoanalyser AAA 400 (Ingos, Praha, Czech Republic).

Calculations

Organic matter digestibility was calculated from pepsin-cellulase digestibility using regression equation from INRA 2007 (Agabriel *et al*., 2007). The protein effective degradability (deg) of the protein supplements was calculated according to Ørskov and McDonald (1979) using an outflow rate from the rumen of 0.06 h^{-1}. True intestinal digestibility of rumen undegradable protein (dsi) of EFC, EFFS and concentrates was calculated using following equation of Sauvant *et al*. (2004):

$$\text{dsi}\,(\%) = 88.3 + 0.371 \times \text{CP} + -0.0037 \times \text{CP2} - 1.07 \times \times \text{ADL} - 0.313 \times \text{NDOM},$$

where NDOM is non digestible organic matter (%). All other variables are in % of DM. Values of deg and dsi of other feeds were adapted from Tables INRA 2007 (Agabriel *et al*., 2007). Values of the undegraded dietary protein digestible in the small intestine PDIA, PDIN, PDIE and the net energy for lactation (NEL) of dietary components were calculated using methods published in Tables INRA 2007 (Agabriel *et al*., 2007). For calculation of the essential amino acids truly digestible in the small intestine (essential AADI in % PDIE) the procedure according to Rulquin *et al*. (2001a) was used. Requirement of essential AA for dairy cows was based on the work of Rulquin *et al*. (2001b).

Statistical Analysis

For all statistical evaluations week means were used. All dependent variables were subjected to analysis of variance using the GLM procedure of STATISTICA 7.0 (StatSoft) according to following model:

$$Y_{ijklm} = \mu + T_i + S_j + C_k(S_j) + P_l + W_m(P_l) + \varepsilon_{ijklm},$$

where

μ .... general mean,
T_i .... effect of treatment (i = 2),
S_j .... effect of square (j = 2),
$C_k(S_j)$ .... effect of cow within square (k = 4),
P_l .... effect of period (l = 4),
$W_m(P_l)$ ...... effect of week within period (m = 3),
ε_{ijklm} .... residual error.

RESULTS

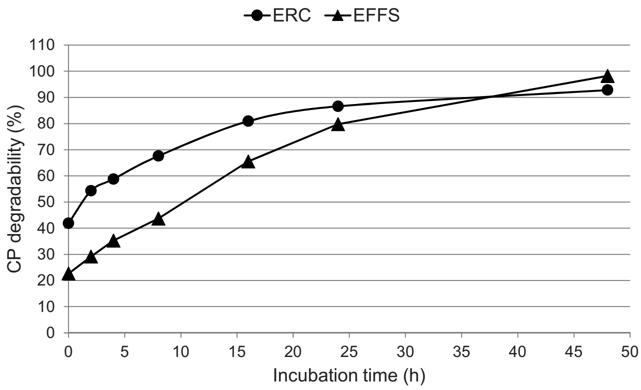
Nutritional Value of Protein Supplements

Nutritional parameters of ERC and EFFS are given in Tab. II. EFFS had a higher content of CP and ether extract and lower content of CF, NDF, ADF and ADL than ERC. Based on INRA 2007 (Agabriel *et al*., 2007), calculated content of PDIA, PDIN, PDIE and NEL was higher in EFFS in comparison to ERC. Values for OMD and dsi were higher while content of deg (Fig. 1) was lower in EFFS than in ERC.

Content of essential AA and calculated AADI values of protein supplements are presented in Tab. II. The content of Met was 1.73 and 1.45% of total amino acids (TAA) in ERC and EFFS, respectively. Similarly, content of TAA was 313 and 415 g.kg^{-1} DM, respectively. Results in the case of AADI values were similar however lower difference between compared feeds was observed by reason of inclusion of AA from microbial protein.

