

# Effects of silage fermentation quality on ruminal fluid parameters

Jonas Jatkauskas,

Vilma Vrotniakienė

*Department of Animal Nutrition and Feeds,  
Institute of Animal Science,  
Lithuanian Veterinary Academy,  
Baisogala, Lithuania*

The effects of using a microbial inoculant (lactic acid producing bacteria *Lactobacillus plantarum* and *Pediococcus acidilactici* in mixture with the enzyme cellulase) or a formic acid-based chemical additive on the fermentation quality, aerobic stability and nutritive value of legume–grass silages were examined. Fermentation parameters in ruminal fluid, nutrient digestion, dry matter intake of silages and cattle performance were evaluated. Untreated silage served as control. The addition of the inoculant resulted in well preserved silage with a significantly lower ( $p < 0.01$ ) pH, acetic acid and butyric acid contents and significantly higher ( $p < 0.01$ ) lactic acid contents. Inoculation decreased ( $p < 0.01$ ) protein breakdown as measured by ammonia-N concentration with values of 64.2 (C), 35.4 (I) and 53.6 (A) g kg<sup>-1</sup>N. The addition of the formic acid-based additive restricted fermentation and successfully preserved water-soluble carbohydrates. Also, the formic acid-based additive resulted in the least aerobic spoilage in silage. Both additives significantly increased dry matter and organic matter digestibility (*in vivo*) when fed to sheep. Rumen fermentation was affected by the type of silage. When ruminal fluid samples ( $n = 3$ ) were analyzed, the number of protozoa tended to be higher with A-treated silage. Rumen pH, ammonia-N, total volatile fatty acids (VFA) did not differ between diets in the mean values, but the proportion of acetate was significantly lower ( $p < 0.05$ ) with I-treated silage and the proportion of propionate was significantly higher ( $p < 0.01$ ) when I and A silages were fed compared with C silage.

**Key words:** lactic acid bacteria, fermentation, silage, cattle, ruminal fluid, digestion

## INTRODUCTION

Silage fermentation is an exceptionally complex process involving biochemical interactions among the forage, microbial populations and the ensiling environment [1]. Successful silage production depends upon the promotion of the fermentation brought by beneficial bacteria [2, 3]. Due to a high buffering capacity and low water-soluble carbohydrate content herbage can be difficult to ensile and the degradation of protein can occur during ensilage [4, 5]. Silages that are poorly conserved may also be unstable when exposed to air, when yeasts that oxidize the preserving acids generally initiate aerobic spoilage [6]. The objective of using silage additives

is to ensure that lactic acid bacteria dominate the fermentation which results in well-preserved silage and reduced dry matter losses [7–9].

Application of formic acid restricts silage fermentation and preserves water-soluble carbohydrates in the silages [7, 10, 11], and in many studies the general effects have been an increased silage intake and a beneficial effect on cattle performance [7, 12, 13].

Because of an increased interest in ecological farming in Europe and the safety of the use of additives, inoculants have become more important in recent years. Many studies have reported a positive effect of bacterial inoculants on silage quality, nutrient losses, the extent of protein breakdown during ensilage, milk or meat production and nitrogen efficiency in cattle [9, 13, 14]. However, due to differences among microbial strains or herbage used for silage, experimental results obtained with one product or one silaging herbage cannot be extrapolated to another. Cattle production in Lithuania

Correspondence to: Dr. Jonas Jatkauskas, Institute of Animal Science of Lithuanian Veterinary Academy, R. Žebenkos 12, Baisogala LT-82317, Radviliškis distr., Lithuania. E-mail: lgi\_pts@siauliai.omnitel.net

generally involves indoor feeding seven months per year. Over 70% of the feed used is roughage, of which 60–70% is preserved as grass and legume–grass silage.

The extent of fermentation of water-soluble carbohydrate (WSC) during ensilage into lactic acid and VFA can change the end-products of rumen fermentation. End-products of lactic acid fermentation in rumen may be very depending on microbial population and rumen pH. The majority of published reports indicate that propionate is the main end-product of lactate fermentation with grass silage-based diets [15]. Diets based on restrictively fermented grass silages, which are high in water WSC and low in lactate, favour a rumen fermentation pattern rich in butyrate or acetate and low in propionate. Silages low in WSC and high in lactic acid have increased the proportion of propionate in ruminal fluid [16]. The rumen fluid of animals feeding on silages alone had higher coefficients of rumen transformation as well as a higher number of protozoa [17]. In the majority of trials reported in the literature, silages treated with inoculants appeared to be more digestible than untreated silages [4]. The ingestion of silage fermentation end products may modify the rumen fermentation pattern and nutrient digestion, the intake of forage and performance of animals. The profile of VFA formed in the rumen also has environmental consequences, because methane emissions by ruminants are involved in the global climate change. There are uncertainties in the estimates, but approximately 14% of methane emissions may be caused by domestic animals of which 97% are ruminants [18].

