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EFFECT OF ADDING FIBROLYTIC ENZYMES TO DAIRY COW RATIONS ON DIGESTIVE ACTIVITY IN THE RUMEN

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Abstract

The objective of the study was to determine whether supplementing the rations of Red-and-White Polish Holstein-Friesian dairy cows with exogenous fibrolytic enzymes in the form of Fibrozyme™ preparation containing a blend of active xylanase and cellulase will have a beneficial effect on degradation of dry matter, crude protein, starch and NDF in the rumen and its fermentative activity. In experiment 1 with dry cows fitted with permanent rumen fistulas, the degradation of fibre components (meadow hay) of roughages, starch components (barley) of concentrates and high-protein components (soybean meal) of concentrates was determined *in sacco*. The digestibility of these feeds was analysed after 21-day feeding of a standard diet with or without enzyme preparation, using different incubation times for different components: 2–72 h for hay, 2–48 h for ground barley and 4–24 h for soybean meal. At the end of incubation, degradation of hay DM and NDF, barley grain DM and starch, and soybean meal DM and CP was calculated. In experiment 2 with lactating cows receiving a complete TMR, the parameters determined were pH and content of ammonia, total VFA, content of individual fatty acids and their percentage in VFA, as well as the acetic (C2) to propionic acid (C3) ratio in the sampled ruminal contents. The experiment involved 12 cows (6 per group) in the first period of lactation. A sample of ruminal contents was collected twice (before morning feeding and 3 h postprandially) with a suction pump after 21-day TMR feeding with or without enzyme preparation. In both experiments, the preparation was added daily to concentrate included in the diet. The addition of exogenous fibrolytic enzymes to the standard diet composed of meadow hay and concentrate significantly improved *in sacco* degradation of meadow hay DM and NDF, barley grain DM and starch, and soybean meal DM and CP in the rumen. In lactating cows fed the complete diet (TMR), the addition of enzyme preparation also caused a significant increase in total VFA and different fatty acid types in the ruminal contents. The feed supplement had no significant effect on pH, rumen ammonia content, percentage of different acids in total VFA, and the acetic (C2) to propionic fatty acid (C3) ratio in the rumen.

Key words: cows, exogenous fibrolytic enzymes, *in sacco* degradation, fermentative activity in the rumen

The high production potential of modern Holstein-Friesian (HF) dairy cows caused conventional feeding and housing systems to become less effective (Strzetelski et al., 2009). Compared to dual-purpose cattle, HF cows require not only better

housing and management conditions, but also more accurate ration formulation in different physiological periods (Osięgłowski and Strzetelski, 2006). The transition period is critically important to the feeding of high-producing dairy cows because it involves a decrease in appetite, disturbed fermentation processes in the rumen, and an energy deficit (Drackley, 1999). A considerable role in reducing the negative energy balance of the cows is played by stimulation of appetite and the use of feed additives that stabilize rumen fermentation in early lactation when large amounts of concentrates have to be fed (Bowman et al., 2002). An important role in this regard, especially in increasing the digestibility of structural carbohydrates and regulating rumen digestion, can be played by a new generation of feed additives such as exogenous fibrolytic enzymes (Beauchemin et al., 2003; Bowman et al., 2002; Nowak et al., 2003).

There is a growing interest in the production and use of dietary fibrolytic enzymes in the nutrition of dairy cows because current technology offers lower production costs while some results of relevant research on high-producing dairy cows are promising (Kung et al., 2002). It was decided to determine whether using an enzyme preparation containing a blend of active xylanase and cellulase in the nutrition of Red-and-White Polish Holstein-Friesian cows characterized by lower milk production potential will positively affect fermentative activity of the rumen.

The objective of the study was to determine whether supplementing the rations of Red-and-White Polish Holstein-Friesian dairy cows with exogenous fibrolytic enzymes in the form of Fibrozyme™ preparation containing a blend of active xylanase and cellulase will have a beneficial effect on degradation of dry matter, crude protein, starch and NDF in the rumen and its fermentative activity.

