Effects of Physical Form of Barley Straw and Urea Supplementation on Intake and Digestion of Sheep Kept Under High Ambient Temperature

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ABSTRACT

This research was designed to examine the effect of both physical form of the roughage (chaff or ground/pelleted) and or urea supplementation on intake, and digestion by sheep fed barley straw housed at high ambient temperature (40°C). The experimental design was factorial 2 x 2 x 4. Sixteen Merino sheep, weighing 26.3 ± 2.1 (SE) kg were randomized into four groups (n=4). Each group was fed one of the following diets: C = chaffed barley straw; CU= chaffe d barley straw + 2% urea; P= ground/pelleted barley straw; PU= ground/pelleted barley straw + 2% urea, all with mineral and vitamin supplement. The interactions between treatments were significant on dry matter intake (DMI) (P<0.01) but were not significant on dry matter digestibility (DMD; P>0.05). Dry matter digestibility was lower on diet P than on C (33 vs. 41%), but was not affected (P<0.05) by urea supplementation. The digestible DMI (DDMI) was significantly affected by the interaction between treatments (P<0.01). It was concluded that while urea supplementation and grinding/pelleting led to increase in DMI, the actual response to urea was small and in the case of ground/pelleted material in the absence of urea, there was a concurrent reduction in DMD.

Key words: barley straw, physical form, urea, sheep.

INTRODUCTION

Ruminants fed solely on straw-based diets generally have a low voluntary intake and experience a loss in live weight (Leng, 1990). The underlying causes of this low voluntary intake and low animal performance are a low digestibility of the straw, which is caused mainly by its high level of lignifications and by deficiencies of critical nutrients to support an efficient population of microorganisms in the rumen. Diets consisting solely of straw are associated with a low availability and an imbalance of nutrients and the available metabolisable energy is inefficiently used for live weight gain (Wheeler et al., 2002).

One obvious way of increasing the utilization of straw is to reduce its particle size and to thus improve its digestion (Carmona and Greenhalgh, 1972). These authors reported that milling as compared to chopping of barley straw led to a 34% increase in digestible organic matter intake by sheep, and suggested that this was because grinding increases the surface area of the feed particles which in turn provided more surface area for rumen microbial attachment. In addition, smaller particle size can result in the greater outflow rate (France and Siddons, 1993). This is because smaller particle feeds have a greater ability to pass the reticulum by ruminal contractions than greater particle feeds. Since straw and other low-quality roughages contain only 3-5% crude protein (Jackson, 1977), there is often insufficient nitrogen to allow microbes to grow efficiently in the rumen, and consequently the addition of protein and or non protein nitrogen (NPN) to these diets is necessary to maintain the rumen microbes and to support maximum animal productivity (Wheeler et al., 2002). However, since protein supplements are usually limited in availability and very costly, the use of dietary urea to supply N for ruminants may be a more economic alternative for smallholder farmers in particular. The experiment was thus undertaken in order to further advance our understanding of the mechanism of the effect of particle size of barley straw and urea supplementation on intake and digestion by sheep under high ambient temperature.

MATERIAL AND METHODS

Location and time

This experiment was conducted at the animal house and laboratory of the Department of Animal Science of the University of New England, Armidale, Australia from March to August 1997.

Animals, experimental design and diets

Sixteen Merino sheep, approximately 18 months of age and weighing 26.3 ± 2.1 kg, were allocated by stratified randomization to four dietary groups, each of four animals. A seven week experimental period was adopted. For the first 14 days, dietary adaptation was allowed, and sheep were housed individually in floor pens in a room at an ambient temperature of 20±3°C. Room temperature was
then progressively increased by 3°C each day between days 15 and 21 until a level of 40±3°C was reached. Relative humidity was controlled between 40-50%. On day 22, data collection of feed intake was started. On the day 37, the animals were transferred to individual metabolism crates in the same room. A container was placed under each cage to collect faeces for the last seven days. In this case, each animal was fitted with a faecal collection harness to which a polyethylene faeces collection bag was attached. Lighting was provided from 06.00 to 18.00 hours daily.

