

FINAL REPORT

PROJECT TITLE:

A Sustainable Year-round Forage System for Goat Production in the Southern USA

**Project # LS02-141
Coop # 2002-38640-11764**

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February 2006

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I. SUMMARY

A comparison of production systems indicated that animals on feedlot or Marshall ryegrass grew faster and reached expected slaughter weight in less time when compared to bahiagrass pasture and mimosa. However, economically Marshall ryegrass was superior followed by mimosa browse. Stocking rates of mimosa fields, rotationally browsed, and Marshall ryegrass, continuously grazed were 4-5 goats/acre and 11-12 goats/acre, respectively. Mimosa did not have an anthelmintic activity when fed for 21 days, however, animals needed less parasite control than those on bahiagrass pastures. Performance of buck was superior to wether and purity of breed without documentation did not guarantee better performance.

II. INTRODUCTION

The sharp increase in the Hispanic and Muslim populations in the United States has resulted in a substantial increase in the demand for goat meat (Figure 1). Hispanic population will be more than 25% by year 2050. This shift in population results in changes in agricultural products that meets the demand for new products like goat meat.

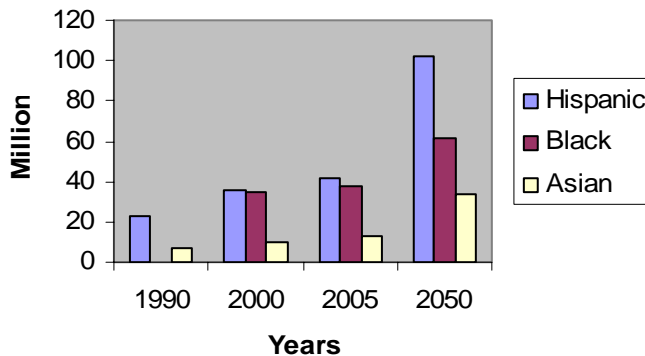


Figure 1. Ethnic Population Changes

Local production of goats is unable to meet current demand. Consequently, more than 8500 metric tons of goat meat, equivalent to about 500,000 goat carcasses are being imported from Australia and New Zealand to meet the demand (Figure 2).

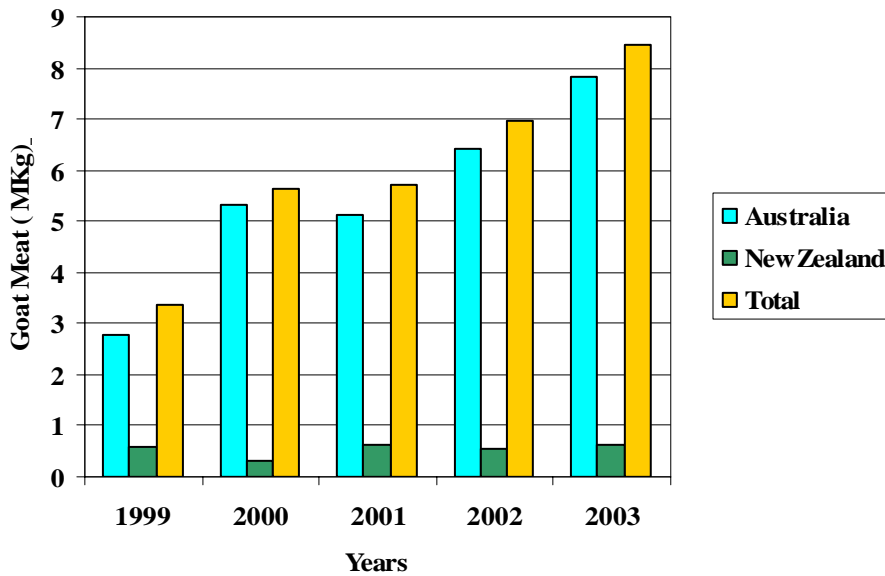


Figure 2. Goat Meat Imports

This creates profitable opportunities for limited resource farmers in the Southeast to maximize economic return from small farms and to maximize return per acre. On the other hand, despite poor soils, the southern US is well suited to forage production. In Alabama about 4.5 million acres of pastures are used to support a little less than one million brood cows. However, due to their size and relative inefficiency, cattle are not well suited to small farm operations, and will not match small ruminants in their ability to provide a high economic return per acre. Goats are even more efficient from a reproductive perspective, because of their high proportion of multiple births (twins and triplets). However, according to veterinarians, the humid environment of the eastern United States results in gastro-intestinal parasites posing a major challenge for goat producers: these parasites can result in lower weight gain, but can also lead to high mortality rates. Compared to perennial pastures, annual pastures planted on a prepared seedbed are expected to reduce the need for deworming because parasite larvae are destroyed and diluted during tillage operations. Consequently, forages such as annual ryegrass would appear to have promise for goat production. Considerable information is available for cattle production from annual ryegrass, but there are no data available for goats. Of particular importance is identification of an optimal range of stocking rates for goats.

Goats are typically browsing animals: if allowed free access to grazing and browse they generally obtain 60 to 80 % of their diet from browse plants. They are also very sensitive to

gastro-intestinal parasites which are abundant in the humid climate of the Southeast, and which are likely to pose more of a problem when animals are grazing (because larvae are typically located in the grass layer, close to the ground) than when they are browsing. Although research on the forage potential of mimosa (*Albizia julibrissin*) has been conducted by Auburn University for over 10 years (Bransby, 1993; Morrison and Bransby, 1997), no animal production or behavior data on goats have been collected. Typically, woody forage plants need to be rotationally stocked in order to ensure long term survival. A frequency of defoliation study in which plants were completely defoliated by hand every 4, 6, 8, 10 and 12 weeks indicated that a defoliation interval of 6 to 8 weeks would probably be optimal (Bransby, 1993), and another unpublished hand defoliation study suggested that removal of about 70% of foliage would result in greater forage yields than total defoliation. In the latter experiment, about 33%, 67% and 100% of the leaves were removed evenly within the vertical plane of the mimosa canopy. However, livestock may not defoliate mimosa in the same way. Consequently, one of the objectives of this study were to collect preliminary data on defoliation patterns of mimosa by goats.

Goat produces leaner meat with low cholesterol as compared to beef, pork and even chicken and may meet the demand for designer meat diet of health conscious American. Therefore another objective of this project was to investigate quality of meat produced by different production systems.

The goat industry is one of the fastest growing sectors of agriculture in Alabama and the U.S. The growth of the industry has not been easy and obstacles remain before goats can become as economical as beef, pork or chicken. Public perception, inconsistencies in price and quality of goats entering the market are among the problems facing the goat industry. Although there is an establish demand for goat meat, goat marketing lacks infra structure. In order for the industry to grow, more consumer education on quality of goat meat is necessary. Producer education on meat goat quality assurance programs similar to those for beef, pork and chicken are needed for wholesome goat meat production. As a part of the outreach component, two farmers were involved with this project and an outstanding video is produced for producer education.

III. OBJECTIVES/ PERFORMANCE TARGETS

The general goal of this project was to develop and demonstrate a profitable and sustainable year-round forage system (mimosa in the summer, and annual ryegrass pasture in the winter) for goat production, especially suited to limited resource producers, and with special focus on high quality forage and reduction of GI parasites. Accordingly, our specific objectives were to:

- 1) Study the pattern of foliage removal from mimosa by goats, and determine the optimal degree and frequency of defoliation;
- 2) Determine whether mimosa has any anthelmintic effect when consumed by goats;
- 3) Determine carcass quality and if there is a consumer preference for meat from browse-fed goats;
- 4) Establish the optimal stocking rates and associated animal weight gain for goats when feeding on mimosa in summer, and annual ryegrass in winter;
- 5) Compare productivity of goats on ryegrass with that of cattle: and
- 6) Evaluate (on an experiment station) and demonstrate (on two small farms) an integrated year-round forage system of mimosa in summer and annual ryegrass in winter for goat production by limited resource farmers.

IV. MATERIALS AND METHODS/RESULTS AND DISCUSSION/MILESTONE

In this report materials and methods/ results and discussion/milestones will be reported under each objective.

A. Objective 1. Study the pattern of foliage removal from mimosa by goats, and determine the optimal degree and frequency of defoliation.

A.1. Materials and Methods

A 1-acre paddock of 6-year-old mimosa was used in this study. Mimosa plants had been planted in rows 6 ft apart, with about 1.5 ft between plants within rows. However, annual mowing in late winter had caused considerable thinning of the stand. The paddock was mown in April, 2002, and growth was allowed to accumulate without defoliation for the entire summer. By the end of September, mimosa plants had mostly 5 to 8 stems that ranged between 6 and 10 ft

in length and from 0.5 in. to 1.5 in. in diameter at the base. The paddock also contained a considerable amount of common bermudagrass and broad leaf weeds. Fifteen mimosa plants were identified and marked within three randomly located transects in the paddock. A single representative stem on each of these plants was marked into bottom (< 2ft above ground), middle (2-4 ft above ground), and top (> 4 ft above ground) sections, and the number of mature leaves in each section was recorded. Immediately following this (October 1), forty-five cross bred wether goats weighing mostly between 30 and 50 lb were turned out into the paddock where they were allowed to feed during the day for a period of 14 days. Goats were penned at night for protection from predators. Each day during the grazing period the number of leaves within each section of all the marked stems was recorded to determine leaf disappearance patterns. In addition, all leaves from several stems were separated into rachis, leaflet, and secondary leaflet (Benson, 1965) components which were analyzed for crude protein (CP), acid detergent fiber (ADF), lignin and ash.

A.2. Results and Discussion

Unlike cattle and deer, goats strongly selected the leaflets from mimosa leaves, and did not consume the rachis unless the leaf was very young. Previous observations indicated that cattle consumed the entire leaf, as well as twigs up to 0.25 in in diameter. Deer tend to remove the entire distal portion of the leaf, including both rachis and leaflets, but leave the entire basal part of the leaf intact. However, goats tended to remove all the leaflets from a leaf, leaving the entire rachis intact. This suggests that goats are more selective than deer.

Secondary leaflets, rachis and rachilla comprised 70.3%, 17.0% and 12.7% of dry matter, respectively, within mimosa leaves. Forage quality data suggest that nutritive value of forage in this experiment was somewhat lower than that measured in previous studies. This was probably due to the forage being very mature as a result of season-long accumulation. The CP content of the whole leaf appeared to be higher than in leaflets, and ADF was lower in secondary leaflets than in the primary leaflets and the whole leaf (Table 1). Lignin and ash concentrations were relatively high in all components of the leaf. Since goats consumed mainly the primary leaflets, these forage quality data suggest that there is no clear nutritional advantage in their feeding behavior.

