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Effects of wilted grass silages varying in fermentation quality on rumen fermentation of dairy cows

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ABSTRACT

Four wilted grass silages (dry matter 280 g kg^{-1}) varying in fermentation type were fed to rumen fistulated dairy cows to study the effect of silages on rumen fermentation. All additive treatments improved silage quality compared to untreated silage. Formic acid treated, restrictively fermented silage resulted in increased proportion of acetate, while the silages treated with *Lactobacillus plantarum* increased proportion of propionate of rumen volatile fatty acids.

KEY WORDS: wilted silage, *Lactobacillus plantarum*, potassium sorbate, rumen fermentation

INTRODUCTION

Inoculation using *Lactobacillus plantarum* VTT E-78076 (E76) has resulted in efficient lactic acid fermentation, low pH and small proportion of NH_4-N in wilted grass silage. However, E76 silage has been prone to aerobic deterioration. In laboratory scale silos aerobic stability has been enhanced by potassium sorbate (E202) (Saarisalo et al., 2003a). With unwilted silages an additive affects the type of silage fermentation and consequently the balance of absorbed nutrients and efficiency of animal production (Miettinen, 1997; Huhtanen, 1998). Wilting as such restricts silage fermentation. This experiment was conducted to study the effects of silage additives used for wilted silages on rumen fermentation.

MATERIAL AND METHODS

Four silages were made from first cut timothy-meadow fescue ley wilted for 6-15 h and ensiled in bunker silos. The grass dry matter (DM) was 291 g kg^{-1}

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and it contained crude protein 139, water-soluble carbohydrates (WSC) 131 and NDF 555 g kg^{-1} DM. The four additive treatments were: 1. No additive (NO), 2. AIV®2000 (5.4 l t^{-1}, formic acid 550, ammonium formate 240, propionic acid 50, benzoic acid 10, ethyl benzoate 10 g kg^{-1}, Kemira Chemicals Ltd) (FA), 3. *Lactobacillus plantarum* VTT-E78076 (E76), and 4. E76 + potassium sorbate 300 g t^{-1} (E76S). The target level of the inoculant addition was 10^6 cfu g^{-1} grass.

In the physiological study four rumen fistulated dairy cows were used in a balanced 4 × 4 Latin square design with periods of 14 days. Silage was given *ad libitum* and concentrate 10 kg d^{-1} in four portions (barley 324.5, oats 324.5, sugar beet pulp 150, rapeseed meal 170 and minerals 31 g kg^{-1}; crude protein 166, starch 347 and NDF 209 g kg^{-1} DM). Intake and milk production data from the last six days of each period were used. Rumen fermentation samples were collected on day 13 every 1.5 h from 6.00 to 18.00. Silage, milk and rumen fluid samples were analysed according to the standard procedures of the Animal Nutrition laboratory of MTT.

Intake and milk production data and the daily means of rumen fermentation parameters were tested using the SAS GLM procedure using a model including animal, period and diet. The sums of squares for diet effects were further separated by using orthogonal contrasts into single degree of freedom comparisons: 1. NO vs additives, 2. FA vs E76 and E76S, 3. E76 vs E76S. The rumen fermentation data were tested also with MIXED procedure with a model including sampling time, time × period and time × diet interactions.

RESULTS AND DISCUSSION

In vitro organic matter digestibility of silages was 760 g kg^{-1} DM. Fermentation quality of the silages was good except for NO with increased amount of NH_4-N (Table 1). However, there was a clear difference in the type of fermentation. Proportion of lactic acid of total acids was 0.81, 0.77, 0.91 and 0.91 in NO, FA, E76 and E76S, respectively. Fermentation was most extensive in NO resulting in least WSC (27.4 g kg^{-1} DM) and most acetic acid, butyric acid and ethanol (17.5, 1.0 and 11.0 g kg^{-1} DM). FA restricted fermentation resulting in highest amount of WSC (94.2 g kg^{-1} DM). Silage pH was 0.3 units lower with the inoculants than with NO or FA. Based on small proportions on NH_4-N in E76 and E76S, lactic acid production was fast in the beginning of the ensiling process as has been observed in laboratory scale experiments with E76 (Saarisalo et al., 2003a). Similar fermentation quality of E76 and E76S indicates that potassium sorbate had no effect on the activity of inoculant.

