Growth rates and testicular characteristics of Ethiopian highland sheep offered chickpea haulm supplemented with incremental levels of *Leucaena leucocephala* leaf hay

Negussie Dana*, Teshome Shenkoru*, Azage Tegegne

*Debre Zeit Agricultural Research Centre, P.O. Box 32, Debre Zeit, Ethiopia
**International Livestock Research Institute (ILRI), P.O. Box 5689, Addis Ababa, Ethiopia

Received 18 August 1999; received in revised form 7 December 1999; accepted 21 December 1999

Abstract

A study was conducted to evaluate the effect of supplementing different levels of *Leucaena leucocephala* leaves on reproductive capacity and growth of male highland sheep (Arsi type) in Debre Zeit Research Centre. Animals were randomly allotted to one of five experimental rations. In treatment 1 (NS) animals were allowed to feed only on chickpea haulm. Treatments 2 (L100), 3 (L200) and 4 (L300) consisted of 100, 200 and 300 g/head per day of sun dried leucaena leaf hay, while animals in treatment 5 (C300) received 300 g/head per day of concentrate mixture. The basal diet, chickpea haulm, was offered ad libitum to all groups. Leucaena supplementation significantly increased total DM intake without marked effect on intake of the basal diet. Live weight of sheep was found to have increased by 68, 88, 94 and 74% as a result of supplementation of 100, 200 and 300 g/head per day of sun dried leucaena leaves and 300 g/head/day of concentrate mixture, respectively. Epididymal growth was retarded in animals maintained solely on chickpea haulm and improved with supplementation. Similar effects were noted in all the epididymal components of both the left and right testes. The scrotal circumference of non-supplemented sheep has been reduced by about 10% while addition of leucaena to the diet increased testicular size by 20–24%. The diameters of the left and right testes were also affected positive by supplementation. It was concluded that supplementation of up to 300 g/head per day of leucaena leaf hay improved body weight gain of sheep with concurrent increases in testicular and epididymal sizes without resulting in clinical symptoms of toxicity. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: *Leucaena leucocephala*; Chickpea haulm; Sheep-feeding and nutrition; Growth; Testicular characteristics

1. Introduction

*Leucaena* contains about 270–340 g/kg crude protein with well balanced proportions of amino acids. It can be an exceptional source of calcium, phosphorus and other dietary mineral nutrients. The tannin content of *leucaena* plays an important role in suppressing bloat and preventing excessive degradation of protein in the rumen (D’Mello, 1992). Results of several studies on the feeding and
supplementary value of leucaena for ruminants in Ethiopia (Tesfaye et al., 1988; Teshome and Goshu, 1994) and elsewhere in the tropics (Abilay and Arinto, 1981; Jones and Hegarty, 1984) have confirmed that this legume has considerable potential for enhancing animal productivity. According to Lambourne and Little (1987), shortage of high protein supplements is one of the major factors contributing to low productivity of sheep in Ethiopia. Conventional concentrates were used as the sole suppliers of protein especially in government and commercial farms. However, due to the limited existence of feed mills and animal feed processing industries in Ethiopia, concentrates are in short supply and expensive when available, making tree legumes attractive alternatives as cheap protein sources.

Nevertheless, in some countries like Ethiopia the use of leucaena as animal feed is limited mainly by its content of the toxic non-protein amino acid, mimosine (β-(N-(3-hydroxy-4-oxopyridyl))-alpha aminopropionic acid) and the rumen degradation product 3-hydroxy-4(1H)-pyridone (3,4-DHP) (as quoted by Hammond, 1995).

The aromatic amino acid mimosine, occurring mainly in the seeds and leaves, is responsible for toxic effects such as abortion and infertility (Hamilton et al., 1971), inhibition of deoxyribonucleic acid (DNA) replication (Gilbert et al., 1994), organ damage and even death (D’Mello, 1992) while DHP is a potent goitrogen (Hammond, 1995).

