Merino ewes, 16 months old, were fed wheat chaff every day and the equivalent of 250 g/d of lupin grain twice weekly. An introductory period of seven weeks was used to quantify differences in wool growth and liveweight gain between individual sheep. Different sulphur sources [2% gypsum, 12% fishmeal, 1.2% methionine or -1.2% hydroxymethyl-methionine (Mepron)] were then added to the lupin grain and fed for a further period of seven weeks. Wool growth was significantly increased only in the sheep fed lupin grain with the addition of fishmeal. Wool growth was decreased in the sheep fed lupin grain with the addition of gypsum and Mepron. Liveweight gain was increased in the sheep given methionine, Mepron and fishmeal.

INTRODUCTION

Feed available to sheep in the Mediterranean environment can be low in sulphur (Jones et al. 1982) due to the low sulphur levels in the pasture. In addition, lupins, which are widely used as a supplementary feed for sheep grazing dry pastures and cereal stubbles, are relatively low in sulphur amino acids. The ratio of N:S for lupins is approximately 20:1, while the ratio of N:S in rumen microbes is around 12:1 indicating that lupins are deficient in the supply of sulphur for microbial production of sulphur amino acids. Grazing sheep given a lupin and sulphur supplement, in the form of gypsum, increased wool growth by 7% and liveweight gain by 13% when compared to sheep supplemented with lupins only (Peter et al. 1987).

The supply of amino acids available to sheep, particularly the sulphur amino acids, can exert a considerable effect on the rate of wool growth (Wright 1971; Reis 1979). Increases in wool growth of up to 80% have been found in sheep fed diets and intra-abomasally supplemented with 1–5 g/d of methionine (Reis and Schinka 1963, 1964; Langlands 1970). However in some situations where animals have been supplemented with dietary methionine, responses have been variable (-24% to 53%) depending on the quality of the diet and the quantity of methionine fed (Graceva 1969; Wright 1971; Doyle and Bird 1975). Methionine has been found to cause complete inappetance and reduce wool growth when fed at greater than 10 g/d (Langar et al. 1973). Furthermore when methionine is fed to sheep, over 80% is degraded in the rumen (Langar et al. 1973) and therefore rumen protected forms have been used where additional dietary methionine is required. Fishmeal derived from steam dehydrating fish offal is an excellent source of amino acids and contains approximately 2% methionine.

Mepron is a commercially available analogue of hydroxymethyl-methionine – methionine, containing approximately 66% methionine, that was designed to reduce its degradation in the rumen. Mepron has been used as a methionine supplement for dairy cattle and was found to increase wool growth by 23% in sheep fed lucerne (Cottle 1988).

Dietary inorganic sulphur can be utilised by rumen microbes to synthesize microbial protein (Bray and Till 1975). Sheep grazing forage sorghum and given access to a salt lick containing 10 % sulphur have been shown to have a 7% increase in wool growth when compared to sheep kept under the same conditions –without sulphur in the lick (Wheeler et al. 1980).
The objective of this experiment was to investigate the potential to improve wool production in sheep supplemented with lupin grain through provision of additional sulphur or sulphur amino acids.

**MATERIALS AND METHODS**

**Animals and experimental design**

Merino ewes aged 16 months and weighing 27.0 ± 0.4 kg (mean ± s.e.) were used in the experiment. Prior to commencement of the experiment the sheep were shorn and drenched with Ivomec (Merck, Sharp and Dohme Australia Pty Ltd). All sheep were housed in individual pens throughout the experiment and water was available at all times. Feed intakes were measured daily.

The experiment consisted of a covariate period, during which all animals received their respective diets without any sulphur supplements, followed by an experimental period in which the animals received their diets with various sulphur supplements. Animals were allocated to treatments on the basis of liveweight. Animals were then fed their experimental diets for seven weeks to measure the effect of the additives on wool growth. There were ten sheep per treatment except for the group not fed any sulphur supplement which had 15 animals. Wheat chaff (600 g/hd) was fed daily and lupins with sulphur supplements were given on Mondays and Thursdays. Animals given the fishmeal supplement received 160 g of lupins and 60 g of oats to balance the protein levels across treatments.

The five treatments fed during the experimental period are summarised below:

1. Chaff (600 g/hd/d) plus lupins (the equivalent of 250 g/hd/d – fed twice/week) – the controls.
2. Treatment 1 plus gypsum (20 g/kg lupins).
3. Treatment 1 plus DL-methionine (12 g/kg lupins).
4. Treatment 1 plus Mepron (12 g/kg lupins).
5. Chaff (600 g/hd/d) plus lupins/oats (220 g) and 30 g Fishmeal (a total of 250 g/hd/d – fed twice/week),

The sulphur supplements were sprinkled on the lupins.

**Experimental measurements**

**Live weight** Animals were weighed at weekly intervals for the duration of the experiment.

**Wool production** Clean wool growth was determined by clipping and measuring mid-side patches (10 x 10 cm). Mid-side patches were removed by small animal clippers (Oster, Milwaukee USA, blade size 40) at the end of the two week introduction period (and the wool discarded) and cut again after the sheep had been on their respective basal diets for a further five weeks (and the wool kept for production measurements). This wool, grown over a five week period when animals were fed on the basal diet, was used as a covariate in the statistical analysis. The wool grown during the subsequent seven week period was used to measure the effect of the sulphur additives.

