Partial substitution of *Atriplex lentiformis* for wheat straw in the diet of Damascus does

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Abstract

Damascus does were fed either a conventional wheat straw-concentrate ration (control) or a ration where 35% of the straw was replaced with *Atriplex lentiformis* hay, with barley grain added and concentrate level reduced to make both diets isocaloric and isonitrogenous. The rations were fed from 5 months before mating to kidding. Similar amounts of metabolisable energy (ME) and crude protein (CP) were fed and consumed by the does in the 2 groups. Leaves plus flower clusters of *A. lentiformis* contained more CP and ME and less crude fibre and cell wall constituents than stalks. The values for IVDOM in *A. lentiformis* hay were: 516, 629 and 285 g/kg dry matter (DM) for the whole external cover, leaves plus flower-clusters and stalks, respectively; and comparable values for ME were: 6.01, 6.55 and 3.76 MJ/kg DM. The values for buffer-soluble nitrogen were 29 and 39% and for buffer-soluble non-protein nitrogen were 25 and 28% of the total N in leaves plus flower-clusters and stalks, respectively. Live weights, blood serum concentrations, conception rates and duration of pregnancy were similar for does on both rations as were birth weights of kids. It appears that *Atriplex* lentiformis hay can be substituted for some of the wheat straw in conventional straw-concentrate diets for breeding does without detriment to performance, with a resultant saving in amount of concentrate required.

Introduction

In semi-arid and arid areas, pasture grasses are frequently low in protein and cannot support high levels of animal production. In these areas including Syria, conventional diets for goats are based on straw, alfalfa and agricultural by-products as roughages, supplemented with barley and concentrate mix. Straw and agricultural by-products are high in lignocellulosic materials and low in N. While alfalfa supplies N to the diet, it requires high amounts of non-saline water for irrigation. *Atriplex* spp. are high in N and by tolerating saline water, save on usage of non-saline irrigation water, consequently reducing the cost of the forage produced. The low quality and seasonal nature of forage supply, together with low intake by animals and poor digestibility of forages, are major factors contributing to the low productivity of ruminants (Remenyi and McWilliam 1986).

Shrubs such as *Atriplex* spp. are used in many semi-arid and arid parts of the world as protein supplements for low quality forage diets for sheep (BenSalem et al. 2002a; 2002b) and goats (Guevara et al. 2003). *Atriplex canescens* is considered a valuable forage resource for both wild and domestic herbivores (Cibils et al. 2000). *Atriplex halimus* was fed with wheat straw to rams (Alicata et al. 2002), and *Atriplex nummularia* with *Acacia cyanophylla* hay or spineless cactus to sheep (BenSalem et al. 2002a; 2002b), as a nitrogen supplement to improve the feeding value of the diets and animal growth. The nutrient costs for shrub production from *A. nummularia* were lower than those for alfalfa hay as a supplement for goat production (Guevara et al. 2003).

However, Zarkawi et al. (2003) found that 50% of Damascus does fed lentil straw and concentrate plus 300 g daily of *Sesbania aculeata* hay failed to kid, and attributed this to either a failure to conceive or early embryonic mortality.

There is a dearth of information in the literature concerning the nutritive value of *A. lentiformis* (a member of the Chenopodiaceae family,
grown on salty soils and irrigated with saline water and its effect on the reproductive performance of small ruminants. Salt-affected soils are widespread in Syria, resulting in large areas of agricultural land being withdrawn from agricultural production annually. Attempts are being made to make these areas productive again by utilising available saline groundwater and salt-tolerant plants such as *Atriplex* spp. Therefore, the main objectives of the present study were to determine:

- the nutritive value of *A. lentiformis* (whole external cover, stalks and leaves plus flower-clusters) grown on salty soils and irrigated with saline water; and
- the value of *A. lentiformis* hay as a partial substitute for cereal straw in mixed straw-concentrate diets for Damascus does during the reproductive cycle.

Materials and methods

**Site description and planting**

*Atriplex lentiformis* shrubs were grown on salty soils (EC = 31.7 dS/m, pH = 7.54, total carbonate = 21%, organic matter = 0.39% at 25–50 cm depth; silt-loam texture), located at the “Farm of 7th April” in north-eastern Syria (39°41.3′ E, 36.3°34.1′ N; 203 m asl), with an average annual rainfall of 160 mm, mainly occurring between October and January, and were irrigated bi-weekly from February to September with saline water (15–22 dS/m), totalling an average of 7143 m³/ha/yr.