On average silage intake was 12.2 kg DM d^{-1} and there were no differences between the silages. Extensive secondary fermentation and formation of NH_4-N generally decrease silage intake (Huhtanen, 1998). Wilting as such restricts fermentation and therefore differences between additives are likely to be smaller with wilted silages.

Table 1. Fermentation quality of silages, feed intake, milk production and rumen fermentation of dairy cows

Indices	Silage[1]				SEM	Statistical significance[2]		
	NO	FA	E76	E76S		NO vs others	FA vs E76's	E76 vs E76S
Dry matter, g kg^{-1}	280	301	280	261				
pH	4.20	4.17	3.92	3.90				
WSC[3], g kg^{-1} DM	27.4	94.2	50.9	54.6				
Lactic acid, g kg^{-1} DM	82.4	51.0	102.6	108.3				
Ethanol, g kg^{-1} DM	11.03	2.20	4.28	5.13				
Acetic acid, g kg^{-1} DM	17.47	13.51	8.53	8.71				
Propionic acid, g kg^{-1} DM	0.39	0.75	0.61	0.35				
Butyric acid, g kg^{-1} DM	1.00	0.45	0.74	0.82				
NH_4-N, g kg^{-1} N	83.0	75.3[4]	30.5	28.5				
Intake, kg DM d^{-1}								
silage	12.3	12.1	12.2	12.2	0.52			
concentrate	8.4	8.4	8.4	8.3	0.07			
Milk, kg d^{-1}	27.6	26.9	27.9	28.2	0.65			
Energy corr. milk, kg d^{-1}	27.4	28.0	28.1	28.8	0.42			
Milk composition, g kg^{-1}								
fat	41.9	44.6	42.2	43.3	0.87			
protein	32.7	33.1	32.6	33.0	0.25			
lactose	47.7	48.0	47.8	47.8	0.11			
urea mg dl^{-1}	22.4	20.2	22.6	24.2	0.53		**	o
Rumen fermentation								
pH	6.31	6.34	6.25	6.34	0.05			
NH_4, mmol l^{-1}	5.91	7.12	7.98	8.03	0.72	o		
VFA, mmol l^{-1}	107.2	104.2	107.0	107.3	1.32			
mmol mol^{-1} VFA								
acetate	626	645	629	624	3.1		**	
propionate	197	180	201	208	3.9		**	
butyrate	134	136	131	131	3.7			

[1] NO: no additive, FA: formic acid based additive 5.4 l t^{-1}, E76: *Lact. plantarum* VTT E-78076, E76S: E76 + potassium sorbate 0.30 kg t^{-1} ; [2] significance: o ($P<0.10$); * ($P<0.05$); ** ($P<0.01$);
[3] water soluble carbohydrates; [4] 31.3 when corrected with the amount added in the additive

Energy corrected milk yield was smaller with NO than with treated silages (27.4 vs 28.3). However, the difference was not statistically significant ($P=0.13$). Numerically milk fat, protein and lactose concentrations increased with FA compared with inoculated silages ($P>0.05$). Likewise in the production trial with the same silages FA tended to increase fat and protein concentrations ($P<0.10$; Saarisalo et al., 2003b).

Despite substantial difference in silage pH, rumen pH (on average 6.31) was not affected by diet, probably due to buffering capacity of saliva. Time x diet interaction was not significant for the rumen parameters except for the proportion of butyrate. Diurnal variation was very small with inoculated silages while with NO and FA butyrate proportion was low before feeding but rapidly increased above the levels of E76 and E76S after feeding.

Proportion of acetate was smaller with inoculants than with FA (627 vs 645 mmol mol^{-1}; P>0.01) while the opposite was observed for propionate (205 vs 180 mmol mol^{-1}; P>0.01). Probably lactic acid of silage was transformed into propionate in rumen (Jaakkola and Huhtanen, 1992). Acetate and butyrate absorbed from the rumen are used for milk fat synthesis. Propionate is needed for gluconeogenesis and synthesis of milk lactose. If there is not enough propionate available, amino acids are used for gluconeogenesis (Huhtanen, 1998).

CONCLUSIONS

All the treatments improved fermentation quality of silage compared with the untreated. Potassium sorbate had no effect on function of inoculant.

Rumen fermentation was affected by the type of silage, which explains results of production trials. Inoculated silages with increased amounts of lactic acid increase proportion of propionate needed for gluconeogenesis. Restrictively fermented silage high in WSC produced more precursors for milk fat synthesis.

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