Sheep & Goat Research Journal
Volume 22, 2007

Growth and Carcass Characteristics in Goat Kids Fed Grass- and Alfalfa-Hay-Based Diets with Limited Concentrate Supplementation[1]

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Acknowledgements:

This research was partially supported by USDA-ARS Cooperative Agreement 58-1932-9-040, and is published as VSU Agricultural Research Station publication No. 255. Use of trade names are simply for the convenience of the reader and does not imply endorsement by VSU, NCSU, or USDA over comparable products.

Summary

Two experiments were conducted to evaluate the effect of feeding legume hay (alfalfa; *Medicago sativa* L.) or mixed-grass hay on ADG and carcass characteristics of growing goats. In Experiment 1, 24 Spanish kids, equally representing female, intact male and wether goats, were pen-fed *ad libitum* either chopped alfalfa (16.8 percent CP) or mixed grass hay (9.4 percent CP) (3 pens/diet) and a corn/soybean meal supplement (16 percent CP) at 1.5 percent BW for 102 d. Goats were harvested at a commercial abattoir. Average daily gain (62 vs. 37 g/d; $P < 0.01$), carcass weight (14.8 vs. 12.8 kg; $P < 0.05$) and dressing percent (52.9 percent vs. 50.4 percent; $P < 0.05$) were higher in alfalfa than grass-hay-fed goats, respectively. Backfat and percentage kidney/pelvic fat was lower ($P < 0.05$) in bucks (0.12 cm and 1.8 percent) than in does (0.17 cm and 5.7 percent) and wethers (0.22 cm and 4.0 percent). In Experiment 2, 10-month-old Boer and Boer-cross wethers (n=16) were pen-fed *ad libitum* either chopped alfalfa (15.2 percent CP) or grass hay (10.9 percent CP) for 84 days. Forage was supplemented with concentrate (16.3 percent CP) at 1 percent of BW. Carcass characteristics were determined as described for Experiment 1. Wethers fed alfalfa hay had a higher ADG (158 vs. 119 g/d; $P < 0.01$) and dressing percentage (54.0 percent vs. 52.2 percent, $P < 0.05$), but did not differ in other carcass characteristics. Alfalfa feeding improved growth rate and dressing percentage, but had no effect on other carcass characteristics, whereas sex class influenced primarily carcass-fat content.

Introduction

Goat production systems are more diverse, and markets more varied than for many of the more traditional livestock species in the United States. Finishing goats in feedlots on high concentrate diets is not a widespread practice, and goats are generally used more efficiently when utilizing browse and forage. Pen feeding of goats may achieve faster growth rates and allow for finishing at specific target weights (Lupton et al., 2007), but feedlot goats have shown only a marginal response in growth rate when dietary crude protein increased from 14 percent to 16.4 percent, or roughage content decreased with removal of cottonseed hulls from the feedlot ration (Huston and Waldron, 1996).

Goat meat has been extensively compared to lamb and mutton, and difference in flavor and aroma have been noted (Webb et al., 2005). Goats tend to be leaner (intra-muscular and back fat), have a lower dressing percentage, and higher muscle shear force values than sheep (Sen et al., 2004; Van Niekerk and Casey, 1988). Carcass composition in goats may be influenced by level of feed intake and diet composition (Warmington and Kirton, 1990), but additional information is needed on the specific effects of breed and diet on carcass characteristics.

The utilization of forages by ruminants is dependent on a variety of inter-related factors that include not only forage nutritive value, but also intake and digestibility (Reid et al., 1990). Forage type (grass vs. legume) can have a significant impact. Alfalfa not only has a higher CP concentration than most grasses, but generally has lower levels of ADF, and a greater organic matter intake and digestibility can be expected when consumed by goats compared to sheep (Coleman et al., 2003; Park et al., 1989; Reid et al., 1990). Therefore the objective of this study was to estimate the effect of the improved nutritional value of alfalfa hay compared to mixed grass hay on animal growth and carcass characteristics in young goats.

Materials and Methods

Feeding trials were conducted at the Small Ruminant Facilities of Virginia State University, Petersburg, Virginia. The first trial (Experiment 1) was conducted in fall (late August through November), while the second trial (Experiment 2) was conducted in December through March the following year. The experiments were approved by the Virginia State University Agricultural Animal Care and Use Committee.

