Effects of dietary protein sources on mohair growth and body weight of yearling Angora doelings


E (Kika) de la Garza Institute for Goat Research, Langston University, Langston, OK 73050, USA

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Abstract

Fifty-one yearling Angora doelings (20±0.6 kg initial body weight (BW)) were used to determine effects of different dietary protein sources on BW change and mohair growth. Diets consisted of approximately 40% roughage and 18–19% CP (DM basis), of which two-thirds was supplied by corn gluten meal (CG), cottonseed meal (CT), hydrolyzed feather meal (FT) or menhaden fish meal (FI); DM intake was restricted at approximately 0.7 kg/day. During the 94-day experiment, fleece-free ADG was greatest (P<0.05) for FI (35, 33, 35 and 50 g), whereas greasy fleece weight was greatest (P<0.05) for CG (4.4, 3.6, 3.4 and 3.4 kg for CG, CT, FT and FI, respectively). Likewise, mohair growth rate was greatest among treatments (P<0.05) for CG in each of the three 31- or 32-day periods. Ruminal fluid ammonia N concentration was 8, 11, 6 and 13 mg/dl (S.E. 1) immediately before feeding; 10, 18, 11 and 23 mg/dl (S.E. 2) at 2 h after feeding; 8, 15, 10 and 18 mg/dl (S.E. 2) at 4 h after feeding; and 4, 6, 5 and 8 mg/dl (S.E. 1) at 6 h after feeding for CG, CT, FT and FI, respectively. Total VFA concentration in ruminal fluid was similar among treatments (P>0.05) at 4 and 6 h, but was generally lower for CG and FT than for CT and FI immediately before feeding (29, 33, 26 and 37 mM; S.E. 2) and at 2 h after feeding (44, 57, 45 and 51 mM for CG, CT, FT and FI, respectively; S.E. 3). In conclusion, the different protein supplements had dissimilar effects on ADG (greatest for FI) and mohair growth (greatest for CG). Factors responsible for these results are unclear, and the range of experimental or production conditions under which comparable findings might occur are unknown and deserve further study.

Keywords: Angora goats; Mohair; Protein supplements

1. Introduction

Angora goat farming in the US occurs in areas such as Texas, where cottonseed meal is the supplemental protein source of choice, but also in regions where other protein sources are available and relatively inexpensive. In comparison with cottonseed meal, protein sources such as hydrolyzed feather meal, corn gluten meal and fish meal are more resistant to ruminal degradation and contain high concentrations of sulfur amino acids.

The US Angora goat, on a body weight (BW) basis, is one of the highest fleece-producing ruminants (Litherland and Sahlu, 1997). Mohair growth requires little energy but much protein is needed. In particular, requirements for the sulfur-containing amino acids cysteine and methionine are high (Reis and Sahlu, 1994). Based on amino acid concentrations, ruminal microbial protein cannot supply sufficient sulfur amino acids for mohair growth (Qi et al., 1994).
Feeding protein sources with high concentrations of sulfur amino acids, which are generally resistant to ruminal degradation, can alter postruminal amino acid supply (Cecava et al., 1990). When additional sulfur amino acids have been supplied postruminally to the Angora goat, mohair growth increases (Sahlu and Fernandez, 1992). However, the array of amino acids needed for fleece-free BW gain is different from that needed for fiber growth. Thus, diets containing supplemental protein sources promoting high BW gain may not necessarily do so for fiber growth, which would be of special importance for growing, fiber-producing ruminants, such as yearling Angora doelings typically bred for kidding at 2 years of age. Therefore, objectives of this study were to determine if different common supplemental dietary protein sources have similar effects on live weight and mohair growth in yearling Angora doelings.