Nutritional Value of Diets and Their Effect on Cow Performance

Nutrient content, feeding values and content of AADI of diet components is mentioned in Tab. III, the effect of the diet on nutrient and AADI intake is presented in Tab. IV. Intake of DM, CP and NEL was not affected by the type of diet however CP intake tended to be lower in D-ERC in comparison to D-EFFS ($P = 0.095$). The intake of PDIA, PDIN and PDIE was lower in D-ERC than in D-EFFS ($P < 0.001$, $P < 0.01$ and $P < 0.001$, respectively). Intake of individual as well as total essential AADI was lower in D-ERC in comparison to D-EFFS ($P < 0.01$).



1: *Protein degradability of extruded rapeseed cake (ERC) and extruded full-fat soybean (EFFS)*

III: *Nutrient content (in dry matter), feeding values and content of essential amino acids digestible in intestine of diet components*

Item	Unit	Maize	Hay	C-ERC[1]	C-EFFS[2]
Dry matter	g.kg⁻¹	283	881	880	884
Crude protein	g.kg⁻¹	83	69	174	180
Ether extract	g.kg⁻¹	34	19	61	58
Crude fibre	g.kg⁻¹	218	318	101	83
NDF[3]	g.kg⁻¹	448	608	260	225
PDIA[4]	g.kg⁻¹	18	18	46	54
PDIN[5]	g.kg⁻¹	51	43	114	121
PDIE[6]	g.kg⁻¹	69	62	102	110
NEL[7]	MJ.kg⁻¹	6.37	4.59	7.60	7.73
Essential amino acids digestible in intestine					
ArgDI	%PDIE	4.58	4.92	5.15	5.41
HisDI	%PDIE	1.97	2.02	2.18	2.16
IleDI	%PDIE	5.54	5.49	5.27	5.28
LeuDI)	%PDIE	9.11	8.46	8.39	8.32
LysDI	%PDIE	6.86	7.32	7.09	6.91
MetDI	%PDIE	2.01	2.00	1.90	1.70
PheDI	%PDIE	4.97	5.51	5.07	5.24
ThrDI	%PDIE	5.29	5.32	5.15	5.02
ValDI	%PDIE	5.76	6.00	5.91	5.76

[1]concentrate with extruded rapeseed cake, [2]concentrate with extruded full-fat soybean, [3]neutral detergent fiber, [4]dietary protein undegraded in the rumen, [5]protein digestible in intestine (energy not limiting), [6]protein digestible in intestine (degraded N not limiting), [7]net energy for lactation

Yield and composition of milk is given in Tab. V. Milk yield (difference −2.1 kg.day^{-1}, it is–9.2%, P < 0.001) and yield expressed in ECM (difference −1.2 kg.day^{-1}, it is–5.5%, P < 0.01) was lower in D-ERC than in D-EFFS. Concentration of milk fat and protein were higher in D-ERC than in D-EFFS (P < 0.05 and *P* < 0.01, respectively) while concentration of lactose was not affected by the treatment (*P* > 0.05). Due to lower milk yield achieved in D-ERC, protein yield was lower (difference −47 g.day^{-1}, it is −6.5%, *P* < 0.001) and fat yield tended to be lower (*P* > 0.05) in this group.

Concentrations of free AA in blood plasma are shown in Tab. VI. Concentration of AA was not affected by the type of fed diet except of His and Ile that were higher in D-EFFS (P < 0.01) resulting in tendency to higher concentration of EAA in D-EFFS (P = 0.095). Sum of NEAA and TAA tended to be higher in D-EFFS than in D-ERC (P < 0.1).

DISCUSSION

Nutritional Value of Protein Supplements

Generally, chemical composition of ERC and EFFS is in agreement with the characteristics of these feeding components given in e.g. Sauvant *et al.* (2004). Content of CP in ERC determined in our study is comparable with values reported for extruded RM (Sauvant *et al.*, 2004) or RC (Rinne *et al.*, IV: *Effect of the type of diet on nutrients and essential AADI intake*