Experiment 1

Twenty-four Spanish goat kids (16 bucklings and 8 doelings) were randomly selected from a fall kid crop at 6 months of age. Eight bucklings were surgically castrated and allowed to recover for 1 month to establish three sex classes (does, bucks and wethers). At 7 months of age animals were weighed and randomly allocated by sex class to six semi-enclosed pens (26 m^2; equipped with automated waterers) with four animals/pen (two pens per sex class). Forage-based diets consisted either of commercially produced grass (predominantly orchard grass, *Dactylis glomerata*) or alfalfa (*Medicago sativa* L.) hay and were fed to one pen per sex class.

Hay samples were analyzed for CP (total N x 6.25; Carlo-Erba Ea 1108 CHNS elemental analyzer, Fisons Instruments, Beverly, Mass.), neutral detergent fiber (NDF) and acid detergent fiber (ADF) using ANKOM procedures (Ankom Technology Corp., Fairport, N.Y.) and results are presented in Table 1. Forage (square bales) was processed through a hydraulic bale chopper prior to feeding, and cut to a particle length of 10 cm. Hay was offered at 15 percent to 25 percent over estimated daily intake and refusal removed and bunks cleaned daily prior to supplement feeding. In order to improve expected ADG and produce a harvestable product, all animals were supplemented with a cracked corn/soybean meal mixture (calculated at 16.0 percent CP and 75 percent TDN) at 1.5 percent BW, and animals had access to a trace-mineral mix with ammonium chloride. Supplement was fed in the cleaned bunks and complete consumption by individual animals was monitored (usually within 5 minutes), prior to the daily feeding of hay. Estimates of forage intake by animals temporarily placed into individual pens during the trial were 1.7 percent and 2.1 percent of BW for grass and alfalfa diets, respectively.

Body weight was recorded at 34-day intervals and supplement levels adjusted at this time. Pre-prandial blood samples were collected via jugular venipuncture at time of weighing, plasma harvested and analyzed for blood urea nitrogen (BUN) using a colorimetric technique (Sigma Diagnostic™ Test Kit Procedure No. 640).

After 102 days on trial animals were weighed at 0800 h; feed, but not water, was removed for 24 h, and shrunk BW was recorded to subsequently determine dressing percentage. Animals were transported to a commercial abattoir for harvest. Hot and cold carcass weight, ribeye area, back fat, and kidney and pelvic fat were measured, and retail cuts (shoulder, rack, loin and leg) were obtained and weighed. Data were analyzed using the GLM procedures of SAS ver. 9.1 (SAS Institute Inc., Cary, N.C.) in a model with animal as the experimental unit and forage type and sex class as main effects. Means were separated when significant ($P < 0.05$) F-values were indicated. Blood urea N data were analyzed using a repeated measures analysis.

Table 1. Nutritional values of the commercial mixed grass (predominantly orchard grass) and alfalfa hay used in the Experiment 1 and the commercial mixed grass (predominantly tall fescue) and alfalfa hay used in Experiment 2.

	Experiment 1		Experiment 2	
% (DM basis)[1]	Grass	Alfalfa	Grass	Alfalfa
CP	9.4	16.8	10.9	15.2
NDF	71.3	64.3	83.0	70.2
ADF	39.2	47.3	50.1	41.5

[1] CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber

Experiment 2

The second experiment evaluated the effect of an improved forage diet on growth performance and carcass characteristics in a breed type with a higher growth potential than the Spanish goats in Experiment 1. Animals for this experiment originated from the goat research herd of North Carolina State University. The 16 wether goats (7 Boer and 9 Boer cross) were castrated at birth, transported to Virginia State University after weaning at 90 days of age, and maintained on pasture. For the experiment the animals were weighed and randomly allocated to one of two semi-enclosed pens (44 m^2; equipped with automated waterers) at 10 months of age, with Boer and Boer-cross goats represented in each pen. Pens were fed either the grass-hay or alfalfa-hay-based diet. The mixed-grass hay in this trial was commercial, predominantly tall fescue [*Lolium arundinaceum* (Schreb.) Darbysh], whereas alfalfa was first-cutting, commercial hay (Table 1).