Table 1. Forage quality measurements of the whole leaf (rachis, rachilla and secondary leaflets), primary leaflet (rachilla and secondary leaflets), and secondary leaflets of mimosa.

| | Crude Protein | ADF | Lignin | Ash |
|-------------------|-----------------------------|------|--------|-----|
| | ----- % of dry matter ----- | | | |
| Whole leaf | 19.9 | 26.5 | 12.0 | 5.4 |
| Leaflet | 15.8 | 28.0 | 14.5 | 6.3 |
| Secondary leaflet | 16,5 | 20.7 | 10.1 | 6.9 |

On average, the proportion of leaves in the bottom, middle and top sections of the stems was 9%, 41% and 50%, respectively. Visual observation suggested that the relatively low proportion of leaves in the bottom section was due to leaf senescence. Although some of the leaf disappearance during the study was due to leaf senescence, relative to total animal consumption the contribution of senescence to leaf disappearance was considered to be negligible. Therefore, leaf disappearance was assumed to be primarily due to consumption by goats.

During the first 7 days goats consumed very little mimosa (Table 2). This was probably because they were not accustomed to browsing, and therefore spent most of this initial period feeding on grass and broad leaf weeds. However, having consumed only 16% of the mimosa leaves in the first week, they consumed 81% in the second week. Relative consumption proceeded faster in the bottom section of the stems than in the middle and top sections. This was probably due to senescence occurring mainly in this section of the canopy, as well as easy access of the leaves in this section to the goats. Relative consumption appear to proceed slightly faster in the middle section than in the top section.

Table 2. Average relative leaf removal (number of leaves removed as a percent of the number present prior to browsing) from the bottom, middle and top section of 15 mimosa stems during 14 days of browsing by goats.

| Day | Bottom | Middle | Top | Whole Plant |
|---------------|--------|--------|-----|-------------|
| ----- % ----- | | | | |
| 1 | 13 | 4 | 3 | 4 |
| 2 | 20 | 6 | 3 | 6 |
| 3 | 20 | 9 | 3 | 7 |
| 4 | 35 | 13 | 3 | 10 |
| 5 | 45 | 14 | 3 | 11 |
| 6 | 50 | 17 | 3 | 13 |
| 7 | 63 | 21 | 3 | 16 |
| 8 | 68 | 32 | 12 | 25 |
| 9 | 83 | 45 | 33 | 44 |
| 10 | 85 | 58 | 50 | 56 |
| 11 | 88 | 70 | 66 | 69 |
| 12 | 88 | 72 | 68 | 71 |
| 13 | 98 | 75 | 78 | 79 |
| 14 | 100 | 95 | 98 | 97 |

On average, 69% utilization was achieved on day11, and 97% by day 14(Table 2). However, these averages are extremely misleading, because 47% of the plants had been completely (100%) defoliated, and utilization was 80% or greater on 73% (Table 3). Utilization on the remaining 27% of the plants ranged from 7% to 23%. These data supported visual observations: goats tended to remove all or most of the foliage from each stem, one stem at a time. This was done by larger goats pushing the stems over and holding them down with their front legs while they removed the leaves. Smaller animals that did not have this capability learned to follow the larger animals and also feed on the leaves from the limbs that were bent over. In addition, all animals learned to stand upright on their back legs to browse forage that was otherwise out of reach.

Table 3. Relative defoliation of 15 mimosa plants on day 11 of the study.

| Plant # | % defoliation | Plant # | % defoliation | Plant # | % defoliation |
|---------|---------------|---------|---------------|---------|---------------|
| 1 | 100 | 6 | 23 | 11 | 100 |
| 2 | 80 | 7 | 82 | 12 | 100 |
| 3 | 100 | 8 | 13 | 13 | 100 |
| 4 | 91 | 9 | 16 | 14 | 100 |
| 5 | 7 | 10 | 98 | 15 | 100 |

A.3. Impact of Results/Outcome

There appeared to be no nutritional advantage to the selection patterns of goats browsing mimosa in this study. Goats tended to remove all or most of the leaves from mimosa, one stem at a time. This suggests that, given the canopy structure in this study, relatively uniform partial defoliation of all plants in a paddock by goats would not be feasible. Altering canopy structure by pruning stems to about 2 ft and allowing only limited regrowth prior to defoliation may be more effective in achieving more uniform partial defoliation.

B. Objective 2. Determine if *Albizia julibrissin* (mimosa) fed to goats with experimentally induced *Haemonchus contortus* larvae would exert observable effects on parasite burdens and select blood parameters.

B.1. Materials and Methods

Anecdotal information in the literature suggests that mimosa (*Albizia julibrissin*) may have anthelmintic properties, and parasite control is a major management concern in the southeastern U.S., especially for goats. This experiment was conducted to determine the effect of mimosa fed to goats, with experimentally induced *Haemonchus contortus* larvae, on parasite burdens and selected blood parameters. Eighteen Boer cross goat kids (BW 15.8 ± 0.07 kg) were housed in individual pens and randomly assigned to two dietary treatments: 1) 90% fresh cut mimosa with 10% alfalfa hay (MA), as fed, and 2) a control treatment of 85% green chop soybeans with 15% of bermudagrass hay (SB), as fed. Mimosa and green chop soybean were cut

and carried to goats every other day for 4-wk. Goats were inoculated orally with 2500 stage three cultured *Haemonchus contortus* larvae donated by Elanco Animal Health via Dr. Daniel Snyder. Once all goats were producing quantifiable numbers of eggs in feces they were divided into experimental treatment groups. There were wide variations in fecal egg per gram counts so animals were ranked from highest to lowest in pre-treatment egg production and divided into high and low groups then randomly assigned to treatment diets. Dietary treatments were calculated to be isonitrogenous on a DM basis. Feed intake and refusals were monitored daily and intake was adjusted weekly for 4 wk. Body weight was recorded weekly after a 4 h withdrawal from water and feed. Mimosa, green chop soybean, alfalfa and bermudagrass hay were analyzed for DM and Kjeldahl nitrogen (N) according to AOAC (1995). Kjeldahl N was then multiplied by 6.25 to estimate crude protein. Neutral and acid detergent fiber were determined on mimosa, green chop soybean, alfalfa and bermudagrass hay. Fresh feces were collected from each goat weekly and fecal egg counts were conducted using a modified McMaster method. Blood samples were collected weekly, via the jugular vein, and were analyzed for pack cell volume and plasma protein.

Statistical Analysis. Body weight, pack cell volume and plasma protein data were statistically analyzed using GLM procedures of SAS (SAS Inc, Cary, NC) for a completely randomized design. Means were separated using least-square means. Fecal egg counts were analyzed using the NPAR1WAY procedure of SAS (SAS Inc.). Differences were declared significant at $P < 0.05$ unless otherwise indicated.

B.2. Results and Discussion

Table 4 demonstrates chemical composition of diet ingredients. Green chop soybean had lower % DM, NDF and ADF with higher energy content when compared to other forages.

Bermudagrass hay was high in quality as it is indicated by high protein and low fiber content.

However, composition of dietary treatments as indicated in Table 2, were similar.

Table 4. Diet composition

| Item^a | Mimosa | Soybean | Bermuda | Alfalfa |
|-------------------------|---------------|----------------|----------------|----------------|
| DM% | 95.04 | 62.46 | 86.30 | 86.69 |
| CP % | 24.75 | 26.25 | 14.00 | 17.31 |
| NDF % | 37.00 | 27.00 | 68.00 | 38.00 |
| ADF % | 27.00 | 22.00 | 33.00 | 27.00 |
| NE (M) Mc/kg | 1.43 | 1.56 | 1.24 | 1.41 |
| NE (G) Mc/kg | 0.71 | 0.84 | 0.52 | 0.69 |

^aValues are on dry matter basis.

Table 5. Composition of dietary treatments.

| Item^a | Mimosa / Alfalfa | Soybean / Bermuda |
|-------------------------|-------------------------|--------------------------|
| % of diet | 90/10 | 85/15 |
| CP % | 24.01 | 24.41 |
| NDF % | 37.10 | 33.15 |
| ADF % | 27.00 | 23.65 |
| NE (M + G) Mc/kg | 2.30 | 2.14 |

^aValues are on dry matter basis.

Dry matter intake was higher ($P < 0.01$) for animals fed MA (344 and 305 g/d, SE \pm 4.2, respectively) and they tended ($P = 0.08$) to loose less weight (-49.8 and -78.5 g/d, SE \pm 11, for MA and SB, respectively) (Figure 3). Total egg count did not drop based on Kruskal -Wallis and Mann -Whitney tests during the 4 wk experimental period. Initial fecal egg counts were 5522 ± 2317 and 4555 ± 1385 , and final egg counts were 8878 ± 3155 and 8800 ± 1234 , for treatment groups MA and SB, respectively (Figure 3 and Table 6). Pack cell volume and plasma protein showed no difference ($P > 0.10$) between dietary treatments or over time (Table 7). These results indicated that short-term treatment of goats with mimosa was not effective in eliminating or managing *Haemonchus contortus* under controlled feeding conditions. However, long term feeding of mimosa under field conditions may have benefits as a parasite management tool because it allows the animal to browse rather than graze.