Barley straw was the basal feedstuff and the following four dietary treatments were imposed in a factorial design employing two factors (physical form of roughage and urea supplementation) at two levels: (i) Chaffed barley straw (1-5 cm chaff length) and no urea (C), (ii) Chaffed barley straw (1-5 cm chaff length) mixed with 2% urea (CU), (iii) Hammer-milled and pelleted barley straw (1 mm particle size) and no urea (P), (iv) Hammer-milled and pelleted barley straw (1 mm particle size) mixed with 2% urea (PU). Urea solution (1 kg/5L in water at 60°C) was sprayed on either the chaffed straw or on the ground straw before pelleting of rations 2 and 4 above (CU and PU). All diets were supplemented with sulfur as Na2SO4 (2 g S/kg basal diet) and Pfizer 422 mineral and vitamin supplement (1 g/kg basal diet). Each dietary treatment consisted of four animals as replications. Feed was offered twice daily (at 09.00 and 16.00 hours respectively) and fresh drinking water was continuously available at all times.

Measurements
Feed intake was measured daily. Feed offered to and refused by each sheep was recorded twice per day at feeding at 09.00 h and 16.00 h. Feed was sampled daily for determination of DM (24 h at 105°C). The total faeces from each sheep was collected daily during the last seven days of the experimental period, and a sample (well mixed) of 500 g was dried to a constant weight (48 h) in a forced draught oven at 80°C for determination of DM.

Statistical analysis
Data obtained during the experiment were analyzed using the Minitab 10.1 statistical program (Ryan et al., 1985). A two-way analysis of variance was employed to determine significant effects of the treatment groups. Least significant difference was used to test any differences between treatment means (Steel and Torrie, 1980)

RESULTS AND DISCUSSION
Dry matter intake
For DMI there was a significant interaction between the physical form of the roughage (ground/pelleted or chaffed) and urea supplementation (P<0.01). There was no significant difference in daily DMI (P>0.05) between sheep fed barley chaff and supplemented with either 0 or 2% urea. On the other hand, the mean daily DMI in sheep fed ground/pelleted barley straw was increased significantly (P<0.01) (Figure 1 and Table 1) by dietary urea supplementation. Grinding/pelleting of barley straw was associated with only a 9% (43 g/d) increase in the DMI of sheep fed the basal chaff diet with urea (P>0.05) (Table 1).

The effect of urea supplementation was to increase the DMI of chaff by 7.8% (37 g/d) (P<0.05), but that of ground/pelleted straw by 36% (187 g) (P<0.01). Grinding together with urea supplementation increased the DMI of straw by 48% (230 g/d) over the DMI of the basal diet of chaffed straw (P<0.01).

Table 1. Dry matter intake (DMI), dry matter digestibility (DMD) and digestible dry matter intake (DDMI) of Merino sheep fed chaffed or pelleted barley straw with or without urea supplement at high ambient temperature (mean±SE, N=4).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Dietary treatments</th>
<th>Probability value</th>
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<tbody>
<tr>
<td></td>
<td>C</td>
<td>CU</td>
</tr>
<tr>
<td>DMI (g/d)</td>
<td>477±33</td>
<td>514±14</td>
</tr>
<tr>
<td>DMD (%)</td>
<td>40.8±2.1</td>
<td>42.4±1.3</td>
</tr>
<tr>
<td>DDMI (g/d)</td>
<td>195±11</td>
<td>218±10</td>
</tr>
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Annotation: C= Chaffed barley straw; CU= Chaffed barley straw mixed with 2% urea; P = Hammer-milled and pelleted barley straw; PU = Hammer-milled and pelleted barley straw mixed with 2% urea.

Figure 1. Effect of physical form of barley straw (C and P) and urea supplementation on total dry matter intake (DMI) of Merino sheep at high ambient temperature (vertical bars = SEM of total DMI). Annotation: C = Chaffed barley straw; CU = Chaffed barley straw mixed with 2% urea; P = Hammer-milled and pelleted barley straw; PU = Hammer-milled and pelleted barley straw mixed with 2% urea.

