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THE FEEDING VALUE OF THE RATION BASED ON ALFALFA HAYLAGE SUPPLEMENTED WITH HIGH MOISTURE CORN IN WETHER SHEEP

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The objectives of the experiment were to examine the effects of high moisture corn (HMC) supplementation to alfalfa haylage (Medicago sativa L.) (AH) on feed intake, digestibility and nitrogen (N) balance in wether sheep.

The study consisted of three feeding treatments incorporating AH only and AH supplemented with 5 or 10 g HMC $d^{-1}kg^{-1}$ body weight of Suffolk wethers.

Inclusion of HMC in the AH based ration had negative linear effects on acid detergent fibre (ADF) intake ($p<0.001$) and digestibility ($p<0.05$) while a positive on the digestibility of dry matter (DM) ($p<0.05$), organic matter (OM) ($p<0.01$) and the digestibility of OM in DM (D-value) ($p<0.01$). A positive associative response of AH and HMC was observed for DM and OM ad libitum intake (g $kg^{-1}M^{0.75}d^{-1}$) (quadratic, $p<0.05$ and $p<0.01$, respectively). Negative linear effects of AH and HMC were observed for nitrogen (N) intake ($p<0.05$). The inclusion of HMC into AH based ration did not influence N balance in wether sheep. It was concluded that a positive associative response of the two forages was recorded for a limited number of parameters, probably due to lower quality of HMC than required for improved utilization of the AH based ration.

Key words: alfalfa haylage, digestibility, high moisture corn, intake, N balance

INTRODUCTION

Alfalfa haylage (AH) is rich in proteins that are extensively degraded in the rumen, but due to lack of energy the microbial protein synthesis is low. Previous studies investigated the efficiency of energy supplements on the nutritional value of forages rich in proteins (grass silage, alfalfa haylage) (Mulligan *et al.*, 2002; Knežević *et al*., 2007; Vranić *et al*, 2008; 2009). It is shown that the positive response of the protein and energy based forages included in the ration depends on the quality of both. High moisture corn (HMC) is rich in rapidly digested starch grains in the rumen. By this reason it could be efficiently used as a supplemental forage to protein rich forage (Mendoza *et al.*, 1999). Besides, ensiling HMC, as an effective method of handling and an alternative to artificial drying, reduces fuel and labor costs and eliminates costly delays during harvest (Merrill, 1971).

The hypothesis of this study was that HMC (5 and 10 grams kg^{-1} sheep body weight) supplemented to AH improves feed *ad libitum* intake, digestibility and N balance. The objectives of the experiment were to examine the effects of HMC supplementation to AH on *ad libitum* feed intake, *in vivo* digestibility and N balance in wether sheep.

MATERIALS AND METHODS

The sward and silage making

Alfalfa haylage (AH) was made in 2009 (22^{nd} of May) at the early flowering stage. The crop was mown and allowed to wilt for 24 h before harvesting (400-500 g DM kg^{-1} fresh sample) with a round baler. Bales were wrapped in four layers of 500 mm-wide white plastic film. The weather at harvest was warm and sunny.

The high moisture corn (*Zea mays L., cultivar BC 566*) (HMC) was ensiled grinded through 3 mm screen without any additive into jumbo bags (600 kg of fresh material bag^{-1}) and allowed to ferment.

Dietary treatments

The experiment consisted of 3 feeding treatments: (i) AH fed alone, (ii) AH supplemented with 5 g HMC kg^{-1} body weight (AH5); (iii) AH supplemented with 10 g HMC kg^{-1} body weight (AH10).

Just before the experiment started HMC was compressed into plastic bags (30 litre each) and stored in a cold chamber maintained at a temperature of 4°C. AH was chopped to approximately 3-5 cm using a commercial chopper. The chopped material was compressed into plastic bags (approximately 10 kg AH bag^{-1}) and stored in a cold chamber maintained at a temperature of 4°C. The AH and HMC were fed separately. No supplementary feeds were provided. HMC was weighted into plastic bags for daily feeding in the quantity of 5 or 10 grams kg^{-1} body weight.