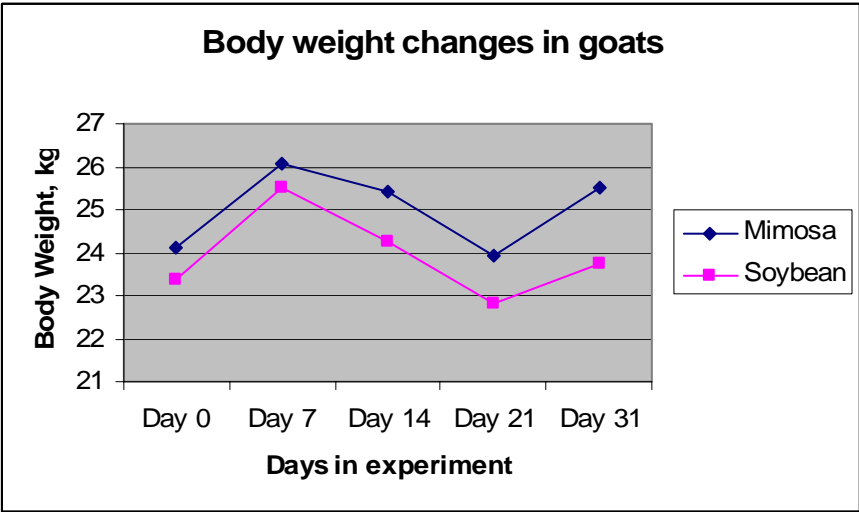


Figure 3. Body weight changes of goats during experimental period

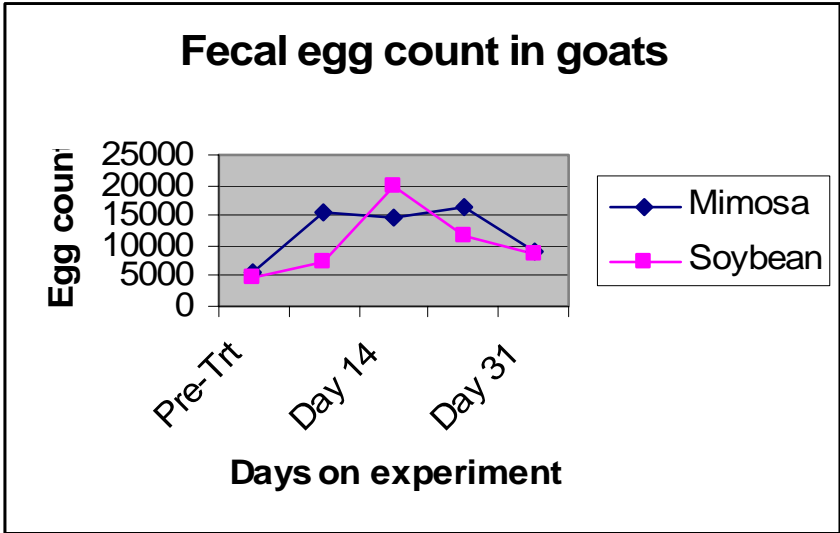


Figure 4. Fecal egg counts of goats on experimental diets.

Table 6. Fecal egg counts per week in Boer cross wether goats inoculated with *Haemonchus contortus* larvae.

| | Treatment | | Mean \pm SE | | |
|---------|--------------------------|---------------------------|------------------|------------------|-----------------|
| | Pre-trt EPG ^a | Post-trt EPG ^b | | | |
| | d0 | d7 | d14 | d21 | d31 |
| Mimosa | 5522 \pm 2317 | 15522 \pm 3155 | 14533 \pm 4432 | 16500 \pm 4999 | 8877 \pm 3050 |
| Soybean | 4555 \pm 1385 | 7277 \pm 1234 | 19622 \pm 4803 | 11466 \pm 4113 | 8800 \pm 3049 |

^a The mean number of *H. contortus* was not significantly different among the treatments (Kruskal-Wallis test, $P = .81$).

^b The mean number of *H. contortus* was not significantly different among the treatments (Kruskal-Wallis test, $P = .33$).

Table 7. Packed cell volume (PCV) and plasma protein (T/S) per week in Boer cross wether goats inoculated with *Haemonchus contortus* larvae.

| | Treatment ^a | | Mean \pm SE | | |
|----------------|------------------------|----------------|----------------|----------------|----------------|
| | Pre-trt | Post-trt | | | |
| | d0 | d7 | d14 | d21 | d31 |
| Mimosa | | | | | |
| PCV% | 22.3 \pm .97 | 22.8 \pm 1.0 | 21.6 \pm 1.2 | 22.6 \pm 1.2 | 20.9 \pm .84 |
| T/S mg/dl | 6.1 \pm .15 | 6.1 \pm .19 | 6.0 \pm .18 | 6.2 \pm .17 | 6.3 \pm .16 |
| Soybean | | | | | |
| PCV% | 22.4 \pm 1.0 | 24.3 \pm .65 | 23.5 \pm 1.3 | 23.2 \pm 1.4 | 20.4 \pm 1.8 |
| T/S mg/dl | 5.9 \pm .11 | 6.0 \pm .26 | 6.0 \pm .25 | 6.0 \pm .38 | 5.8 \pm .36 |

^a The observed mean difference between treatments was not significant ($P < 0.05$).

The average pre-treatment FEG increased from 1067 on day 14 post infection to 4339 on day 21 post infection for all 18 goats. This increase in FEG indicated that the *Haemonchus contortus*

larvae had matured and were producing viable eggs in the goats. Intakes of mimosa with alfalfa hay and soybean with bermudagrass hay were .95 kg/d/goat and 1.27 kg/d/goat, respectively over a 29 day collection period. Fecal egg counts among treatment diets varied over time, but did not significantly drop over a 31 day period. Although the egg per gram of feces can give some indication of level of parasitism, Gasbarre (1997) noted that 54% of the variance can be attributed to animal-to-animal variation and 36% can be attributed to sample-to-sample variation in one animal. Pack cell volume percentages and plasma protein levels showed no difference between treatment diets or weeks of exposure. Sharma et al. (2001) reported lower plasma protein levels in 42 Barbari male goats infected with *H. contortus* over 24 control goats. Blood parameters are good tools for diagnosis of some diseases. Due to a wide range in upper and lower limits of blood parameters, results may vary according to the number of experimental animals used.

B.3. Impact of Results/Outcome

Albizia julibrissin (mimosa) is not effective in eliminating *Haemonchus contortus* in Boer cross goats. However, mimosa may have benefits as a parasite management tool for farmers because it allows the goat to browse above the ground reducing exposure to L3 larvae. Further experimentation with plant species proven to possess anthelmintic properties may one day yield low-cost and sustainable methods of internal parasite control in goats. Parasites will continue to be a priority in the small ruminant sector of temperate and subtropical areas. Proper pasture management, multispecies forage planting (browse), as well as, multispecies grazing are important issues in controlling parasites in all species. Commercial anthelmintic medications will continue to be the treatment of choice for goats. However, farmers must become educated in diagnosis of parasitism and the proper usage of such medications.

C. Objective 3. Determine carcass quality and if there is a consumer preference for meat from browse-fed goats.

C.1. Materials and Methods

Animals and diets

Twenty four high percentage (HP; 87.5%), with average initial body weights of 23.15 ± 0.74 kg and twenty one low percentage (LP; 50.0%), with average initial body weights of 18.99

± 0.79 kg, Boer wether goat kids were raised under different production systems and used to evaluate potential purity of breed differences that represent the meat goat industry in the Southeastern United States and. The Tuskegee University and Auburn University Animal Care and Use Committees approved the animal care, handling and sampling procedures. Animals were confined indoors for a period of 14 days and fed 40:60 protein pellets: soy hulls-bermudagrass hay diet on a DM basis. Animals were weighed for two consecutive days, stratified by body weight (BW) and randomly assigned within purity of breed to one of three production systems: 1) concentrate grain diet (CONC) containing 40% protein pellets, 40% soybean hulls, and 20% bermuda grass hay; 2) ad libitum consumption of bahiagrass pasture (BG) supplemented with 150 g/head/day protein pellets; 3) ad libitum consumption of mimosa browse (MB) supplemented with 100 g/head/day of cracked corn. The CONC animals were housed individually in 1.8 m x 2.1 m pens with raised mesh floors. Fresh water and feed were supplied daily. The BG animals were grazed on 2 acres pasture containing bahiagrass and fed protein pellet once daily. The MB animals were rotated every two weeks between four mimosa plots (1 acres) with trees trimmed to a height of 1.2 m and fed cracked corn once daily. Body weights were recorded after a four hour withdrawal from feed and water, for two consecutive days every two weeks. The growth period consisted of 14 wk. Pasture, browse, hay and supplement samples were collected weekly during the entire trial, ground through a 1 mm screen in a Wiley Mill (Thomas Scientific, Swedesboro, NJ), and pooled by month for chemical analysis of dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), cellulose, acid detergent lignin (ADL), and acid insoluble ash (AIA).

Intake and digestibility

Intake and digestibility were measured on eight goats from each treatment group for 10 days during the performance period. Goats were fitted with canvas fecal collection bags and allowed three days to adapt to the bags before initiation of a five day fecal collection period. Fecal collection bags were emptied twice daily. Daily feces were weighed, mixed, and a constant percentage for each animal was taken to be dried at 55 C; this was followed by a 24 hour air equilibration to determine air dried fecal output. Daily fecal samples were pooled relative to the 24 hour air dried fecal output to provide a representative sample of the five day collection period.

During the five day collection period, samples of pasture, browse, hay and supplements were taken daily, composited, and subsampled. Samples were ground through a 1 mm screen in a Wiley Mill prior to laboratory analyses. Feed samples and fecal samples from the fecal collection period were analyzed for dry matter (DM), and nitrogen, determined by the combustion method (AOAC International, 1998) utilizing the Leco FP-2000 (Leco Corporation, St. Joseph, Michigan) crude protein (CP) was calculated as $N \times 6.25$. Neutral detergent fiber (NDF), acid detergent fiber (ADF), cellulose, acid detergent lignin (ADL) were analyzed in an Ankom fiber apparatus (Ankom Technology, Fairport, NY).

Slaughter and sampling procedures

Animals were harvested when a final BW of 35.0 ± 5.0 kg was obtained or when the forage season for Mimosa and bahiagrass ended. The end of forage season for Mimosa occurred when regrowth following defoliation ceased and the forage season ended for bahiagrass pastures when adequate animal weight gains approached zero. Final weights were obtained on two consecutive days, and goats were transported approximately 40 km to the Auburn University Lambert Meat Abattoir. Goats were harvested according to USDA approved guidelines. The Institutional Meat Purchase Specifications for fresh goat, series 11, (IMPS; USDA, 2001) was used to report live and carcass selection criteria. According to the IMPS, selection criteria range from No. 1 to No.3. Selection No.1 designated the highest proportion of muscle to bone ratio while selection No.3 designated the lowest muscle to bone ratio evaluated on live animals or carcasses of animals. Hot carcass weight (HCW) was determined on the d of slaughter. Carcass selection grade, chilled carcass weight (CCW), carcass shrink weight, fat depth over the longissimus muscle at the 12th rib, body wall fat (BWF), adjusted fat thickness (ADFT), percentage of kidney and pelvic fat (KPF), dressing percentage (DP) and longissimus muscle area (LMA) were determined 48 hours postmortem. Longissimus pH and temperature were measured at the last rib at 1, 3, 5 and 24 hours after stunning. Temperature and pH measurements were collected using a portable meter (IQ Scientific Instruments, model IQ150, San Diego, CA). The longissimus muscle at the 12th rib were evaluated for objective color measurements with a Hunter Miniscan XE Plus (HunterLab, Reston, VA) for Hunter L*, a*, and b* values. The

Miniscan utilized a D65 light source, a 10° viewing angle, and a 35mm viewing area. The Miniscan was calibrated according to manufacturer's recommendations.