Although a lot of information has been documented on the role of feeding leucaena on intake and growth of different classes of animals, data on the effect of feeding leucaena on the reproductive performance of ruminants are scarce and often inconsistent. For instance, inclusion of up to 750 g/kg of leucaena in the ration of goats resulted in no adverse effect on the reproductive performance (Abilay and Arinto, 1981). On the contrary a review by Hammond (1995) revealed that leucaena given to unadapted cattle resulted in reduced calving percentage due to early embryonic mortality. The influence of feeding various levels of leucaena on sheep reproduction is not very clear. Hence the purpose of the present work was to estimate through testicular measurements the reproductive capacity of male highland sheep supplemented with increasing levels of leucaena leaf hay. The other objectives of this study include evaluation of the effects of levels of inclusion of leucaena on growth performance of sheep maintained on chickpea haulm basal diet and demonstration of its value as an alternative to commercial concentrate mixture.

2. Materials and methods

2.1. Description of the study area

The study was conducted at Debre Zeit Research Centre located 45 km East of Addis Ababa at an altitude of 1900 m above sea level. The average annual rainfall of the area is 851 mm and the average minimum and maximum temperature range from 8.9°C to 24.3°C, respectively; the mean average being 16.6°C. The major soil types of the centre are described to be alfisol/mollisol and vertisol (DZARC, 1992). According to the weather report of DZARC (1996) annual rainfall of 950 mm, average minimum, average maximum and mean average temperatures of 11.5, 26.5 and 19°C, respectively and relative humidity of 56.4% were recorded during the study year.

2.2. Animals and management

Forty intact male highland lambs (Arsi breed type) of similar age and body weight (range: 16–17.2 kg) were used for this study. The testes, seminal vesicles and scrotum of each lamb were palpated and carefully inspected before purchase. Sheep were quarantined upon arrival at the station and treated against endo- and ecto-parasites. They were allowed to adapt to the environment and experimental feeds for 30–40 days. The sheep were randomly divided into 10 groups and housed in group pens and randomly allocated to five treatment groups. Each treatment was replicated twice. A completely randomised design was used and data were collected for 15 weeks.

In treatment 1(NS) animals were allowed to feed only on chickpea haulm. Treatments 2 (L100), 3 (L200) and 4 (L300) consisted of 100, 200 and 300 g/head per day of sun dried leucaena leaf hay while animals in treatment 5 (C300) received 300 g/head per day of concentrate mixture. The concentrate feed
consisted of wheat bran, noug cake, molasses, and salt and was formulated to supply about 200 g/kg crude protein of dry matter.

The basal diet, chickpea haulm, was offered ad libitum to allow 250 g/kg feed refusal (as fed basis) based on intake of the previous day. Mineral licks and water were freely available at all times. Chickpea haulm was offered once and leucaena and concentrate twice daily (08:00 and 04:00 h).

2.3. Data and sample collection, and feed analyses

2.3.1. Body weight, feed intake and composition

Amount of feed offered and refused was recorded daily to determine feed intake. Daily samples of feeds offered and refused were collected, bulked weekly and sub samples taken after thorough mixing. The samples were analysed for dry matter (DM), ash and total nitrogen (N), to determine crude protein (CP), according to AOAC (1984), and neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined using the procedures developed by Goering and Van Soest (1970) (Table 1). Solutions for analysis of Ca and P were prepared by the dry ashing method of AOAC (1984) and were diluted to optimum detection levels. Ca was analysed by flame photometry (Gallenkamp Flame Analyser) and P by continuous flow analysis (Hornchurch Essex, 1978). Animals were weighed fortnightly after fastening for 16 h.