The objectives of the present study were 1) to determine the effects of a fermentation stimulator (bacterial strains of *Lactobacillus plantarium* and *Pediococcus acidilactici* and enzyme cellulase) and a fermentation inhibitor, formic acid, ammonium tetraformate, propionic acid and ethylbenzoate on silage fermentation characteristics, and 2) to assess how silages with different levels of fermentation end products are related with the ruminal fermentation parameters, nutrient digestion and growth of fattening bulls.

## MATERIALS AND METHODS

**Ensiling procedure and treatments.** Big bale silages were made from a 2-year-old second cut mixed legume grass sward composed of 72% red clover (*Trifolium pratense* L. cv. Arimaiciai), 20% timothy (*Phleum pratense* L. cv. Gintaras), 5% meadow fescue (*Festuca pratensis* Huds. cv. Kaita) and 3% of other grass. At harvesting, timothy was in heading maturity. The three additive treatments were: 1. No additive (C); 2. Treatment with lactic acid producing bacteria (*Lactobacillus plantarium*, NCIB 30083; 30084 and *Pediococcus acidilactici*, NCIB 30085, 30086 [ $\text{min } 6.7 \times 10^{10} \text{ CFU g}^{-1}$ ] and the enzyme cellulase – 43000 HEC [HEC – cellulase activity as the release of reducing sugars from hydroxyethylcellulose  $\text{g}^{-1}$ ], Medipharm, Sweden) (I). The target

level of inoculant addition was  $10^6 \text{ cfu g}^{-1}$  fresh grass; 3. Treatment with a formic acid based additive, AIV 2000 (formic acid  $523 \text{ g kg}^{-1}$  ( $\text{CH}_2\text{O}_2$ ), ammonium formate  $261 \text{ g kg}^{-1}$  ( $\text{HCOONH}_4$ ), propionic acid  $54 \text{ g kg}^{-1}$  ( $\text{C}_3\text{H}_6\text{O}_2$ ), ethyl benzoate  $11 \text{ g kg}^{-1}$  ( $\text{C}_9\text{H}_{10}\text{O}_2$ ), Kemira Chemicals Oy, Finland) (A). The target level of the AIV 2000 was  $6 \text{ l t}^{-1}$  fresh grass. All silages were made from one field on the same day. Five big bale silages from each treatment (C, I, A) were weighed after wrapping and again after 90 days of storage for measuring DM losses.

**Sampling and analytical methods.** Representative samples of the herbage were taken directly from the swath during silage making time, and one composite herbage sample was taken for every sixth–seventh bale. Herbage samples were chopped and subsampled prior to analysis. Silages were sampled from every ninth bale from each treatment during the feeding trial (28 November 2003 to 1 May 2004) which commenced 98 to 248 days after ensiling. Silage samples were chopped and subsampled prior to analysis. The buffering capacity of the herbage was analyzed according to Playne and McDonald [19]. Fresh herbage and silage dry matter (DM) content was determined by oven drying at  $67^\circ\text{C}$  for 24 h, equilibrated to room humidity overnight, milled through a 1.00 mm sieve and further dried at  $105^\circ\text{C}$  to the constant weight. Standard methods [20] were used for chemical analysis of feed and faeces.

**Total N content** was determined by the Kjeldahl method with the Kjeltect System 1002 apparatus (Foss Tecator, Sweden).

**Ammonia concentration** was determined using a Kjeltect System 1002 (Sweden) and procedure 920.03 from the Association of Official Analytical Chemists (AOAC).

**WSC** was estimated by the anthrone method of Thomas [21].

For determination of **crude fibre** the AOAC method 962.09 and the Fibercap2021 system (Foss Tecator AB, Sweden) were used.

**Neutral detergent fibre (NDF)** [22] and **acid detergent fibre (ADF)** [23] were analyzed using the Ankom filter bag technology (USA) with the Ankom fiber analyzer.

