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# Value of Protein Supplementation for Lambs and Meat Goat Kids Grazing Bermudagrass in Central Oklahoma

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**Abstract:** Bermudagrass (*Cynodon dactylon*) is a high quality, abundant warm-season grass grown in temperate regions of the United States. While research data exists to support protein supplementation of steers grazing bermudagrass pastures, no such data exists for management of lambs and meat goat kids. The objective was to evaluate growth response of lambs and meat goat kids grazing bermudagrass with or without access to a commercial 21% CP protein tub (PT vs. NPT). Two trials were conducted in El Reno, Oklahoma, starting in June and ending in August in 2007 and 2008. In 2007 and 2008, respectively 29 and 54 meat goat kids (90±5 days of age) and 68 and 62 lambs of wool and hair breeds (and reciprocal crosses; 100±5 days of age) were utilized. Animals were stratified by weight, breed and gender and randomly assigned to 1.2 ha of common bermudagrass pasture with (n = 2) or without (n = 2) access to a commercial 21% CP protein tub. Growth of animals was assessed by change in body weights and serum concentrations of leptin every 2 weeks during grazing periods of 71 days for 2007 and 56 days for 2008. Sheep had greater ADG than goats ($p<0.05$) and breeds of sheep differed in ADG ($p\leq 0.05$). *Ad libitum* protein supplementation tubs had no effect on ADG or serum leptin of either lambs or kids grazing bermudagrass. These data do not support the need for protein supplementation of lambs and meat goat kids grazing bermudagrass.

**Key words:** Sheep, goats, protein supplementation, bermudagrass, leptin, grazing

## INTRODUCTION

Bermudagrass (*Cynodon dactylon*) is a high quality warm season grass that can produce large quantities of forage if treated with a nitrogen-based fertilizer (Hill *et al*., 1993). Bart *et al*. (1982) reported that steers grazing bermudagrass pastures in late summer experienced a protein deficit. Molasses-based protein supplements increased ADG in steers grazing bermudagrass pastures (Phillips and Horn, 1998) and protein supplementation increased productivity of grazing ruminants in other studies (Judkins *et al*., 1987; Huston *et al*., 1993).

Similar scenarios utilizing small ruminants grazing bermudagrass have not been determined but are needed since meat goats and hair sheep are becoming more popular and economically viable in the United States.

The objective was to evaluate the growth and development responses of stocker lambs and meat goat kids grazing common bermudagrass with or without access to a commercial 21% CP protein tub (PT vs. NPT).

## MATERIALS AND METHODS

All animal related procedures were conducted in compliance with Missouri State University and USDA Animal Care and Use committee guidelines.

**Overview and climatological data:** In 2007 and 2008, replicated trials were conducted on the same four 1.2 ha pastures at the USDA/ARS Grazinglands Research Laboratory, El Reno, OK. In 2007, grazing lasted 71 days (June 22 to August 31) and in 2008 grazing lasted 56 days (June 13 to August 8).

Pastures assigned to treatment or control in 2007 were assigned opposite treatments in 2008. Detailed climatological data for the grazing times and region are available from Mesonet.org. In 2007, rainfall accumulation in June, July and August totaled 65.5 cm (the 3rd highest yearly rainfall in recorded history) and average daily temperatures were 22.7, 24.8 and 26.8°C, respectively. In

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2008, rainfall accumulation in June, July and August totaled 35.6 cm and average daily temperatures were 25.1, 26.9 and 25.2°C, respectively.

**Pasture description, forage quality and dry matter availability:** Forages within the pastures consisted primarily of bermudagrass (*Cynodon dactylon*) with trace quantities of meadow foxtail (*Alopecurus creticus*). Pastures were fertilized each year in May at a rate of 68 kg N $ha^{-1}$. In both years, 8 forage plots within pastures were sampled weekly starting in June and continued weekly through August. All forage samples were ground to pass a 0.5 mm screen using a cyclone mill. Total N concentration was determined by automated flash combustion (Elementar varioMacro, Elementar Americus, Inc., Mt. Laurel, NJ) and the value multiplied by 6.25 for estimates of CP. Crude protein in both years averaged 14.6±0.7% at the initiation of the study and declined steadily to 9.8±0.7% by August. Neutral detergent fiber was 71.7±0.7% in June and remained constant to 71.5±0.7% in August. Average ADF was 29.6±0.8% and ranged from 27.3±1.0% in June to 32.7±1.0% by August. Average IVDMD was 57.6±1.0% and ranged from 61.5±1.3% in June to 54.65±1.3% by August. Percentage forage moisture was stable at approximately 75% for both years. Forage dry matter availability was estimated visually throughout the study and consistently exceeded dry matter requirements of the lambs and goats in all months.

