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Effects of alfalfa haylage harvesting systems on dry matter intake and feeding behaviour of East Friesland ewes in late pregnancy

Efecto del sistema de cosecha de henilaje de alfalfa sobre el consumo de materia seca y comportamiento del consumo de ovejas Frisón Oriental en el último tercio de preñez

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RESUMEN

Tres henilajes fueron confeccionados a partir de un cultivo de alfalfa, segándola y marchitándola por 24 h. La cosecha fue dividida en tres bloques y recogida utilizando la misma cosechadora, ajustando la cantidad de repicadores para producir henilajes con distintos tamaños de picado, es decir henilaje sin repicado (L); repicado simple (S) y repicado doble (D). Los henilajes resultantes fueron de un alto contenido de materia seca (557, 640 y 700 g/kg MS), con un largo de picado en promedio de 250, 70 y 20 mm para L, S y D respectivamente. Veinticuatro ovejas Frisonas, en su último tercio de preñez, fueron asignadas a los tres tratamientos. Los animales tenían acceso a henilaje durante todo el día, con forraje fresco ofrecido diariamente a las 9.00 h. Las ovejas fueron distribuidas en bloques al azar con ocho ovejas por tratamiento y encerradas en corrales individuales. Todas las ovejas recibieron 0,85 kg/día de concentrado. Los resultados indican que el consumo de MS se ve afectado por el sistema de cosecha de la alfalfa. Las ovejas asignadas al tratamiento L consumieron un 10,7% y 30,4% menos materia seca que aquellas que consumían los henilajes S y D, respectivamente. Se observó que las tasas de consumo de las ovejas que consumían henilaje D fueron un 83,2% y un 218% más altas que cuando se ofrecía los henilajes S y L respectivamente. Al final del experimento se observó una mejor condición corporal de los animales que consumían el henilaje preparado con las 12 cuchillas repicadoras (tratamiento D) comparado con el consumo observado para S o L.

Key words: haylage, alfalfa, harvesting, ewes.

Palabras clave: henilaje, alfalfa, cosecha, ovejas.

INTRODUCTION

The effects of the harvesting system used during ensiling on animal performance have been examined in a number of experiments (e.g. Dulphy *et al* 1984, Dulphy and Van Os 1996, Kononoff *et al* 2003). These have shown that reductions in silage chop length generally improve dry matter intake, with increased intake reflecting improvements in fermentation in the silo and increases in the rate of passage of material through the digestive tract. Furthermore, it has been demonstrated that sheep are more sensitive to silage chop length than bovines (Allen 1996). For example, intake of long-chopped grass silage by store lambs are generally low, resulting in low liveweight gains (Fitzgerald 1996^{a, b}).

With the recent introduction of alfalfa in Chilean Patagonia (Aysén), its use as silage or haylage has to be reviewed in relation to animal performance. It has been pointed out that forage legumes retain their high intake potential when ensiled (Fraser *et al* 2000). For example, lambs offered red clover (Speijers *et al* 2005), or alfalfa (Marley *et al* 2007) wilted silages had significantly higher

DM intake and liveweight gain compared to those offered ryegrass silage. In mature ewes, although a beneficial effect of the pre and postpartum feed supplementation using grass silage has been reported (Sepulveda *et al* 1999, Sepulveda *et al* 2001, Sormunen-Cristian and Jauhianen 2001), relatively little research has been carried out regarding their effects on voluntary intake and performance of ewes in their pre partum period using this alternative forage.

The objective of this experiment was to evaluate the effects of different alfalfa haylage harvesting systems on dry matter (DM) intake and eating behaviour of East Friesland ewes in late pregnancy.