Animals and design

Three Suffolk wethers were selected on the basis of live weight (mean body weight 38.3 kg, s.d. 5.8 kg) and condition score. All the animals were treated for internal parasites prior to the start of the experiment. The sheep were subjected to artificial lightening from 08:00 to 20:00 hours daily. Each sheep was randomly allocated to treatment sequences in a 3x3 latin square design with three 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 balance measurements) where feed offers, feed refusals and urine excretion were measured and total faeces was 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 x 148.5 cm) during the measurement period. Rations were offered twice a day (8:30 and 16:00 h) in equal amounts, designed to ensure a refusal margin of 10–15% AH each day. During the measurement period, fresh weights and DM contents of feed offered and feed refused were recorded daily. Subsamples of offered feed were taken daily and stored at a temperature of –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 a temperature of –20°C prior to chemical analyses.

Daily production of faeces was collected separately. Total daily faecal production of each animal was stored frozen until completion of the collection period. Bulked faecal output from each animal was then weighed and subsampled prior to subsequent analyses. The sheep were weighted on the 10^{th}, 14^{th} and 21^{st} day of each period and the mean weight was used to calculate the daily voluntary intake of fresh matter (FM) and dry matter (DM) expressed per unit of metabolic weight, i.e., g per kg $M^{0.75}$. The experiment followed the Council Directive issued by the European Economic Community (EEC) (1986) on the approximation of laws, regulations and administrative provisions of the Member States regarding the protection of animals used for experimental and other scientific purposes.

Chemical analysis

The DM contents of the feed offered, feed refused and faeces were determined by oven drying to a constant weight at a temperature of 60°C in a fan-assisted oven (ELE International). The samples were ground to pass a 1 mm screen.

Ash of feed offered, feed refused and faeces was measured by igniting samples in a microwave oven (Milestone PIYRO, Italy) at 550°C for 3h. 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 N analyzer. In addition, N concentration was expressed as crude protein (CP) (total N x 6.25) g kg^{-1} DM for feed offered, feed refused and faeces.

Neutral Detergent Fibre (NDF) and acid detergent fibre (ADF) were analyzed using the procedure of Van Soest *et al.* (1991) by the Ancom Filter bag technology (USA) with an Ancom fiber analyzer. Forage pH was determined in a water extract from 10 g of fresh silage and 100 mL distilled water using a pH meter 315i (WTW). Forage volatile fatty acids (VFA) were measured by liquid gas chromatography and lactic acid was determined enzymatically on an Express Auto biochemical analyzer using the juice expressed from silage.

Statistical analysis

Results were analyzed using mixed model procedures (SAS 1999). 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. Orthogonal contrasts were made using the CONTRAST statement of SAS for assessment of the linear and quadratic effects for the levels of DC inclusion to AH.

RESULTS AND DISCUSSION

Alfalfa contains more than 180 g CP kg^{-1} DM if mowed at the beginning of flowering (Ball *et al*., 2002) which is slightly higher than 171.4 g CP kg^{-1} DM determined in this research (Table 1) confirming correctly described stage of maturity of alfalfa at harvest. Relatively high average DM content of AH (534.7 g kg^{-1} fresh sample) as a result of 24-hour wilting prior to harvest, fits well DM requirements of fresh material (400-600 g kg^{-1} DM) prior to ensiling into big bales (Chamberlain and Wilkinson, 1996).

Table 1. Chemical composition of alfalfa haylage and high moisture corn

Chemical parameter	Forage	Mean	Min	Max	CV (%)
DM (g kg^{-1} fresh sample)	AH	534.7	512.0	578.5	4.67
	HMC	796.0	77.2	80.8	1.67
OM (g kg^{-1} DM)	AH	916.5	910.9	927.1	0.62
	HMC	985.4	984.7	986.8	0.09
CP (g kg^{-1} DM)	AH	171.4	118.0	155.0	9.08
	HMC	111.8	106.6	115.9	3.45
NDF (g kg^{-1} DM)	AH	459.3	368.9	505.3	10.47
	HMC	98.5	92.3	112.5	7.65
ADF (g kg^{-1} DM)	AH	378.5	300.6	442.9	12.37
	HMC	34.2	27.9	37.3	9.82
Fermentation characteristics (g kg^{-1} DM)					
Lactic acid	AH	16.9	11.4	27.1	35.7
	HMC	0.9	0.3	1.5	58.4
Acetic acid	AH	14.5	11.7	30.7	86.5
	HMC	0.8	0.2	2.3	117
Butyric acid	AH	0.0	0.0	0.0	0.0
	HMC	0.0	0.0	0.0	0.0
pH	AH	5.0	4.9	5.1	1.46
	HMC	6.1	5.9	6.3	2.9
NH_3-N g N kg^{-1} total N	AH	79.8	76.0	83.5	3.8
	HMC	16.3	14.9	18.4	7.9