Material and methods

The enzyme preparation Fibrozyme™, used in the present study (experiments 1 and 2), is a blend of active xylanase and cellulase, which are a dried mixture of fermentation extracts from *Aspergillus niger* and *Trichoderma longibrachiatum* fungi. The effect of the enzyme preparation on the degradation rate of feed components (meadow hay, barley and soybean meal) was investigated in experiment 1, and on the level of volatile fatty acids (VFA), ammonia (NH_3-N) and pH of rumen fluid in experiment 2.

Experiment 1 was carried out with three dry cows fitted with permanent rumen fistulas (ANKOM Products, Fairport, NY, USA), 12.5 cm in diameter. Animals were kept in non-litter tie-up stalls (rubber mats) equipped with automatic drinkers and trough partitions. Cows were fed individually twice daily (at 0800 and 1500 h) with a standard diet composed of 6 kg meadow hay of medium quality and 2.4 kg concentrate, which contained (%): ground barley 44, wheat bran 40, soybean meal 12, ground limestone 1, premix CJ 3 – containing (1 kg DM): 0.98 UFL, 127 g PDIN and 115 g PDIE. The weight ratio of roughage to concentrate dry matter in the ration (70.7 : 29.3) was similar to that recommended by Michael-Doreau et al. (1987).

The cows' ration met their maintenance requirement determined in accordance with the IZ-INRA system (2001). After mixing with concentrate, the enzyme preparation (15 g/animal/day) was placed in the trough during morning feeding. During the period preceding the bag incubation period, animals were fed a standard diet for three weeks.

Feeds intended for incubation were dried in a 50°C forced-air drying oven for 48 h. After drying, samples were pulverized in a Fritsch mill (Germany) fitted with 1.5-mm mesh screens. Ankom polyester bags (internal dimensions: 9 × 10 cm) were used for the incubation. Prior to incubation, each bag was permanently labelled, dried at 80°C and weighed on an analytical balance to the nearest 0.0001 g. Weighed amounts of feed (3 g ±0.0001) intended for incubation were placed into each bag so prepared. Bags were then sealed with a heat sealer (AVC, Super-Magnet-Sealer, The Netherlands) and placed into a weighted large-mesh bag (35 cm × 60 cm, pore size 5 mm) and inserted into the ventral sac of the rumen. Each feed sample (meadow hay, barley grain, soybean meal) was incubated *in sacco* in the rumen (Michalet-Doreau et al., 1987). Tests were performed in two stages, i.e. when the diet was fed without the enzyme preparation and when the diet fed contained the preparation. Incubation time varied according to feed (h): 2, 4, 8, 16, 24, 48 and 72 for hay; 2, 4, 8, 16, 24 and 48 for barley grain; 4, 16 and 24 for soybean meal.

Degradation of dry matter, crude protein, starch and NDF was calculated using the formula of Michalet-Doreau et al. (1987) based on feed composition and incubation residues. Feed samples intended for incubation and incubated samples were analysed for chemical composition using the standard procedure (AOAC, 1995), for starch content according to Faisant et al. (1995), and for NDF content in meadow hay using the method of Van Soest et al. (1966).

Experiment 2 was conducted in a production facility with 12 lactating cows kept in tie-up stalls bedded with straw and equipped with automatic drinkers and trough partitions. The 35-day experiment consisted of a 14-day preliminary period, in which animals were adapted to the new diet, and a 21-day trial period. During the experiment, cows were individually fed a complete diet (TMR) formulated according to the IZ-INRA system (2001) using INRAtion ver. 3.3 software (2006). The TMR diet (containing in 1 kg DM: 0.88 UFL, 97 g PDIN and 93 g PDIE) consisted of (% DM): maize silage 27.1, wilted meadow grass silage 24.8, ensiled brewers' grains 5.3, meadow hay 3.7, concentrate mixture 39.1, containing (%): ground maize 21, ground wheat 13, ground barley 18, ground triticale 9, soybean meal 18, rapeseed meal 7.9, rapeseed cake 4.8, ground limestone 4, premix CJ 4, sodium bicarbonate 0.3. TMR feed was offered twice daily with at least 6-h feeding intervals. During the trial period, mean daily intake of TMR dry matter was similar in both groups at 24.3 kg (±2) per animal.

