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Maize silage supplementation to lower quality grass silage improves the intake, apparent digestibility and N retention in wether sheep

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Summary

The objective of this experiment was to study the effects of interactions between lower quality grass silage (GS) dominated by orchardgrass (*Dactylis glomerata* L.) and maize silage (MS) (*Zea mays* L.) on ad libitum intake, digestibility and N retention in wether sheep. The study consisted of four feeding treatments involving GS and MS alone, and GS and MS mixtures in ratios of 67:33 or 33:67 (DM basis) fed twice daily. The GS was harvested at the beginning of flowering of orchardgrass (about 35 % of plants were in flower) while the MS used was of lower DM and starch concentration (264 g kg^{-1} fresh weight and 211 g kg^{-1} DM respectively). Mean DM content of GS was 408 g kg^{-1} fresh weight. MS was lower in crude protein (CP) (62 g kg^{-1} DM) than the GS (98 g kg^{-1} DM) ($P<0.001$). GS contained larger quantities of neutral detergent fibre (NDF) and acid detergent fiber (ADF) ($P<0.001$) than MS. Inclusion of MS in the diet (33 % vs. 67 %) had positive linear effects on fresh matter (FM) voluntary intake ($P<0.05$), digestibility of DM, organic matter (OM), digestible OM in the DM (D-value) ($P<0.05$), starch digestibility ($P<0.05$), N intake ($P<0.01$), N output in faeces ($P<0.05$) and absorbed N ($P<0.05$). A positive associative effect of GS and MS was observed for all intake parameters measured (FM, DM, OM, NDF) (quadratic, $P<0.05$ to $P<0.01$), digestibility of DM, ADF (quadratic, $P<0.05$), CP (quadratic, $P<0.01$), N intake and absorbed N (quadratic, $P<0.01$). It was concluded that positive interactions of GS and MS were recorded for a limited number of parameters because of the lower quality MS than required for the full benefit of two forages fed together.

Key words: grass silage, maize silage, intake, digestibility, N retention

Introduction

Silage quality can be estimated in terms of the chemical composition, fermentation characteristics, intake and digestibility of nutrients (Vranić et al., 2008a, 2009a, 2009b; Knežević et al., 2009). Early harvest grass silage (GS) ensures higher intake, digestibility, nitrogen (N) intake and dry matter (DM) degradability in comparison with the medium and late cut GS due to better balance between protein and available energy (Knežević et al., 2009; Vranić et al., 2008a, 2009b). GS proteins are extensively degraded in the rumen, but microbial protein synthesis in the rumen of animals fed with grass sila-

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ge as sole diet is low due to a lack of energy. Energy supplements to improve the nutritional value of GS based diets have been investigated (Fitzgerland and Murphy, 1999; Phipps et al., 1992b, 1995) but maize silage (MS) is frequently used because of its high energy yield per unit area and high feeding value (Chenais et al., 1997; Fitzgerland et al., 1994; Phipps et al., 1992a, 2000).

Inclusion of MS into early cut grass silage had a positive associative effect on DM and organic matter (OM) intake, N intake and N balance, but no positive responses were recorded for digestibility (Knežević et al., 2007a; 2007b; Vranić et al., 2008b) due to lower MS quality (lower starch concentration) than required for improved utilization of early cut GS. In contrast, the inclusion of MS into grass silage, harvested at late flowering, improved all the parameters measured (intake, digestibility and N balance) (Vranić et al., 2007) because MS was a sufficient energy source to improve utilization of low-quality, late cut GS. Positive responses could be expected when the GS to be replaced is of lower quality than the included forage substitute (Weller et al. 1991).

The combination of lower and higher quality GS than described in previous papers (Knežević et al., 2007b; Vranić et al., 2007, respectively) and MS was offered under the hypothesis that feeding a mixture of these supplements would have positive associative effects on food intake, digestibility and N retention in sheep. The objective of this experiment was to examine the effects of interactions between lower quality GS, dominated by orchardgrass (*Dactylis glomerata L*), and MS on feed intake, digestibility and N retention in wether sheep.

Materials and methods

Sward and silage making

The GS was made from a semi-permanent, predominately orchardgrass meadow harvested on 25 May 2002, primary growth, and early flowering stage (about 35 % of orchardgrass was in flower). Two applications of a commercial inorganic fertilizer were provided during the growing season. In February 2002, 450 kg ha^{-1} N-P-K fertilizer (8:26:26), and thirty-five days prior to harvesting 150 kg ha^{-1} of ammonium nitrate were applied.