Animals were offered hay at 15 percent over estimated daily intake. Forage was processed and fed as described for Experiment 1, and supplemented at 1 percent BW with a cracked corn/whole cottonseed/soybean meal concentrate (calculated at 16.3 percent CP and 73 percent TDN) that included ammonium chloride. Supplement level was reduced in this trial to allow for greater consumption of forage. Supplement was again fed in clean bunks and complete intake monitored by all animals prior to feeding hay. Animals had *ad lib* access to a trace-mineral mix. Body weight was recorded in 14-day intervals and supplement levels were adjusted at this time. Pre-prandial blood samples were collected via jugular venipuncture on days 1, 42 and 84 of the trial, and plasma harvested and analyzed for BUN using automated procedures (Ciba-Corning Express Plus Chemistry Analyzer; Ciba-Corning Diagnostics Corp., Medfield, Mass.).

After 84 days on trial, animals were weighed and harvested as described for Experiment 1. Data were analyzed for the effect of forage type on BW, ADG, and carcass characteristics with animal as experimental unit using the GLM procedure of SAS ver. 9.1 (SAS Institute Inc., Cary, N.C.).

Results and Discussion

The ADG of the Spanish goat kids in Experiment 1 was 25 g/d higher ($P < 0.01$) in the alfalfa than the grass-hay-fed kids (Table 2). In Boer and Boer-cross wethers in Experiment 2, ADG of alfalfa-hay-fed wethers was 39 g/d higher ($P < 0.01$) than the grass-fed wethers (Table 2).

In a previous feeding trial at our location, using alfalfa-hay-based diets supplemented with concentrate at 0.5 percent BW, mixed-breed goat kids had intermediate ADG (103 g/d) to those observed in the two present experiments (Turner et al., 2005). In the Turner et al. (2005) trial ADG of alfalfa-hay-fed goats was 80 percent higher than in goats fed sericea lespedeza [*Lespedeza cuneata* (Dum.-Cours.) G. Don] hay. Spanish goat kids fed alfalfa pellets (17.9 percent CP) compared to prairie-grass hay (7.4 percent CP) in another trial had marked improvement in ADG (82 vs. 0 g/d) (Wuliji et al., 2003), exceeding the difference between diets observed in the present study. In the study by Wuliji et al. (2003) ADG of alfalfa-hay-fed kids was similar to those receiving an all-concentrate diet. Mixed-breed dairy goats, slightly younger and lighter (5 months; 20 kg) than animals in Experiment 1 offered alfalfa hay (18 percent CP) had lower ADG (46 g) (Gelaye et al., 1990) than the Spanish goats fed alfalfa hay in Experiment 1 (62 g/d). In this study by Gelaye et al. (1990) goats offered rhizoma peanut (*Arachis glabrata* Benth.) hay had similar daily gains (63 g/d) to the Spanish goats in Experiment 1.

In an earlier study we observed no differences in ADG between Boer-cross and Spanish goats fed alfalfa-hay diets (Turner et al., 2005), whereas results from the two experiments here suggest otherwise, though there was no direct comparison of the breeds. Waldron et al. (1996) reported higher ADG in Boer x Spanish compared to Spanish kids when provided feedlot diets, but not when grazing rangeland. Boer-cross wethers fed sudan grass (*Sorghum vulgare*) hay diets supplemented with various legumes (3:2 grass to legume) and corn had somewhat lower ADG (75 to 95 g) (Kanani et al., 2006) than the Boer and Boer-cross wethers in the present study.

Spanish kids fed alfalfa hay had higher ($P < 0.05$) carcass weight and dressing percent, but similar ribeye area,

Table 2. Body weight, ADG, and carcass characteristics (mean±SEM) in Spanish (Experiment 1) and Boer goats (Experiment 2) fed either alfalfa or grass hay-based diets with limited concentrate supplementation.