Two groups of early-lactation cows (each having 6 cows) with a daily yield of 30–35 kg milk were assembled. Animals were selected based on the analogue principle according to lactation number, milk yield during the previous 100-day lactation and calving date. In the control group (C), TMR ration was fed without enzyme preparation, and group E received the same ration with a Fibrozyme™ preparation at 15 g per animal per day. Each day the preparation was added during the morn-

ing feeding to the concentrate contained in TMR. On the final day (21) of the trial period, liquid ruminal contents were collected from each cow using a probe connected to a suction pump. Samples of ruminal contents were collected twice: before the morning feeding and 3 h after a fresh TMR diet was fed. The ruminal samples were strained through four layers of cheesecloth into 50 ml beakers. The so-prepared samples were analysed in the barn for pH using a Mera Tronik N517 pH meter. The other determinations in the samples of ruminal contents: volatile fatty acids (VFA) and ammonia (NH_3-N) were made in a laboratory. Depending on the planned analyses, the samples were stabilized by adding metaphosphoric acid for VFA determination or mercuric chloride for NH_3-N determination. VFA analyses were performed by gas chromatography (Varian 3400CX, column DB-FFAP, 30 m × 0.53 mm × 1.0 micron, FID detection, 260°C, range 11, helium as carrier gas, 6 ml/min, injector temperature 200°C, analysis time 17 min, sample injection volume 1.0 µl), using 8200 CX autosampler. Ammonia was determined using Conway's microdiffusion method (1962).

Statistical calculations of the results obtained in both experiments were performed by one-way analysis of variance (ANOVA) using SAS package (1999/2001), and significance of differences between the groups was determined using Fisher's test (SAS, 1999/2001).

Results

The nutrient content and nutritive value of the roughages and concentrates given to animals (Table 1) were characteristic of medium-quality feeds (Kański et al., 2005).

Table 1. Chemical composition (% DM) and nutritive value of feeds

Ingredients	Maize silage	Grass silage	Ensiled brewers' grains	Meadow hay	Concentrate mixture (exp. 1)*	Concentrate mixture (exp. 2)*
Dry matter	29.20	37.50	23.63	85.20	87.41	88.24
Crude ash	4.48	11.00	4.25	9.23	9.82	10.30
Crude protein	8.59	12.15	27.84	9.11	15.38	16.42
Crude fat	3.97	3.92	8.35	1.78	1.12	1.34
Crude fibre	19.83	29.36	16.06	34.19	6.12	3.13
N-free extractives	63.13	43.57	43.23	45.69	67.56	68.81
NDF	51.60	56.12	45.13	73.35		
Lactic acid	7.68	3.25	3.70			
Acetic acid	1.40	1.47	1.50			
Butyric acid	0.14	0.16	0.15			
pH of silage	3.67	4.70	4.10			
Content in 1 kg DM:						
UFL	0.82	0.72	0.74	0.66	0.98	1.09
PDIN (g)	52.1	73.3	206.2	56.3	127	156
PDIE (g)	65.4	60.8	179.0	66.9	115	131

*for composition (%), see Material and methods.