MATERIAL AND METHODS

TREATMENTS AND ANIMALS

The herbage used in this trial was the second cut of an alfalfa (*Medicago sativa*) sward at the Tamel Aike Research Station (INIA), located in the Simpson Valley, Western Patagonia, Chile (45°45' S latitude, 72°02' W longitude, 480 m altitude). The alfalfa sward was cut on March 7th, 2000, using a mower conditioner and wilted for 24 h. The wilted sward was then divided into three blocks and picked up using different harvesting systems, i.e. long, unchopped haylage (L); single chopped (S) and double-chopped (D)

haylage. All haylages were harvested using the same forage harvester (Elho, model DC1700 T). The L haylage was produced unchopped, since the forage was blown into the trailer with the edge-cutting flails but having all rotary knives removed; S haylage was harvested with the same harvester but with the rotary chopper-blower fitted with six knives, and D haylage was harvested with the same harvester but with the rotary chopper-blower fitted with twelve knives. The forage was cut under dry weather conditions and ensiling was completed within 8 h. The three haylages were ensiled in trench silos of 10 m³ capacity. The walls of the silos were lined with plastic sheets prior to ensiling and the ensiled herbage was covered with plastic sheeting immediately after completion and weighed down with a layer of soil.

Twenty four pure bred East Friesian ewes, between 24 and 36 months of age, were oestrus synchronized, following treatment for 14 days, using intra-vaginal pessaries (Chronogest, 20 mg; Intervet Laboratories Ltd). At 48 h after removal of the sponges, each of the ewes was mated individually with East Friesian rams. All ewes were treated uniformly except the last 6 weeks of pregnancy, when the experimental treatments were imposed.

Ewes were allocated according to live weight and age. This resulted into three groups ($n = 8$ per treatment) with a mean LW of 75.3 ± 9.2 ; 75.0 ± 12.5 and 75.4 ± 9.8 kg for L, S and D treatments.

The animals were housed in individual pens of 1.5 x 1.5 m, arranged in three rows and separated by metal wire partitions. Throughout the experiment, the animals were offered forage *ad libitum* once daily, with feeding levels designed to ensure a refusal margin of 10% per day. In addition, ewes received a concentrate supplement that was formulated (g/kg dry weight basis) from oats (577), fish meal (316) and a mineral mix (107). Concentrate was offered at 0.85 kg/day doses on a dry weight basis, in one daily meal separate from the haylage. Water was freely available at all times from drinking troughs.

Daily subsamples of haylages offered and refused were also taken for chemical composition, and stored at -20°C. The subsamples of each haylage was then bulked throughout the week and analyzed for oven dry matter concentration (DM), ammonia N, pH, crude protein concentration (CP), ash, acid detergent fiber (ADF) and residual water soluble carbohydrates

(WSC). Full details of the analytical procedures used are described by Cushnahan and Gordon (1995). The residual WSC were analyzed as described by Sabag (1988).

The chop length distribution for each of the three haylages was determined by particle size separation. The length of each particle in a 200 g sample of fresh material was measured, and the particles were separated into four size categories namely: < 50 mm; 51-100 mm; 101-150 mm and >151 mm, as described by Mayne (1983). The dry weight of each category was expressed as a proportion of the total dry weight.

DRY MATTER INTAKE AND FEEDING BEHAVIOUR

Data was first recorded after a 21 day adaptation period. Fresh haylage was offered daily at 09.00 h. Daily haylage DM intake was calculated on an oven DM basis; and eating rate as described by Forbes *et al* (1972). All animals were weighed non fasted, with live weight (LW) and body condition scored once per week, according to a scoring scale from 0 to 5 as described by Russel *et al* (1969).

STATISTICAL ANALYSIS

Animals were allocated to a complete randomized block design with eight ewes per treatment, three treatments (haylage harvesting system) and eight replicates (ewes).

Condition score was analyzed using a non-parametrical Kruskal-Wallis test, with treatment differences being analyzed according to the Nemenyi multiple range at 0.05 (Walpole and Myers 1992).

Experimental data was subjected to analysis of variance, with treatment differences tested by least significant difference. Haylage composition data was analyzed as a randomized block experiment using the weekly data as replicate.

RESULTS

CHEMICAL COMPOSITION OF THE SILAGES AND CONCENTRATES AS FED

The chemical composition of the three haylages offered is presented in table 1. The DM contents of the

Table 1. Chemical composition and mean particle lengths of haylages as removed from the silos.
Composición química y tamaño de partícula de los henilajes, tal como fue ofrecido.