**Lactic acid, VFA** were determined on an aqueous extract for fresh silage by the standard methods [24].

The **pH value** of silages was determined electrometrically using a pH-meter.

**Aerobic stability measurement.** Aerobic deterioration of silages was measured by an increase in temperature. Representative silage samples (200 g) from five bales from each treatment (one bale was one replicate) were incubated in open plastic bags in polystyrene boxes (volume about 1.5 l, wall thickness 10 mm) with an opening (diameter 25 mm) in the lid of the box through which the rest of the plastic bag was pulled and opened so that air could freely pass through. A temperature probe was inserted into the mid point of silage through

the opening. The boxes were kept at a steady room temperature ( $\approx 20$  °C). The temperature of the samples was measured once a day following exposure for 10 days. The time of measurement was also recorded. Aerobic stability was defined as the time needed to increase the temperature by 2 °C above the ambient temperature.

**In vivo digestibility study.** *In vivo* digestibility of silages was studied in trials including four wethers per treatment. The animals were fed silage at maintenance level for 14 days for adaptation and the further 7 days for collection of faeces. Faeces were subsampled daily and stored at +1 °C for laboratory analysis.

**Physiological and feed intake study.** In the physiological study, fifteen Lithuanian Black-and-White bulls (initial live weight 312 kg) were used in accordance to analogue groups design with pre-experimental (24 days) and experimental (126 days) periods. After the pre-experimental period the animals were divided into three blocks of 5 animals according to live weight and were at random allocated to the treatments within each block. Silage was offered *ad libitum* and a concentrate 2.37 kg d<sup>-1</sup> in two portions (barley 800, protein-mineral-vitamin mixture 200 g kg<sup>-1</sup>). The animals were fed individually and silage intake data were recorded every week, and the animals were weighed on two consecutive days on the starting and last days of experiment and monthly during the experimental period. Ruminal contents were collected with a stomach tube from three bulls within each of three different silages and obtained approximately 1.5 h after feeding; pH and ammonia concentrations were determined in fresh samples. Aliquots of samples were fixed in formal-saline for protozoal enumeration. Volatile fatty acids, lactate and protein were also determined.

**Statistical analysis.** The results were analysed by one-way analysis of variance (ANOVA). The diet represented the intersubject factor where subjects were bulls

in this case. The differences between treatment means were tested using the Fisher's least significant difference (LSD) [25]. All differences quoted in the text are significant at the 0.05 level unless stated otherwise.

## RESULTS

### Crop and silage quality

The herbage ensiled in this experiment had a low DM (179 g kg<sup>-1</sup> FM) and WSC (97 g kg<sup>-1</sup> DM) content, and the content of crude protein was medium (166 g kg<sup>-1</sup> DM). The buffering capacity was high (619 mequiv kg<sup>-1</sup> DM), but at a normal level for a second cut legume-grass sward.

The chemical composition and fermentation characteristics of the silages are shown in Table 1. The treatment with the bacterial inoculant resulted in a well preserved silage with a lower ( $p < 0.01$ ) pH, butyric acid and ammonia content compared with the untreated silage. As intended, inoculated silage contained more (by 12.1 g kg<sup>-1</sup> DM,  $p < 0.01$ ) fermentation acids and three time less ( $p < 0.01$ ) acetic acid compared to untreated silage. The content of crude fibre was lower by 39.2 g kg<sup>-1</sup> DM ( $p < 0.01$ ) for the inoculated silage compared to the untreated silage. The reason for this improvement is that fiber-degrading enzymes liberate soluble sugars from plant cell walls, making them available to lactic acid bacteria for lactic acid production. The content of different fibre fractions (ADF, NDF) were not affected significantly by silage additive. Treatment with a chemical additive restricted fermentation, and these silages contained less ( $p < 0.01$ ) fermentation acids than inoculated or untreated silages. Compared with the control, lactic acid concentrations were higher ( $p < 0.01$ ) in silages treated with a chemical additive, but lower than in inoculated silage. Acetic acid concentrations of chemically treated silages were lower ( $p < 0.01$ )