After chilling for 48 hours, carcasses were split in half and the 9-10-11th rib sections from the right side and the entire left side of the carcass were used to determine carcass composition. Soft tissue and bone were dissected from the left side of the carcass and the 9-10-11th sections of the right side of the carcass. Soft tissue samples were placed in plastic bags and stored at -20°C for later analysis. Soft tissue from the 9-10-11th rib section and left half of the carcass were thawed at 4°C overnight and were ground twice with a Hobart meat grinder (Model 4822) utilizing a 9.5 mm grinding plate (C. D. Triump; No. 22). Samples were ground an additional two times with a KitchenAid® Mixer / Grinder (Model K5SS, KitchenAid®, Inc., St. Joseph, Michigan) utilizing a 5 mm grinding plate. Soft tissue samples were thoroughly mixed and sub-sampled. Soft tissue samples were analyzed for moisture by drying 5 g samples at 100°C for 48 hours. Ash content was determined on dried samples by ashing samples in a muffle furnace at 600°C overnight. Ether extract (EE) was determined on wet samples using the Soxtec Avanti System (Foss Tecator model 2055) and results were calculated on wet basis (AOAC, 1995). Nitrogen was determined by the combustion method (AOAC International, 1998) utilizing the Leco FP-2000 (Leco Corporation, St. Joseph, Michigan) and CP was calculated as N x 6.25 and results were expressed on wet basis. The semimembranosus and biceps femoris were removed from the right side of the carcass, aged for 14 days and utilized for sensory evaluation, shear force determination and cook loss. Samples were vacuum packed and stored at -20 C for later analysis.

Fatty acid and cholesterol analysis

Samples for fatty acid and cholesterol analysis were taken from the right half of the carcass, across the whole width of the longissimus dorsi muscle at the 12th – 13th rib. Samples were vacuum packed and stored at -80 C. Total lipid was determined following the chloroform-methanol procedure of Folch et al. (1957). Nonadecanoate acid (C19:0) (Avanti Polar Lipids, Inc.) was added as an internal standard. Fatty acid methyl esters (FAME) were prepared following the procedure of Park and Goins (1994). The FAME were analyzed using a Agilent Technologies 6890N gas chromatograph, and separated using a 60-m DB-23 capillary column

(0.25 mm i.d. and 0.25 µm film thickness, Agilent Technologies). Individual fatty acids were identified by comparison of retention times with standards (Nu-chek Prep, Inc.) and quantified using the internal standard.

Cholesterol content was determined following the procedure of Rule et al. (2002). Cholesterol was analyzed using a Agilent Technologies 6890N gas chromatograph, and separated using a 30-m HP-5 capillary column (0.32 i.d. and 0.25 µm film thickness, Agilent Technologies). Stigmasterol was used as the internal standard (Matreya, Pleasant Gap, PA). Cholesterol was identified by comparison of retention time with the standard and quantified using the internal standard.

Warner-bratzler shear force and cooking loss

Muscle samples were tempered in vacuum package bags at 4 C for 24 hours, removed from the bags, weighed and cooked to an internal temperature of 70 C on a clam-shell grill (model 25300 type ST09 grill, Hamilton Beach/ Proctor Silex, Inc. Racine, WI.). Samples were removed from the grill, weighed and stored at 4 C for 24 hours on a pan covered with PVC overwrap. Six 1.27 cm diameter cores were taken from each muscle group parallel with the direction of muscle fibers and sheared once perpendicular to the length of the core using a Warner-Bratzler shear device (1955 model, G-R Electric Manufacturing Co., Manhattan, KS). Peak force for each core was recorded in kg and six cores per muscle group were averaged. Cook loss was measured as the percent of pre-cooked weight lost during cooking and averaged across muscle groups.

Sensory evaluation

Sensory evaluation of boneless semimembranosus and biceps femoris was conducted by a six member trained sensory panel. Muscle groups were prepared and cooked as previously described for shear force evaluation. After cooking, muscle groups were cut into 1 cm x 1 cm x 1 cm pieces and held in metal double stack poachers filled with sand and placed in a warming oven for a minimal period of time prior to sensory evaluation. Each panelist was given two

pieces of muscle to evaluate on an eight point scale for tenderness, juiciness, flavor and off flavor.

Statistical Analysis. All data were analyzed using proc mixed of SAS. Differences were detected at $P < 0.05$.

C.2. Results and Discussion

Diet composition

Chemical composition of bahiagrass pasture and mimosa browse during 98 days of performance phase and 10 days of digestion phase are presented in the Table 8. Quality of bahaigrass (BG) pasture dropped from June-October as indicated by decrease in CP and increase in fiber. Mimosa had lower protein content during July and August. Crude protein and lignin content of mimosa was higher than bahaigrass and fiber content (NDF, ADF) was lower. To optimize for protein and energy, animals on pasture were supplemented with 150 grams of protein pellets per animal per day and animals on mimosa were supplemented with 100 grams of corn per animal per day, respectively.

Table 8. Chemical composition of bahiagrass and mimosa harvested monthly during the performance phase and digestibility phase of goat kids

| Item ^a | Performance phase (98 d) | | | | |
|-------------------|--------------------------|-------|-------|-------|-------|
| | Bahiagrass | | | | |
| | June | July | Aug. | Sept. | Oct. |
| Partial DM, % | 31.28 | 30.32 | 33.23 | 33.73 | 39.77 |
| CP, % | 12.13 | 7.50 | 6.56 | 7.13 | 6.98 |
| NDF, % | 68.00 | 69.00 | 70.00 | 76.00 | 76.00 |
| ADF, % | 39.00 | 35.00 | 36.00 | 39.00 | 39.00 |
| ME, Mcal/kg | 1.24 | 1.22 | 1.20 | 1.14 | 1.12 |
| GE, Mcal/kg | 0.52 | 0.50 | 0.48 | 0.42 | 0.41 |
| | Mimosa | | | | |
| | June | July | Aug. | Sept. | Oct. |
| Partial DM, % | 27.56 | 30.54 | 30.25 | 41.92 | 37.40 |
| CP, % | 24.25 | 17.13 | 16.25 | 20.88 | 21.24 |
| NDF, % | 37.00 | 40.00 | 40.00 | 39.00 | 34.00 |
| ADF, % | 27.00 | 29.00 | 29.00 | 25.00 | 23.00 |
| ME, Mcal/kg | 1.43 | 1.39 | 1.39 | 1.40 | 1.46 |
| GE, Mcal/kg | 0.71 | 0.67 | 0.67 | 0.68 | 0.74 |

| Item ^a | Digestibility phase (10 d) | | | |
|-------------------|----------------------------|-------|--------|-------|
| | Bahia grass | | Mimosa | |
| | Aug. | Sept. | Aug. | Sept. |
| Partial DM, % | 33.23 | 33.73 | 30.25 | 41.92 |
| CP, % | 7.91 | 8.80 | 16.79 | 20.74 |
| NDF, % | 72.14 | 75.05 | 37.22 | 37.46 |
| ADF, % | 36.57 | 36.49 | 23.76 | 20.85 |
| Cellulose, % | 33.46 | 33.74 | 15.09 | 11.41 |
| ADL, % | 2.99 | 2.66 | 8.56 | 9.27 |
| AIA, % | 0.68 | 1.04 | 0.17 | 0.22 |

^a DM basis

Chemical composition of CONC diet is presented in Table 9. Animals on CONC diet received 40% protein pellet (Grain), 40% soy hulls and 20% bermudagrass (hay) on DM basis.

Table 9. Chemical composition of concentrate-based diet during the performance phase and digestibility phase of goat kids

| Item ^a | Performance phase (98 d) | | | |
|-------------------|--------------------------|---------|-------|-------|
| | Hay | Soyhull | Grain | Corn |
| DM, % | 88.00 | 89.75 | 92.25 | 87.00 |
| CP, % | 11.75 | 14.12 | 15.75 | 7.80 |
| NDF, % | 66.00 | 60.00 | 25.00 | 9.00 |
| ADF, % | 32.00 | 42.00 | 10.00 | 3.3 |
| ME, Mcal/kg | 1.26 | 1.11 | 1.74 | 1.88 |
| GE, Mcal/kg | 0.55 | 0.40 | 1.02 | 1.28 |

| Item ^a | Digestibility phase (10 d) | | | |
|-------------------|----------------------------|---------|-------|-------|
| | Hay | Soyhull | Grain | Corn |
| DM, % | 90.25 | 89.75 | 89.25 | 89.00 |
| CP, % | 12.27 | 15.00 | 17.75 | 8.69 |
| NDF, % | 71.00 | 60.00 | 22.00 | 11.00 |
| ADF, % | 33.00 | 42.00 | 7.00 | 2.00 |
| Cellulose, % | 29.00 | 40.00 | 6.00 | 1.57 |
| ADL, % | 3.91 | 1.82 | 1.32 | 0.41 |
| AIA, % | 0.38 | 0.18 | 0.24 | 0.06 |

^a DM basis

Intake and digestibility

Digestibility of bahaiagrass pasture and mimosa browse was calculated using acid insoluble ash as marker in feed and feces. Intake was estimated using total fecal output and digestibility estimates. Intake and digestion of animals receiving concentrate diet were measured directly. Table 10 represent growth performance, intake and digestibility measured on 8 animals each of different dietary treatments. Dry matter intake and digestibility were highest for goats receiving concentrate diet and lowest for those receiving mimosa browse with no differences in fecal output. However, animals on mimosa had highest feed efficiency. Animals on mimosa browse, based on chemical composition alone having high protein content and low cell wall, should have higher intake and digestibility, therefore, more body weight gain; however, intake and digestibility was lowest and efficiency of growth was highest among goats fed mimosa. Higher lignin content of mimosa also may contribute to lower dry matter digestibility.