	L	s.e.	S	s.e.	D	s.e.
Dry matter (g/kg)	557.0 ^a	17.9	640.0 ^b	7.6	700.0 ^c	5.4
pH	5.8 ^a	0.02	5.8 ^a	0.17	5.9 ^a	0.13
Crude protein (g/kg DM)	153 ^a	1.4	158 ^a	1.2	156 ^a	1.8
Ammonia N (g/kg TN)	175.0 ^b	16.3	199.0 ^b	18.7	118.0 ^a	14.0
WSC (g/kg DM)	70 ^a	1.7	79 ^b	1.9	71 ^a	0.8
Ash (g/kg DM)	103 ^a	1.0	102 ^a	0.9	105 ^a	1.8
ADF (g/kg DM)	319.0 ^a	4.3	308.0 ^a	2.3	325.0 ^a	17.5
Mean particle length (mm)	250	—	70	—	20	—

resulting silages differed markedly, with double-chop haylage (D treatment) presenting higher ($P < 0.05$) dry matter content than L treatment haylage, and with the dry matter content of S treatment haylage being intermediate. The three haylages were similar in terms of crude protein concentration, ADF and ash but the S treatment haylage had a significantly ($P < 0.05$) higher water soluble carbohydrate content when compared to the other two haylages. The three haylages showed a similar pH content, however, double-chop haylage presented a lower ($P < 0.05$) ammonia nitrogen content than the other two haylages.

The chemical composition of the offered concentrate is presented in table 2.

SIZE DISTRIBUTION OF HAYLAGE PARTICLES

The size particle distribution of the three haylages are presented in figure 1. Particles of the D haylage were shorter than those of the L haylage, while particles of the S haylage were intermediate having 0.68, 0.12 and 0.42% of particles shorter than 50 mm, respectively. Conversely, the L haylage and S haylage had 0.54 and 0.09% of particles longer than 151 mm respectively, whereas the D haylage had only 0.04% of particles in this category. The mean particle lengths of the three haylages were 20 mm, 70 mm and 250 mm for the D, S and L haylages respectively (table 1).

FOOD INTAKE AND FEEDING BEHAVIOUR

Live weight, feeding behaviour, haylage dry matter intakes and live weight gains of the animals on the individual treatments are shown in table 3.

Animals offered L haylage had lower ($P < 0.05$) eating rate during the first meal than those offered the other two haylages. Compared to haylage L, DM intake of the rotary blower chopped haylages S and D was significantly higher ($P < 0.05$) by 10.7% and 30.4%, respectively.

The condition score evolution of the animals is presented in figure 2. Ewes offered D haylage maintained their CS throughout the experiment and had a significantly ($P < 0.05$) higher condition score at the end of the experiment than when

Table 2. Chemical composition of the concentrate offered (g/kg DM, unless otherwise stated).

Composición química del concentrado ofrecido (g/kg, si no se indica otra cosa).

	Oat	Fish meal	Mineral mix
Dry matter	889.0	902.0	998.0
Crude protein	117.0	659.0	—
Ash	14	239	—
ME (Mcal/kg)	2.94	2.22	—
P	9	34	95
Ca	1	51	150

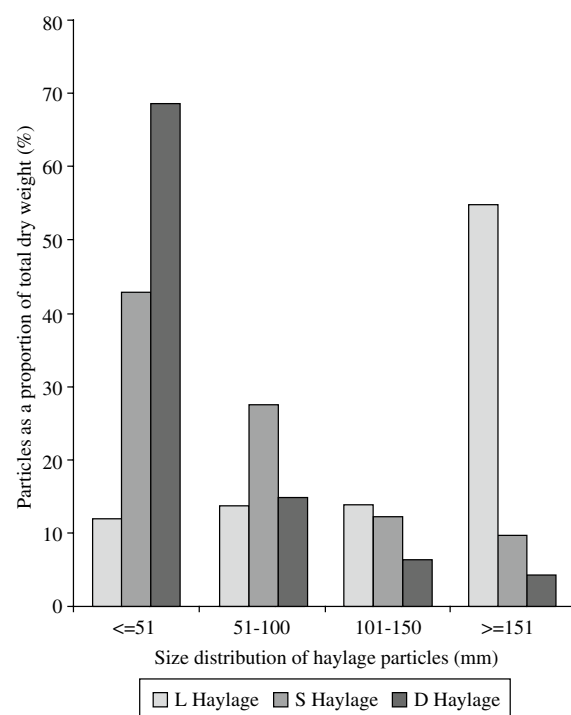


Figure 1. Effect of harvesting system on particle size distribution for the resulting long, unchopped haylage (L); single chopped (S) and double chopped (D) haylage.