Table 2. Ruminal degradation (%) of meadow hay DM and NDF at different incubation times

Ingredients	Incubation time (h)	Group		SEM	P
		K	E		
DM	2	30.46	31.29	1.436	0.340
	4	32.70 B	36.50 A	1.034	0.001
	8	35.59 B	39.46 A	1.040	0.001
	16	40.97 B	42.96 A	1.488	0.001
	24	43.21B	52.60 A	1.499	0.001
	48	63.66 B	69.25 A	1.281	0.001
	72	73.73 B	81.74 A	2.458	0.002
NDF	2	1.02	1.63	0.788	0.175
	4	3.43 B	10.47 A	0.621	0.001
	8	6.96 B	12.31 A	1.156	0.001
	16	13.05 B	17.26 A	1.398	0.004
	24	20.72 B	31.57 A	1.514	0.001
	48	49.47 B	56.54A	2.743	0.001
	72	63.88 B	76.65 A	1.683	0.001

Table 3. Ruminal degradation (%) of barley grain DM and starch and soybean meal DM and CP at different incubation times

Feed	Ingredients	Incubation time (h)	Group		SEM	P
			K	E		
Barley	DM	2	60.96 B	65.59 A	1.538	0.001
		4	63.46 B	74.03 A	1.719	0.001
		8	74.70 B	80.85 A	2.833	0.004
		16	80.28 B	83.69 A	0.863	0.001
		24	84.96	86.70	2.702	0.29
		48	87.59 B	89.80 A	1.247	0.01
	Starch	2	72.71 b	78.68 a	4.491	0.04
		4	75.17 b	82.68 a	5.556	0.04
		8	78.67 B	87.99 A	5.380	0.01
		16	84.13 b	90.52 a	5.819	0.05
		24	85.38 b	91.66 a	4.868	0.05
		48	85.63 b	91.79 a	5.015	0.05
Soybean	DM	4	41.10 B	55.28 A	2.518	0.001
		16	77.06 b	79.91 a	3.011	0.05
		24	88.34	90.51	1.912	0.08
	CP	4	26.17 B	43.30 A	1.756	0.001
		16	68.97 B	76.12 A	3.102	0.002
		24	83.77 B	92.25 A	0.795	0.001

Values for *in sacco* ruminal degradation of meadow hay DM and NDF, barley grain DM and starch, and soybean meal DM and CP are shown in Table 2 and 3. Compared to the control group (C), the addition of fibrolytic enzymes in the form of Fibrozyme™ preparation (group E) significantly ($P<0.01$) increased the ruminal degradation of meadow hay DM and NDF at all hours of incubation (4–72 h)

(Table 2). Similar differences between the groups were also found for the determinations of barley grain DM and starch (Table 3). Also for the incubation of soybean meal it was shown that compared to the control group (C), the enzyme preparation added to the ration (group E) significantly ($P<0.01$ or $P<0.05$) increased the rate of ruminal DM degradation at 4 and 16 h of incubation, and the rate of CP degradation in all incubation intervals (4, 16 and 24 h) (Table 3).

Table 4. Content of ammonia (NH_3-N) and volatile fatty acids (VFA), and pH of ruminal contents