Table 10. Growth, intake and digestibility (lsmean \pm SE) from pasture-fed, browse-fed and concentrate-fed goat kids

| Trait | pasture | browse | concentrate |
|---------------------|---------------------------------|---------------------------------|---------------------------------|
| No. of animals | 8 | 8 | 8 |
| | Performance phase (98 d) | | |
| Body weight, kg | | | |
| Initial | 27.75 \pm 1.45 ^a | 28.46 \pm 1.72 ^a | 28.53 \pm 1.59 ^a |
| Final | 32.33 \pm 1.24 ^c | 36.95 \pm 1.46 ^b | 39.67 \pm 1.36 ^a |
| ADG, g/d | 49.23 \pm 4.82 ^c | 89.83 \pm 4.82 ^b | 116.96 \pm 2.79 ^a |
| FE | 0.06 \pm 0.01 ^c | 0.15 \pm 0.01 ^a | 0.12 \pm 0.01 ^b |
| | Digestibility phase (10 d) | | |
| Avg. BW, kg | 29.47 \pm 1.60 ^b | 31.44 \pm 1.89 ^b | 33.96 \pm 1.75 ^a |
| DMI, g/d | 821.41 \pm 51.08 ^b | 610.95 \pm 51.08 ^c | 978.88 \pm 29.49 ^a |
| DMI, %BW | 2.67 \pm 0.32 ^a | 1.74 \pm 0.38 ^b | 2.71 \pm 0.35 ^a |
| Fecal DM output g/d | 277.07 \pm 16.14 ^a | 265.86 \pm 16.14 ^a | 273.74 \pm 9.32 ^a |
| DM Digestibility, % | 63.78 \pm 2.58 ^b | 55.91 \pm 2.71 ^c | 71.40 \pm 1.93 ^a |

^{abc} Means within the same row with different letters differ $P < 0.05$.

Rumen protein metabolism and volatile fatty acids

Protein content of mimosa was higher than concentrate diet and energy and fiber contents were basically the same. It appears that animals on mimosa had higher protein: energy ratio in the diet than those on concentrate diet. As indicated in figure 5 blood urea nitrogen of animals raised indoor on concentrate diet and outdoor on grass pasture were similar at zero hour, two hours and four hours after feeding when compared to mimosa brows fed goats. Goats browed on mimosa had higher blood urea nitrogen at zero hours and stayed higher after two and four hours after feeding. Mimosa diet had higher protein content when compared to pasture or concentrate diets (Tables 8 and 9). These results may indicate that either the energy: protein ratio in mimosa diet may not be sufficient for microbes in the rumen of browse fed goats to incorporate nitrogen into microbial protein, or the protein content in mimosa is more rapidly soluble and supplementing goats with corn grain did not supplement readily available carbohydrates. Or it was not enough. Goats on mimosa may require more rapidly fermentable carbohydrates such molasses to utilize the high nitrogen level present in mimosa.

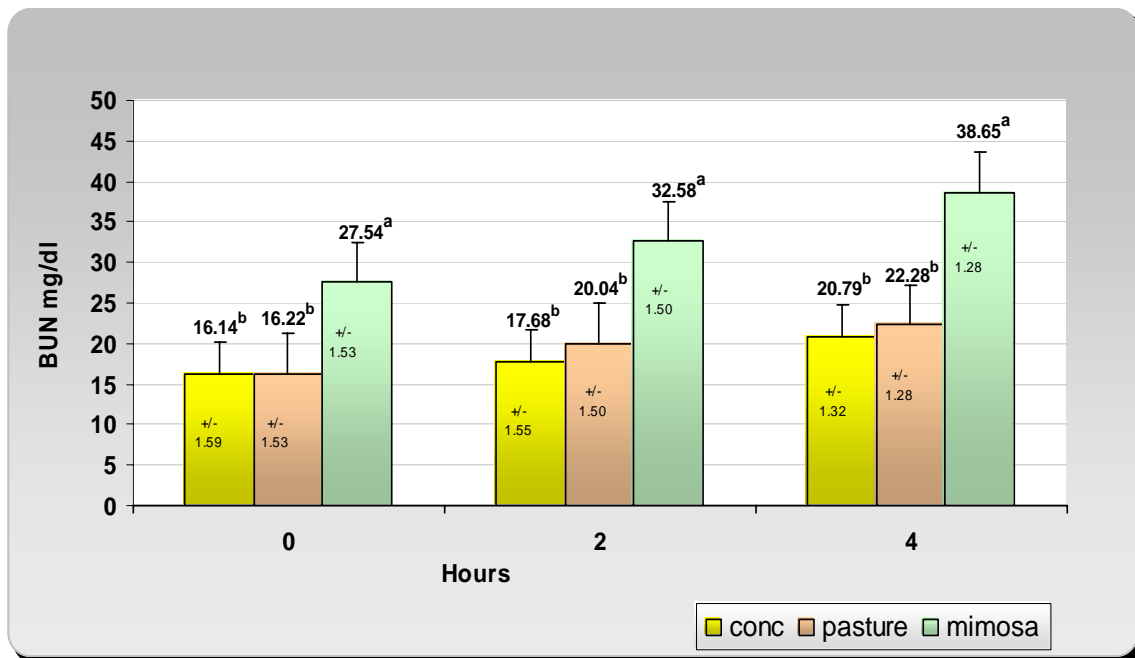


Figure 5. Interaction of time vs. production system (lsmean \pm SE) for blood urea nitrogen (BUN) levels in goat kids.

As indicated in Table 11, browse fed goats had higher pH value in the rumen that may indicate higher level of ammonia. This was reflected in higher blood urea nitrogen of these goats. However, goats on higher concentrate diet exhibited lower pH in the rumen that is characteristic of grain fed animals.

Browse fed goats had lowest ($P < 0.05$) acetate and highest ($P < 0.05$) isobutyrate and isovalerate. Although propionate was 10 to 15% units higher for grain fed goats as compared to pasture and mimosa browse, due to high animal variation differences were not significant. Acetate: propionate ratios were higher ($P < 0.05$) for pasture and browse fed goats when compared to concentrate fed animals.

Table 11. Rumen fluid measurements (mean \pm SE) from pasture-fed, browse-fed and concentrate-fed goat kids

| Trait | pasture | browse | concentrate |
|--------------------------|--------------------|--------------------|--------------------|
| No. of animals | 6 | 6 | 6 |
| Ruminal fluid pH | 6.72 ± 0.10^b | 7.40 ± 0.10^a | 6.07 ± 0.06^c |
| | mol/100 mol | | |
| Acetate | 55.36 ± 1.17^a | 44.69 ± 1.17^c | 52.23 ± 0.67^b |
| Propionate | 19.04 ± 5.24^a | 15.83 ± 6.37^a | 29.07 ± 5.64^a |
| Acetate:propionate ratio | 3.00 ± 0.10^b | 3.02 ± 0.10^b | 2.34 ± 0.06^a |
| Isobutyrate | 5.92 ± 0.46^b | 8.20 ± 0.46^a | 2.61 ± 0.26^c |
| Butyrate | 6.67 ± 1.62^a | 5.81 ± 1.62^a | 7.91 ± 0.94^a |
| Isovalerate | 8.41 ± 1.04^b | 13.77 ± 1.04^a | 4.55 ± 0.59^c |
| Valerate | 5.03 ± 2.58^a | 9.29 ± 1.78^a | 7.92 ± 1.03^a |

^{abc} Means within the same row with different letters differ ($P < 0.05$).

Performance and carcass traits

Initial body weight of goat kids was similar among production systems. Goats receiving the BG treatment had the lowest ADG $46.23 \text{ g/day} \pm 4.57$ followed by goats receiving the MB treatment $82.43 \text{ g/day} \pm 4.45$ ($P < 0.05$) and required more days on feed to reach harvest end points (Table 12). Goats receiving the CONC treatment exhibited the highest ADG $124.14 \text{ g/day} \pm 4.77$ ($P < 0.05$) over the 14 wk growth period and reached harvest end point two to four weeks faster than BG or MB treatments.

Table 12. Growth performance (lsmean \pm SE) from pasture-fed, browse-fed and concentrate-fed goat kids

| Trait | BG (pasture) | MB (browse) | CONC (concentrate) |
|--------------------------|-------------------------------|-------------------------------|--------------------------------|
| No. of animals | 15 | 15 | 15 |
| Performance phase (98 d) | | | |
| Body weight, kg | | | |
| Initial weight | 21.21 \pm 0.91 ^a | 21.19 \pm 0.91 ^a | 22.86 \pm 0.91 ^a |
| Final weight | 25.93 \pm 0.93 ^c | 29.42 \pm 0.93 ^b | 35.12 \pm 0.93 ^a |
| ADG, g/day | 46.23 \pm 4.57 ^c | 82.43 \pm 4.45 ^b | 124.14 \pm 4.77 ^a |

^{abc} Means within the same row with different letters differ $P < 0.05$.

Goats fed the CONC treatment had heavier harvest, hot carcass weight, and cold carcass weight ($P < 0.05$) with higher dressing and shrinkage percentages ($P < 0.05$) than did carcasses of the BG or MB treatments (Table 13). No differences were observed ($P > 0.10$) in kidney pelvic fat, back fat, adjusted fat thickness, or carcass selection grades between treatment groups (Table 13). Carcasses from the CONC and MB treatments had larger LMA ($P < 0.05$) than carcasses of the BG treatment (Table 13). The results from the analyses that included harvest weight as a covariate indicate that the significant differences among carcass traits are largely a function of harvest weight differences. Johnson et al. (1998) compared the effect of intensive and semi-intensive diet/management systems on carcass traits of does from the Florida native breed. The intensive diet/management system produced heavier final and harvest weights, higher dressing percentages and larger longissimus muscle areas than goats produced under the semi-intensive system. Oman *et al.* (1999) indicated that feedlot goats of the Boer x Spanish and the Spanish breeds produced heavier live and carcass weights with a more desirable lean to bone ratio than range goats of the same breeds.

USDA live and carcass selection criteria were unaffected by production system (Table 13). Goats in the ML group graded in the live animal selection criteria No.2 by 34% (100% would be a perfect selection No.2) followed by the BG group graded in the selection criteria No.2 by 29% and CONC group graded in the selection criteria No.2 by 21%. The carcasses of the CONC group graded in the selection criteria No.2 by 43% very similar to the BG group which graded in the selection criteria No.2 by 40%. Carcasses of MB group graded in the

selection criteria No.2 by 22%. This selection grade system is specific to goats and limited to the subjectivity of the USDA graders.