Urea supplementation of the sheep receiving ground/pelleted barley straw was associated with an increase of 48% in DMI relative to that in the chaffed only group. A similar effect on voluntary intake was observed by Campling and Freer (1966) in sheep supplemented with urea on a diet of pelleted and ground oat straw. Furthermore, the current results indicate that while both grinding/pelleting or urea supplementation per se increased total DMI, the most dramatic occurred as a result of a combination of these two treatments. The increase in DMI as a result of grinding/pelleting is consistent with a number of earlier findings (Berger et al., 1994; Weston, 1996) that a reduction in particle size of the basal diet reduces the mean retention time of digesta, allowing more feed to be ingested. Faichney (1993) also noted that grinding increase the reticulo-rumen digesta volume and in particular, rumen DM fill, presumably because the smaller particles of ground hay were able to be packed more closely together in the reticulo-rumen.

Dry matter digestibility and digestible dry matter intake
The interaction between treatments was non significant (P>0.05) for DMD, which was significantly lower on the ground/pelleted diet (by 8 units) (P<0.05) than on chaff,
but was not significantly affected by urea supplementation (Table 1). Grinding/pelleting the roughage in this experiment led to a decrease in DMD and this depression was greater on the unsupplemented than on the urea-supplemented diet; supplementation of barley chaff with urea resulted in a small but non-significant increase in DMD.

The observed reduction in DMD of the ground/pelleted diet agrees with many reports in which both cattle and sheep were given long and ground roughages (Minson, 1963; Beardsley, 1964). This depression in DMD associated with grinding is considered to be at least partly due to the fact that ground roughages pass more quickly through the reticulo-rumen than long roughages (Mertens, 1993; Berger et al., 1994). Thus, the decline in fiber digestion observed when ground barley straw was fed in this experiment was most probably due to a decrease in the retention time of small feed particles in the rumen. Similar conclusions have been reached by previous workers (Meyer et al., 1959), who fed ground lucerne.

Another possible reason for the reduction in DMD as a result of grinding/pelleting was an associated loss of digestible organic matter during the grinding and pelleting process. Wainman and Blaxter (1972) reported that changes in the chemical composition of a hay diet that had been both ground and pelleted, and suggested that the loss of some 9% of the organic matter may have been due to partial pyrolysis of the carbohydrate during the pelleting process. If part of the organic matter was lost during processing in this experiment, the DMD would be expected to be lower on the ground/pelleted than on the chaffed diet.

Urea supplementation per se did not significantly improve the DMD of barley straw in either the chaffed or ground/pelleted form. This is not in agreement with a number of studies (Horton, 1981; Pearson and Archibald, 1990), which observed a significant increase in the DMD of low quality roughages supplemented with urea. The short duration of the adaptation in this experiment may have contributed to the difference, since evidence in the literature on the time required for adaptation to urea is conflicting. Some workers have concluded that adaptation requires a period of 50 or more days (Coomeb and Christian, 1969) while others have reported that adaptation occurred within 19 days (McLaren et al., 1959; Smith et al., 1960).

For DDMI, the interaction between the physical form of the roughage and urea supplementation was significant (P<0.01) (Table 1). For barley chaff, urea supplementation had a non-significant effect on DDMI (195 vs. 218 g/d), while for the ground/pelleted diet, on the other hand, urea supplementation did significantly increase (P<0.05) DDMI by 52% (from 164 to 249 g/d). The most likely reason for this difference in response is a difference in total daily DMI. In sheep fed barley chaff, urea supplementation increased the DMI by 7.8%. On ground/pelleted barley straw, on the other hand, urea supplementation increased total daily DMI by 36%.

Although a combination of grinding and pelleting the roughage and urea supplementation improved the DMI to a greater extent than was achieved by either reducing the particle size or urea supplementation alone, grinding and pelleting significantly depressed DMD, possibly due to a reduction in the digesta retention time in the rumen. The magnitude of the improvement in DMD of barley chaff when supplemented with 2% urea was not significant, while on ground/pelleted barley straw, a significant depression actually occurred.

REFERENCES