Efecto del sistema de cosecha en la distribución del tamaño de partícula de los henilajes sin repicado (L); repicado simple (S) y repicado doble (D).

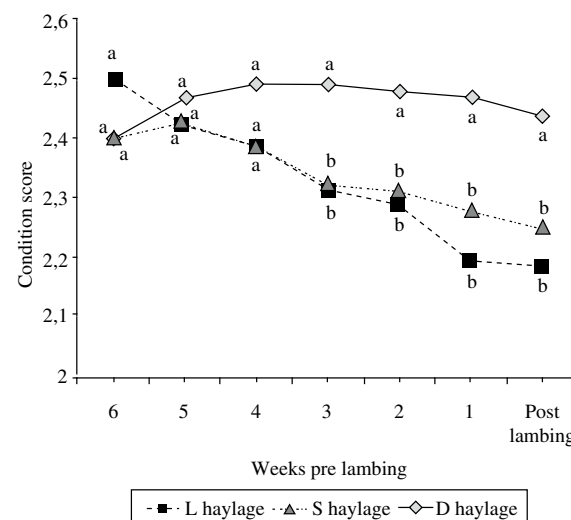


Figure 2. Body condition score evolution of ewes eating long, unchopped haylage (L); single chopped haylage (S) and double chopped (D) haylage.

Evolución de la condición corporal de ovejas alimentadas con henilaje sin repicado (L); repicado simple (S) y repicado doble (D).

Table 3. Treatment effects on haylage DM intake, feeding behaviour and LW gain.
Efecto de los tratamientos sobre el consumo de MS, comportamiento del consumo e incremento del peso vivo.

	L	s.e.	S	s.e.	D	s.e.
LW at the start of the experiment (kg)	75.3 ^a	3.3	75 ^a	4.4	75.4 ^a	3.5
L W at the end of the experiment (kg)	86.3 ^a	3.6	86.1 ^a	4.6	85.1 ^a	3.5
Haylage dry matter intake (g/kg W ^{0.75})	43.1 ^a	0.9	47.7 ^b	1.1	56.2 ^c	1.3
Eating rate during the first meal (g DM/min)	8.3 ^a	0.3	15.2 ^b	0.2	18.1 ^b	2.1
Live weight gain (kg/day)	0.30 ^a	0.03	0.28 ^a	0.02	0.31 ^a	0.04

offered either S or L haylages, while differences between the last two treatments were not significant ($P > 0.05$) for this parameter at the end of the experiment.

Animal live weights and live weight gains were not significantly ($P > 0.05$) affected by the harvesting system.

DISCUSSION

EFFECT OF HARVESTING SYSTEM ON HAYLAGE COMPOSITION

Physical characteristics. The distributions of particle lengths of the haylages used in the present study are in accordance with results reported by Mayne (1983) and Elizalde (1993) who described the physical characteristics of silages using the same technique of manual particle separation.

The flail-harvested single chop haylage was poorly chopped as expected, with 0.19% of particles greater than 151 mm and it was observed that a high proportion of forage, although lacerated, passed through the machine unchopped.

Chemical composition. All three haylages were heavily wilted ($> 55\%$ DM), reflecting a restricted fermentation as described by Muck (1987), with the DM contents of the resulting silages differing by approximately 8 percentage units between L and S haylages, and by 6 percentage units between S and D haylages. There were no significant differences in terms of crude protein, ADF and ash content. The high ash content recorded on the three haylages (103 g/kg DM on average), is attributed to a high degree of soil contamination arising from the suction action of flail-type harvesters (Marsh, 1978), and enhanced by the very dry ground conditions during the harvesting period.

In the present study the D treatment haylage had a better fermentation, indicated by the lower ammonia concentration when compared to L and S treatment haylages, suggesting some degree of secondary fermentation and aerobic deterioration in relation to the last two haylages. Similar trends in ammonia concentration were noted by Luchini *et al* (1997), indicating lower extents of fermentation in alfalfa silages with higher DM.