Item	Group		SEM	P
	K	E		
Before morning feeding:				
pH	6.36	6.44	0.076	0.09
Ammonia (mg/dl)	51.6	54.00	3.11	0.31
Total VFA (mmol/l):	70.55 B	85.82 A	0.522	0.001
Acetic (C2)	46.22 B	56.13 A	4.166	0.01
Propionic (C3)	15.20 B	18.12 A	0.692	0.002
Butyric	6.34 B	7.82 A	0.550	0.01
Isobutyric	0.86 B	1.28 A	0.140	0.001
Isovaleric	1.07 B	1.49 A	0.149	0.001
Valeric	0.86 B	0.98 A	0.152	0.01
Proportion in total VFA (%):				
Acetic (C2)	68.21	68.39	0.496	0.56
Propionic (C3)	22.43	22.08	0.875	0.22
Butyric	9.35	9.53	0.794	0.94
Isobutyric	1.21	1.47	0.270	0.64
Isovaleric	1.50	2.44	0.214	0.69
Valeric	1.20	1.12	0.110	0.53
C2 : C3 acid ratio	3.04	3.10	0.345	0.87
3 h after feeding:				
pH	6.33	6.39	0.078	0.65
Ammonia (mg/dl)	115.3	117.9	0.466	0.001
Total VFA (mmol/l):	94.00 B	113.89 A	0.660	0.001
Acetic (C2)	61.06 B	74.30 A	3.269	0.01
Propionic (C3)	20.11 B	23.92 A	0.892	0.01
Butyric	8.43 B	10.69 A	0.745	0.002
Isobutyric	1.17 B	1.23 A	0.014	0.01
Isovaleric	1.49 B	1.79 A	0.219	0.001
Valeric	1.82 B	1.96 A	0.352	0.01
Proportion in total VFA (%):				
Acetic (C2)	68.15	68.22	1.864	0.91
Propionic (C3)	22.44	21.96	1.211	0.65
Butyric	9.41	9.81	1.001	0.34
Isobutyric	1.17	1.12	0.283	0.67
Isovaleric	1.79	1.28	0.199	0.71
Valeric	1.82	1.78	0.213	0.76
C2 : C3 acid ratio	3.04	3.11	0.259	0.77

The effect of the analysed enzyme preparation on the course of ruminal fermentation in lactating cows fed TMR ration in the first period of lactation is presented in

Table 4. The data indicate that compared to the control group (C), use of the enzyme preparation (group E) significantly ($P<0.01$ or $P<0.05$) increased total volatile fatty acids (VFA) and the content of different types of acids in ruminal contents. This may be indicative of the beneficial effect of the enzyme preparation on the rate of starch and NDR degradation in the ration. No statistically significant ($P>0.05$) differences were found between the groups in the pH of ruminal contents, which ranged from 6.3 to 6.5. Likewise, there were no significant ($P>0.05$) differences between the groups in ammonia (NH_3-N) content, the acetic (C2) to propionic acid (C3) ratio and the percentage of different types of acids in total VFA. In cows from group E, slightly higher numerical values were observed compared to the control group (C) for ammonia content and the C2:C3 acid ratio in the ruminal contents. Regardless of the time of rumen sampling (before or after feeding), the percentage ratios of different fatty acid types in total VFA were similar (Table 4).

Discussion

The results obtained in this feeding and physiological trial with cows fitted with permanent rumen fistulas suggest a positive effect of Fibrozyme™ enzyme preparation on the rate and final extent of DM and NDF degradation in meadow hay, DM and starch degradation in barley grain, and DM and CP degradation in soybean meal. For meadow hay, the largest differences between the groups (by about 13 percentage units) were found for NDF degradation at 72 h of incubation. Similar results for DM and NDF degradation in lucerne hay were also reported by Yang et al. (1999), who added exogenous fibrolytic enzymes in liquid form. Likewise, in an *in vitro* study using commercial enzyme supplements, Eun et al. (2007) observed their favourable effect on degradation of hay and maize silage DM, NDF and ADF. A beneficial effect of enzyme preparations (containing xylanase or cellulase or both) on DM, NDF and ADF degradation in roughages was also reported by other authors investigating heifers fitted with permanent rumen fistulas (Feng et al., 1996) and sheep fed meadow hay (Giraldo et al., 2008). Another *in vitro* research (Wylęgała et al., 2006) demonstrated that cellulase, β-glucanase and xylanase added as aqueous solution or powder increased the rate of DM degradation in TMR fed to dairy cows. Meanwhile, Nowak et al. (2003) found DM and NDF degradation to increase only in the initial hours of incubation, whereas Lewis et al. (1999) observed increased degradation of these components at much later incubation times (beyond 32 h).