Normally, common bermudagrass in Oklahoma fertilized with 68 kg N $ha^{-1}$ provides sufficient forage to carry one cow per 0.6 ha or about 910 kg $ha^{-1}$ liveweight. In these trials, the maximum total weight of sheep and goats per pasture was 812.5 kg in 2007 and 676 kg in 2008, both below the normal carrying capacity of common bermudagrass fertilized at 68 kg N $ha^{-1}$. Additionally, sheep and goats were grazed <90 days in this study consequently, forage dry matter was not limiting in either year.

**Animal description and management:** Lambs used in the study were from the USDA Grazinglands Laboratory and kids were from Redlands Community College (RCC), El Reno, Oklahoma. Goat breeds used in both years consisted of Boer (BI; 75% or greater Boer) and Savanna x Spanish (SP) while sheep breeds consisted of Katahdin (KK), Suffolk x Katahdin (SK), Katahdin x Suffolk (KS) and Suffolk (SS) breed of sire is presented first. Gender of animals consisted of females or castrated males. Lambs and kids were weaned a minimum of 30 days prior to the initiation of the trials. Lambs were weaned and provided free choice alfalfa hay along with a 16% CP pellet diet at the rate of 0.11/kg/day. Kids were housed at RCC and provided a protein tub for acclimation and fed a 16% CP ration (Acco, Minneapolis, MN) at the rate of 0.45/kg/day. Animals were weighed, assigned to treatment (by weight, gender and breed) and acclimated to their respective pastures for 10 days prior to the start of the trial. In 2007 and 2008, respectively 29 and 54 weaned meat goat kids (90±5 days of age) and 68 and 62 weaned lambs of wool and hair breeds (and reciprocal crosses; 100±5 days of age) were utilized.

Table 1: Components of a commercial 21% Archer Daniels Midlands Alliance Nutrition® Co-Graze Tub supplement tub offered to weaned lambs and meat goat kids grazing bermudagrass pastures

| Feed component | Not less than | Not more than |
|---|---|---|
| Crude protein[1] | 21.0% | - |
| Crude fat | 3.5% | - |
| Crude fiber | 5.5% | - |
| Calcium | 1.35% | 1.85% |
| Phosphorus | 0.75% | - |
| Salt (NaCl) | 11.1% | 13.3% |
| Copper | 25.0 ppm | 35.0 ppm |
| Selenium | 2.6 ppm | - |
| Vitamin A | 22, 500.0 IU $lb^{-1}$ | - |

[1]This includes not >2.1% equivalent crude protein from non-protein nitrogen

Lambs and kids in the two pastures assigned to PT were provided *ad libitum* access to commercial maize syrup-based protein supplement (cattle, sheep and goats) 57 kg tubs which consisted of soybean meal (47.5% CP), distiller's soluble grains, soy flour and ammonium chloride as a sole source of NPN (Table 1). Tubs were located in areas where animals tended to congregate such as around shelter and water and tubs were weighed at the beginning and end of the trial to animal supplement intake. In 2007 and 2008, two tubs per treatment pasture (approximately 1 tub per 17 animals) were provided. The two control pastures (NPT) were not supplemented with the protein tubs. Fresh water, shelter and loose goat mineral was provided *ad libitum*.

In 2007 and 2008 all animal health procedures were performed according to veterinarian instructions. All animals were vaccinated for clostridium (Covexin 8®, Schering-Plough, Whitehouse Station, NJ) and lambs were treated for coccidiosis with amprolium (CORID®, MERIAL Limited, Duluth, GA) during the weaning process prior to the initiation of the trial. Due to the above normal rainfall during the first half of the 2007 study, animals were infected with internal parasites. In order to minimize death losses, all animals were dewormed every 2 weeks with moxidectin (Cydectin®, Ft. Dodge Health, Overland Park, KS) and treated for coccidiosis with ponazuril (Marquis®; Bayer Animal Health, Shawnee

Mission, KS). Still, between 10 kids and 5 lambs in the animals used in 2007 did not complete the study due to illness attributed to internal parasites according to the attending veterinarian. In 2008, animals were treated with moxidectin and ponazuril at the initiation of the trial. Animals were treated again with moxidectin and 5 g copper oxide wire bolus if their FAMACHA© (Kaplan *et al*., 2004) score was four or greater. In 2008, between 8 kids and 4 lambs (6%) did not complete the study due to illness attributed to internal parasites according to the attending veterinarian.