The whole external vegetative cover (70 cm) of 3-year-old plants was harvested at the flowering stage in early autumn from different field locations. Harvested material was well mixed. Five representative samples, 4 kg each, were randomly taken from the mixed material and used as samples for whole external cover (n = 5). In addition, 5 representative samples, 4 kg each, were also randomly taken from the mixed material and were divided into leaves plus flower-clusters (n = 5) and stalks (2–4 mm diameter) (n = 5). All harvested material was dried in the shade (average temperature 30°C) for 6 weeks. The weight ratio (dried stalks:leaves plus flower-clusters) was 1:2.1. Samples were ground to pass through a 1 mm sieve and stored in sealed nylon bags at −20°C for subsequent analysis and evaluation. The total harvested material after drying was chopped into 8 cm lengths and thoroughly mixed to be fed later to the experimental group of does.

Nutritive components of the whole external vegetative cover, leaves plus flower-clusters and stalks of 3-year-old plants are shown in Table 1.

**Estimated and measured parameters**

Dry matter (DM), crude ash, crude protein, crude fibre, ether extract and cell wall constituents [neutral-detergent fibre (NDF), acid-detergent fibre (ADF) and acid-detergent lignin (ADL)] were determined by the methods of Naumann and Bassler (1976) and Goering and van Soest (1970). Buffer-soluble nitrogen (BSN) and non-protein nitrogen (BSNPN) were determined according to Makkar and Becker (1996).

The experimental samples were incubated in 100 mL calibrated glass syringes at 39°C with ruminal fluid mixed with medium, basically by the procedures of Menke *et al.* (1979), to determine the rate of gas production and to estimate in vitro digestible organic matter (IVDOM) and

<p>| Table 1. Nutritive components and nitrogen forms (g/kg DM) and energetic value (MJ ME/kg DM) in plant samples of dried <em>Atriplex lentiformis</em> (whole external cover, leaves plus flower-clusters, stalks) (n = 5). |
|---|---|---|---|---|---|---|---|---|</p>
<table>
<thead>
<tr>
<th>Ash</th>
<th>CP</th>
<th>CF</th>
<th>EE</th>
<th>NDF</th>
<th>ADF</th>
<th>ADL</th>
<th>IVDOM</th>
<th>Total N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole external cover</td>
<td>170</td>
<td>122</td>
<td>321</td>
<td>22</td>
<td>591</td>
<td>376</td>
<td>116</td>
<td>516</td>
</tr>
<tr>
<td>Leaves plus flower-clusters</td>
<td>287</td>
<td>141</td>
<td>151</td>
<td>35</td>
<td>412</td>
<td>212</td>
<td>101</td>
<td>629</td>
</tr>
<tr>
<td>Stalks</td>
<td>49</td>
<td>41</td>
<td>505</td>
<td>10</td>
<td>829</td>
<td>579</td>
<td>133</td>
<td>285</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>10</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>38</td>
<td>7</td>
<td>7</td>
<td>10</td>
</tr>
</tbody>
</table>


2 Values in parentheses are percentages of total nitrogen.

3 70 cm of 3-year-old plants fed to the experimental group during the study.
metabolisable energy (ME). As a modification, the syringes were incubated standing upright in a water bath instead of being stacked horizontally on a slowly turning rotor housed in an incubator (Blümmel and Ørskov 1993). The equations used to estimate digestible organic matter and metabolisable energy values were:

\[
IVDOM \ (g/kg \ DM) = 14.88 + 0.8893(\text{mL gas produced}) + 0.0448(\text{protein, g/kg DM}) + 0.0651(\text{ash, g/kg DM})
\]

\[
ME \ (MJ/kg \ DM) = 2.20 + 0.136(\text{mL gas produced}) + 0.0057(\text{protein, g/kg DM}) + 0.00029(\text{lipid, g/kg DM})^2
\]

The volume of gas was based on that produced by incubating 200 mg of substrate for 24 h. The equations for roughages were chosen according to Menke and Steingass (1988).

Ruminal fluid was collected from 3 rumen-fistulated Awassi rams. To avoid changes in ruminal fluid activity during the experiment, the fistulated rams were fed twice daily on a predominantly roughage diet (lentil straw and alfalfa) and received 185 g crude protein and 10.6 MJ ME per day. Ruminal fluid samples were taken once every 7 days, 17 h after the last feed. The ruminal fluid was homogenised and strained through 100 µm nylon cloth into a warm flask (39°C) filled with CO₂. A total of 30 mL medium, consisting of 10 mL ruminal fluid and 20 mL of bicarbonate-mineral-distilled water mixture (1:1:2 by vol.), was pumped with an automatic pipette into the warmed syringes containing the samples or hay standards (200 mg) and into the blank syringes. The syringes were shaken by hand for a couple of seconds, twice in the first hour and once again after 3, 5 and 7 hours of incubation (Al-Masri 2003). Gas production was recorded after 24 h and compared with that produced by the standard hay sample (Hohenheim University, Germany) used by Steingass and Menke (1986) to standardise the quality of the ruminal fluid.