Our study has confirmed the suggestions of other authors (Feng et al., 1996; Nsereko et al., 2002) that exogenous fibrolytic enzymes added to the rations may stimulate the proliferation of hemicellulose-degrading bacteria in the rumen. As a result, they can improve the rate of roughage NDF degradation in the rumen and the digestibility of cell-wall nutrients. Some authors (Rode et al., 1999) stress that this may be of particular importance in the feeding of high-producing periparturient and early-lactation cows, in which lower feed intake capacity can be compensated by better digestibility. Like in our experiment, other studies (Feng et al., 1996) showed

a positive effect of adding exogenous fibrolytic enzymes on ruminal degradation of concentrate starch and crude protein. It has been noted, however, that the results obtained *in sacco* using the nylon bag technique may be associated with some error (Michalet-Doreau et al., 1987), because many experimental factors, such as the way bags are placed in and removed from the rumen, may influence the rumen milieu and the ultimate results of analysis. However, taking into account the relatively small variation of our results on the degradation of analysed nutrients in incubated feeds, our findings are considered reliable.

The positive results obtained in the physiological and feeding trial using *in sacco* procedure also largely support our findings concerning the fermentative activity of the rumen in lactating cows fed a TMR diet. The higher total volatile fatty acids (VFA) and the higher content of basic types of acids (acetic, propionic and butyric) in the rumen samples, which we found in cows supplemented with fibrolytic enzymes (group E) compared to cows from the control group (C), may be evidence of a favourable effect of the enzyme composite on the rate of starch and NDF degradation in the ration. The similar results obtained in both groups (K and E) for pH value and concentration of ammonia (NH_3-N) in the rumen as well as percentage of different types of acids in total VFA indicate that when cows have constant access to the TMR diet, the addition of fibrolytic enzymes has no significant effect on these parameters. It should be mentioned, however, that in both groups the pH values of ruminal contents were similar (6.3–6.5), which is indicative that they become stable when cows are fed TMR diets. This also shows that under these feeding conditions rumen microorganisms perform well, the digestion and metabolism of structural carbohydrates take a normal course, and the supply of energy components and nitrogen compounds in the diet are well synchronized. The slightly lower pH values (by 0.03–0.05) obtained postprandially compared to pH values obtained in our study before feeding are also evidence that the diet was well balanced for the dry matter roughage to concentrate ratio, physical structure of TMR diet and the effective fibre content (Osięgłowski and Strzetelski, 2006). In the case of excessive amounts of easily fermented carbohydrates in the diet, this could excessively lower the pH of ruminal contents. As a consequence, this could depress crude fibre digestion and stimulate propionic fermentation, as reflected in a change in the acetic (C2) to propionic acid (C3) ratio in favour of the latter acid and shorten the rumination of the solid fraction of digesta, which was not observed in the present study. Similar results to ours for pH value and NH_3-N concentration in the ruminal contents of cows fed TMR diets supplemented with different enzyme preparations (xylanase or cellulase or both) were reported by other authors *in vivo* (Beauchemin et al., 2003; Giraldo et al., 2008; Pinoz-Rodriguez et al., 2008) and *in vitro* (Giraldo et al., 2007). Also experiments with sheep fed diets high in meadow hay (Giraldo et al., 2008) or bulls fattened with diets high in crushed barley grain with straw or barley silage (Krause et al., 1998) showed a generally favourable effect of exogenous fibrolytic enzymes on digestion in the rumen, especially with regard to the degradation of ADF and barley grain starch. Another study (Beauchemin et al., 2000) with dairy cows demonstrated that the use of exogenous fibrolytic enzymes only caused a tendency for increased total VFA and acetic acid in the ruminal contents. As suggested by some authors

(Sutton et al., 2003), it can be assumed that the different results for the digestive activity of the dairy cows' rumen obtained in different experiments could be due to environmental factors, in particular feed type, feed allocation method, the type of enzyme blend and the lactation period.