Table 1. Composition of the silages in the experiment

	Treatment			LSD <sub>0.05</sub>	S <sub>x</sub>
	Control	Inoculant	Formic acid-based		
DM, g kg <sup>-1</sup>	214.5	237.3**	226.9**	5.018	0.72
Crude protein, g kg <sup>-1</sup> DM	146.4	165.6**	167.0**	11.274	2.29
Crude fibre, g kg <sup>-1</sup> DM	270.4	231.2**	259.8	11.193	1.43
NDF, g kg <sup>-1</sup> DM	517.6	504.3	513.2	19.859	1.26
ADF, g kg <sup>-1</sup> DM	400.4	393.9	398.3	16.256	1.33
WSC, g kg <sup>-1</sup> DM	43.9	45.9	54.2**	3.789	2.56
pH	4.51	4.28**	4.30**	0.073	0.54
Total acids, g kg <sup>-1</sup> DM	60.6	72.7**	56.4**	0.804	0.41
Lactic acid, g kg <sup>-1</sup> DM	31.5	62.8**	43.2**	2.542	1.80
Acetic acid, g kg <sup>-1</sup> DM	25.4	8.56**	12.68**	1.824	3.80
Butyric acid, g kg <sup>-1</sup> DM	2.85	0.26**	0.14**	0.373	11.23
Ammonia N, g kg <sup>-1</sup> total N	64.2	35.4**	53.6	8.871	5.64
DM losses, g kg <sup>-1</sup> DM	11.41	9.29*	9.26*	1.675	4.85
Metabolizable energy, MJ kg <sup>-1</sup> DM	8.51	9.11**	9.03**	0.033	0.12

\* and \*\* denote significance level of 0.05 and 0.01, respectively.

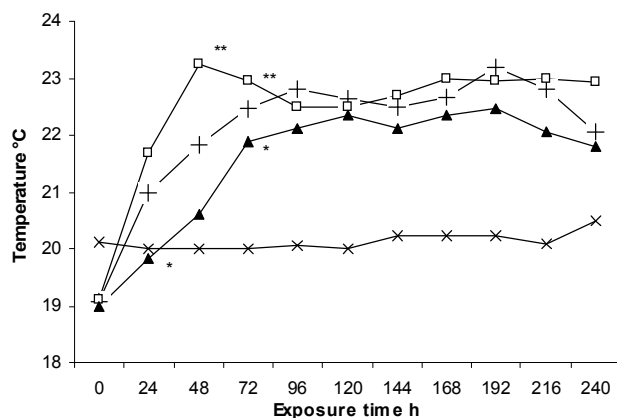
compared with control silages, but higher than those of inoculated silages. Silages treated with a formic acid based additive had the lowest ( $p < 0.01$ ) butyric acid concentrations, but ammonia-N concentration did not differ as compared with control silages. The content of residual WSC in the silages reflected the extent of fermentation, therefore, the content of residual WSC was higher by  $10.3 \text{ g kg}^{-1}\text{DM}$  ( $p < 0.01$ ) in the chemically treated silage. Dry matter losses were less by 7.0% and 6.1% ( $p < 0.05$ ) for the in inoculated and formic acid-based treated silages as compared with untreated silage.

### Aerobic stability

Inoculated silage was more prone to aerobic deterioration than the chemically treated silage (Figure). Inoculated silage started heating 24 to 36 h after its fresh samples were removed from the bale and put into boxes. This was sooner than for untreated ( $p < 0.01$ ) and chemically treated silage. Inoculated silage showed a temperature rise of more than  $2^\circ\text{C}$  within 24 h, untreated silage in more than 48 h, while chemically treated silage within 120 h.

### Nutrient digestion

The effects of different silage treatments on silage digestibility for sheep are shown in Table 2. Dry matter and



**Figure.** Effect of additive treatment on the aerobic stability of legume-grass silages. —+—, control; —□—, inoculant; —▲—, formic acid-based additive; —×—, ambient temperature; \* and \*\* denote significance level of 0.05 and 0.01, respectively

**Table 2.** *In vivo* digestibility of experimental silages for sheep

	Treatment			LSD <sub>0.05</sub>	S <sub><math>\bar{x}</math></sub>
	Control	Inoculant	Formic acid-based		
<i>In vivo</i> digestibility, %					
Dry matter	59.8	63.7**	63.8**	2.273	1.05
Organic matter	62.2	66.1*	66.2*	3.647	1.43
Crude protein	60.1	60.5	64.3*	3.299	1.36
Crude fat	67.4	68.1	68.4	3.718	1.39
Crude fibre	54.3	59.2*	57.3	4.827	2.16
Nitrogen free extracts	61.3	65.2*	64.3	3.731	1.49

\* and \*\* denote significance level of 0.05 and 0.01, respectively.

organic matter digestibility *in vivo* was increased ( $p < 0.01$ ) under inoculant or formic acid-based treatment compared with untreated silage. Inoculation increased ( $p < 0.05$ ) the digestibility of crude fibre and nitrogen free extracts, and formic acid-based treatment increased ( $p < 0.05$ ) the digestibility of protein in silage. Therefore silages treated with inoculant and formic acid based additive had a significantly higher energy concentration. No significant ( $p > 0.05$ ) differences in nutrient digestibility were observed between inoculated or chemically treated silages.