2.3.1.1. Reproductive data

Measurements were taken on scrotal circumference, testis diameter and scrotal skin thickness at intervals of 2 weeks. Scrotal circumference was measured at the point of maximum diameter by restraining the sheep in the standing position and then stretching the skin of the scrotum around the base of the testis to prevent retraction (Alkass et al., 1982). Scrotal circumference was measured using a simple scrotal tape (modified from Lane Manufacturers Co., USA) while the maximum testicular diameter and testicular skin thickness at the tip of the scrotum was measured using vernier calliper (Ahmed and Noakes, 1995). Five sheep from each treatment group were open castrated to determine testicular and epididymal weights at the end of the study period.

2.4. Statistical analysis

Data from the trials were analysed according to the general linear model (GLM) procedures using SAS (SAS, 1994). Treatment means were separated using Tukey’s studentized range test procedure protected by a significant F-test for treatment effects. Relationships among parameters were analysed by correlation analysis (Gomez and Gomez, 1984).

The statistical model used in the analysis was:

\[ Y_{ij} = \mu + \alpha_i + e_{ij} \]

where \( \mu \) is the overall mean; \( \alpha_i \) the treatment effect; and \( e_{ij} \) the random error term.

3. Results

3.1. Feed composition and intake

Table 1 shows chemical composition of the feeds used in the experiment. Chickpea haulm is the poorest in CP content with the largest values of NDF and ADF components. Both leucaena and concentrate were rich in CP and have reasonably low contents of fibre. No deficiencies or excesses were noted in both of the minerals analysed. Leucaena has larger quantities of Ca than either chickpea haulm or concentrate mixture. The concentrate mixture was found to be superior in its content of P followed by leucaena.

Leucaena supplementation significantly increased

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Chemical composition (g/kg DM) of Leucaena leucocephala leaves, chickpea haulm and concentrate mixture (AOAC, 1984)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed</td>
<td>DM</td>
</tr>
<tr>
<td>Leucaena</td>
<td>920</td>
</tr>
<tr>
<td>Chickpea haulm</td>
<td>940</td>
</tr>
<tr>
<td>Concentrate</td>
<td>930</td>
</tr>
</tbody>
</table>
total DM intake but did not affect intake of chickpea haulm. However, increments in total DM intake resulting from increments in the level of leucaena inclusion were not significant. Concentrate supplementation slightly reduced consumption of chickpea haulm without a notable effect on total DM intake.

Water consumption per dry matter intake of animals in the different treatment groups varied in a very narrow range. Animals feeding on the concentrate ration had the highest daily water consumption.

3.2. Daily weight gain

Supplementation significantly improved the daily weight gain of sheep (Table 2). Treatments NS and L300 resulted in the lowest and highest extremes in weight gain respectively, while animals under treatments L200 and L300 did not differ significantly \((P > 0.05)\) from each other. Live weight of the control animals changed very little whereas those supplemented with three levels of leucaena and concentrate increased in weight by 68.1, 88.1, 93.6 and 74.3\%, respectively, by the end of the experiment. The increments over time were approximately linear.

Clinical symptoms of leucaena toxicity were not observed throughout the experimental period (Table 2).

3.3. Testicular and epididymal characteristics

Tables 3 and 4 show the effects of supplementing with different levels of leucaena leaf hay on testicular and epididymal growth in sheep. Highly significant differences were noted in most of the testicular and epididymal measurements among the different treatment groups. The lowest values were recorded for animals maintained solely on chickpea haulm in all measurements considered, the largest values being recorded in those receiving the highest level of leucaena (L300).

3.4. Scrotal measurements

Scrotal measurements (Table 5) indicated a highly significant \((P < 0.001)\) difference in scrotal circumference, scrotal skin thickness and in the diameters of the left and right testis. The SC of non-supplemented sheep was reduced by about 10\%. Addition of 100, 200, 300 g/head per day of leucaena to the diet has increased testicular size by 20, 24 and 21\%, respectively while a 25\% increment was achieved with the concentrate supplement. Fig. 1 shows the comparative changes in these parameters.