**Weights and blood sampling:** Growth and development of animals was assessed by change in body weights over the course of the trials and serum concentrations of leptin (an endocrine indicator of animal nutritional well-being) every 2 weeks during grazing. Non-fasted body weights were recorded every 14 days. All weights were obtained using a digital scale (True Test© MP600, Adamsville, OH). In 2007, excessive rainfall in June delayed project initiation, consequently, six data collections occurred starting June 22, 2007 and were extended to August 31. In 2008, a total of 5 data collections occurred starting June 12 and ending August 8, 2008.

Blood samples were obtained via jugular venipuncture using 10 mL red topped tubes (Vacutainer brand; Becton-Dickison, Franklin Lakes, NJ) for later determination of serum concentrations of leptin. After clotting for a minimum of 1 h at room temperature, blood samples were placed at 4°C for 12 h. Serum was separated by centrifugation at 2,400×g for 30 min at 4°C, collected and stored at -20°C until analyzed for serum leptin as described by Delavaud *et al*. (2000). Due to differences in evaluating body condition scores between sheep and goats and hair and wool breeds of sheep, body condition scores were not obtained. Since, the analysis of leptin is a non-subjective analysis of adiposity and since leptin has been shown in previous literature to be strongly correlated to body condition (McFadin *et al*., 2002; Morrison *et al*., 2002), body condition scores were not recorded.

Due to time and labor constraints in the 2nd year of the study, blood collection procedures were modified from 1 year. Blood samples were collected from all animals only at the initiation and conclusion of the trial. Bi-monthly samples were collected from 13 animals per pasture (5 goats and 8 sheep) for leptin analysis as described earlier.

**Statistical analyses:** Data for animal weight and gain were analyzed using Proc Mixed (SAS Institute, 2003, Cary, NC) as a split plot design and the analyses included the fixed effects of year, treatment, species, breed nested within species, gender and all possible interactions. Random effects of the model included pasture nested within year and treatment and any random residual effects. Leptin was analyzed similarly with the exception of date of sample (initial, final) which was included as a repeated measure with associated interactions of fixed effects of year, treatment, species, breed nested in species and gender. Means were separated with t-statistics at $p<0.05$.

## RESULTS AND DISCUSSION

**Protein supplement intake:** Consumption of the protein supplement in the 57 kg tubs in 2007 ranged from 5-8% (approximately 0.0023/kg/day) for the test period in 2007. In 2008, consumption ranged from 10-15.2% (approximately 0.004/kg/day) over the course of the 2008 test period. Consumption rates on the feed company tag suggest consumption for sheep and goats of approximately 0.11/kg/day however, the observations were that intake was minimal and well below the companies suggested consumption rate for both years. Observational data suggests that the animals were not enticed to consumer the supplement tubs. Perhaps this is due to the novel concept of a feed in a solid like form or perhaps animals were consuming sufficient quantities of forage as to not be enhanced by the supplemental feed. Perhaps the tubs were simply not palatable to the research animals.

**Performance data**

**Initial weights:** Least squares means and standard errors for breed within species for initial weight in each treatment group are shown in Table 2. Initial body weight did not differ ($p\geq 0.79$) between treatments within species but lambs weighed more than kids (27.2±0.5 vs. 17.2±0.7 kg, $p\leq 0.001$). There was some evidence of differences in ranking of sheep breed groups between treatments but this interaction does not appear to be of practical significance. Averaged over treatment, Katahdin lambs were lower in initial weight than other breed groups followed by Suffolk x Katahdin and then Suffolk lambs with Katahdin x Suffolk lambs being the greatest in initial

Table 2: Breed by protein within species least squares means and standard errors for initial weight (kg) of lamb breed groups and meat goat kids on protein supplemented pastures versus no protein supplemented pastures

| Breed[1] | N[2] | Protein | N[2] | No protein |
|---|---|---|---|---|
| KK | 17 | 23.6±1.3[b] | 19 | 21.9±1.1[c] |
| SK | 17 | 23.7±1.2[b] | 20 | 28.0±1.2[b] |
| KS | 12 | 31.2±1.6[a] | 8 | 32.3±1.7[a] |
| SS | 22 | 29.4±1.1[a] | 20 | 27.8±1.2[b] |
| BI | 17 | 18.4±1.8[x] | 21 | 17.2±1.1[x] |
| SP | 22 | 16.1±1.1[x] | 22 | 17.0±1.2[x] |