### Fermentation parameters in ruminal fluid and feed intake

Rumen pH, ammonia-N or total VFA concentration did not differ among the diets in their mean values (Table 3). The minimum pH after feeding was lowest with untreated (C) silage, and the highest value of ammonia-N was observed also with C silage. The molar proportion of butyrate was not affected, but the proportion of acetate was significantly lower ( $p < 0.05$ ) with inoculant-treated silage than with C silage. The proportion of propionic acid was significantly higher ( $p < 0.01$ ) when I and A silages were fed as compared with C silage. The molar proportion of isovalerate was numerically lower in I diet and significantly lower ( $p < 0.05$ ) in A diet as compared with C diet. The number of rumen protozoa tended to be higher with A treated silage, but the difference was not significant. When compared to the ruminal fluid from the bulls offered C silage, the acetate: propionate ratio was significantly lower ( $p < 0.01$ ) in I or A silages offered bulls' samples.

All silages were consumed readily and there were no significant differences among treatments, however, the intake of inoculated and formic acid-based additive treated silages tended to be higher than in untreated ones ( $8.47$  and  $8.28$  vs  $7.86 \text{ kg DM d}^{-1}$ ). Thus, live-weight gain tended to be higher with inoculated or chemically treated than with untreated silages ( $1.22$  or  $1.21$  vs  $1.12 \text{ kg d}^{-1}$ ).

### DISCUSSION

The type and extent of silage fermentation depends on the composition of herbage ensiled, DM, crude protein and WSC contents. In our experiment, legume-grass

Table 3. Rumen fermentation in cattle (end of experiment) given diets with differently treated silage

	Treatment			LSD <sub>0.05</sub>	S <sub>x̄</sub>
	Control	Inoculant	Formic acid-based		
Rumen fermentation:					
protozoa, 10 <sup>5</sup> ml <sup>-1</sup>	4.49	4.54	4.98	0.613	3.34
pH	6.77	6.74	6.74	0.282	1.06
total VFA, mmol l <sup>-1</sup>	95.9	98.0	96.0	10.120	2.67
acetate, mol.%	61.90	57.46*	59.47	2.722	1.16
propionate, mol.%	16.73	21.77**	21.45**	1.622	2.07
isobutyrate, mol.%	1.68	1.50	1.33	0.305	5.16
butyrate, mol.%	14.65	14.88	14.10	2.167	3.80
isovalerate, mol.%	2.05	1.68	1.47*	0.398	5.84
valerate, mol.%	1.97	1.76	1.67	0.285	4.03
caproate, mol.%	1.01	0.95	0.52*	0.361	11.11
AP <sup>1</sup> ratio	3.70	2.64**	2.77**	0.316	2.65
ABP <sup>2</sup> ratio	4.57	3.33**	3.43**	0.354	2.39
Ammonia-N mmol l <sup>-1</sup>	9.11	8.03	8.61	1.368	3.62

\* and \*\* denote significance level of 0.05 and 0.01, respectively; AP<sup>1</sup> = acetate / propionate; ABP<sup>2</sup> = (acetate + butyrate) / propionate.