Table 13. Growth and carcass traits (lsmean \pm SE) from pasture-fed (BG), browse-fed (MB) and concentrate-fed (CONC) goat kids

| Trait | Dietary Treatments | | |
|------------------------------------|-------------------------------|-------------------------------|-------------------------------|
| | BG | MB | CONC |
| No. of animals | 15 | 15 | 15 |
| Final weight, kg | 27.12 ^c \pm 0.97 | 31.85 ^b \pm 0.97 | 35.11 ^a \pm 0.97 |
| Hot carcass weight, kg | 11.77 ^c \pm 0.23 | 13.59 ^b \pm 0.21 | 16.19 ^a \pm 0.33 |
| Cold carcass weight, kg | 11.73 ^c \pm 0.23 | 13.46 ^b \pm 0.21 | 15.19 ^a \pm 0.33 |
| Dressing % | 36.81 ^c \pm 0.71 | 43.42 ^b \pm 0.65 | 49.03 ^a \pm 0.99 |
| 48 hr cooler shrink % | 0.64 ^b \pm 0.63 | 1.09 ^b \pm 0.57 | 7.26 ^a \pm 0.87 |
| Kidney & pelvic fat, kg | 0.17 \pm 0.02 | 0.22 \pm 0.02 | 0.17 ^a \pm 0.03 |
| Back fat thickness, cm | 0.06 \pm 0.02 | 0.09 \pm 0.02 | 0.05 \pm 0.03 |
| Body wall fat, cm | 0.10 ^b \pm 0.07 | 0.21 ^b \pm 0.06 | 0.67 ^a \pm 0.09 |
| Adjusted fat thickness, cm | 0.06 \pm 0.02 | 0.04 \pm 0.02 | 0.03 \pm 0.03 |
| LMA ^d , cm ² | 6.21 ^b \pm 0.33 | 7.55 ^a \pm 0.30 | 7.63 ^a \pm 0.45 |
| Live animal grade ^e | 2.29 \pm 0.14 | 2.34 \pm 0.13 | 2.21 \pm 0.19 |
| Carcass grade ^d | 2.40 \pm 0.20 | 2.22 \pm 0.18 | 2.43 \pm 0.28 |

^{abc} Means within the same row with different letters differ ($P < 0.05$).

^d Longissimus muscle area

^e USDA Selection Criteria range, 1= superior meat type conformation with thickly muscled throughout the body; 2= average meat type conformation with moderately muscled throughout the body; 3= inferior meat type conformation, narrow in width and very angular in appearance.

All commercial cuts are presented in Table 14. All meat cuts were similar for goats raised under pasture, browse or concentrate system except for loin, ribs and trim that was higher for concentrate fed animals followed by browse fed animals. However, the hindshank cut was higher for browse fed animals indicative of animals using their hind legs to reach for browse more frequently than pasture fed and concentrate fed goats.

Table 14. Commercial cuts (lsmean \pm SE) as a proportion of half carcass weight from pasture-fed, browse-fed and concentrate-fed goat kids

| Cut | pasture | browse | concentrate |
|------------------------|-------------------------------|-------------------------------|-------------------------------|
| No. of animals | 6 | 6 | 6 |
| Half carcass weight | Kg | | |
| Shoulder, foreshank, | 4.95 \pm 1.92 ^a | 6.55 \pm 1.92 ^a | 7.53 \pm 1.83 ^a |
| Breast and neck | 1.61 \pm 0.19 ^a | 1.87 \pm 0.19 ^a | 2.06 \pm 0.21 ^a |
| Rack | 0.52 \pm 0.10 ^a | 0.67 \pm 0.10 ^a | 0.59 \pm 0.10 ^a |
| Loin | 0.51 \pm 0.06 ^b | 0.67 \pm 0.06 ^{ab} | 0.71 \pm 0.06 ^a |
| Sirloin | 0.38 \pm 0.11 ^a | 0.56 \pm 0.10 ^a | 0.62 \pm 0.10 ^a |
| Hind leg, shank off | 1.26 \pm 0.15 ^a | 1.37 \pm 0.11 ^a | 1.60 \pm 0.18 ^a |
| Hindshank | 0.27 \pm 0.19 ^b | 0.70 \pm 0.10 ^a | 0.58 \pm 0.11 ^{ab} |
| Ribs, breast bone off | 0.16 \pm 0.28 ^b | 0.35 \pm 0.36 ^{ab} | 0.85 \pm 0.25 ^a |
| Trim (ground products) | 0.25 \pm 0.03 ^c | 0.36 \pm 0.03 ^b | 0.52 \pm 0.03 ^a |
| | % | | |
| Shoulder, foreshank, | 32.55 \pm 3.20 ^a | 28.75 \pm 3.20 ^a | 27.32 \pm 3.39 ^a |
| breast, neck | 10.50 \pm 1.82 ^a | 10.13 \pm 1.82 ^a | 7.81 \pm 1.93 ^a |
| Rack | 10.38 \pm 1.02 ^a | 10.23 \pm 1.02 ^a | 9.41 \pm 1.07 ^a |
| Loin | 7.70 \pm 0.84 ^a | 8.54 \pm 0.84 ^a | 8.26 \pm 0.89 ^a |
| Sirloin | 25.44 \pm 2.10 ^a | 20.94 \pm 2.10 ^a | 21.31 \pm 2.23 ^a |
| Hind leg, shank off | 5.29 \pm 1.89 ^b | 11.05 \pm 1.89 ^a | 7.70 \pm 2.01 ^{ab} |
| Hindshank | 3.18 \pm 1.16 ^a | 5.09 \pm 1.16 ^a | 11.23 \pm 1.23 ^a |
| Ribs, breast bone off | 5.04 \pm 0.50 ^b | 5.08 \pm 0.58 ^{ab} | 6.95 \pm 0.53 ^a |
| Trim (ground products) | | | |

^{ab} Means within the same row with different letters differ $P < 0.05$.

Carcass composition

Table 15 indicates that moisture % was lower and fat % was higher in the carcasses of goats fed concentrate diet when compared with those on pasture or brows; however, ash was lower and protein content was similar for different feeding systems. Data from 9-10-11th rib section showed similar trends in composition as that obtained from half carcass except for protein. More carcass data is needed to verify the use of 9-10-11th rib section composition for whole carcass composition.

Table 15. Chemical composition (lsmean \pm SE) from half carcass and 9-10-11th rib section of pasture-fed, browse-fed and concentrate fed goat kids

| Item ^c | Pasture | Browse | Concentrate | <i>P</i> -value |
|------------------------------|--------------------------------|-------------------------------|-------------------------------|-----------------|
| <u>9-10-11th rib section</u> | | | | |
| moisture % | 67.75 \pm 0.80 ^a | 66.83 \pm 0.65 ^a | 60.49 \pm 0.75 ^b | 0.0001 |
| fat % | 8.31 \pm 2.27 ^b | 10.07 \pm 2.54 ^b | 18.64 \pm 2.69 ^a | 0.021 |
| protein % | 22.52 \pm 1.15 ^a | 22.09 \pm 1.42 ^a | 18.88 \pm 2.47 ^a | 0.157 |
| ash % | 1.01 \pm 0.02 ^a | 1.01 \pm 0.02 ^a | 0.90 \pm 0.02 ^b | 0.004 |
| Total % | 99.59 | 100 | 98.91 | |
| Half carcass | | | | |
| moisture % | 70.30 \pm 0.88 ^a | 70.01 \pm 0.87 ^a | 64.46 \pm 0.95 ^b | 0.0001 |
| fat % | 8.03 \pm 0.75 ^b | 9.06 \pm 0.61 ^b | 13.39 \pm 0.71 ^a | 0.0001 |
| protein % | 20.55 \pm 0.51 ^{ab} | 19.99 \pm 0.42 ^b | 21.30 \pm 0.49 ^a | 0.046 |
| ash % | 1.11 \pm 0.07 ^a | 0.94 \pm 0.09 ^{ab} | 0.85 \pm 0.09 ^b | 0.027 |
| Total % | 99.99 | 100 | 100 | |

^{ab} Means within the same row with different letters differ $P < 0.05$.

^c Reported on as is basis.

Fatty acid and cholesterol in goat meat

The total amount of fatty acids was greater in the CONC group (2279.35 mg/100g) than the MB (1520.09 mg/100g) or BG (1443.54 mg/100g) groups reflecting their greater carcass fatness (Table 16). Principle fatty acids in the intramuscular fat of the longissimus muscle were, in all production systems, palmitic (C16:0), stearic (C18:0) and oleic (C18:1). Mahgoub *et al.* (2002) reported similar results in Akhdar goats of different sexes and weights. Beserra *et al.* (2004) also reported a high percentage of palmitic, stearic and oleic fatty acids in Moxoto' goats and their crosses. Results from the present study demonstrated an influence of the production system on fatty acid composition of percentage Boer goat kids. Goats raised in the CONC group contained higher proportions of linoleic acid (C18:2 n-6) than in the ML or BG groups. Linolenic acid (C18:3 n-3) was higher in the MB group (16.68 mg/100g) but was not different among the CONC (6.14 mg/100g) and the BG group (6.17 mg/100g). The C18:2n-6/c18:3n-3 ratio was

smallest in the MB group (3.21) followed by the BG group (6.83) and the CONC group (8.75). These results can be explained by the addition of a protein supplement required in the diet of the BG group in order to maintain a positive average daily gain. The PUFA/SFA ratio is used to calculate the risk factor of foods with regard to blood cholesterol rise. Saturated fatty acids tend to increase cholesterol low density levels in the plasma, while PUFA reduce these same levels. The ratios calculated for each production system in this study were below the recommended values of 0.45 (Department of Health, 1994). The PUFA/SFA ratio was lowest for the CONC group (0.23) when compared to the MB group (0.32) and the BG group (0.34) ($P < 0.05$).

Cholesterol concentration of the longissimus muscle was not affected by production system ($P > 0.05$; Table 16). The cholesterol concentrations in the present study are in agreement with Young et al. (1991) who reported cholesterol values for goat longissimus muscle at 57.8 mg/100g muscle in young dairy goats of the Alpine and Nubian breeds and Beserra et al. (2004) who reported cholesterol values of 69.4 mg/100g muscle in Moxoto' goats at 8-10 weeks of age.