Intake	Unit	D-ERC[1] (n = 8)	D-EFFS[2] (n = 7)	Diff. (%)	SEM[3]	P
DMI[4]	kg.day^{-1}	18.88	18.86	0.1	0.28	0.883
Forage[5]	kg.day^{-1}	9.81	9.85	–0.3	0.09	0.545
Concentrate	kg.day^{-1}	9.07	9.01	0.6	0.24	0.710
Crude protein	kg.day^{-1}	2.33	2.38	–2.2	0.05	0.095
Ether extract	kg.day^{-1}	0.87	0.83	3.8	0.02	0.017
Crude fibre	kg.day^{-1}	3.20	3.04	5.2	0.04	< 0.001
NDF	kg.day^{-1}	7.00	6.68	4.6	0.07	< 0.001
PDIA[7]	kg.day^{-1}	0.59	0.66	–12.1	0.01	< 0.001
PDIN[8]	kg.day^{-1}	1.52	1.58	–3.5	0.03	0.009
PDIE[9]	kg.day^{-1}	1.59	1.66	–4.4	0.03	< 0.001
NEL[10]	MJ.day^{-1}	116	117	–0.9	1.9	0.329
ArgDI	g.day^{-1}	78.4	84.6	–7.9	1.9	0.007
HisDI	g.day^{-1}	33.3	34.6	–4.0	0.5	0.018
IleuDI	g.day^{-1}	85.5	89.3	–4.4	2.7	0.002
LeuDI	g.day^{-1}	138	143	–3.8	0.6	0.001
LysDI	g.day^{-1}	112	115	–2.8	1.5	< 0.001
MetDI	g.day^{-1}	31.0	30.3	2.1	1.5	0.012
PheDI	g.day^{-1}	80.4	85.7	–6.5	1.6	< 0.001
ThrDI	g.day^{-1}	82.8	85.1	–2.8	1.8	0.013
ValDI	g.day^{-1}	93.2	96.0	–2.9	1.7	< 0.001
Ess. AADI[6]	g.day^{-1}	734	763	–4.0	13.7	0.001

[1]maize silage based diet containing extruded rapeseed cake, [2]maize silage based diet containing extruded full-fat soybean, [3]SEM counted for n = 8, if n = 7 then SEM was multiplied by 1.069, [4]dry matter intake, [5]maize silage + hay intake, [6]total essential amino acids digestible in intestine

V: *Effect of the type of diet differing in protein source on yield and composition of milk and efficiency of nutrients utilization.*

	Unit	D-ERC[1] (n = 8)	D-EFFS[2] (n = 7)	Diff. (%)	SEM[3]	P
			Yield			
Milk	kg.day^{-1}	22.6	24.7	–9.2	0.49	< 0.001
ECM[4]	kg.day^{-1}	22.4	23.6	–5.5	0.49	0.004
Protein	g.day^{-1}	728	775	–6.5	13.51	< 0.001
Fat	g.day^{-1}	909	941	–3.5	29.42	0.193
Lactose	g.day^{-1}	1100	1194	–8.5	21.35	< 0.001
			Concentration			
Protein	g.kg^{-1}	32.2	31.7	1.7	0.30	0.036
Fat	g.kg^{-1}	40.1	37.9	5.7	1.05	0.013
Lactose	g.kg^{-1}	48.6	48.4	0.5	0.32	0.399
			Efficiency of utilization			
Milk P/CPI[5]	g.kg^{-1}	313	327	–4.2	5.93	0.010
ECM/CPI[6]	kg.kg^{-1}	9.61	9.90	–3.0	0.23	0.120
ECM/NELI[7]	kg.MJ^{-1}	0.19	0.20	–4.3	0.01	0.012

[1]maize silage based diet containing extruded rapeseed cake, [2]maize silage based diet containing extruded full-fat soybean, [3]SEM counted for n = 8, if n = 7 then SEM was multiplied by 1.069, [4]energy corrected milk yield calculated according to Sjaunja *et al.* (1990), [5]milk protein/crude protein intake, [6]energy corrected milk/crude protein intake, [7]energy corrected milk/NEL intake

1999 or Lund *et al.*, 2008). The content of CP in EFFS used in present study was comparable to value of Gonzáles *et al.* (2002) and higher than that reported for the same type of feed in feed tables of Sauvant *et al.* (2004). Content of CP in ERC was found out lower than in EFFS; this is in agreement with e.g. Sauvant *et al.* (2004).