2. Materials and methods

2.1. Animals and experiment design

Fifty-one 1-year-old Angora doelings, averaging 20 kg BW (S.E. 0.6), 3.0 kg fleece weight (S.E. 0.18; shorn on 22 February) and 26.6 μm fiber diameter (S.E. 0.29), were used in the experiment. For allocation to treatments, first animals were ranked or stratified by BW, then randomly allocated within BW grouping to the four treatments. After this initial allocation, means and S.D. for each treatment were calculated for BW, fleece weight and fiber diameter. Some changes in treatment allocation were made to achieve similar means and variation within treatments for these variables. There were three treatments with 13 animals and one with 12. Once the four treatment groups had been formed, they were randomly assigned to the dietary treatments. Dietary treatments were different supplemental protein sources: cottonseed meal (CT; 41% CP, DM basis), corn gluten meal (CG; 73% CP, DM basis), hydrolyzed feather meal (FT; 90% CP, DM basis) and Menhaden fish meal (FI; 66% CP, DM basis). The protein sources composed between 10 and 24% of dietary DM and supplied 65–70% of total dietary CP (Table 1). Diets were formulated to be 65% total digestible nutrients and 18% CP (DM basis).

The experiment commenced on 28 March and was 94 days in length. Doelings were housed individually, subjected to ambient temperature and natural photoperiod and had ad libitum access to water. Feed was offered once daily at a constant level, which was

| Table 1
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<thead>
<tr>
<th>Diet composition (% dry matter)</th>
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<tr>
<td>Item</td>
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<tr>
<td><strong>Ingredient composition</strong></td>
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<tr>
<td>Cottonseed hulls</td>
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<tr>
<td>Ground corn</td>
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<td>Corn gluten meal</td>
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<td>Cottonseed meal</td>
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<td>Feather meal</td>
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<td>Fish meal</td>
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<td>Calcium carbonate</td>
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<td>Trace mineral premix b</td>
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<td>Vitamin premix c</td>
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<td><strong>Chemical composition</strong></td>
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<td>Crude protein</td>
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<td>Neutral detergent fiber</td>
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<td>Acid detergent fiber</td>
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a CG: corn gluten meal; CT: cottonseed meal; FT: hydrolyzed feather meal; FI: fish meal.
b Contained 94–95% NaCl and greater than 0.2% Mn, 0.16% ferrous Fe, 0.14% ferric Fe, 0.033% CU, 0.10% Zn, 0.007% I and 0.005% Co.
c Contained 220,000 IU/g Vitamin A, 2200 IU/g Vitamin D and 0.2 IU/g Vitamin E.
calculated based on individual BW and assuming 0.119 M cal ME/kg^0.75 BW required for BW maintenance and mohair growth and an additional 0.007 M cal ME/kg ADG for 100 g ADG (NRC, 1981), since at approximately 1 year of age the doelings still had growth potential and would need to increase in BW for kidding at 2 years of age.

2.2. Measures

Doelings were weighed before feeding at 2 weeks intervals. Every 31 or 32 days, fiber regrowth rate and fiber diameter were estimated by clipping a 12 cm × 12 cm square on the right mid-side. At the end of the experiment, doelings were shorn, fleece weight was measured and a grab sample was removed from the left mid-side for determination of fiber diameter, stretched staple length and kemp. Greasy and clean mohair weights were determined according to ASTM (1988). Fiber diameter, percentage of kemp fibers and diameter of kemp fibers (patch samples) were determined on 3000–4000 snippets using an optical fiber distribution analyzer (OFDA 100; Zellweger Uster, Inc., Charlotte, NC, USA). Feed efficiencies were calculated for fleece-free BW and fleece mass.

On Days 45 and 90 of the experiment, ruminal fluid was sampled at 0, 2, 4 and 6 h after feeding. Concentrations of amino acids in protein supplements were determined as described by Puchala et al. (1995) using an AminoQuant system (Hewlett Packard, San Fernando, CA) and precolumn derivatization with o-phthalaldehyde and 9-fluorenylmethyl-chloroformate and UV detection. Ruminal fluid was sampled by stomach tube, acidified with HCl, frozen at −20°C and later assayed for ammonia N by the phenol-hypochlorite procedure of Broderick and Kang (1980) and VFA by gas chromatography (Hewlett Packard, Avondale, PA) as described by Lu et al. (1990). Daily samples of diets and feed refusals were used to form composites for three 31- or 32-day periods. Composite samples were ground to pass a 1 mm screen and analyzed for ash, CP (AOAC, 1984), NDF and ADF (Goering and Van Soest, 1970).