**Experimental animals, diets and management**

Eighteen cycling Damascus does, 3–4 years of age with an average live weight of 48.4 ± 2.9 kg, and with no previous record of reproductive disorders, were used. They were divided into 2 groups (control and experimental) and penned individually (except for the time when males joined the females for breeding). The control group was fed wheat straw and a concentrate mix (33% of the total ration) containing 40% barley, 40% wheat bran, 18% decorticated cotton cake, 1% sand and 1% sodium chloride with CP 211g/kg DM and ME 11.2 MJ/kg DM. For the experimental group, *A. lentiformis* hay replaced 35% of the wheat straw in the daily ration offered to the control group (Table 1), while the level of concentrate mix was reduced and barley added to make both rations isocaloric and isonitrogenous as recommended by Kirchgessner (1982) and Friesecce (1984). The level of feed offered was increased to satisfy the changing nutrient requirements of the does as the reproductive cycle advanced (Table 1). The rations were offered in 2 equal portions daily at 08.00h and 14.00h and all feed offered was consumed. Water was provided *ad libitum*. Does were weighed weekly in the morning before feeding, throughout the experiment.

Oestrus was synchronised in all does 5 months after the commencement of *A. lentiformis* hay feeding, using intravaginal sponges containing 40 mg of flugestone acetate (FGA, Intervet, the Netherlands) for two weeks.

**Oestrus detection and mating**

Three fertile Damascus bucks were released among the females outdoors the day after removal of the intravaginal sponges, for a period of 5 hours (08.00–13.00 h) for oestrus detection and natural mating. This process was repeated daily, for about 7 days, until all females were mated. All kids were weighed soon after birth.

**Blood collection and progesterone analysis**

Blood samples (10 ml) were collected from the jugular veins of all animals once-a-week (at 10.00h) throughout the study period (for 5 months before mating and throughout pregnancy). A further sample was collected within 24 hours after kidding. Blood was centrifuged at 3000 rpm for 20 minutes and serum was harvested and stored at −20°C for progesterone analysis using validated COAT-A-COUNT progesterone RIA kits solid phase (DPC Los Angeles, CA). Progesterone levels of ≥3.18 nmol/L were considered indicative of normal luteal function or pregnancy, and levels of <3.18 nmol/L were considered indicative
of the anoestrous, follicular or early luteal phases of the oestrous cycle (Zarkawi 1997).

Statistical analysis

Data were subjected to analysis of variance (ANOVA) using a Statview-IV program (Abacus Concepts, Berkeley, CA) on an IBM system, and means were separated using Fisher’s Least Significant Difference (LSD) test at the 0.05 probability level.

Results

Nutritive value of Atriplex lentiformis

Leaves plus flower-clusters of A. lentiformis had higher concentrations of crude protein, crude ash, IVDOM and ME, and lower concentrations of crude fibre and cell wall constituents (NDF, ADF and ADL) than stalks or the whole external cover (Table 2). Buffer-soluble nitrogen (BSN) levels in A. lentiformis hay were 45% for the whole external cover, and 29% for leaves plus flower-clusters.

Effects on serum progesterone and reproductive parameters

Treatment had no effect on serum progesterone concentration or pattern from the commencement of feeding to mating (5 months) (Figure 1), and from mating through to kidding (Figure 2).

All does exhibited oestrus and mated within 72 hours after the removal of sponges and all conceived. Three does from each group aborted about 1 month before kidding and 7 kids were produced by each group, with no significant difference in the birth weights of kids born, which averaged 3.6 ± 0.7 kg and 3.3 ± 0.5 kg for experimental and control groups, respectively.

Under the conditions of this study, A. lentiformis appeared to have no effect on the duration of pregnancy, which averaged 148.5 ± 4.5 days and 147.5 ± 2.7 days for the experimental and control groups, respectively.

Effects on live weights of goats

Average live weights of the control and experimental groups of Damascus does for 5 months before mating and from mating to kidding were similar (Figure 3).

Discussion

Results of this study suggest that 35% of the straw in the daily ration of Damascus does fed wheat straw plus a concentrate mix can be replaced with A. lentiformis hay, without any adverse effects on live weights of the goats or their reproductive

Table 2. Daily intake of nutrients1 and feed ingredients by Damascus does in the control and experimental groups.