[a, b, x]Means in the same column with different superscripts differ ($p\leq 0.05$), [1]KK = Katahdin; SK = Suffolk x Katahdin; KS = Katahdin x Suffolk; SS = Suffolk; BI = Boer; SP = Savanna x Spanish; [2]Sum of animals used per breed for 2007 and 2008

Table 3: Breed by protein within species least squares means and standard errors for final weight (kg) of lamb breed groups and meat goat kids on protein supplemented pastures versus no protein supplemented pastures

| Breed[1] | N[2] | Protein | N[2] | No protein |
|---|---|---|---|---|
| KK | 19 | 29.9±1.3[b] | 19 | 26.8±1.1[c] |
| SK | 18 | 29.5±1.3[b] | 19 | 34.1±1.2[ab] |
| KS | 13 | 36.2±1.7[a] | 8 | 37.8±1.8[a] |
| SS | 24 | 33.6±1.1[a] | 19 | 31.3±1.2[b] |
| BI | 16 | 22.1±1.9[x] | 21 | 19.5±1.1[x] |
| SP | 22 | 18.2±1.1[x] | 22 | 18.6±1.2[x] |

[a,b,c,x]Means in the same column with different superscripts differ ($p \le 0.05$), [1]KK = Katahdin; SK = Suffolk x Katahdin; KS = Katahdin x Suffolk; SS = Suffolk; BI = Boer; SP = Savanna x Spanish; [2]Sum of animals used per breed for 2007 and 2008

Table 4: Breed by protein within species least squares means and standard errors for average daily gain (g day$^{-1}$) of lamb breed groups and meat goat kids on protein supplemented pastures versus no protein supplemented pastures

| Breed[1] | N[2] | Protein | N[2] | No protein |
|---|---|---|---|---|
| KK | 19 | 110.3±14.0[a] | 18 | 83. 7±13.0[ab] |
| SK | 17 | 97.7±13.6[a] | 19 | 105.9±13.4[a] |
| KS | 13 | 84.6±16.1[ab] | 8 | 113.6±17.1[a] |
| SS | 22 | 68.7±12.6[b] | 21 | 72.7±13.2[b] |
| BI | 14 | 45.4±17.4[x] | 21 | 47.0±12.8[x] |
| SP | 17 | 33.5±12.8[x] | 17 | 32.2±13.4[x] |

[a,b,c,x]Means in the same column with different superscripts differ ($p \le 0.05$), [1]KK = Katahdin; SK = Suffolk x Katahdin; KS = Katahdin x Suffolk; SS = Suffolk; BI = Boer; SP = Savanna x Spanish; [2]Sum of animals used per breed for 2007 and 2008

weight compared to other breed groups ($p<0.0001$). Initial weights of Boer cross goat kids (17.8±1.0 kg) were similar to Savannah cross goat kids (16.6±0.8 kg).

**Final weight:** Least squares means and standard errors for final weight for each breed within species in each treatment group are shown in Table 3. Averaged over breed within species, there was little evidence that supplementing growing stocker lambs and meat goat kids on pasture with Protein Tubs (PT) affected final animal weight ($p>0.69$) regardless of year ($p = 0.25$). There were species, gender, breed within species and breed by treatment within species differences ($p \le 0.01$; Table 3). Katahdin lambs had lower final weights than other sheep breeds ($p<0.01$) with the exception of Suffolk x Katahdin lambs in the protein treatment. Averaged over treatment, Katahdin lambs were lower in final weight than other breed groups ($p<0.05$), Suffolk and Suffolk x Katahdin were intermediate and Katahdin x Suffolk lambs were greatest in final weight compared to other breed groups ($p<0.05$). Averaged over treatment, there was no evidence of differences between Boer influenced kids and Savannah cross kids. Final weight in lambs was greater than final weight in kids (32.4±0.5 vs. 19.6±0.7 kg; $p<0.0001$).