2.3. In situ N disappearance

Three mature, ruminally cannulated Angora wethers were fed a diet composed of equal parts of the four diets with different protein sources at 120% of the ME requirement for BW maintenance. After a 2 weeks adaptation period, duplicate dacron bags (14 cm × 9 cm bags; 50 μm pore size) containing 3.1 g (DM) of the protein sources (ground to pass a 2 mm screen) were incubated in the rumen for 2, 4, 8, 12, 24 or 48 h. Bags were emersed in tap water before incubation. Also, loss through solubilization and washout through bag pores (i.e. 0 h disappearance) was estimated by soaking in water for 20 min. After removal of bags from the rumen, bags were immediately emersed in cold water then washed in cold water in a washing machine for 10 min, dried for 24 h at 55°C and analyzed for N. Extent of ruminal N disappearance was calculated as described by Ørskov (1990) assuming a ruminal digesta passage rate of 0.05/h.

2.4. Statistical analyses

Single time-point measures were analyzed with treatment in the model by general linear models procedures of SAS (1990), and differences among means were determined by least significant difference and a protected F-test (P<0.05). Patch sample measures, including clean mohair growth rate, were analyzed separately for each 31- or 32-day period. Ruminal fluid measures with different days and times of sampling were analyzed by repeated measures analysis and the Wilks’ Lambda test of significance.

3. Results

3.1. Diet composition

The dietary CP concentration was similar to that formulated for (Table 1), and NDF concentration did not differ greatly among treatments. The extent of in situ ruminal N disappearance was 38, 61, 33 and 51% for corn gluten, cottonseed, feather and fish meals, respectively.

3.2. ADG and fleece

As expected, the quantity of feed refusals was relatively small, averaging 3.5±1% of DM intake. In accordance, DM intake was similar among treatments
P < 0.10; Table 2). Fleece-free ADG was greatest (P < 0.05) among treatments for FI, whereas greasy fleece weight was greatest (P < 0.05) for CG. In part because of greatest ADG and grease fleece weight for FI and CG, respectively, final BW was similar among treatments (P > 0.10). Treatment differences in ratios of fleece-free ADG and grease fleece weight to DM intake were similar to those in ADG and grease fleece weight. Fiber diameter, stretched staple length and percentage of kemp fiber were similar among treatments (P > 0.10).

Clean fiber yield averaged 81% of grease fleece weight. In agreement with greatest grease fleece weight for CG, clean mohair growth rate was greatest (P < 0.05) among treatments for CG (Table 2). In general, the magnitude of difference was similar among 31- or 32-day periods. Other period measures (fiber diameter, percentage kemp and kemp fiber diameter) were not affected by treatment (P > 0.10).

3.3. Ruminal fluid ammonia N and VFA concentrations

Day effects and interactions were nonsignificant (P > 0.05) for ruminal fluid ammonia N and VFA concentrations. Interactions between time after feeding were significant (P < 0.05) for ruminal fluid concentrations of ammonia N and total VFA, but not for

<table>
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<td>Effects of dietary protein source on dry matter intake, average daily gain and fleece measures in yearling Angora doelingsa</td>
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<td>Item</td>
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<tr>
<td>DM intake (kg/day)</td>
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<td>Final body weight (with fleece; kg)</td>
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<td>Fleece-free ADG (g)</td>
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<td>Greasy fleece weight (kg)</td>
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<td>Fleece-free ADG:DM intake</td>
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<td>Greasy fleece weight:DM intake</td>
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Day 94 whole fleece measures