4. Discussion

4.1. Composition of feeds

Crude protein content of chickpea haulm in the present study (5.6 g/kg) is far below the critical levels of 7–8 g/kg at which voluntary intake and digestibility are reduced (Van Soest, 1982). Teshome and Goshu (1994) reported a higher CP content (8.9 g/kg) in this by product which, according to the authors, was attributed to inefficient threshing of the crop that left grains in the residue. Leucaena had the

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Chickpea haulm intake (g DM/head/day)</th>
<th>Total DM intake (g/day)</th>
<th>CP intake (g/day)</th>
<th>Water intake (l/kg DMI)</th>
<th>BWG (g/day)</th>
<th>FCR (g DM/g BWG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td>627 (115)^a</td>
<td>627 (115)^b</td>
<td>33.2 (6.1)^c</td>
<td>2.1 (0.1)^d</td>
<td>0.2 (4.0)^e</td>
<td>237.0 (0.1)^a</td>
</tr>
<tr>
<td>L100</td>
<td>974 (165)^a</td>
<td>1066 (264)^a</td>
<td>74.1 (8.6)^c</td>
<td>2.1 (0.1)^d</td>
<td>51.2 (4.2)^a</td>
<td>20.7 (3.8)^b</td>
</tr>
<tr>
<td>L200</td>
<td>893 (73)^a</td>
<td>1077 (73)^a</td>
<td>92.5 (4.0)^c</td>
<td>2.3 (0.1)^d</td>
<td>66.3 (3.9)^a</td>
<td>16.3 (0.9)^b</td>
</tr>
<tr>
<td>L300</td>
<td>899 (5)^a</td>
<td>1175 (5)^a</td>
<td>114.8 (0.3)^c</td>
<td>2.1 (0.1)^d</td>
<td>70.8 (3.9)^a</td>
<td>16.2 (0.4)^b</td>
</tr>
<tr>
<td>C300</td>
<td>614 (126)^a</td>
<td>893 (126)^a</td>
<td>102.7 (5.9)^c</td>
<td>2.6 (0.1)^d</td>
<td>55.2 (3.9)^a</td>
<td>16.1 (0.4)^b</td>
</tr>
</tbody>
</table>

^a Least square means in column with different superscript Capital letters are significantly different from each other \((P < 0.05)\).

^b No supplement, chickpea haulm only.
Table 3
Effect of supplementing 100, 200, and 300 g/head per day of leucaena leaf hay (L100, L200 and L300, respectively) and 300 g/head per day of concentrate (C300) on testicular and epididymal weights of sheep

<table>
<thead>
<tr>
<th>Parameters (Weight, g)</th>
<th>Treatments</th>
<th>NS b</th>
<th>L100</th>
<th>L200</th>
<th>L300</th>
<th>C300</th>
<th>Overall</th>
<th>CV</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paired testes (total)</td>
<td>81.0(13) a</td>
<td>237.0(13)b</td>
<td>260.0(13)b</td>
<td>272.0(13)b</td>
<td>233.0(13)b</td>
<td>217.0(5)</td>
<td>13.4</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Head, epid.</td>
<td>5.4(1.1)a</td>
<td>14.8(1)b</td>
<td>16.4(1.1)b</td>
<td>16.6(1.6)b</td>
<td>13.6(1.1)b</td>
<td>13.4(0.5)</td>
<td>17.8</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Body, epid. (total)</td>
<td>1.4(0.5)a</td>
<td>4.8(0.5)b</td>
<td>3.8(0.5)b</td>
<td>3.4(0.5)b</td>
<td>3.8(0.5)b</td>
<td>3.4(0.2)</td>
<td>29.7</td>
<td>0.0007</td>
<td></td>
</tr>
<tr>
<td>Tail, epid. (total)</td>
<td>7.8(0.9)a</td>
<td>20.0(0.9)b</td>
<td>19.2(0.9)b</td>
<td>22.8(0.9)b</td>
<td>20.2(0.9)b</td>
<td>18.0(0.4)</td>
<td>12.0</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Total epid. (both testes)</td>
<td>14.6(1.8)a</td>
<td>39.4(1.8)b</td>
<td>39.0(1.8)b</td>
<td>42.6(1.8)b</td>
<td>37.4(1.8)b</td>
<td>34.6(0.8)</td>
<td>11.8</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Right testis</td>
<td>40.0(6.7)b</td>
<td>117.0(6.7)b</td>
<td>131.0(6.7)b</td>
<td>135.0(3.7)b</td>
<td>116.0(6.7)b</td>
<td>108.0(3)</td>
<td>13.9</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Left testis</td>
<td>41.0(6.4)b</td>
<td>121.0(6.4)b</td>
<td>137.0(6.4)b</td>
<td>137.0(6.4)b</td>
<td>118.0(6.4)b</td>
<td>109.0(2.8)</td>
<td>13.0</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Testicular/epid. weight (Ratio)</td>
<td>5.6(0.2)a</td>
<td>6.0(0.2)b</td>
<td>6.7(0.2)b</td>
<td>6.4(0.2)b</td>
<td>6.2(0.2)b</td>
<td>6.2(0.1)</td>
<td>7.7</td>
<td>0.0311</td>
<td></td>
</tr>
</tbody>
</table>