**Average daily gain:** Least squares means and standard errors for ADG for each breed within species in each treatment group are shown in Table 4. Neither year, gender nor treatment effected ADG ($p \ge 0.27$). There were species and breed within species effects ($p<0.01$) but only a slight trend of breed by protein supplementation within species interactions ($p<0.17$; Table 4). Averaged over treatment, sheep had substantially greater ADG than goats (93.0 vs. 37.9 g day$^{-1}$, $p \le 0.0001$). Generally meat goats have lower ADG than sheep (Van Niekerk and Casey, 1988). Furthermore, when the two species are managed under similar management conditions, sheep can have both greater gain and live weights than goats (Sen *et al*., 2004). Average daily gains of goats on this study are similar to those found by Muir (2006) where goats gained 68 g day$^{-1}$ on unfertilized and 90 g day$^{-1}$ on fertilized wheat pastures. Katahdin sheep generally have less genetic potential for growth than Suffolk sheep (Wildeus, 1997). However, averaged across treatments, SS lambs were lower in ADG ($p<0.05$), compared to KK, SK and KS lambs. As reported by Wildeus (1997), in multiple trials that compared hair sheep to wool breeds, hair sheep consistently had lower ADG when animals were placed on high concentrate diets. When Barbados Blackbelly, Dorset and the reciprocal cross were fed Bermudagrass or Orchardgrass, Barbados Blackebelly and Barbado x Dorset lambs were competitive to Dorset lambs in voluntary intake and gain (Mann *et al*., 1987). Hair breeds of sheep may be better suited for the hot and humid environment during the summer of this area of Oklahoma as compared to the more traditional wool breeds. Certainly lambs and kids with a greater propensity for growth can only realize their genetic advantage when nutritional density of their diet is consistent with their genetic potential.

Boer influenced goats have been shown to have better genetic potential for growth (Van Niekerk and Casey, 1988; Cameron *et al*., 2001) than other meat goat breed types and this was evidenced in these results by the trend ($p<0.12$) for Boer-cross kids to have greater ADG than Savannah-cross kids.

**Leptin:** Least squares means and standard errors for serum concentrations of leptin for each breed within species in each treatment group are shown in Table 5. Neither treatment nor gender nor breed within species effected serum concentrations of leptin ($p \ge 0.24$). However, there was a species and date (initial vs. final) difference ($p \le 0.001$) and there was a breed by date within species interaction ($p = 0.05$). Due to sampling differences in collection dates across years only initial and final leptin samples were analyzed. Goats had greater serum final leptin concentrations than sheep (6.52 vs. 5.43 ng mL$^{-1}$; $p \le 0.0001$). Leptin values were greater ($p \le 0.0001$) at the

Table 5: Least squares means and standard errors for initial and final serum leptin concentration (ng $mL^{-1}$) in lamb breed groups and meat goat kids averaged over protein supplementation treatment

| Breed[1] | N[2] | Initial | Final |
|---|---|---|---|
| KK | 37 | 6.1±0.30$^a$ | 4.8±0.3$^b$ |
| SK | 35 | 6.2±0.30$^a$ | 4.8±0.3$^b$ |
| KS | 21 | 6.4±0.48$^a$ | 5.0±0.4$^b$ |
| SS | 38 | 5.8±0.30$^a$ | 4.3±0.3$^b$ |
| BI | 34 | 7.6±0.30$^x$ | 5.3±0.4$^x$ |
| SP | 45 | 7.0±0.30$^x$ | 6.2±0.3$^y$ |

$^{a, b, x, y}$Means within species in the same column with different superscripts differ (p<0.001); [1]KK = Katahdin; SK = Suffolk x Katahdin; KS = Katahdin x Suffolk; SS = Suffolk; BI = Boer; SP = Savanna x Spanish; [2]Sum of animals used per breed

initiation of the study (6.7 ng $mL^{-1}$) versus at the conclusion of the study (5.2 ng $mL^{-1}$) possibly indicating that as forage nutrients declined so did adiposity.

Gender did not influence leptin concentrations (p = 0.60) which agrees with research done by Geary *et al.* (2003) who found little evidence of effects of gender in leptin concentrations in steers and heifers in contrast studies of humans (Hellstrom *et al.*, 2000), horses (Buff *et al.*, 2002) and pigs (Berg *et al.*, 2003) found females had greater concentration of leptin than did males.