Green and DM yield (t ha^{-1}) was determined at mowing by calculating the weight of 30 forage samples randomly taken by a quadratic frame (0.25x0.25m). Botanical composition was determined from the same samples by manual separation of sward components (grasses, clovers, forbs).

The sward contained 80.6 % orchardgrass, 13.7 % legumes (11.2 % white clover (*Trifolium repens L.*) and 2.5 % red clover), 2.3 % other grasses and 3.4 % forbs on a DM basis. Forage DM content at harvest was 169 g kg^{-1} fresh sample and DM yield was 5.43 t ha^{-1}. The crop was allowed to wilt for 24 h before harvesting with a round baler. Bales were wrapped in 4 layers of 500 mm-wide white plastic film. The weather at harvest was warm and sunny. No additive was applied.

Forage maize crop (hybrid Bc 566) was sown on March the 8th 2002 into a prepared (ploughed and rolled) seedbed. The crop was sown with a row space of 75 cm and the establishment target was 70000 plants ha^{-1}. Whole crop maize was harvested on September 23rd 2002 to a nominal stubble height of 25 cm above ground (pre-harvest DM of 275 g kg^{-1} fresh weight). The DM yield of forage maize at harvest was 13.5 t ha^{-1}, whiles the cob DM to total DM ratio was 1:6. The forage was chopped at harvest to standard chop length, ensiled into a clamp silo immediately, without any additive, and the tractor rolled thoroughly before being sheeted with plastic and covered with rubber tyres to ensure exclusion of air.

Dietary treatments

The treatments consisted of either GS or MS alone, or a forage mixture (DM based) of GS and MS of 670 g kg^{-1} GS and 330 g kg^{-1} MS (GGM) or 330 g kg^{-1} GS and 670 g kg^{-1} MS (MMG). Just before the experiment started, the MS for experimental needs was compressed into 8 plastic containers (approximately 200 L each) and stored in a cold chamber maintained at 4 °C. The GS was chopped to approximately 3-5 cm using a commercial chopper. The chopped material was compressed into plastic bags (approximately 20 kg GS per bag) under continuous CO_2 flushing and stored in a cold chamber (4 °C). Prior to feeding, the forage was mixed weekly and held in plastic bags in a cold room (4 °C) to prevent heating. No concentrate supplementary feeds were provided.

Animals and experimental design

Ten Charolais wethers were selected on the basis of their live weight (mean body weight 43.5 kg, s.d. 3.8 kg) and body condition. All animals were treated for internal parasites prior to the start of experiment. The sheep were subjected to artificial lighting from 08:00 to 20:00 hours daily. Each sheep was randomly allocated to treatment sequences in an incomplete changeover design with four periods. A 10-day acclimatization period was followed by an 11-day measurement period (4-day *ad libitum* intake was followed by 7-day digestibility and N retention measurements) where feed offers and refusals were measured and total urine and faeces were collected. The animals were housed in individual pens (1.5 x 2.2 m) over the acclimatization period and in individual crates (136 cm x 53 cm x149 cm) during the measurement period. Diets were offered twice a day (8:30 and 16:00 h) in equal amounts, designed to ensure a refusal margin of 10-15 % each day. During the measurement period, the fresh weights and DM contents of feed offered and feed refused were recorded daily. Subsamples of the feed "as offered" were taken daily and stored at -20 °C until the end of the experiment, when they were bulked prior to chemical analysis. Daily subsamples of refusals were bulked on an individual animal basis and stored at -20 °C prior to chemical analysis. Daily production of urine and faeces were collected separately. Daily output of urine from each animal was preserved by acidification (100 mL of 2 mol L^{-1} sulphuric acid to achieve a pH value of 2-3) and its volume was measured. Daily subsamples of urine from individual animals were then bulked over the measurement week and stored at -20 °C until analysis. Total daily faecal production of each animal was stored frozen until completion of the collection period. The bulked faecal output from each animal was then weighed and subsampled prior to subsequent analysis. The sheep were weighed on the 10^{th}, 14^{th} and 21^{st} day of each period and the mean weight was used to calculate daily voluntary intake of fresh matter (FM), DM and OM expressed per unit of metabolic weight, i.e., g kg^{-1} $M^{0.75}$.