AH, alfalafa haylage; HMC, high moisture corn; DM, dry matter; OM – organic matter; CP-crude protein; NDF – neutral detergent fibre, ADF – acid detergent fibre; NH_3-N – ammonium N; CV-coefficient of variation

The DM concentration in HMC is similar to DM in HMC (<80%) in the experiment of Owens *et al.* (1997), but much higher than the upper limit of DM concentration in HMC described in previous papers (680-740 g DM kg^{-1} fresh sample) (Corah, 1976, Mader *et al.*, 1983). The reason was an unusually hot summer in 2009, which shortened the growing season of maize crop and resulted in higher DM concentration at harvest. CP concentration in HMC fits the range from 82-104 g CP kg^{-1} DM for corn hybrids (Owens, 1997).

Lactic acid was the major organic fermentation acid in the silages and pH ranged from 4.9 to 5.1 in AH while from 5.9 to 6.3 in HMC.

Intake and digestibility

Table 2 shows *ad libitum* intake and total tract *in vi*vo digestibility of AH supplemented with 5 or 10 g HMC kg^{-1} body weight of wether sheep.

Table 2. *Ad libitum* intake and total tract *in vivo* digestibility of alfalfa haylage fed to wether sheep as a sole feed or supplemented with high moisture corn

Parameters determined	AH	AH5	AH10	S.E.M.	Significance	L	Q
Voluntary intake							
Fresh matter	114^a	102^b	106^c	2.81	*	N.S.	*
DM (g kg^{-1} $M^{0.75}$ d^{-1})	67.2^{ab}	64.3^a	69.5^b	1.26	**	N.S.	*
DM (kg d^{-1})	0.96	0.94	0.99	0.28	N.S.	N.S.	N.S.
OM (g kg^{-1} $M^{0.75}$ d^{-1})	62.5^a	58.9^b	65.2^a	1.20	*	N.S.	**
ADF (g kg^{-1} $M^{0.75}$ d^{-1})	13.9^a	25.5^b	29.2^c	0.06	***	***	***
Digestibility (g kg^{-1}DM)							
DM	615^a	648^{ab}	652^b	11.91	*	*	N.S.
OM	637^a	675^b	677^b	10.51	**	**	N.S.
ADF	439^a	417^{ab}	388^b	14.17	*	*	N.S.
CP	693	688	667	9.49	N.S.	N.S.	N.S.
D-value	593^a	622^{ab}	636^b	11.47	*	**	N.S.

AH, alfalfa haylage; AH5, alfalfa haylage supplemeted with 5 grams of HMC kg^{-1} body weight; AH10 alfalfa haylage supplemeted with 10 grams of HMC kg^{-1} body weight; DM, dry matter; OM, organic matter; CP, crude protein; ADF, acid detergent fibre; D-value, digestibility of the organic matter in the dry matter; SEM, standard error of the mean; Values within the same row with different superscripts differ significantly ($p<0.05$). NS, $p>0.05$; *$p<0.05$; ***$p<0.001$; NS, not significant; L, linear effect of high moisture corn in the diet; Q, quadratic effect of high moisture corn in the diet

Voluntary DM intake across the three feeding treatments was within the intake range of 800-1100 g d^{-1} for 50 kg intact male lambs (AFRC 1993). A positive associative response of AH and HMC was recorded for the intake of DM (g kg^{-1} $M^{0.75}$ d^{-1}) ($p<0.05$), organic matter (OM) ($p<0.01$) and ADF ($p<0.001$) which is contrary to some reports of decreased DM intake with HMC supplementation to grass silage (Owens *et al.*, 1997). This is partly explained with lower DM concentration in HMC in previous studies than in this research because of the known negative relationship between forage moisture content and forage DM intake (Steen *et al.*, 1998; Mulligan *et al.*, 2002). Besides, sheep prefer forage richer in energy (O'Doherty *et al*., 1997).

A positive linear response of AH and HMC was recorded for the digestibility of DM ($p<0.5$), OM ($p<0.01$) and D-value (digestibility of OM in DM) ($p<0.01$) while a negative for the digestibility of ADF ($p<0.5$). The supplemented energy in the form of HMC improved microbial activity by developing a better environment for rumen fermentation and reduced indigestible materials of the diets (Matsui *et al*., 1998). This is consistent with some studies showing that HMC is rapidly degraded in the rumen and has improved cattle efficiency (Ladely *et al*, 1995). Also, the present results are in agreement with previous research showing that with higher quality forages, feeding starch-based energy supplements causes negative associative effects on fibre digestibility (Pordomingo *et al.,* 1991). A better way of increasing digestibility is to supplement low quality forage with higher quality forage, which is corroborated by the current results and confirmed by previous research (Matejovsky and Sanson, 1995).