VI: *Effect of the type of diet on blood plasma concentration of EAA (mmol.l⁻¹)*

Item	D-ERC[1] (n = 8)	D-EFFS[2] (n = 7)	Diff. (%)	SEM[3]	P
Essential amino acids					
Arg	73.5	79.1	–7.6	4.44	0.151
His	42.6	47.6	–17.2	2.79	0.045
Ile	94.4	104	–10.7	4.11	0.010
Leu	84.2	86.7	–5.4	4.36	0.512
Lys	75.2	77.9	–4.1	3.94	0.438
Met	19.0	18.8	–0.7	1.09	0.869
Phe	36.3	37.1	–4.2	1.75	0.567
Thr	67.5	68.2	–0.5	3.37	0.833
Val	190	198	–4.6	10.3	0.371
Non-essential amino acids					
Ala	220	251	–14.1	15.1	0.024
Asn	47.6	58.2	–20.4	3.26	0.001
Asp	10.7	10.3	4.8	0.64	0.511
Citrulline	68.8	78.2	–18.5	4.95	0.036
Cysteine	63.4	61.9	0.7	3.87	0.667
Gln	340	399	–16.6	26.9	0.016
Glu	60.0	55.4	8.0	3.57	0.149
Gly	361	361	1.1	28.7	0.996
Ornithine	55.0	58.0	–5.3	2.79	0.222
Pro	57.0	65.6	–16.2	3.17	0.004
Ser	74.8	78.9	–3.8	5.38	0.384
Taurine	40.6	36.8	8.0	3.29	0.188
Tyr	42.1	49.2	–16.4	2.28	0.001
Sums of amino acids					
EAA[4]	682	717	–6.1	36.1	0.196
NEAA[5]	1441	1564	–8.2	104	0.054
BCAA[6]	368	389	–6.4	18.7	0.195
TAA[7]	2491	2670	–7.4	159	0.072

[1]maize silage based diet containing extruded rapeseed cake, [2]maize silage based diet containing extruded full-fat soybean, [3]SEM counted for n = 8, if n = 7 then SEM was multiplied by 1.069, [4]total essential amino acids, [5]total non-essential amino acids, [6]total branch-chained amino acids, [7]total amino acids

A deg value is a more important parameter than CP content because it determines amount of dietary protein flowing to the small intestine and corresponding change of AA composition of digesta to this. Although the value of deg is characteristic for individual feeds, it can be influenced by a type of treatment during technological processing of feedstuffs (Kendal *et al.*, 1991). The deg value of ERC determined in our study is in agreement with values for full-fat rapeseed (Sauvant *et al.*, 2004) and for heat-treated RC (Weisbjerg *et al.*, 1996). On the other hand, lower deg value was reported by Lund *et al.* (2008) for untreated or expanded RC (119 °C), by Rinne *et al.* (1999) for heat-treated RC or by Homolka *et al.* (2007) for untreated RC. However in the latter mentioned study, higher deg value was found in RM expeller after hot pressing of rapeseed.

Value of deg of EFFS determined in our study was comparable to values described by Gonzáles *et al.* (2002) but higher than that reported by Sauvant *et al.* (2004) or by Nowak *et al.* (2005) for a similarly treated soybean. These dicrepancies in deg values are probably caused by used heat treatment technology that is supposed to contribute to deg value changes as mentioned by Kendall *et al.* (1991) suggesting that 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. In spite of a similar technological processing, values of deg of ERC and EFFS determined in our study differed considerably. Higher deg found in ERC supplement was probably caused by lower temperature exposition during extrusion (Lund *et al.*, 2008). Furthermore, lower response of rapeseed protein to heat treatment in comparison to soybean protein could contribute to this differency as well as suggested by Petit *et al.* (1997).

According to Schingoethe (1996) feed protein with AA composition near to that in milk is more effectively utilized for milk protein synthesis. This property of feed is quantified and expressed as a milk protein score (MPS). From this point of view, MPS of rapeseed in comparison to soybean is higher because of higher Met portion (Schingoethe, 1996). Content of Met in TAA determined in our ERC is near to that of RM reported by Piepenbrink and Schingoethe (1998) but lower in comparison to values reported for full-fat rapeseed (Sauvant *et al.*, 2004), heat-treated RM (Dakowski *et al.*, 1996) or expanded RC (Lund *et al.*, 2008). Portion of Met in EFFS is in agreement with value for the same type of feed given in feed tables (Sauvant *et al.*, 2004) and for SM reported by O'Mara *et al.* (1997).