Fiber diameter (µm) | 31.6 | 29.9 | 29.9 | 29.6 | 0.7 |
Stretched staple length (cm) | 10.2 | 10.1 | 9.0 | 9.1 | 0.4 |
Kemp (%) | 0.28 | 0.14 | 0.18 | 0.20 | 0.03 |

Patch sample measures

Clean mohair growth rate (mg cm⁻² per day) |
Day 1–31 | 1.46 a | 1.23 b | 1.23 b | 1.25 b | 0.06 |
Day 32–62 | 1.66 a | 1.39 b | 1.27 b | 1.35 b | 0.08 |
Day 63–94 | 1.55 a | 1.32 b | 1.26 b | 1.27 b | 0.08 |
Fiber diameter (µm) |
Day 1–31 | 30.4 | 29.0 | 29.6 | 29.0 | 0.6 |
Day 32–62 | 31.8 | 30.1 | 30.4 | 30.4 | 0.7 |
Day 63–94 | 33.7 | 31.9 | 31.8 | 31.7 | 0.7 |
Kemp (%) |
Day 1–31 | 0.20 | 0.18 | 0.22 | 0.21 | 0.04 |
Day 32–62 | 0.32 | 0.22 | 0.29 | 0.28 | 0.05 |
Day 63–94 | 0.46 | 0.18 | 0.29 | 0.30 | 0.05 |
Kemp fiber diameter (µm) |
Day 1–31 | 59 | 60 | 57 | 59 | 3 |
Day 32–62 | 63 | 61 | 59 | 62 | 3 |
Day 63–94 | 74 | 66 | 65 | 64 | 5 |

a Within a row, means without a common letters differ (P < 0.05).
b CG: corn gluten meal; CT: cottonseed meal; FT: hydrolyzed feather meal; FI: fish meal.
molar VFA percentages. In general, ruminal ammonia N concentration was greater for CT and FI than for CG and FT, with differences at 6 h of lesser magnitude than at other times (Table 3). In general, differences among treatments and trends for differences in total VFA concentration were similar to those in ammonia N concentration. Molar percentages of acetate and propionate and the acetate to propionate ratio were similar among treatments \((P>0.05)\). The butyrate molar percentage was greatest among treatments for CG \((P<0.05)\).

4. Discussion

4.1. Ruminal protein disappearance and nitrogenous compounds

Extents of ruminal disappearance of supplement protein estimated in situ were within ranges reported for other ruminant species of 15–55% for CG, 30–70% for FI, 29–40% for FT and 46–68% for CT (NRC, 1985; Titgemeyer et al., 1989; Calsamiglia et al., 1995; Yoon et al., 1996; Piepenbrink and Schingoethe, 1997). Values for FI, FT and CT fell within four percentage units of mean values presented by NRC (1985), although the estimate for CG was seven percentage units less than that given by NRC (1985). The in situ ruminal protein disappearance estimates agree with differences among diets in ruminal ammonia N concentration.

Ruminal ammonia N concentrations were low considering the relatively high dietary CP level, which can be at least partially explained by the high level of dietary inclusion of the protein sources, some of which were low in ruminal degradability, and moderate to high level of ground corn. Ruminal ammonia N concentrations at 6 h post-feeding were near the level of 2–5 mg/dl, often considered required for normal microbial growth (Satter and Slyter, 1974). Therefore, at later times after feeding ruminal availability of nitrogenous compounds might have limited microbial activity, particularly for CG and FT as suggested by their lower ruminal ammonia N levels at earlier times. In support, total VFA concentrations at 0 and 2 h were lower for CG and FT compared with CT and FI, and total VFA concentration at 4 and 6 h was numerically lowest among treatments for CG. Thus, energy availability for CG doelings may have been lowest among treatments, and restricted microbial protein synthesis is possible as well. In accordance, in a separate Latin square experiment with adult Angora wethers fed the same diets (our unpublished observations), ADF digestibility was lowest among treatments for CG (34, 39, 44 and 48% for CG, CT, FT and FI, respectively). Similarly, in other instances supplementation of diets high in protein sources not extensively degraded in the rumen with urea or protein highly degradable in the rumen has increased ruminal microbial growth, digestibility and (or) ruminant performance (Church et al., 1982; Aderibigbe and Church, 1983; Cecava et al., 1990; Lu et al., 1990; Sahlu et al., 1992).