a Least square means in a row with different superscript Capital letters are significantly different (P<0.05) from each other.
b Epididymis.
c No supplement, chickpea haulm only.

Table 4
Effect of supplementing 100, 200, and 300 g/head per day of leucaena leaf hay (L100, L200 and L300, respectively) and 300 g/head per day of concentrate (C300) on growth of epididymal components of the right and left testes

<table>
<thead>
<tr>
<th>Parameters (Weight, g)</th>
<th>Treatment</th>
<th>NS b</th>
<th>L100</th>
<th>L200</th>
<th>L300</th>
<th>C300</th>
<th>Overall</th>
<th>CV</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total epid. (right testis) b</td>
<td>7.4(0.7)a</td>
<td>19.6(0.7)b</td>
<td>19.3(0.7)b</td>
<td>21.3(0.7)b</td>
<td>18.5(0.7)b</td>
<td>16.8(0.3)</td>
<td>14.0</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Head, epid.(right testis)</td>
<td>2.6(0.6)a</td>
<td>7.6(0.6)b</td>
<td>8.2(0.6)b</td>
<td>8.4(0.6)b</td>
<td>6.8(0.6)b</td>
<td>6.7(0.2)</td>
<td>18.6</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Body, epid.(right testis)</td>
<td>0.8(0.2)a</td>
<td>2.2(0.2)b</td>
<td>2.2(0.2)b</td>
<td>1.8(0.2)b</td>
<td>1.8(0.1)b</td>
<td>1.8(0.1)</td>
<td>31.0</td>
<td>0.0039</td>
<td></td>
</tr>
<tr>
<td>Tail, epid. (right testis)</td>
<td>3.8(0.5)a</td>
<td>9.8(0.5)b</td>
<td>9.6(0.5)b</td>
<td>11.2(0.5)b</td>
<td>9.8(0.5)b</td>
<td>8.8(0.2)</td>
<td>12.0</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Total epid. (left testis)</td>
<td>7.4(0.6)a</td>
<td>19.9(0.6)b</td>
<td>19.1(0.6)b</td>
<td>21.3(0.6)b</td>
<td>18.9(0.6)b</td>
<td>17.0(0.3)</td>
<td>15.7</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Head, epid.(left testis)</td>
<td>2.8(0.6)a</td>
<td>7.8(0.6)b</td>
<td>8.2(0.6)b</td>
<td>8.4(0.6)b</td>
<td>6.8(0.6)b</td>
<td>6.8(0.2)</td>
<td>18.0</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Body, epid.(left testis)</td>
<td>0.8(0.3)a</td>
<td>2.4(0.3)b</td>
<td>1.6(0.3)b</td>
<td>1.6(0.3)b</td>
<td>1.8(0.3)b</td>
<td>1.6(0.1)</td>
<td>41.0</td>
<td>0.0237</td>
<td></td>
</tr>
<tr>
<td>Tail, epid.(left testis)</td>
<td>4.0(0.5)a</td>
<td>10.0(0.5)b</td>
<td>9.8(0.5)b</td>
<td>11.6(0.5)b</td>
<td>10.4(0.5)b</td>
<td>9.2(0.2)</td>
<td>12.7</td>
<td>0.0001</td>
<td></td>
</tr>
</tbody>
</table>