Chemical analysis

The DM contents of feed offered, feed refused and faeces were determined by oven drying to a constant weight at 60 °C in a fan-assisted oven (ELE International). Ash was measured by igniting samples in a muffle furnace (Nabertherm) at 550 °C for 16 h. Total N concentrations of feed offered, feed refused, faeces and urine were determined by the Kjeldahl method (AOAC 1990, ID 954.01) using a Gerhardt nitrogen analyzer. Additionally, N concentration was expressed as crude protein (CP) (total N x 6.25) g kg^{-1} DM for feed offered, feed refused and faeces. Acid Detergent Fibre (ADF) and Neutral Detergent Fibre (NDF) were measured using the procedure of Van Soest et al. (1991). Silage pH was determined in a water extract from 10 g of fresh silage and 100 ml distilled water using the pH meter 315i (WTW). Starch content of the feed offered, feed refused and faeces was determined by polarimetry according to the European Communities Marketing of Feedstuffs Regulations (1984).

Silage volatile fatty acids (VFA) were measured by liquid gas chromatography and lactic acid was determined enzymatically on an Express Auto biochemical analyzer using juice expressed from the silage.

Statistical analysis

Results were analyzed using mixed model procedures (SAS 1999). Mean separation was calculated using the LSD values if the F-test was significant at P=0.05. Also, orthogonal contrasts of *ad libitum* intake, digestibility and N utilization of GS versus GGM and MMG diets as well as between GGM and MMG diets were made using the CONTRAST statement of SAS. Linear and quadratic effects of the level of MS inclusion in GS on *ad libitum* intake, digestibility and N utilization were examined using the CONTRAST statement of SAS. The model applied: $Yij = \mu + Ti + Pj + eij$, where Y is the overall model, μ = grand mean, T=treatment, P= period, e=experimental error, I=number of treatments, and j=number of periods.

Results and discussion

Diet chemical composition

The chemical composition of GS, MS and mixtures of the two forages is presented in Table 1. Lower quality of GS was evidenced by the high fiber (NDF and ADF) content (705 and 433 g kg^{-1} DM, respectively) and low CP (98 g kg^{-1}DM). Ball et al. (2002) reported CP values for orchardgrass at the

Table 1: Chemical composition of grass and maize silages and the mixtures of the two forages
Tablica 1: Kemijski sastav travne i kukuruzne silaže i njihovih kombinacija

Chemical parameter Kemijski parametar	Diet/Hrana Grass silage Travna silaža	GGM	MMG	Maize silage Kukuruzna silaža	s.e.m.	Sig.
DM (g kg^{-1} fresh weight) ST (g kg^{-1} svježeg uzorka)	408^a	374^b	322^b	264^c	9.6	*
DM composition (g kg^{-1} DM)/Sadržaj ST (g kg^{-1} ST)						
Organic matter/Organska tvar	913^d	922^c	929^b	955^a	1.1	***
Crude protein/Sirovi protein	98^a	92.1^b	87.8^b	62^c	1.7	**
Neutral-detergent fibre Neutralna detergent vlaknina	672^b	681^b	705^a	582^c	8.4	*
Acid-detergent fibre Kisela detergent vlaknina	433^a	419^{ab}	409^b	321^c	6.5	**
Starch/Škrob	19.9^c	30.5^c	57.4^b	211^a	5.8	***
pH	5.1^a	4.6^b	4.2^b	3.7^c	0.1	*
Butyric acid/Maslačna kiselina	NF	NF	NF	NF	ND	
Acetic acid/Octena kiselina	36.3	13.9	5.9	67.1	ND	
Lactic acid/Mliječna kiselina	44.1	28.6	24.7	93.7	ND	
NH_3-N g kg^{-1} total N NH_3-N g kg^{-1} ukupnog N	146.7	116.2	69.1	165.2	ND	

GGM, grass 670 g kg^{-1} DM, maize 330 g kg^{-1} DM/travna silaža 670 g kg^{-1} ST, kukuruzna silaža 330 g kg^{-1} ST; MMG, maize 670 g kg^{-1} DM, grass 330 g kg^{-1} DM/kukuruzna silaža 670 g kg^{-1} DM, travna silaža 330 g kg^{-1} ST; DM, dry matter/ST, suha tvar. Sig. - significance/signifikantnost; s.e.m. - standard error of mean/standardna greška; NF: not found/nije pronađena; ND: not determined/nije utvrđivano;values within the same row with different superscripts differ significantly/vrijednosti u jednom redu označene različitim slovima se statistički značajno razlikuju (*, P<0.05; **, P<0.01; ***, P<0.001)

early flowering stage from 80-120 g kg^{-1} DM, which is in agreement with the CP content in this research. Wilting the grass crop 24 hours prior to harvest resulted in a relatively high DM content of GS (408 g kg^{-1} fresh silage), which is a little above the recommended DM values for grass silage from 300-400 g DM kg^{-1} fresh silage (O'Kiely and Muck, 1998).