Nitrogen balance

Table 3 shows N utilisation of AH supplemented with 5 or 10 g HMC kg^{-1} body weight.

Table 3. Nitrogen utilization of alfalfa haylage fed as a sole feed or supplemented with high moisture corn in wether sheep

Nitrogen balance (g d^{-1})	AH	AH5	AH10	S.E.M.	Significance	L	Q
N intake	27.3^{a}	24.9^{b}	24.9^{b}	0.80	*	*	N.S.
N output in faeces	5.39^{a}	8.71^{b}	10.8^{c}	0.09	***	***	***
N output in urine	10.7^{a}	9.8^{a}	7.6^{b}	0.39	***	***	N.S.
N balance	11.2	6.4	6.5	0.84	N.S.	N.S.	N.S.

AH, alfalfa haylage; AH5, alfalfa haylage supplemeted with 5 grams of HMC kg^{-1} body weight; AH10, alfalfa haylage supplemeted with 10 grams of HMC kg^{-1} body weight; N, nitrogen; S.E.M.: standard error of the mean; L, Linear effect of high moisture corn in the diet. Q Quadratic effect of high moisture corn in the diet. N.S.: not significant. *$p<0.05$; ***$p<0.001$.

A linear decrease in N intake with increasing HMC supplementation to AH (Table 3) suggests that the intake of N was negatively affected by the energy level of the diet. N output in faeces responded quadratically ($p<0.001$) to increasing levels of HMC while N balance was not affected by HMC supplementation.

Energy and nutrient supplies to rumen microorganisms are of major importance because they influence bacterial lysis (Meng *et al.*, 1999), predation of bacteria by protozoa (Clark *et al.*, 1992) and the share of nutrient consumption for maintenance of rumen microbes (Hespell and Bryant, 1979). It therefore appears more likely that rumen degradable CP, i.e., N supply from AH, was higher than the available energy from HMC for improved N utilization.

CONCLUSIONS

There were advantages of alfalfa supplementation with high moisture corn in wether sheep in terms of dry matter and organic matter *ad libitum* intake and digestibility while ADF intake and digestibility were negatively affected by high moisture corn supplementation to alfalfa haylage. No advantages for the ration crude protein digestibility and N balance were recorded.

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HRANLJIVA VREDNOST SENAŽE LUCERKE UZ DODATAK VLAŽNOG ZRNA KUKURUZA U ISHRANI OVACA

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SADRŽAJ

Cilj ovih istraživanja je bio da se utvrdi uticaj dodatka vlažnog zrna kukuruza (VZK) senaži lucerke (SL) (*Medicago sativa* L.) na konzumaciju, svarljivost hraniva i balans azota (A) u ishrani kastriranih ovnova. Istraživanje je obuhvatilo tri tretmana ishrane: ishrana samo senažom lucerke, kao i ishrana senažom lucerke uz dodatak 5 ili 10 g VZK d^{-1} u odnosu na telesnu masu kastriranih ovnova Suffolk rase. Dodatak VZK obroku baziranom na SL je doveo do negativnog linearnog uticaja na konzumaciju kiselih deterdžentskih vlakana (KDV) ($p<0,001$) i njihove svarljivosti ($p<0,05$), a pozitivnog na svarljivost suve materije (SM) ($p<0,05$), organske materije (OM) ($p<0,01$) i svarljivost OM u SM (D-vrednost) ($p<0,01$). Pozitivan udruženi učinak SL i VZK je utvrđen za *ad libitum* konzumaciju SM i OM ($g\ kg^{-1}M^{0.75}d^{-1}$) ($p<0,05$ i $p<0,01$ pojedinačno). Negativan linearni uticaj SL i VZK je utvrđen za konzumaciju azota ($p<0,05$). Dodatak VZK obroku baziranom na SL nije uticao na balans azota kastriranih ovnova. Zaključeno je da je pozitivan združeni uticaj dva krmiva hranjena u kombinaciji dobijen za ograničen broj utvrđivanih bioloških parametara verovatno zbog niže hranljive vrednosti VZK od potrebnog za bolje iskorišćenje obroka baziranog na SL.