<table>
<thead>
<tr>
<th>Feed ingredient</th>
<th>Control</th>
<th>Experimental</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intake</td>
<td>ME</td>
</tr>
<tr>
<td></td>
<td>(g/d)</td>
<td>(MJ/d)</td>
</tr>
<tr>
<td>Before mating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat straw</td>
<td>600</td>
<td>14.1</td>
</tr>
<tr>
<td>A. lentiformis2</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Concentrate3</td>
<td>300</td>
<td>58.2</td>
</tr>
<tr>
<td>Barley</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Total</td>
<td>900</td>
<td>72.3</td>
</tr>
<tr>
<td>From 1–105 days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>of pregnancy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat straw</td>
<td>800</td>
<td>18.8</td>
</tr>
<tr>
<td>A. lentiformis3</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Concentrate</td>
<td>400</td>
<td>77.6</td>
</tr>
<tr>
<td>Barley</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Total</td>
<td>1200</td>
<td>96.4</td>
</tr>
<tr>
<td>From 106 days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>of pregnancy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>until kidding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat straw</td>
<td>1050</td>
<td>24.7</td>
</tr>
<tr>
<td>A. lentiformis3</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Concentrate</td>
<td>525</td>
<td>101.9</td>
</tr>
<tr>
<td>Barley</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Total</td>
<td>1575</td>
<td>126.6</td>
</tr>
</tbody>
</table>

1 CP: crude protein, ME: metabolisable energy.
2 whole external vegetative cover (70 cm) of 3-year-old plants.
3 40% barley, 40% wheat bran, 18% decorticated cotton cake, 1% sand and 1% sodium chloride. CP: 211g/kg DM, ME: 11.2 MJ/kg DM.
functions (oestrus expression, conception rate, duration of pregnancy, blood serum progesterone concentration and birth weights of progeny). While 33% of does aborted during the study, levels were the same in both groups, so losses cannot be attributed to the feeding of atriplex. However, the low numbers of animals involved in this study preclude any definitive statements on kidding rates.

By keeping daily energy and protein intakes similar to those in the control group, replacement of 35% of the wheat straw with *A. lentiformis* hay in the ration allowed a reduction in level of barley plus concentrate (principally protein meal) fed of 20 g/animal/day. This resulted in a significant financial benefit in feed costs and was possible because of the higher crude protein concentration in the atriplex than the wheat straw.

The crude protein concentrations in leaves plus flower-clusters (141 g/kg DM) and whole external cover (122 g/kg DM) suggest that this material could be a very useful fodder. Levels were similar to the crude protein concentrations of 136–193 g/kg DM in *Atriplex halimus* reported by Alicata *et al.* (2002). However, the high crude protein concentration in atriplex leaves can
be misleading, because up to 60% of this fraction can be non-protein nitrogen (Benjamin et al. 1992) and some N can be unavailable to the animal because of the presence of anti-nutritional agents, e.g. tannins. In our study, buffer-soluble non-protein nitrogen (BSNPN) and buffer-soluble protein nitrogen (BSPN) in leaves plus flower-clusters were 25% and 3% of total nitrogen, respectively. Moreover, our results indicated that buffer-soluble nitrogen (BSN) in A. lentiformis hay was 45% for the whole external cover and 29% for leaves plus flower-clusters. These are similar to the BSN range of 25–40% in leaves of some Sesbania species reported by Hossain et al. (2001). The fate of the high levels of N not soluble in the rumen could be important for nutrition of the animals. If this N was digested in the lower tract, e.g. because of the binding of proteins by tannins, it would be unavailable to the animal and would be voided in the faeces. Our results do not allow any estimation of the level of availability of the non-soluble N.

The similar live weights of the 2 groups of does throughout the study indicated no adverse effect of including atriplex in the diet. BenSalem et al. (2002a) reported that supplementing cactus-based diets with Atriplex nummularia foliage improved the feeding value of these diets and improved sheep growth. Moreover, Guevara et al. (2003) indicated that the nutrient costs for shrub production (Atriplex nummularia and spineless cactus) were lower than those for alfalfa hay, the conventional feed used by many stockmen, and BenSalem et al. (2002a) suggested that a diet of acacia supplemented with cactus and Atriplex nummularia could be a cost-effective ration for sheep during dry seasons. Nsahlai and

**Figure 3.** Average live weight of the control and experimental groups of Damascus does: (a) for 5 months before mating; and (b) from mating to kidding.
Umunna (1996) found no benefit on live weight of sheep from feeding Sesbania sesban with oat hay despite the higher oat hay and total intake, whereas Kaitho et al. (1998) reported that sheep fed teff straw supplemented with Sesbania sesban had higher dry matter intake and live weight gain than those fed only teff straw. By restricting intake and controlling energy and protein concentrations in the two rations in our study, we eliminated the opportunity for the two groups of goats to consume different levels of feed and perform differently.

While this study suggests that Atriplex lentiformis hay can play an important role in feeding of Damascus does in Syria, more detailed studies are needed to determine how the rations can be manipulated to take advantage of the moderate crude protein concentration in this forage. Greater savings in production costs may be possible than those reported here.

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References


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