a Least square means in a row with different superscript Capital letters are significantly different (P<0.05) from each other.
b Epididymis.
c No supplement, chickpea haulm only.

Table 5
Least square means (±SE) of body weights and scrotal measurements of sheep supplemented with 100, 200 and 300 g/head per day of Leucaena leucocephala leaf hay (L100, L200 and L300, respectively) and 300 g/head per day of concentrate (C300)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Treatments</th>
<th>NS b</th>
<th>L100</th>
<th>L200</th>
<th>L300</th>
<th>C300</th>
<th>Overall</th>
<th>CV</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight (kg)</td>
<td>16.8(0.5)a</td>
<td>27.0(0.5)b</td>
<td>30.4(0.5)c</td>
<td>31.7(0.5)c</td>
<td>27.3(0.5)b</td>
<td>26.7(0.2)</td>
<td>9.7</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Scrotal circumference (cm)</td>
<td>19.6(0.3)a</td>
<td>27.9(0.3)b</td>
<td>27.9(0.3)b</td>
<td>28.6(0.2)c</td>
<td>26.8(0.2)b</td>
<td>26.2(0.1)</td>
<td>5.2</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Right testis diameter (mm)</td>
<td>3.5(0.1)a</td>
<td>4.8(0.1)b</td>
<td>4.8(0.1)b</td>
<td>4.9(0.1)b</td>
<td>4.6(0.1)b</td>
<td>4.5(0.05)</td>
<td>13.6</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Left testis diameter (mm)</td>
<td>3.5(0.1)a</td>
<td>4.7(0.1)b</td>
<td>4.8(0.1)b</td>
<td>5.0(0.1)b</td>
<td>4.6(0.1)b</td>
<td>4.5(0.1)</td>
<td>13.7</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Scrotal skin thickness (mm)</td>
<td>0.4(0.06)a</td>
<td>0.8(0.06)b</td>
<td>0.75(0.06)b</td>
<td>0.8(0.06)b</td>
<td>0.9(0.06)b</td>
<td>0.67(0.03)</td>
<td>52.5</td>
<td>0.0001</td>
<td></td>
</tr>
</tbody>
</table>

a Figures in a row followed by different superscript Capital letters are significantly different from each other (P<0.05).
b Not supplemented, chickpea haulm only.
highest CP content and very low NDF and ADF values. The values agree very well with the values reported by NAS (1977). The roughage is very high in fibre content as would be expected but the values were lower compared to cereal straws. Values reported for the concentrate were more or less similar to that of leucaena leaf hay.

Both Ca and P contents of leucaena were sufficient enough to meet the demands of most tropical ruminants as suggested by Kearl (1982) although the values were low compared to those reported by NAS (1977). The ratio of Ca to P was high in both leucaena (7.8:1) and chickpea haulm (6.5:1) when compared with the recommended dietary proportion of 1:1 or 1.5:1 (NRC, 1984). However, calcium to phosphorus ratio as large as 15.9:1 was reported for leucaena in the review of Topps (1995). Although such proportion seem to be abnormal it is unlikely to be deleterious especially in sheep since these animals were recognised to have a tolerance for very wide range of Ca:P (Kearl, 1982).