There is a long tradition of high-quality MS production on family farms in Croatia, with high DM and starch concentrations (353 g kg^{-1} fresh silage and 339 g kg^{-1} DM, respectively) (Vranić et al., 2005); however, unfavorable rainy growing seasons may result in production of lower quality MS like the one used in this experiment. Mean DM and starch contents (264 g kg^{-1} fresh silage and 211 g kg^{-1} DM, respectively) of MS used is an indicator of the milk-drought maturity stage of green maize forage at harvest (INRA, 1988). Grass silage was higher in DM than MS (P<0.05), thus inclusion of MS in the diet (33 % *vs.* 67 %) reduced the DM content of the diet (P<0.05). MS was lower in CP than GS (P<0.01), which resulted in a lower CP content of the forage mixture at both levels (33 *vs.* 67 %) of MS inclusion (P<0.01).

MS was higher in starch (P<0.001), which comprised 211 g kg^{-1} DM and lower in NDF and ADF (P<0.05 and P<0.001, respectively) than GS. Therefore, with increasing MS inclusion in forage mixtures, there was an increase in starch concentration (P<0.001) and a decrease in NDF and ADF concentrations (P<0.05 and P<0.01, respectively).

Lower pH of the high moisture immature MS than of the low moisture GS was expected (3.7 and 5.1, respectively) because of the higher water soluble carbohydrate concentration of the maize crop compared to grass, which normally made it easier to

Table 2: *Ad libitum* intake and *in vivo* total tract digestibility of grass silage, maize silage and their mixtures fed to wether sheep

Tablica 2: *Ad libitum* konzumacija i *in vivo* probavljivost travne silaže, kukuruzne silaže i njihovih kombinacija u hranidbi kastriranih ovnova

Parameters determined Utvrđivani parametri	Grass silage Travna silaža	GGM	MMG	Maize silage Kukuruzna silaža	s.e.m.	Maize silage response/utjecaj dodatka kukuruzne silaže, P<[a]			
						L	Q	[b]Grass silage vs. GGM, MMG	[c]GGM vs. MMG
Voluntary intake/Konzumacija po volji									
Fresh matter/Svježi obrok (kg d^{-1})	2.5	3.3	3.8	3.6	0.2	<0.01	0.02	<0.01	0.11
Dry matter/Suha tvar (kg d^{-1})	0.97	1.28	1.35	0.93	0.08	0.93	<0.01	<0.01	0.56
Organic matter/Organska tvar (kg d^{-1})	0.88	1.1	1.25	0.9	0.08	0.91	<0.01	<0.01	0.5
NDF (kg d^{-1})	0.66	0.84	0.94	0.66	0.47	0.30	<0.01	<0.01	0.14
Fresh matter/Svježi obrok(gkg^{-1}M$^{0.75}$d^{-1})	134	182	227	206	9.6	<0.01	<0.01	<0.01	<0.01
Dry matter/Suha tvar (g kg^{-1} M$^{0.75}$ d^{-1})	58	69	68	50	5.9	0.36	0.02	0.15	0.90
Organic matter/Organska tvar (gkg^{-1} M$^{0.75}$d^{-1})	48	64	74	49	3.5	0.37	<0.01	<0.01	0.08
NDF (g kg^{-1} M$^{0.75}$ d^{-1})	36	46	56	31	2.8	0.74	<0.01	<0.01	<0.05
Digestibility/Probavljivost (g kg^{-1})									
Dry matter/Suha tvar	534	628	679	631	27.5	0.02	0.02	<0.01	0.21
Organic matter / Organska tvar	551	648	692	651	31.1	0.03	0.05	<0.01	0.34
NDF	592	652	695	595	35.6	0.74	0.05	0.09	0.40
ADF	570	623	671	562	33.9	0.87	0.04	0.09	0.34
Crude protein/Sirovi protein	512	564	637	469	30.1	0.65	<0.01	0.41	0.12
Starch/Škrob	970	985	990	998	4.4	<0.01	0.51	<0.01	0.40
D-value/D-vrijednost (g kg^{-1} DM)	524	598	640	617	23.3	0.01	0.06	<0.01	0.22