Table 16. Intramuscular fatty acid composition and cholesterol (lsmean \pm SE) from pasture-fed (BG), browse-fed (MB) and concentrate-fed (CONC) goat kids

| mg per 100 g muscle | | | |
|---------------------------|----------------------|---------------------|----------------------|
| Fatty acid | BG | MB | CONC |
| 16:0 | 296.21b \pm 43.92 | 299.86b \pm 35.69 | 474.71a \pm 41.59 |
| 18:0 | 236.71 \pm 36.53 | 260.86 \pm 29.68 | 336.72 \pm 34.59 |
| 18:1 trans-9 | 2.14a \pm 1.13 | 5.09b \pm 0.92 | 0.11a \pm 1.07 |
| 18:1 cis-11 | 32.86 \pm 6.57 | 37.03 \pm 5.34 | 45.46 \pm 6.22 |
| 18:1 cis-9 | 537.94b \pm 90.14 | 571.45b \pm 73.14 | 1010.39a \pm 85.25 |
| 18:1 cis-7 | 18.96b \pm 2.22 | 17.87b \pm 1.80 | 27.50a \pm 2.10 |
| 18:2 cis-10,12 | 6.25 \pm 5.64 | 1.16 \pm 4.58 | 10.84 \pm 5.34 |
| 18:2 cis-9,12 | 65.01 \pm 8.90 | 63.16 \pm 7.23 | 83.54 \pm 8.43 |
| 18:3 cis-9,12,15 | 6.17a \pm 1.13 | 16.68b \pm 0.92 | 6.14a \pm 1.07 |
| 18:2 cis-9, trans-11 CLAd | 11.60 \pm 2.13 | 13.69 \pm 1.73 | 11.85 \pm 2.02 |
| SFA _d | 590.31b \pm 86.19 | 620.89b \pm 70.03 | 878.12a \pm 81.63 |
| MUFA _d | 649.51b \pm 103.83 | 691.83b \pm 84.37 | 1165.20a \pm 98.34 |

| | | | |
|----------------------|-------------------|-------------------|-------------------|
| PUFAd | 171.58 ± 9.37 | 179.92 ± 7.61 | 189.92 ± 8.87 |
| n-6de | 138.76ab ± 7.58 | 125.45b ± 6.16 | 158.91a ± 7.18 |
| n-3de | 21.21a ± 1.86 | 40.78b ± 1.51 | 19.16a ± 1.76 |
| n-6:n-3 | 6.83b ± 0.56 | 3.21c ± 0.46 | 8.75a ± 0.53 |
| PUFA:SFA | 0.34ab ± 0.04 | 0.32b ± 0.03 | 0.23a ± 0.03 |
| Total fatty acids | 1443.54b ± 200.65 | 1520.09b ± 163.04 | 2279.35a ± 190.03 |
| Cholesterol, mg/100g | 66.12 ± 2.39 | 60.99 ± 1.94 | 63.28 ± 2.26 |

^{abc} Means within the same row with different letters differ $P < 0.05$.

^d CLA: conjugated linoleic acid, SFA: saturated fatty acids, MUFA: monounsaturated fatty acids, PUFA: polyunsaturated fatty acids.

^e n - 6 fatty acids include: 18:2c10,12, 18:2c9,12, 20:2c11,14, 20:3c8,11,14, 20:4c5,8,11,14,

Meat quality, color and shelf life

Table 17 indicates that goat meat from mimosa brows fed animals was darker than pasture fed goats and it was slightly darker than concentrate fed goats. Goat meat from all carcasses were similar in redness; however, pasture fed and browse fed goats had more yellow tint in their meat.

Table 17. CIE L^* , a^* and b^* color parameters (lsmean ± SE) of *m. longissimus* muscle from pasture-fed, browse-fed and concentrate-fed goat kids measured 48 h postmortem (d 0).

| Parameter | pasture | browse | concentrate |
|--------------------------|---------------------------|---------------------------|----------------------------|
| No. of animals | 15 | 15 | 15 |
| L^* value ^c | 47.86 ± 3.59 ^a | 33.65 ± 5.46 ^b | 42.18 ± 4.97 ^{ab} |
| a^* value ^c | 13.01 ± 1.36 ^a | 14.32 ± 1.84 ^a | 12.77 ± 1.82 ^a |
| b^* value ^c | 15.92 ± 0.52 ^a | 15.92 ± 0.42 ^a | 13.67 ± 0.68 ^b |

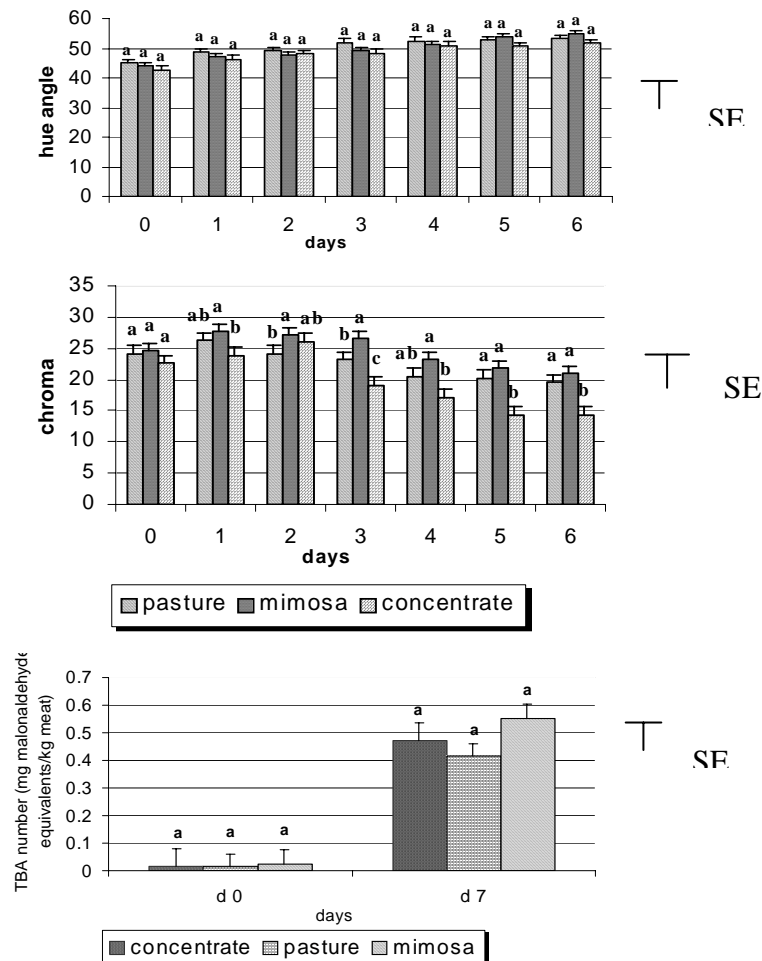
^{ab} Means within the same row with different letters differ $P < 0.05$.

^c L^* values are a measure of lightness (higher value indicates a lighter color); a^* values are a measure of redness (higher value indicates a redder color); b^* values are a measure of yellowness (higher value indicates a more yellow color).

Effect of dietary treatments (pasture, browse and concentrate) on retention of redness (a^*), yellowness (b^*), color saturation (chroma), and proportions of redness and yellowness (hue

angle) of goat meat after 6 days on shelf (shelf life) was measured (Figure 6). Chroma and hue angle are products of a^* and b^* and may more precisely measure the color change. There was no difference in proportion of redness and yellowness (hue angle) in meats as affected by treatment. Although there was no difference in color saturation (chroma index) between treatments at day 0, chroma was lower for grain fed goat meat after day 3 of shelf life as compared to pasture fed or browse fed goats. Color of meat was more stable for goats fed pasture and browse and these diets stabilized redness and color saturation, and extended color display life of fresh goat meat.

Thiobarbituric acid reactive substances (TBARS) indicates fat oxidation in fresh meat. There was no difference in fat oxidation of meats harvested from goats on different dietary treatments.



^{abc} Means within the same column with different letters differ ($P < 0.05$).

Figure 6 . The effects of treatment * storage day on hue angle, chroma calculations and thiobarbituric acid reactive substances (TBARS) for *m. longissimus* muscle chops.

As indicated in Table 18 and Figure 7 there was no difference in temperature or pH changes post harvest among carcasses of goats raised under different dietary systems or purity of breeds. However, pH and temperature dropped from time zero to 24 hours postmortem.

Table 18. The *F*-statistic probabilities for main effects and interactions of *m. longissimus* muscle pH and temperature.

| Sources | pH | Temperature |
|----------------|--------|-------------|
| Breed | 0.33 | 0.82 |
| Trt | 0.69 | 0.26 |
| Hour | 0.0001 | 0.0001 |
| Breed*trt | 0.95 | 0.53 |
| Trt*Hour | 0.002 | 0.0001 |
| Breed*trt*Hour | 0.69 | 0.60 |

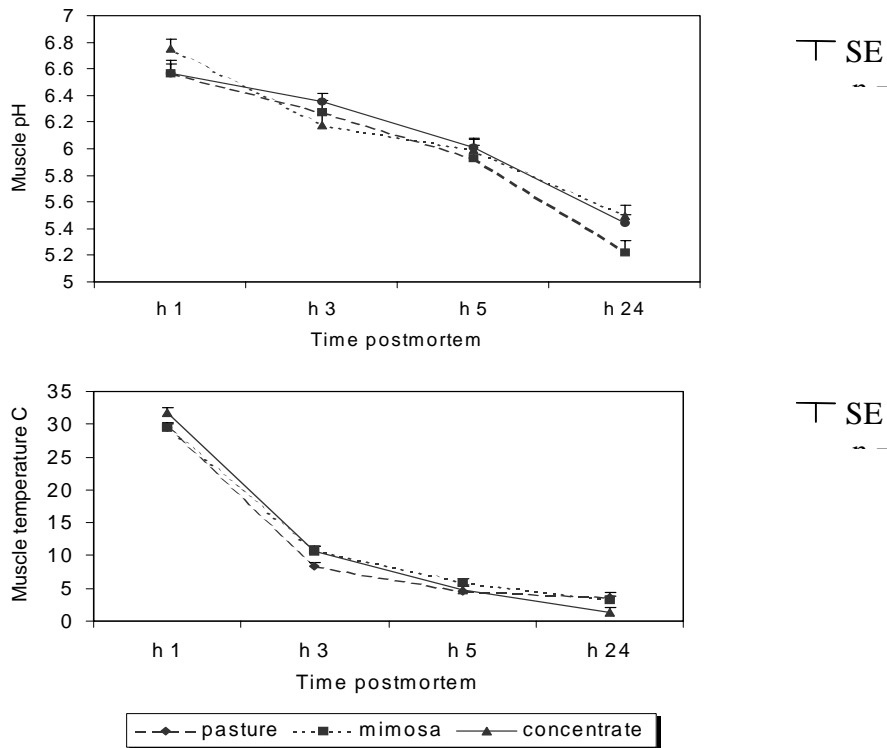


Figure 7. The effects of treatment * postmortem time on *longissimus* muscle pH and temperature.