Goats have been found to have less dissectible fat than sheep (Tshabalala *et al.*, 2003; Sen *et al.*, 2004). Adipose cell size and location can affect leptin synthesis (Hood, 1982; Cianzio *et al.*, 1985; Casanueva and Dieguez, 1999). Leptin synthesis combined with differences found in ADG could provide some explanation as to why leptin differed between species. Animals originating in the tropics deposit more omental fat than subcutaneous fat, presumably to affect evaporative cooling (Sen *et al.*, 2004). Goats tend to deposit more visceral fat than sheep, so perhaps the difference in adipose tissue deposition could explain differences in leptin production (Mahgoub and Lodge, 1998; Whitley *et al.*, 2005). In humans, leptin is produced in greater quantities by the subcutaneous adipocytes than omental adipocytes (Montague *et al.*, 1997). Boer influenced goats lost more adipose as evidenced by changes in leptin during the course of the study than did SP (p = 0.003). More research is needed to determine if place of origin (tropics vs. temperate vs. polar) plays a role in serum leptin concentrations and if there is a difference in leptin production between sheep and goats.

Leptin values decreased from June to August as forage quality decreased. Daniel *et al.* (2002) found that as the nutritional status of sheep declines so does circulating leptin concentration. Lents *et al.* (2005) concluded that nutrient intake has a greater affect on serum leptin concentration than does adiposity.

## CONCLUSION

In this study, growth and development responses of stocker lambs and meat goat kids grazing common bermudagrass did not benefit from *ad libitum* access to a maize syrup-based protein tub supplement. Had animals consumed the tubs, differences may have been noted. However, the AGD of both lambs and kids is similar results reported by others conducting non-supplemented grazing trials. Sheep had higher initial and final weights as well as greater ADG in relation to goats and hair sheep and hair sheep crosses had an advantage in growth in these trials over Suffolk lambs.

## IMPLICATIONS

Lambs whose genetic makeup is influenced by hair breeds of sheep may have greater growth rates grazing warm season forages and be a better option for grass based livestock producers utilizing warm season forages. Supplementation of grazing lambs and kids with molasses-based protein tubs in this study had no overall effect on growth.

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## REFERENCES

Bart, K.M., J.B. Mcharen, H.A. Fribourg and L.A. Carver, 1982. rude protein content of forage consumed by steers grazing nitrogen-fertilized Bermudagrass and orchard grass-ladino clover pastures. J. Anim. Sci., 55: 1008-1014.

Berg, E.P., E.L. McFadin, K.R. Maddock, R.N. Goodwin, T.J. Baas and D.H. Keisler, 2003. Serum concentrations of leptin in six genetic lines of swine and relationship with growth and carcass characteristics. J. Anim. Sci., 81: 167-171.

Buff, P.R., A. Dodds, C.D. Morrison, N. Whitley, E.L. McFadin, J. Daniel and D.H. Keisler, 2002. Leptin in horses: Tissue localization and relationship between peripheral concentrations of leptin and body condition. J. Anim. Sci., 80: 2942-2948.

Cameron, M.R., J. Luo, T. Sahlu, S.P. Hart, S.W. Coleman and A.L. Goetsch, 2001. Growth and slaughter traits of Boer x Spanish, Boer x Angora and Spanish goats consuming a concentrate-based diet. J. Anim. Sci., 79: 1423-1430.

Casanueva, F.F. and C. Dieguez, 1999. Neuroendocrine regulation and actions of leptin. Front. Neuroendocrinology, 20: 317-363.

Cianzio, D.S., D.G. Topel, G.B. Whitehurst, D.C. Beitz and H.L. Self, 1985. Adipose tissue growth and cellularity: Changes in bovine adipocyte size and number. J. Anim. Sci., 60: 970-976.

Daniel, J.A., B.K. Whitlock, J.A. Baker, B. Steele, C.D. Morrison, D.H. Keisler and J.L. Sartin, 2002. Effect of body fat mass and nutritional status on 24 h leptin profiles in ewes. J. Anim. Sci., 80: 1083-1089.

Delavaud, C., F. Bocquier, Y. Chilliard, D.H. Keisler and A. Gertler, 2000. Plasma leptin determination in ruminants effect of nutritional status and body fatness plasma leptin concentration assessed by a specific RIA in sheep. J. Endocrinol., 165: 519-526.

Geary, T.W., E.L. McFadin, M.D. MacNeil, E.E. Grings, R.E. Short, R.N. Funston and D.H. Keisler, 2003. Leptin as a predictor of carcass composition in beef cattle. J. Anim. Sci., 81: 1-8.