sward was harvested in rainy weather conditions, leading to the harvest of forage with low DM and WSC contents. The difficulty of ensiling such forage was shown in the findings of other authors [2, 4, 26]. The higher DM content in silages with additives compared with untreated silages may be explained by addition of DM to silages with additives as well as delays in the fermentation processes in untreated silages, which cause DM losses [27]. Both additive treatments reduced the pH of the silages to desirable levels for unwilted silages [4]. The ordinary silages had a significantly higher pH. Although the WSC content of the legume–grass sward as ensiled was low and the buffering capacity rather high, the untreated silage was poorly preserved, with high contents of acetic and butyric acids. The data presented in this paper show that inoculation with the lactic acid producing bacteria *Lactobacillus plantarum* and *Pediococcus acidilactici* in mixture with cellulase increased the extent of acidification and lactic acid production compared with the untreated silage. This can be explained by the fact that inoculants are added to silage to compensate for low levels of lactic acid bacteria in the crop and to introduce a homofermentative flora that can rapidly begin producing lactic acid [3, 6, 9]. As compared with the untreated silage, the inoculant reduced proteolysis and lowered protein breakdown as indicated by the lower ( $p < 0.01$ ) ammonia-N content. The control silages had excessively high concentrations of ammonia-N. Winters et al. [13] found that inoculation with *L. plantarum* improved silage quality and reduced the extent of protein breakdown during ensilage of red clover, possibly because the rapid production of acids reduces the liberation of ammonia. In crops containing low amounts of fermentable sugars, ammonia production can be a major cause of an unacceptable yield, since in the presence of NH<sub>3</sub> more lactic acid is requir-

ed to reduce pH to a stable level [28]. The inoculant with enzyme treatment significantly ( $p < 0.01$ ) lowered the content of crude fibre in silage. Fibre-degrading enzymes liberate soluble sugars from plant cell walls, making them available to lactic acid bacteria for production of lactic acid, and this thesis agreed with our experimental data where the inoculated silage had the highest amount of lactic acid. The decrease in fiber content may be due to partial acid hydrolysis of hemicelluloses. Some data suggest that certain microbial inoculants can increase fiber digestion [29]. The content of different fibre fractions (ADF, NDF) were not affected significantly by silage additives [7]. The chemically treated silage contained less fermentation acids as compared with the inoculated or untreated silages, but more ( $p < 0.01$ ) lactic acid as compared with the untreated silage. The contents of WSC reflected the extent of fermentation, because in the chemically treated silage WSC was preserved more efficiently ( $p < 0.01$ ). The higher production of acetic acid under chemical treatment compared with inoculation indicates a more heterolactic type of fermentation with a chemical additive. Also, it could be that enterobacteria were not sufficiently inhibited by the acids added [7]. Acetic acid always produces higher losses than lactic acid in a homofermentative pathway [4]. The two additive treatments were able to reduce clostridial fermentation and acetic acid concentrations and to decrease ( $p < 0.01$ ) DM losses.

The poor aerobic stability of inoculated silage in our experiment was probably related to high initial numbers of yeasts in the silages of opening [7]. The greater rates of aerobic deterioration with the inoculant-treated silages are likely to be due to the fact that some lactic acid bacteria can, under conditions of hexose limitation, metabolize lactic acid as an energy source under aerobic conditions [30]. This is also can be due to a lower

content of acetic acid and other potential antifungal end products, because acetic acid is a known inhibitor of yeast and mould growth [31]. A field study in Norway also showed that inoculant-produced silage evokes more frequent problems of self-heating in comparison with the use of formic acid-based additives [32]. Our study therefore supports the findings of Adesogan and Salawn [33] who reported that the silage treated with a formic acid-based additive was stable for over 5 days.

The *in vivo* digestibility trials with sheep at maintenance level showed that the digestibility of dry matter and organic matter were higher with inoculation and formic-acid based additive treatment as compared with the untreated silage. The effect of treatments on digestibility could be due to reduced aerobic losses during ensilage and reduced losses through fermentation [7]. Therefore good fermentation in the silo would yield more energy for rumen microbes and support greater rates of nutrients digestion. The digestibility of crude fibre was significantly higher with inoculation. The effect of inoculation on the digestibility of crude fibre could be caused by the lowered content of crude fibre due to the activity of fiber-degrading enzymes. The digestibility of crude protein and nitrogen-free extracts was significantly higher with chemical treatment than without it. The observation that formic acid-based additives resulted in a higher nutrient digestibility was reported by many authors [4, 7, 27, 33].