	Experiment 1[1]		Experiment 2[2]	
Hay type (N of animals)	Grass (12)	Alfalfa (12)	Grass (8)	Alfalfa (8)
Starting BW, kg	21.6±1.1	21.6±0.6	37.6±1.8	36.2±1.8
Final BW, kg	25.4±1.3	27.9±0.6	47.6±1.9	49.5±2.3
ADG, g/d	37±4	62±4**	119±6	158±10**
Cold carcass wt., kg	12.8±0.8	14.8±0.4*	24.3±1.0	26.2±1.3
Dressing %	50.4±0.8	52.9±0.7*	52.3±0.5	54.0±0.4*
Ribeye area, cm^2	9.5±0.4	9.9±0.4	14.3±0.7	13.6±0.5
Backfat, cm	0.17±0.02	0.17±0.02	0.29±0.04	0.32±0.06
Kidney/pelvic fat, %	3.6±0.5	4.1±0.6	5.30±0.8	5.55±0.3
Retail cuts, %				
Shoulder	38.1±0.7	39.6±1.1	36.3±0.7	34.9±0.7
Rack	17.3±0.5	16.4±0.4	18.4±0.9	19.0±0.5
Loin	13.6±0.4	12.8±0.4	15.7±0.6	17.3±0.9
Leg	31.0±0.4	31.2±1.0	29.6±0.8	28.8±0.8

[1] Mixed-sex Spanish goat kids 7 mo of age at onset of trial; concentrate supplement at 1.5% BW

[2] Boer and Boer x Spanish crossbred wether goats 10 mo of age at onset of trial; concentrate supplement at 1% BW

*, ** Means differ between diets within experiment (* $P < 0.05$, ** $P < 0.01$)

back fat and kidney/pelvic fat compared to the grass-hay-fed kids (Table 2). There were no differences in retail cut percentages between the two forage groups. In Experiment 2, the alfalfa-hay-fed Boer and Boer-cross goats also had a higher ($P < 0.05$) dressing percentage, but there were no differences between diets in any of the other carcass characteristics measured.

Goats in the two experiments reported here were harvested at different weights and age, thus not allowing a direct comparison of carcass characteristics, but carcass fat content (back fat and kidney pelvic fat) in the Boer and Boer-cross goats was considerably higher than in the Spanish goats. Similar differences between the two breeds were observed when animals were fed 80 percent concentrate feedlot diets (Oman et al., 2000), but not when grazed on rangeland at a lower plane of nutrition (Oman et al., 1999).

Increasing CP concentration of diets resulted in higher dressing percentage in wether goats (Shahjalal et al., 1992), similar to those in the alfalfa-hay-fed animals in the present study. However, Shahjalal et al. (1992) also noted an increased ribeye area, which we did not observe. No effect of increasing dietary CP on carcass characteristics was reported in intact male Tunisian goats (Atti et al., 2004). Wuliji et al. (2003) reported that ribeye area but not back fat (determined by ultrasonic measurements in live animals) was greater in alfalfa-hay-fed compared to the prairie-grass-hay-fed Spanish kids. This difference with our findings, however, is likely associated with the greater difference in BW between their groups and the lack of sensitivity of ultrasound scanning technique when used to determine the carcass measurements in goats.

There was no diet by sex class interactions on body weight, ADG, and carcass characteristics in Spanish goat kids. Sex class had no effect on body weight and ADG, or on carcass weight and dressing percentage in the Spanish goat kids in Experiment 1 (Table 3). However, ribeye area was greater ($P < 0.05$) in wethers than in does and bucks. Wethers also had greater ($P < 0.05$) back fat than bucks, with does being intermediate. Percent kidney/pelvic fat was different ($P < 0.05$) between all sex classes, being highest in does, intermediate in wethers, and lowest in bucks. Bucks had a larger ($P < 0.05$) percentage of shoulder retail cuts than does and wethers, whereas the portion of loin and leg cuts were smaller.

Table 3. Body weight, ADG, and carcass characteristics (mean±SEM) in three sex classes of Spanish goats fed alfalfa and grass hay-based diets supplemented with concentrate at 1.5% BW (Experiment 1)[1].