GGM, grass 670 g kg^{-1} DM, maize 330 g kg^{-1} DM/travna silaža 670 g kg^{-1} ST, kukuruzna silaža 330 g kg^{-1} ST; MMG; maize 670 g kg^{-1} DM, grass 330 g kg^{-1} DM/kukuruzna silaža 670 g kg^{-1} DM, travna silaža 330 g kg^{-1} ST; NDF, neutral detergent fibre/neutralna detergent vlaknina; ADF, acid detergent fibre/kisela detergent vlaknina; [a]Probability of linear and quadratic effect of increasing MS supplementation/Vjerojatnost linearnog i kvadratnog učinka s povećanjem udjela kukuruzne silaže u obroku; s.e.m., standard error of the mean/standardna greška srednje vrijednosti; L, Linear effect of maize silage in the diet/linearni utjecaj dodatka kukuruzne silaže; Q, Quadratic effect of maize silage in the diet/Kvadratni utjecaj dodatka kukuruzne silaže; [bc]Orthogonal contrast/Kontrasti; D-value, digestible organic matter in the dry matter/D-vrijednost, probavljivost organske tvari u suhoj tvari obroka; M$^{0.75}$, metabolic body weight/metabolička tjelesna masa

ensile. This is further supported by the numerically higher concentration of lactic acid in the MS diet (93.7 g kg^{-1} DM) than in the GS diet (44.1 g kg^{-1} DM).

Feed intake, digestibility and N-balance

Table 2 shows the FM, DM, OM and NDF *ad libitum* intake and total tract apparent digestibility of GS, MS and their mixtures fed to wether sheep. Silage FM intake (kg d^{-1} and g kg^{-1} M$^{0.75}$ d^{-1}) increased linearly ($P<0.01$) as the proportion of MS in the diet increased. A positive associative effect of the two forages was recorded for all intake parameters measured (FM, DM, OM and NDF) (quadratic, $P<0.05$ to $P<0.001$). This was expected since sheep develop preferences for feeds that are richer in energy (Provenza, 1995) and prefer maize to grass silage diets (O'Doherty et al., 1997). Similar results were reported by others (Chenais et al., 1997; Fitzgerland and Murphy, 1999; Knežević et al., 2007b; Phipps et al., 2000; Vranić et al., 2007) when forage based diets were supplemented with an energy source. Furthermore, diets containing

MS (GGM and MMG) led to higher intake of FM, DM, OM and NDF compared to the GS diet only (P<0.01). Higher portion of MS in the diet (MMG *vs*. GGM diet) resulted in higher intake of FM (g kg^{-1} $M^{0.75}d^{-1}$) (P<0.01) and NDF (g kg^{-1} $M^{0.75}d^{-1}$) (P<0.05). That was result of the lower NDF content of MS compared to the NDF content of GS which led to the positive associative effect on the diet DM and OM intake (Van Soest et al., 1991).

The *in vivo* digestibility coefficients of total diets linearly increased for DM, OM, digestibility of OM in DM (D-value) (P<0.05) and starch (P<0.01) as the proportion of MS in the diet increased. A positive associative effect of MS inclusion was recorded for digestibility of DM, ADF (quadratic, P<0.05) and CP (quadratic, P<0.01). This might be explained by the lower quality of GS than that of included MS (Weller et al., 1991). It has been shown that introduction of grain (starch) into highly digestible forage reduces the rate of NDF degradation (Williams et al., 2006) while its introduction into low quality forage improves the quality of the diet (Vranić et al., 2007). The positive associative effect of MS inclusion (33 % *vs*. 67 %) on CP digestibility is probably related to the higher intake and simultaneous increase of total N consumption owing to energy supplementation. Cottrill et al. (1982) reported similar beneficial effects of increased energy levels on N digestibility in young cattle.