The quantity of forage consumed depends on the rate of removal of previously ingested feed from the rumen by the competing processes of digestion and passage. Inoculation gave the highest DM intake from the legume-grass silages. This occurred due to a very good silage quality obtained with the inoculant as far as ammonia-N and volatile fatty acids were concerned. This result confirms the study of Gordon [34] in which inoculant silage showed a higher intake and better performance than formic acid-treated silage. Our results do not conform with the studies of Selmer-Olsen and Mo [7], Winters et al. [8] and others, in which the inoculant gave a lower intake than formic acid-treated silage. High levels of ammonia-N, acetic and butyric acids decreased the voluntary intake of untreated silage. A high concentration of acids in silages has been reported to reduce the intake [35] and acetic acid has been identified as a suppressor of the intake [4]. Despite a substantial difference in silage pH, the rumen pH (on average 6.75) was not affected by the diet, probably due to the buffering capacity of saliva. The proportion of acetate in the rumen fluid was smaller with an inoculant than without any additive (57.5 vs 61.9 mol. %;  $p < 0.05$ ), contrary to propionate (21.8 vs 16.7 mol. %;  $p < 0.01$ ). Probably lactic acid of silage was transformed into propionate in rumen [36, 37]. Acetate and butyrate absorbed from rumen are used for makeweight. Propionate is needed for gluconeogenesis. If there is not enough propionate available, amino acids are used for gluconeogenesis. Similar results gave a formic acid based additive. Average daily gains for the total trial

were not different among the treatments, although bulls fed inoculated or chemically treated silages tended to have a higher average daily gain than bulls fed ordinary made silages. In the two experiments of Kennedy [38] with bigger animals (450 kg), the differences were comparable with our results (60–110 g d<sup>-1</sup>) and were not significant, either.

Differences in the nutrient digestibility, energy and protein values of the three silages can, in part, be attributed to the effect of inoculation or formic acid-based additive treatment on rumen metabolism silage intake and thus on cattle performance [8, 14, 35].

## CONCLUSIONS

The results of our experiment showed that both treatments improved the fermentation quality of silage: the inoculant – by improving the homofermentative fermentation process and the formic acid-based additive by restricting fermentation. Unfortunately, it has been found that the inoculant does not reduce the aerobic deterioration rate of silages.

Rumen fermentation was affected by the type of silage, which explains results of production trials. Inoculated silage with an increased content of lactic acid increased the proportion of propionate needed for gluconeogenesis. The formic acid-based additive restricted fermentation, made silage high in WSC, produced more precursors for muscular synthesis.

The treatment of silages with biological or chemical additives can improve forage intake, average daily gain and feed efficiency. For the optimization of silaging technologies and strategies and the provision for feeding recommendations, experiments with other herbage species or inoculants should be continued.

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**Jonas Jatkauskas, Vilma Vrotniakienė**

### **SILOSO FERMENTACIJOS KOKYBĖS POVEIKIS DIDŽIOJO PRIESKRANDŽIO TURINIO RODIKLIAMS**

#### **Santrauka**

Buvo tiriamas pieno rūgštį gaminančių bakterijų (*Lactobacillus plantarum* ir *Pediococcus acidilactici* derinys su celiuliozės fermentu) – inokuliantu – bei skruzdžių rūgšties pagrindu sukurtos silosavimo priedų efektyvumas siloso fermentacijos kokybei ir pašaro aerobiniam stabilumui. Buvo įvertinti didžiojo prieškrandžio turinio rodikliai, pašaro suėdimas ir maisto medžiagų virškinamumas šeriant penimus galvijus skirtingos fermentacijos silosuotais pašarais. Inokulianto priedas labai pagerino siloso fermentaciją: pH rodiklis, acto ir sviesto rūgšties kiekis buvo patikimai mažesnis ( $p < 0,01$ ), o pieno rūgšties kiekis – patikimai didesnis ( $p < 0,01$ ) lyginant su silosu be priedų. Inokuliantas sumažino ( $p < 0,01$ ) baltymų skilimą, ir tai rodo amoniakinio azoto kiekis: 64,2 (C), 35,4 (I), 53,6 (A) g kg<sup>-1</sup>N. Cheminis priedas slopino fermentacijos procesus (silose buvo mažiau ( $p < 0,01$ ) fermentinių rūgščių ir išliko daugiau ( $p < 0,01$ ) cukraus), ir tai pagerino pašaro aerobinį stabilumą. Chemiškai konservuotu silosu šertų buliukų didžiajame prieškrandyje buvo daugiau infuzorijų. Turinio pH rodiklis, amoniakinio azoto ir bendras lakiųjų riebalų rūgščių kiekis tarp grupių nesiskyrė, tačiau acetato buvo mažiau ( $p < 0,05$ ) I grupėje, o propionato – daugiau ( $p < 0,01$ ) I ir A grupėse lyginant su kontrole. Abu silosavimo priedai pagerino maisto medžiagų virškinamumą.