There were no differences in pH between the three treatment haylages, with a mean observed value of 5.8.

It has been noted that dry matter level had a pronounced effect on final silage pH (Muck 1987, Muck 1990) since the pH for ceasing the growth of lactic acid bacteria should increase as DM level increases (Pitt *et al*, 1985). The overall high final haylage pH recorded in the present study is reflecting the reduced rate and extent of fermentation obtained in heavily wilted alfalfa haylages, as pointed out by Muck (1990). Furthermore, the higher dry matter content of the haylages resulting from short-chopped harvesting systems is in accordance with early results reported in the literature (Castle 1982, Apolant and Chestnutt 1985), and may reflect the fact that with a higher degree of chopping the cell content is more rapidly liberated, which accelerates the drying rate, resulting in silages with a lower moisture content.

HAYLAGE DRY MATTER INTAKE

The harvesting system used during ensilage had variable effects on feeding behaviour and dry matter intake.

Ewes offered D haylage had 31% higher dry matter intake than those offered L haylage and although this difference could be due to a combination of factors, it is likely that it was mainly due to short chopping rather than wilting as reported by Elizalde (1993) in a review which showed that the effects of silage particle length on dry matter intake differ between sheep and cattle, with sheep being more sensitive to silage particle length and less sensitive to the pattern of fermentation of the silage than the cattle. The positive effects of short-chopping on silage consumption have been extensively reported in the literature (Fitzgerald 1996^{a, b}) and it has been suggested that this effect is due to the fact that silages with a high proportion of long particles are ingested more slowly than silages with short particles. Furthermore, when animals are offered long chop material they first reduce it to fine particles, which probably explains the slow rate of eating (Demarquilly and Dulphy 1977).

In the current trial, the harvesting system showed significant effects in terms of dry matter content of the resulting haylages, with a higher dry matter content being concomitant with a higher degree of chopping. It has been established that DM concentration is a major factor explaining silage intake of dairy cows (Dawson *et al* 1999,

Huhtanen *et al* 2007), which is associated with a faster intake and/or higher turn over rate of ruminal particles. Improved preservation of short-chopped silages compared with long-chopped silages (Fitzgerald 1996^b) may also have contributed to the higher intake and performance on the short-chopped haylages. As reported by Gordon (1986) and later by Petit *et al* (1993) when comparing the overall effect of system of silage harvesting on animal performance, the present study was designed to evaluate the effect of different haylage harvesting systems, rather than the single effect of one of the factors involved in the harvesting system, therefore it is possible that a reduction in the chop length accompanied with a higher DM concentration may explain the differences observed in dry matter intake.

The increase in haylage DM intake with fine chopping may result partly from improvements in conservation quality obtained by chopping (Dulphy and Demarquilly 1973), although chop length *per se* is a major factor. For example, chopping of silage just before feeding increases the intake by sheep by 33% (Dulphy and Demarquilly 1973). Similarly, Fitzgerald (1996^a) reported an increase of 31% in dry matter intake when double-chopped silages were offered to sheep, in comparison to intake with long, unchopped silage.

Deswysen and Vanbelle (1978) observed that sheep consumed proportionally more silage dry matter than bovines, expressed on a per unit live weight basis, when offered precision chopped silage rather than flail harvested material. According to Demarquilly and Dulphy (1977), the differences between cattle and sheep are due to the smaller diameter of the esophagus and the reticulo-omasal orifice in sheep.

FEEDING BEHAVIOUR

According to Baumont *et al* (2000), some physical characteristics of the forage, such as dry matter content and particle size are known to affect ease of prehension and thus intake rate. It has been pointed out that the rate of intake represents the motivation to eat especially at the beginning of the first meal, therefore it seems to be a key factor for understanding variations in voluntary intake between forages (Moseley and Antuna Manendez 1989). For example, Van Os and Dulphy (1995) found, using rumen cannulated wethers, that initial eating rate at the beginning of the meal was depressed by the addition of amines in silage.

In the current study, short chopping of herbage with a double chopped harvester system more than doubled (218%) eating rate during the first main meal compared with long, unchopped haylage.