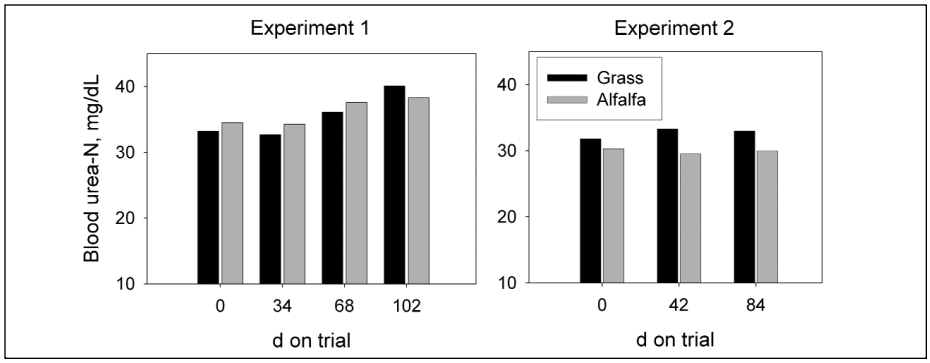
Sex class (N of animals)	Bucks (8)	Does (8)	Wethers (8)
Starting BW, kg	22.4±1.3	19.9±0.5	22.6±1.2
Final BW, kg	27.3±1.3	24.9±0.9	27.8±1.4
ADG, g/d	49±6	49±6	51±8
Cold carcass wt., kg	14.1±0.8	12.9±0.7	14.5±0.9
Dressing %	51.4±0.9	51.8±0.9	51.9±1.1
Ribeye area, cm^2	9.1±0.4[b]	8.9±0.3[b]	10.9±0.4[a]
Backfat, cm	0.12±0.02[a]	0.17±0.03[ab]	0.22±0.03[b]
Kidney/pelvic fat, %	1.8±0.3[c]	5.7±0.3[a]	4.0±0.5[b]
Retail cuts, %			
Shoulder	42.4±1.1[a]	36.6±0.3[b]	37.7±0.7[b]
Rack	16.6±0.6	17.0±0.6	17.0±0.5
Loin	12.1±0.5[b]	13.5±0.5[a]	13.9±0.4[a]
Leg	28.9±1.2[b]	32.9±0.7[a]	31.4±0.5[ab]

[1] Data pooled across dietary treatments with absence of diet by sex class interactions ($P > 0.1$)
[a,b,c] Within a row, means without a common superscript letter differ ($P < 0.05$)

These results are in agreement with other studies that had reported increased fat deposition in does and wethers compared to intact bucks (Colomer-Rocher et al., 1992), but no differences in dressing percentage (Johnson et al., 1995; Mahgoub et al., 2004; Ruvuna et al., 1992). The differences observed in the proportion of retail cuts are similar to those found by Mahgoub et al. (2004) that showed a more developed forequarter, but a lower proportion of musculature in the proximal hind limb in bucks compared to does and wethers.

The higher-CP concentrations in the alfalfa-hay-based diets had no effect on BUN in the animals in either of the experiments (Figure 1). This contrasts earlier findings in our lab that indicated higher levels of BUN when mixed-breed goat kids were fed alfalfa hay (18.7 percent CP) compared to lespedeza hay (11.2 percent CP) (Turner et al., 2005). Sahlu et al. (1993) reported that increases in dietary crude protein in concentrate rations from 8.5 percent to 13.9 percent and 20.3 percent fed to Alpine (dairy), Nubian (meat) and Angora

Figure 1. Blood urea-N concentrations in Spanish (Experiment 1) and Boer goats (Experiment 2) fed grass or alfalfa hay-based rations with some concentrate supplementation. Blood urea-N concentrations were not affected ($P > 0.05$) by forage type. Data were pooled across sex classes for Experiment 1.



(mohair) goats resulted in an associated increase in BUN from 8.3 to 22 and 33.3 mg/dL, respectively, while not affecting other blood metabolites. A rise in BUN was also reported in Spanish goats when CP increased from 8 percent to 16 percent in an otherwise iso-caloric diets (Jia et al., 1995). Differences in dietary CP levels in the present experiments were not as pronounced as those reported in these studies. Differences between studies may also have been due to the protein-to-energy ratio, as diets in the present experiments were not designed to be iso-caloric.

Conclusions

Goats responded with a consistent increase in ADG and dressing percentage to improved forage quality (alfalfa hay) in their diet. The marked differences in ADG between the hay types, regardless of level of concentrate supplementation, indicated the importance of high-quality forage in efficient meat-goat production. Results demonstrated that castration can be used as an effective tool to manipulate the fat content of goat carcasses and altered the composition of retail cuts in the carcass.

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