Digestibility of DM, OM, starch and D-value was lower in GS compared to GGM and MMG diets (P<0.01). No differences between GGM and MMG diets were recorded for the digestibility parameters measured. GGM diet showed a tendency to higher digestibility of all parameters but CP, which was numerically higher in the GGM diet. This might be explained by the fact that grass silage proteins are highly soluble in the rumen, while maize silage proteins are relatively insoluble in the rumen (Phipps et al., 1981). It follows that a diet containing more grass silage than maize silage will have higher *in vivo* digestibility of CP.

Table 3 shows N utilization of GS, MS and their mixtures. Intake of N increased linearly (P<0.01) and so did N output in faeces and absorbed N (P<0.05) as the proportion of MS in the diet in-

Table 3: Nitrogen utilization of grass silage, maize silage and their mixtures fed to wether sheep
Tablica 3: Iskorištenje dušika travne silaže, kukuruzne silaže i njihovih kombinacija u hranidbi kastriranih ovnova

Nitrogen balance Balans dušika (g d^{-1})	Grass silage Travna silaža	GGM	MMG	Maize silage Kukuruzna silaža	s.e.m.	Maize silage response Ujecaj dodatka kukuruzne silaže P<[a]			
						L	Q	[b]Grass silage vs. GGM, MMG	[c]GGM vs. MMG
N intake/Konzumiran N	15.3	19.5	20.2	9.5	1.27	<0.01	<0.01	<0.01	0.59
N output in faeces/N izlučen fecesom	7.5	8.5	7.3	5.8	0.58	0.04	0.06	0.58	0.17
N output in urine/N izlučen urinom	4.5	3.4	9.7	3.9	1.9	0.64	0.26	0.43	0.05
N balance/Balans N	3.3	7.6	3.1	-0.28	2.1	0.14	0.09	0.42	0.17
Faecal N/N intake (%) N izlučen fecesom/konzumiran N (%)	49.6	44.7	36.3	78.9	12.6	0.19	0.09	0.57	0.65
Urine N/N intake (%) N izlučen urinom/konzumiran N (%)	29.9	17.4	49.8	59.5	15.9	0.12	0.50	0.85	0.18
Absorbed N/Absorbiran N (g d^{-1})	7.8	10.9	12.8	3.6	1.0	0.04	<0.01	<0.01	0.21

GGM, grass 670 g kg^{-1} DM, maize 330 g kg^{-1} DM/travna silaža 670 g kg^{-1} ST, kukuruzna silaža 330 g kg^{-1} ST; MMG, maize 670 g kg^{-1} DM, grass 330 g kg^{-1} DM/kukuruzna silaža 670 g kg^{-1} DM, travna silaža 330 g kg^{-1} ST; [a]Probability of linear and quadratic effect of increasing MS supplementation/Vjerojatnost linearnog i kvadratnog učinka s povećanjem udjela kukuruzne silaže u obroku; s.e.m., standard error of the mean/standardna greška srednje vrijednosti; L, Linear effect of maize silage in the diet/Linearni utjecaj dodatka kukuruzne silaže; Q, Quadratic effect of maize silage in the diet/Kvadratni utjecaj dodatka kukuruzne silaže; [bc]Orthogonal contrast/ Kontrasti creased. N intake and absorbed N responded quadratically (quadratic, $P<0.01$) to increasing levels of MS. The positive associative effect in N intake observed with MS supplementation is largely a reflection of higher DM intake and N intake of the forage mixture, as suggested by Adesogan et al. (2002).

N intake and absorbed N were lower in the GS diet compared to GGM and MMG diets ($P<0.01$). No differences in nitrogen utilization were recorded between GGM and MMG diets.

The highest proportion of N output in urine of N consumed was recorded for the MS diet (41 %), indicating an inefficient microbial capture of rumen degradable N and contributing, together with the low N content in MS, to negative N balance for the lambs offered the MS diet (Bondi, 1987; Fraser et al., 2000). This showed that 62 g CP kg^{-1} DM was not enough to meet the N requirements of wether sheep, which is in agreement with the results of Bondi (1987), who suggested that feeds containing less than 60 g CP kg^{-1} DM promote negative N balance owing to protein malnutrition.

The positive associative effect of absorbed N with MS supplementation could be partly attributed to improved microbial protein synthesis of rumen-degraded GS nitrogen in the presence of maize starch (Hvelplund et al., 1987) and an increased supply of non-ammonium N to the abomasum and small intestine (Beever et al. 1986).