4.2. ADG and fiber growth

In general, nutritional plane has affected fiber growth and ADG similarly (Reis and Sahlu, 1994); however, such effects may depend on the nature of diets and animal characteristics. For example, in some
instances an increased dietary level of ruminally undegraded protein has increased fleece growth without change in ADG (Sahlu et al., 1992; Huston et al., 1993). Likewise, in Merino sheep fed a roughage-based diet, FT supported a more rapid rate of wool growth than did CT but lower ADG (Neutze, 1990).

4.2.1. CG and fiber growth

Factors responsible for greatest clean mohair growth rate for doelings consuming the CG diet, yet greatest ADG for FI doelings are unclear. Although, a plausible explanation for greatest fiber growth by CG doelings was alluded to earlier. Perhaps ruminal availability of nitrogenous compounds limited VFA production and, thus, energy absorption to the greatest extent among treatments for CG. The amount of energy required by skin for fiber growth is much less than that for peripheral muscle protein synthesis and maintenance (Harris and Lobley, 1991). In sheep, near maximal rates of wool growth can be sustained with use of a quantity of energy less than 5% of the basal metabolic rate (Black, 1987). Therefore, an energy limitation for CG that restricted nutrient use in peripheral muscle and(or) fat accretion may have caused nutrient partitioning to skin and increased fiber growth (Harris and Lobley, 1991). The response to CG in fleece weight growth implies that the profile of available amino acids was suitable for use in fiber growth. In accordance, greater fiber growth for CG than for FT could relate to a more favorable array of amino acids available for use in fiber growth, such as suggested by high supplemental protein source intakes of leucine and methionine for CG (leucine: 10.9, 3.8, 5.2 and 4.9 g/day; methionine: 1.7, 1.1, 0.7 and 1.9 g/day for CG, CT, FT and FI, respectively). Also, intestinal availability of amino acids in the protein supplements is unknown. Nonetheless, in the separate Latin square experiment referred to earlier (our unpublished observations), apparent total tract CP digestibility was 77, 71, 62 and 79% for CG, CT, FT and FI, respectively. This suggests lowest intestinal digestibility among protein supplements for FT, which is in agreement with findings of Calsamiglia et al. (1995).

4.2.2. FI and ADG

Ruminal ammonia N and VFA concentrations for FI do not indicate that ruminal microbial growth or digestion was restricted or limited by ruminal availability of nitrogenous compounds to the same degree as with CG. Thus, energy absorption might have been greater for FI versus CG and FT, and microbial protein synthesis may have differed as well. Greater energy availability could have allowed increased nutrient partitioning to ADG relative to conditions with CG and FT. Also, it is possible that the profile of absorbed amino acids elicited by dietary inclusion of FI was more favorable for ADG than that for CT, as indicated by relatively high supplemental protein source intakes for fish meal of lysine (0.9, 2.5, 1.5 and 4.6 g/day for CG, CT, FT and FI, respectively) and methionine.

5. Conclusions

Results of this experiment indicate that dietary characteristics promoting high growth or BW gain may not be those most conducive to high mohair growth. In this particular instance, a diet with supplemental fish meal resulted in greater ADG than diets with feather, corn gluten or cottonseed meals, whereas corn gluten meal yielded greatest mohair growth. Further research is necessary to fully understand how dietary properties and nutrient status affects BW gain and mohair growth by yearling Angoras.

Acknowledgements

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References