It is concluded that the addition of exogenous fibrolytic enzymes in the form of Fibrozyme™ containing a blend of active xylanase and cellulase to the standard ration increases *in sacco* degradation of DM, NDF, starch and CP in the rumen of cows. The addition of the enzyme blend containing active xylanase and cellulase to the concentrate contained in the TMR diet for early-lactation Polish Holstein-Friesian cows increases total volatile fatty acids (VFA) and the content of different types of acids in the ruminal contents. Meanwhile, the dietary supplement used in cows yielding 30–35 kg milk/day and fed complete diets in the initial period of lactation has no significant effect on pH changes, ammonia concentration and percentages of different acids in total VFA and the acetic (C2) to propionic acid (C3) ratio in the ruminal contents of the cows.

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Wpływ dodatku enzymów fibrolitycznych do dawek dla krów mlecznych na aktywność trawienną żwacza

STRESZCZENIE

Celem badań było określenie czy dodatek egzogennych enzymów fibrolitycznych w postaci preparatu Fibrozyme™ zawierającego kompozycję aktywnej ksylanazy i celulazy do dawek pokarmowych dla krów mlecznych rasy polskiej holsztyńsko-fryzyjskiej czb wpłynie korzystnie na rozkład suchej masy, białka ogólnego, skrobi i NDF w żwaczu oraz jego aktywność fermentacyjną. W doświadczeniu 1, wykonanym na krowach zasuszonych z trwałymi przetokami żwaczowymi, określano metodą *„in sacco"* rozkład komponentów objętościowych – włóknistych (siano łąkowe), treściwych – skrobiowych (jęczmień) i treściwych – wysokobiałkowych (poekstrakcyjna śruta sojowa). Badania strawności wymienionych pasz przeprowadzono po 21-dniowym okresie żywienia standardową dawką pokarmową bez lub z dodatkiem preparatu enzymatycznego, stosując określony dla poszczególnych komponentów

czas inkubacji (godziny): 2–72 dla siana; 2–48 dla śruty jęczmiennej i 4–24 dla poekstrakcyjnej śruty sojowej. Po zakończeniu inkubacji wyliczano rozkład SM i NDF siana, SM i skrobi ziarna jęczmienia oraz SM i BO poekstrakcyjnej śruty sojowej. W doświadczeniu 2, przeprowadzonym na krowach dojnych żywionych mieszanką pełnoporcjową (TMR), określano odczyn pH i zawartość amoniaku, sumę LKT, zawartość poszczególnych kwasów tłuszczowych i ich procentowy udział w sumie LKT, a także stosunek kwasu octowego (C2) do propionowego (C3) w treści żwacza pobranej sondą. Doświadczenie przeprowadzono na 12 krowach (po 6 szt.) będących w pierwszym okresie laktacji. Treść żwacza pobierano dwukrotnie sondą z pompą ssącą po 21-dniowym okresie żywienia krów dawką TMR bez lub z dodatkiem preparatu enzymatycznego: przed rannym karmieniem i 3 godziny po zadaniu paszy. W obu doświadczeniach preparat dodawano codziennie do mieszanki treściwej wchodzącej w skład dawki pokarmowej. Stwierdzono, że dodatek egzogennych enzymów fibrolitycznych do standardowej dawki pokarmowej złożonej z siana łąkowego i mieszanki treściwej istotnie wpłynął na poprawę rozkładu in sacco SM i NDF siana łąkowego, SM i skrobi ziarna jęczmienia oraz SM i BO poekstrakcyjnej śruty sojowej w żwaczu. U krów dojnych żywionych dawką kompletną (TMR) wykazano, że dodatek preparatu enzymatycznego spowodował również istotny wzrost sumy LKT oraz zawartości poszczególnych rodzajów kwasów tłuszczowych w treści żwacza. Nie stwierdzono natomiast istotnego wpływu stosowanego dodatku paszowego na pH, zawartość amoniaku w żwaczu, procentowy udział poszczególnych kwasów w sumie LKT oraz stosunek kwasów octowego (C2) do propionowego (C3) w żwaczu.