Hellstrom, L., H. Wahrenberg., K. Hruska, S. Reynisdottir and P. Arner, 2000. Mechanisms behind gender differences in circulating leptin levels. J. Int. Med., 247: 457-462.

Hill, G.M., R.N. Gates and G.W. Burton, 1993. Forage quality and grazing steer performance from Tifton 85 and Tifton 78 Bermudagrass pastures. J. Anim. Sci., 71: 3219-3225.

Hood, R.L., 1982. Relationships among growth, adipose cell size and lipid metabolism in ruminant adipose tissue. Federation proc., 41: 2555-2561.

Huston, J.E., C.A. Taylor, C.J. Lupton and T.D. Brooks, 1993. Effects of supplementation on intake, growth rate, and fleece production by female Angora kid goats grazing rangeland. J. Anim. Sci., 71: 3124-3130.

Judkins, M.B., J.D. Wallace, M.L. Galyean, L.J. Krysl and E.E. Parker, 1987. Passage rates, rumen fermentation and weight change in protein supplemented grazing cattle. J. Range Manage., 40: 100-105.

Kaplan, R.M., J.M. Burke, T.H. Terrill, J.E. Miller and W.R. Getz *et al.*, 2004. Validation of the FAMACHA© eye color chart for detecting clinical anemia in sheep and goats on farms in the Southern United States. Vet Parasitol. 23: 105-120.

Lents, C.A., R.P. Wettemann, F.J. White, I. Rubio and N.H. Ciccioli *et al.*, 2005. Influence of nutrient intake and body fat on concentrations of insulin-like growth factor-I, insulin, thyroxine and leptin in plasma of gestating beef cows. J. Anim. Sci., 83: 586-596.

Mahgoub, O. and G.A. Lodge, 1998. A comparative study on growth, body composition and carcass tissue distribution in Omani sheep and goats. J. Agric. Sci., 131: 329-339.

Mann, D.L., L. Goode and K.R. Pond, 1987. Voluntary intake, gain, digestibility, rate of passage and gastrointestinal tract fill in tropical and temperate breeds of sheep. J. Anim. Sci., 64: 880-886.

McFadin, E.L., C.D. Morrison, P.R. Buff, N.C. Whitley and D.H. Keisler, 2002. Leptin concentrations in periparturient ewes and their subsequent offspring. J. Anim. Sci., 80: 738-743.

Montague, C.T., J.B. Prins, L. Sanders, J.E. Digby and S. O'Rahilly, 1997. Depot-and sex-specific differences in human leptin MRNA expression. Implications for the control of regional fat distribution. Diabetes, 46: 342-347.

Morrison, C.C., R. Wood, E.L. McFadin, N.C. Whitley and D.H. Keisler, 2002. Effect of intravenous infusion of recombinant ovine leptin on feed intake and serum concentrations of GH, LH, insulin, IGF-1, cortisol and thyroxine in growing prepubertal ewe lambs. D. Anim. Endocrinol. 22: 103-112.

Muir, J.P., 2006. Weight gains of meat goat kids on wheat (*Triticum aestivum* L.) pastures fertilized at different nitrogen levels. Small Rum. Res., 66: 64-69.

Phillips, W.A. and G.W. Horn, 1998. Supplement intake and performance of steers fed compressed block or liquid protein supplements on bermudagrass pastures. Prof. Anim. Sci., 14: 36-43.

SAS Institute, 2003. SAS Online Doc 9.1. SAS. Institute Inc., Cary, NC., USA.

Sen, A.R., A. Santra and S.A. Karim, 2004. Carcass yield, composition and meat quality attributes of sheep and goat under semiarid conditions. Meat Sci., 66: 757-763.

Tshabalala, P.A., P.E. Strydom, E.C. Webb and H.L. Kocka, 2003. Meat quality of designated South African indigenous goat and sheep breeds. Meat Sci., 65: 563-570.

Van Niekerk, W.A. and N.H. Casey, 1988. The Boer goat II. Growth, nutrient requirements, carcass and meat quality. Small Rum. Res., 1: 355-355.

Whitley, N.C., E.L. Walker, S.A. Harley, D.H. Keisler and D.J. Jackson, 2005. Correlation between blood and milk serum leptin in goats and growth of their offspring. J. Anim. Sci., 83: 1854-1859.

Wildeus, S., 1997. Hair sheep genetic resources and their contribution to diversified small ruminant production in the United States. J. Anim. Sci., 75: 630-640.