The general pattern of consumption observed in the present study was similar to those reported in the literature. For example, Michalet (1975) suggested that the intake of long particle silage was lower than that of short particle material because the latter was ingested more slowly.

When animals are offered long particle silage some long particles reach the rumen, and Demarquilly and Dulphy (1977) concluded that the difficulties in rumination could be due to the presence of these entangled particles and to the fact that the rumen is not properly filled.

Similarly, Deswysen (1980) and Deswysen and Ehrlein (1981), suggested that the physiological reason for pseudo rumination in sheep could be the absence of sufficient small particles of silage in the reticulum for regurgitation, causing a delay in rumination activity. Therefore, although rumination activity was not assessed in the present study, it is probable that an increasing eating rate with the short-chopped silage may partly have resulted from improved rumination, in contrast to what is observed with single-chopped silages.

It seems that the intake of long particle silage is lower than that of short particle length material mainly because it is ingested more slowly. However, the fact that particles leave the rumen at a certain functional density (Teller *et al* 1990, Kaske *et al* 1992) when they have been reduced to a critical size (Van Bruchem *et al* 1991) may also account for the extent of the reduction in silage intake. For example, it takes longer to break down long particle length material, causing a reduction of the rumen outflow rate and consequently, an intake reduction (Teller *et al* 1990, Van Bruchem *et al* 1991).

LIVE WEIGHT AND CONDITION SCORE

All treatments resulted in live-weight gain during the trial. Although no significant differences were detected in terms of liveweight gain between the three haylage harvesting systems, it should be noted that these live-weight gains, including fetal growth, are similar to the average daily growth rates calculated by Rattray *et al* (1974) and pointed out by Russel (1984) for an acceptable level of feeding on twin bearing ewes. It is interesting to note that ewes eating D haylage were able to maintain their condition score throughout the experiment and had 13% higher condition score at the end of the experiment than animals eating long, unchopped haylage. With East Friesland ewes in their prepartum period these significant differences are of great importance, reflecting the higher dry matter intake observed.

Gordon (1982) observed that animals offered precision-chopped silage were significantly heavier than the ones eating direct cut silage. Moreover, according to Petit and Flipot (1990), decreasing the silage chop-length decreased the rumen acetate: propionate ratio which suggests that short-chopped silages would be better used for growth rather than milk production.

In conclusion, the results of this study indicate that alfalfa haylage harvesting systems had a marked effect on the dry matter intake of the resulting haylages and the feeding behaviour of ewes. Ewes offered long, unchopped haylage consumed 10.7% and 30.4% less dry matter than

those offered S and D haylage, respectively. These differences in total intake were accompanied by marked changes in eating rate during the first meal, with eating rate of ewes offered D haylage being 83.2% and 218% higher than when offered S and L haylage. Animals offered D short-chopped haylage were more able to maintain their condition score throughout their late pregnancy than those offered L or S haylages.

SUMMARY

Three haylages were produced from the same regrowth of an alfalfa sward by cutting the grass using a mower conditioner and wilted for 24 h. The product was divided into three blocks and picked up using the same harvester, but adjusted to produce haylages differing in chop length, i.e. long, unchopped haylage (L); single chopped (S) and double chopped (D) haylage. The haylages were high in dry matter (DM) content (557, 640 and 700 g/kg), with a mean particle length of 250, 70 and 20 mm, for the L, S and D haylages respectively. Twenty four late pregnancy East Friesland ewes were allocated to the 3 treatments. Animals had access to silage throughout the day, with fresh silage being offered daily at 9.00 h. Ewes were allocated to a randomized block design with 8 ewes per treatment and housed in individual pens. All ewes received 0.85 kg/day of a concentrate supplement. The results of the present study indicate that DM intake was affected by the different alfalfa haylage harvesting systems. Ewes offered L haylage consumed 10.7% and 30.4% less dry matter than those offered S and D haylage, respectively. These differences in total intake were accompanied by marked changes in the eating rate during the first meal, with initial eating rates of ewes offered D haylages being 83.2% and 218% higher than when offered S and L haylage. A better condition score at the end of the experiment was recorded when animals were offered haylage harvested with 12 knives (D treatment) than when offered S or L haylages.

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