Both GS and MS used in this experiment were low in CP content, but MS was much higher in starch as an important source of energy for ruminants. These differences resulted in positive associative responses of GS and MS for most of the parameters measured, but no positive associative response was recorded for the digestibility of OM, NDF, starch, D-value, N output in urine, N balance, faecal N/N intake (%) and urine N/N intake (%). Previous research involving lower quality grass silage than GS used in this research and the same maize silage showed positive associative responses of the two forages for all the parameters measured (intake, digestibility, N balance) (Vranić et al., 2007). The quality of grass silage should be lower or that of maize silage higher for the full benefit of the two forages fed in combination. Weller et al. (1991) suggested that positive responses could be expected when the GS to be replaced is of lower quality than the included forage substitute. When fed in combination, associative effects depend on the quality of GS and are also related to the maturity of MS (Hameleers, 1998).

The results of this experiment might be useful to producers that produce lower quality grass silage and maize silage of lower DM and starch concentration.

Conclusions

The results of this study support the hypothesis that there are benefits in feeding mixtures of lower quality GS and MS for food intake, digestibility, N intake and absorbed N.

A positive associative effect of the two forages was recorded for all intake parameters measured (FM, DM, OM and NDF)

The *in vivo* digestibility coefficients of total diets linearly increased for DM, OM, digestibility of OM in DM (D-value) and starch as the proportion of MS in the diet increased.

A positive associative effect of MS inclusion was recorded for digestibility of DM, ADF, CP, N intake and of absorbed N.

In general, the results point to the advantages, in terms of intake, digestibility and nitrogen utilization, of replacing up to 75 % of lower quality grass silage with maize silage in sheep diet, but the full benefit could be gained with maize silage of higher or grass silage of lower quality than those used in this experiment.

Dodatak kukuruzne silaže travnoj silaži lošije kvalitete povećava konzumaciju po volji, probavljivost i balans dušika u hranidbi kastriranih ovnova

Sažetak

Cilj istraživanja bio je utvrditi utjecaj interakcije travne silaže lošije kvalitete (TS) u kojoj su dominirale klupčasta oštrica (*Dactylis glomerata L.*) i kukuruzna silaža (KS) (*Zea mays L.*) na *ad libitum* konzumaciju, probavljivost i balans dušika (N) u hranidbi kastriranih ovnova. Istraživana su četiri hranidbena tretmana: 100 % TS, 100 % KS, te kombinacije TS i KS u omjeru 67:33 ili 33:67 bazirano na suhoj tvari (ST). Životinje su hranjene dvaput dnevno u isto vrijeme. Tratina za proizvodnju TS košena je u početku cvatnje klupčaste oštrice (oko 35 % biljaka u cvatnji), a KS je sadržala 264 g ST kg^{-1} svježeg uzorka i 211 g škroba kg^{-1} ST. Sadržaj ST u TS iznosio je 408 g kg^{-1} svježeg uzorka. Sadržaj sirovih proteina (SP) u KS bio je niži (P<0.001) u odnosu na TS (62 g kg^{-1} ST i 98 g kg^{-1} ST, respektivno). Sadržaj neutralnih detergent vlakana (NDF) i kiselih detergent vlakana (ADF) bio je viši u TS u odnosu na KS (P<0.001). Dodatak KS (33 % *vs.* 67 %) u obrok uzrokovao je pozitivan linearni utjecaja na konzumaciju svježeg obroka (P<0.05), probavljivost ST, organske tvari (OT), probavljivost OT u ST (D-vrijednost) (P<0.05), probavljivost škroba (P<0.05), konzumaciju N (P<0.01), količinu N izlučenog fecesom (P<0.05) i količinu apbsorbiranog N (P<0.05). Pozitivan asocijativan utjecaj TS i KS utvrđen je za sve mjerene parametre konzumacije (svježi obrok, ST, OT, NDF) (kvadratni, od P<0.05 do P<0.01), probavljivost ST, ADF (kvadratni, P<0.05), SP (kvadratni, P<0.01), konzumaciju N i količinu apsorbiranog N (kvadratni, P<0.01). Zaključeno je da je pozitivan združeni učinak TS i KS u hranidbi kastriranih ovnova izostao za pojedine mjerene parametre, i to zbog nedostatka energije u obroku, tj. niže kvalitete KS.

Ključne riječi: travna silaža, kukuruzna silaža, konzumacija, probavljivost, balans N

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