4.2. DM and water intakes

Supplementation improved the total daily DM intake of the sheep. Addition of all the three levels of leucaena in the diet of sheep increased the total DM intake significantly with a slight effect on intake of the basal diet. Similar results were reported by Kimambo et al. (1992) with leucaena supplementation to sheep maintained on a maize stover basal diet.

Water intake varied in a very narrow range from 2.1 to 2.6 l/kg DMI and it falls within the normal range of 1.4–17.5 l/kg DMI (NRC, 1984). Sheep in treatment 1(NS) receiving the chickpea haulm alone consumed the lowest volume of water (2.1 l/day) (P<0.05). The high water consumption of animals on the concentrate ration might be due to the salt in this diet. Differences observed among the other treatment groups were not large although the total daily consumption per head was obviously higher for the groups with the larger dry matter intake. In line with the results reported earlier (Zewdu, 1991), a strong positive correlation (r=0.75; P<0.01) was observed between water and feed intake in this study.

4.3. Daily weight gain

Rate of growth increased with levels of leucaena (P<0.05) which agrees with the report of Mtenga and Shoo (1990) and Teshome and Goshu (1994). However, in their study with goats, Abilay and Arinto (1981) found no significant effect on body weight gain of does supplemented with up to 37.5% of the ration as leucaena leaves when fed on napier grass and concentrate mixture diet. Response to
leucaena supplementation varies with susceptibility of animals to mimosine toxicity, which in turn could vary with geographical location and species of animal. Toxicity is some times manifested in terms of reduced efficiency of nutrient utilisation and consequent poor animal performance (D’Mello, 1992).

Weight gain of sheep supplemented with 300 g/day concentrate was comparable to that obtained by supplementing 100 g/day of leucaena but lower than the gain achieved with 200 and 300 g/day of leucaena suggesting that sheep could gain even better if offered leucaena leaf hay instead of a comparable quantity of concentrate mixture. Superior growth performance of animals receiving the legume hay might be due to the tannin content of leucaena. Tannins, present in many browse legumes including *Leucaena leucocephala*, are considered to be beneficial in ruminant nutrition because they prevent excessive degradation of high quality leaf protein in the rumen (D’Mello, 1992).

4.4. Epididymal and testicular measurements

4.4.1. Epididymal weights

Epididymis is one of the most important tissues in male reproduction. It is the site where maturation, storage and transportation of spermatozoa take place.

Epididymal growth was significantly \((P<0.05)\) retarded in animals on the chickpea haulm diet and it improved with supplementation. This confirms the explanation given by Garner and Hafez (1980) of an adverse effect of poor nutrition on growth of male organs of reproduction. Supplementation generally increased the total weights of all the three components of the epididymis (Table 3). Similar effects were observed on the weights of these epididymal components in both the left and right testes (Table 4). However, the body of epididymis was found to be larger in rams on treatment L100 for the left testis and on treatments L100 and L200 for the right testis \((P<0.05)\).

The ratio between testicular and epididymal weights for the different treatments ranged from 5.6:1 (NS) to 6.7:1 (L200). It was significantly lower in sheep given the sole diet of chickpea haulm. Although comparative data are not available for rams these values are smaller than those (10:1) reported for *Bos indicus* bulls (Tegegne et al., 1995).

4.4.2. Scrotal circumference

From the results of this study it is evident that improving DM intake or feeding high quality supplements enhances testicular growth in rams. Leucaena supplementation significantly increased scrotal circumference. A comparable change was achieved with the concentrate supplement. This result is in agreement with the findings of Oldham et al. (1978) in rams as quoted by FAO (1986) in bulls. A similar finding has been reported by Tegegne et al. (1995) who indicated an increment in testicular growth rate of bulls from 0.31 to 0.38 mm/day as a result of protein supplementation.

The scrotal circumference of non supplemented rams was reduced by about 10% although no concurrent changes were noted in their live weight. The reason for this might be attributed to loss of fat from scrotal tissue of rams maintained on such a poor quality roughage diet. Coulter and Kozub (1984) noted a reduction of testicular size in bulls due to loss of fat in scrotal tissue.