**Rumen samples** During the last week of the experimental period, samples of rumen fluid (20 ml) were taken by stomach tube from all animals, 29 h after the Monday lupin supplement containing sulphur additives were fed. The pH of the rumen fluid was measured before the samples were acidified with concentrated sulphuric acid and stored at -20°C for subsequent analysis for VFA’s and ammonia concentration.
RESULTS

There was no significant difference in intake of lupins or chaff between the treatments (means±s.e. across treatments of 249±1 and 591±6, respectively). Liveweight gain and wool growth measured during the final seven weeks of the experimental period are summarised in Table 1. The average clean wool growth rate for all the sheep in the experiment was 8.1 g/m².d. The sheep fed fishmeal grew significantly more (P<0.05) wool, and the sheep in the treatments fed the gypsum or Mepron grew significantly less wool (P<0.05) than those in the control treatment. Liveweight gain was significantly increased (P<0.05) by the addition of methionine (34%), Mepron (28%) and fishmeal (34%) to the lupin supplement.

Table 1 Effect of addition of sulphur to a lupin supplement on liveweight change (g/d) and wool growth (g/m².d) of sheep fed wheat chaff

<table>
<thead>
<tr>
<th>Sulphur source</th>
<th>Liveweight gain</th>
<th>Clean wool growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil</td>
<td>61±a</td>
<td>8.1±a</td>
</tr>
<tr>
<td>Gypsum</td>
<td>73±b</td>
<td>7.8±b</td>
</tr>
<tr>
<td>Methionine</td>
<td>82±b</td>
<td>8.0±a</td>
</tr>
<tr>
<td>Mepron</td>
<td>76±b</td>
<td>7.9±b</td>
</tr>
<tr>
<td>Fishmeal</td>
<td>82±b</td>
<td>8.7±c</td>
</tr>
<tr>
<td>s.e.d.</td>
<td>7.47</td>
<td>0.29</td>
</tr>
</tbody>
</table>

Values in the same column with different superscripts are significantly different (P<0.05)

The measurements made on fluid samples taken from the rumen are summarised in Table 2. The sheep fed fishmeal as a sulphur additive to their lupin supplement had significantly lower (P<0.05) total VFA and ammonia concentrations than all other treatment groups.

Table 2 Effect of addition of sulphur to a lupin supplement on rumen pH, total volatile fatty acid (VFA) concentration (mmol/l) and ammonia concentration (mg NH₃-N/l) of sheep fed wheat chaff

<table>
<thead>
<tr>
<th>Sulphur source</th>
<th>pH</th>
<th>Total VFA concentration</th>
<th>NH₃-N concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil</td>
<td>6.47±a</td>
<td>123±a</td>
<td>250±a</td>
</tr>
<tr>
<td>Gypsum</td>
<td>6.34±b</td>
<td>132±a</td>
<td>255±a</td>
</tr>
<tr>
<td>Methionine</td>
<td>6.30±b</td>
<td>127±a</td>
<td>287±a</td>
</tr>
<tr>
<td>Mepron</td>
<td>6.35±a</td>
<td>122±a</td>
<td>239±a</td>
</tr>
<tr>
<td>Fishmeal</td>
<td>6.49±a</td>
<td>107±b</td>
<td>115±b</td>
</tr>
<tr>
<td>s.e.d.</td>
<td>0.086</td>
<td>6.6</td>
<td>28</td>
</tr>
</tbody>
</table>

Values in the same column with different superscripts are significantly different (P<0.05).

DISCUSSION

The increases in liveweight gain in response to sulphur supplementation indicate an animal requirement for additional sulphur with lupin supplementation. Inorganic sulphur (gypsum) was as effective in increasing liveweight gain (20%) in this experiment as found by Peter et al. 1987 (13%). However the 7% decrease in wool production with sheep supplemented with gypsum in this experiment contradicts the report by Peter et al. (1987) and Wheeler et al. (1980) where a non significant 7% increase in wool growth was found.
major difference between these experiments was that sheep in this experiment where individually fed with the sulphur being added to the lupins and therefore individual intakes of animals were recorded. In the study of Peter et al. (1987) and Wheeler et al. (1980) the sulphur was included in a mineral mix/lick with animals grazing pasture and therefore it was not possible to measure intake of gypsum or pasture for individual animals.

The absence of any difference in liveweight gain between sheep given methionine or Mepron indicates that either the chemical treatment of the Mepron was unsuccessful in protecting it from rumen microbial degradation or that the chemical treatment was such that it reduced absorption of amino acids from the small intestine.

The only positive wool response recorded to the additives given was for fishmeal. It is possible that the methionine provided by the fishmeal (0.7 g/d) was better protected than that provided by the Mepron (2 g/d). The lower concentrations of rumen VFA’s and ammonia in sheep fed the fishmeal supplement further suggest that the responses in liveweight and wool growth were as a result of increased supply of bypass nutrients rather than increased rumen fermentation and more microbial protein synthesis.

A lack of wool growth response to inorganic sulphur, Mepron or methionine may be an indication that although additional methionine was available for liveweight gain a balanced amino acid spectrum, as found in the fishmeal, was lacking with these treatments and prevented expression of increased wool growth.

ACKNOWLEDGEMENTS

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