Comparison of AADI values of protein supplements used in our study with AA requirements (Rulquin *et al.*, 2001b) showed that Met, Leu, Phe and His appeared to be limiting AA in ERC, while EFFS was deficient only in Met and Leu. AADI values of essencial AA were compared with data mentioned in literature. Calculated value of MetDI (1.73% PDIE) in ERC was lower and LeuDI (8.34% PDIE) was higher than reported for full-fat rapeseed (2.1, 7.9% PDIE, respectively; Sauvant *et al.*, 2004). In EFFS, considerably higher values of ArgDI (6.32% PDIE) were detemined in comparison with published data (5.7% PDIE; Sauvant *et al.*, 2004).

Nutritional Value of Diets and Their Effect on Cow Performance

In our study, DMI and NEL intake was not affected by the type of diet ($P > 0.05$). However, higher NDF content in ERC resulted in higher intake of NDF in D-ERC ($P < 0.001$). These findings are in agreement with Shingfield *et al.* (2003) who compared heat-treated RC with SM on dairy cows. Similarly to our results, significantly lower intake of PDIN ($P < 0.01$) and PDIE ($P < 0.001$) after inclusion of rapeseed into the diet were noted by Khalili *et al.* (2001) and corresponded with lower intake of essential AADI ($P < 0.001$) except of MetDI ($P < 0.05$) in their study. Higher content of Met and MetDI in ERC determined in our study in comparison with EFFS resulted in higher intake of MetDI in D-ERC ($P > 0.05$) that is in accordance with the Khalili *et al.* (2001).

Smaller portion of essential AADI in CP intake (CPI) in D-ERC resulted in lower efficiency of CPI utilization for milk protein synthesis (Milk P/CPI) in comparison to D-EFFS (313 vs. 327 $g.kg^{-1}$, respectively, $P < 0.01$). Shingfield *et al.* (2003) reported higher efficiency of RC than SM but their mean values (277 and 267 $g.kg^{-1}$, respectively) were lower than that determined in our study. On the other hand, Khalili *et al.* (2001) found no difference between groups; however their values ranging from 315 to 313 $g.kg^{-1}$ were similar to ours. Efficiency of NEL intake (NELI) utilization for ECM yield was −4.3% lower in D-ERC compared to D-EFFS ($P < 0.05$). On the other hand no effect of rapeseed and soybean products on ECM/NELI ratio was found by Shingfield *et al.* (2003) or Khalili *et al.* (2001). The overall worse results in milk performance and efficiency of CPI and NELI utilization in D-ERC corresponded with lower intake of PDI and AADI compared with D-EFFS.

Lower consumption of total essential AADI with difference between D-ERC and D-EFFS being −4.0% ($P < 0.001$) probably caused tendency to lower concentration of total EAA in blood plasma (682 and 717 $mmol.l^{-1}$, respectively). Similar results in blood plasma were described by Whitelaw *et al.* (1986). These authors also found that supplementation of lower quality protein digested in the small intestine results in lower levels of total EAA in blood plasma.

According to our results mentioned in Tab. VI, only concentration of His and Ile in blood plasma were significantly different ($P < 0.01$). This finding is in agreement with Schingoethe (1996) who reported His as the first limiting AA in RM in the case of maize silage diets. The same authors also reported Ile as the first apparently limiting AA for RM. Contrary to our findings, Shingfield *et al.* (2003) reported higher plasma concentration of His when feeding RC compared to SM.

CONCLUSION

Under described feeding conditions (the same dry matter intake of isonitrogenous and isoenergetic diets differing in protein supplements) milk yield and yield of milk components was higher in cows fed a diet supplemented with extruded full-fat soybean. This result was probably caused by higher intake of PDI and AADI in this diet in comparison to diet supplemented with extruded rapeseed cake.

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