Measurements on scrotal skin thickness of animals receiving the different treatments in this study supported the above explanation. Scrotal skin was thinnest \((P<0.05)\) in non-supplemented sheep towards the end of the experiment, although the values were similar among the treatment groups at the beginning of the experiment. Smaller testicular size in this group of animals where no change in body weight was noted indicates that the testicular tissue of Ethiopian highland sheep (Arsi type) is sensitive to poor nutrition. Lower scrotal circumference has been associated with poor fertility and a lower libido.

Addition of 100, 200 and 300 g/head per day of leucaena to the diet has increased testicular size by 20, 24 and 21%, respectively while a 25% increment was achieved with concentrate supplementation. The associated changes in body weight were 68, 88, 94 and 74% for the respective treatment groups. In contrast, Oldham et al. (1978) and Martin et al. (1987) in their studies with Merino rams, observed greater proportional increases in testicular size (63–67%) than in body weight (32–42%) with supplementation. The reason for the variation in the pattern...
of response to supplementation could possibly be attributed to breed difference.

4.4.3. Testes diameters

The diameters of the left and right testes were significantly affected by dietary treatments, the smallest being recorded for the testes of rams fed on the roughage diet alone (Table 5). No disparities were noted in size between the left and right testes which otherwise might have tempted one to suspect testicular hypoplasia (Ramma and Rao, 1982).

4.5. Correlations

Unlike the findings of Hahn et al. (1969) in dairy bulls the correlation between body weight (BW) and scrotal circumference (SC) in this study was high ($r=0.87; P<0.01$) confirming that the faster growing rams on supplemented diets had larger testes than the non supplemented smaller rams of similar age (Fig. 1). Both body weight and scrotal circumference were highly correlated with total weights of paired testes, and total head, body and tail of epididymis, the coefficients ranging from 0.7 to 0.98 ($P<0.01$). This agrees with the observation of Hahn et al. (1969) for mature Holstein bulls. The association between scrotal circumference and total weight of paired testes ($r=0.7$) observed in this study was comparable to that ($r=0.78$) reported by Coulter and Kozub (1984) in 2-year-old bulls feeding on different levels of dietary energy. The highest coefficient of correlation was obtained between SC and total weight of tail of the epididymis ($r=0.98; P<0.01$).

5. Conclusion

Changes in body weight of animals receiving chickpea haulm alone were very small. Feeding this roughage alone retarded testicular growth. Supplementation of up to 300 g/head per day of leucaena leaf hay improved body weight gain with concurrent increases in testicular and epididymal sizes. However, the influence of leucaena at a higher level of inclusion should be assessed in order to ensure the safety of its inclusion in the diets of these animals. Moreover, pathological analysis of reproductive tissues and other measurements of reproductive capacity of male animals such as seminal characteristics should be studied in order to have a further understanding of the effect of leucaena on reproduction.

Acknowledgements

The authors wish to acknowledge the assistance given by the staff of the Animal Science Department at Debre Zeit Research Centre. The technical support rendered by ILRI, Debre Zeit station is highly appreciated. Our due acknowledgement also goes to Dr Tilahun Sahlu of the Langston University, Institute for Goat Research, USA, for supplying us with some very important equipment.

References


Alkass, J.E., Bryant, M.J., Walton, J.S., 1982. Some effects ofThis agrees with the observation of Hahn et al. level of feeding and body condition upon sperm production and gonadothropic concentrations in the ram. Anim. Prod. 34, 265–270.


Gilbert, D.M., Nelson, A., Migazawan, H., De Pamphilis, M.L.,


Kearl, L.C., 1982. Nutrient requirements of ruminants in developing countries. International Feed Stuffs Institute, Utah Agricultural Experiment Station, Utah State University, Logan, Utah.