Warner-Bratzler shear force (WBSF), cooking loss and sensory evaluation

As indicated in Table 19, no differences were observed in cooking time, cooking loss %, tenderness, juiciness, flavor intensity or off flavor for meats harvested from goats raised under different feeding systems.

Table 19. Warner-Bratzler shear force (WBSF), cooking loss and sensory evaluation (Ismean \pm SE) from pasture-fed, browse-fed and concentrate-fed goat kids

| Trait | pasture | browse | concentrate |
|-----------------------------------|-------------------------------|-------------------------------|-------------------------------|
| No. of animals | 15 | 15 | 15 |
| <i>m. semimembranosus</i> | | | |
| WBSF, kg | 2.05 \pm 1.08 ^a | 3.74 \pm 0.69 ^a | 1.96 \pm 0.91 ^a |
| Cooked temp., °C | 64.30 \pm 0.57 ^b | 63.76 \pm 0.70 ^b | 70.63 \pm 0.89 ^a |
| Cooking time, min | 5.71 \pm 1.14 ^a | 5.89 \pm 0.87 ^a | 5.50 \pm 1.12 ^a |
| Cooking loss, % | 24.76 \pm 8.49 ^a | 34.99 \pm 5.73 ^a | 27.41 \pm 7.49 ^a |
| Sensory | | | |
| Initial tenderness ^c | 5.72 \pm 0.22 ^a | 5.93 \pm 0.26 ^a | 5.24 \pm 0.35 ^a |
| Sustained tenderness ^c | 5.44 \pm 0.23 ^a | 5.51 \pm 0.27 ^a | 5.22 \pm 0.36 ^a |
| Initial juiciness ^c | 5.69 \pm 0.67 ^a | 6.03 \pm 0.51 ^a | 6.09 \pm 0.66 ^a |
| Sustained juiciness ^c | 5.58 \pm 0.98 ^a | 6.02 \pm 0.59 ^a | 6.78 \pm 0.79 ^a |
| Flavor intensity ^c | 6.23 \pm 0.82 ^a | 6.46 \pm 0.44 ^a | 7.44 \pm 0.61 ^a |
| Off flavor ^c | 5.88 \pm 0.79 ^a | 6.00 \pm 0.46 ^a | 7.43 \pm 0.63 ^a |
| <i>m. biceps femoris</i> | | | |
| WBSF, kg | 2.39 \pm 0.10 ^a | 2.55 \pm 0.13 ^a | 2.87 \pm 0.16 ^a |
| Cooked temp., °C | 64.92 \pm 0.68 ^a | 64.57 \pm 0.84 ^a | 66.23 \pm 1.08 ^a |
| Cooking time, min | 2.49 \pm 1.34 ^a | 3.44 \pm 0.68 ^a | 3.31 \pm 0.93 ^a |
| Cooking loss, % | 24.55 \pm 2.10 ^a | 25.93 \pm 2.68 ^a | 18.07 \pm 3.31 ^a |
| Sensory | | | |
| Initial tenderness ^c | 5.95 \pm 0.62 ^a | 5.89 \pm 0.32 ^a | 6.19 \pm 0.71 ^a |
| Sustained tenderness ^c | 5.55 \pm 0.77 ^a | 6.03 \pm 0.62 ^a | 5.57 \pm 0.79 ^a |
| Initial juiciness ^c | 5.83 \pm 0.68 ^a | 6.64 \pm 0.47 ^a | 5.38 \pm 0.62 ^a |
| Sustained juiciness ^c | 5.76 \pm 0.81 ^a | 6.97 \pm 0.54 ^a | 5.29 \pm 0.71 ^a |
| Flavor intensity ^c | 6.54 \pm 0.27 ^a | 6.48 \pm 0.23 ^a | 6.13 \pm 0.29 ^a |
| Off flavor ^c | 6.45 \pm 0.37 ^a | 6.38 \pm 0.30 ^a | 6.11 \pm 0.38 ^a |

^{ab} Means within the same row with different letters differ $P < 0.05$.

^c 1-8 point scale, where 1= extremely tough, extremely dry, extremely bland, extremely uncharacteristic and 8= extremely tender, extremely juicy, extremely intense, extremely characteristic.

C.3. Impact of Results/Outcome

Boer wether goat kids fed a high concentrate diet had higher average daily gains and heavier carcass weights with larger longissimus muscle areas than goats on bahagrass or mimosa systems. Forage quality within production systems was a component of variation for growth and carcass traits in the present study. Mimosa diet had higher protein content as related to its energy content. High soluble protein increased pH of the rumen and elevated blood urea nitrogen in mimosa fed goats. May be supplementing mimosa with more rapidly fermentable carbohydrate is more appropriate than corn grain. Animals consuming mimosa had lower intake and digestibility with higher gain efficiency. The Mimosa system produced higher average daily gains and final body weights with higher carcass weights than the bahagrass system. Mimosa browse fed goats had increased branched chain fatty acids in the rumen and more CLA and omega 3 fatty acids in the goat muscle tissue. Also the supplemental feeding in the bahagrass system probably altered the fatty acid composition of the goat muscle tissue. Carcasses from mimosa fed goats were darker and along with pasture fed goats they had more yellow tinted carcasses; however, the color of carcass was more stable and displayed longer shelf life than grain fed goats. The quality of cooked meat, tenderness, juiciness, and flavor was similar for all meats. The practicality of supplemental feeding with forage based production systems will depend largely on production cost of each system and the market potential for larger carcasses.

Objective D. Establish the optimal stocking rates and associated animal weight gain for goats when feeding on mimosa in summer, and annual ryegrass in winter.

D.1.1. Materials and Methods

Mimosa Study-preliminary

In July and August, 2002, five acres of mimosa were fenced with goat- and predator-proof (mesh and electric) fencing into five one-acre subdivisions for rotational stocking, with shelters and facilities to pen animals at night. Major annual weed infestations of the mimosa paddocks were also eliminated by hand on these five acres during this same period. Forty-five animals with average initial BW of 16.6 ± 3.98 kg were placed on about 5 acres of mimosa plant fields for 49 days. The paddocks were mown in April 2002, and growth was allowed to

accumulate without defoliation for the entire summer. By the end of August, mimosa plants had mostly 5 to 8 stems that ranged between 6 and 10 ft in length. Animals were allowed to browse during the day and they were penned at night to protect from predators. Body weight was recorded every two weeks.

D.2.1. Results/Discussion

Preliminary results indicated that body weight gain ranged from 55.7 g/day to 175.7 g/day with ADG of 102.6 ± 27.4 g. Animals (n=19) with initial body weight (IBW) of 15-20 kg performed better (ADG= 114.9 ± 5.9 , $P < 0.03$) than those (n=19) with lower (10-15 kg, ADG= 92.0 ± 5.9 g) or (n=6) higher IBW (20-29 kg, ADG= 97.2 ± 10.5 g). Smaller animals were probably more challenged to reach the higher branches (6-10 ft) and older animals had slower growth rate. Mimosa plants should be pruned at a lower height (2 ft.) or, for best performance, goats should reach certain weight (IBW of at least 15-20 kg), before placing on mimosa. In December 2002, and January 2003 all mimosa plants in all 5 one-acre paddocks were pruned by hand to a height of about 2 feet in preparation for the 2003 experiment. Preliminary results are very promising when compared to reported ADG of 131 g for similar size goats (IBW of 21 kg) kept indoors and consuming more than 80% grain in their diet (Solaiman et al., 2006).

D.1.2. Materials and Methods

Mimosa study year 1 and 2

In December, 2002-January, 2003, five previously fenced mimosa paddocks (one acre each) were prepared by pruning stems to about 2 ft and growth was allowed to accumulate without defoliation until June. Major annual weed infestations of the mimosa paddocks were also eliminated by hand on these five acres during this same period. Starting on June 11, 2003, sixteen experimental and four non experimental goats with average initial BW of 20.49 kg were rotationally grazed on about 5 acres of mimosa plant fields for 100 days. Animals were allowed to browse 24 h/d and crushed corn grain was provided at 100 g/h/d. Body weight was recorded every two weeks. Mimosa grab samples were collected every two weeks and composite were made monthly. This experiment was repeated again in June of 2004 with same number of goats and preparation.

D.2.2. Results and Discussion

As indicated in Table 20, average daily gain on mimosa for goats was about 80 g/day when goats were browsing rotationally at 20 goats/5 acres. Mimosa appears more nutritious,

indicated by chemical analysis (Table 8), rather than animal performance. The chemical composition of mimosa warrants higher gains; however, either an imbalance in energy to protein ratio or presence of compounds such as condense tannins may be the hindering factor. More research is needed to formulate appropriate supplement for goats on mimosa browse.

Table 20. Average Daily Gain of Goats on Mimosa (Rotational Grazing)

| Year | n/5 acres | <u>Initial BW</u> lbs | <u>Final BW</u> lbs | Days | <u>ADG</u> g/day |
|---------|-----------|--------------------------|------------------------|------|---------------------|
| 2003 | 20 | 48 | 65 | 100 | 77 |
| 2004 | 20 | 55 | 67 | 70 | 83 |
| Average | | 51.5 | 66 | | 80 |

D.1.3. Materials and Methods

Ryegrass Study-Preliminary

This experiment was conducted 1) to determine preliminary performance of goats on annual Marshall ryegrass and 2) to evaluate the effect of castration on animal performance and carcass quality. Twenty six goats (wether and buck kids) were placed on one of the two 2.3 acres of ryegrass pastures and were rotated between the two pastures as needed. Body weights were recorded every two weeks and experiment was carried out for 56 days. Forage samples were collected every 4 wk for forage quality determination. After day 56, 14 animals (7 wethers and 7 bucks) were harvested and hot carcass weight (HCW), cold carcass weight (CCW), dressing percent (DP), kidney and pelvic fat (KPF), longissimus muscle area (LMA), backfat (BF) and other carcass parameters were measured.

D.2.3. Results and Discussion

Intact males gained faster throughout the experimental period as indicated in Figure 8. Average daily gain over 56 days was greater ($P < 0.05$) for intact males than for wethers (139 and

66 g/day, respectively). Table 21 presents carcass traits of buck vs. wether. Carcass selection grades were similar between treatment groups; no differences ($P > 0.10$) were observed in HCW, CCW or DP. Wethers had higher ($P < 0.05$) kidney and pelvic fat than intact males (.51 and .23 kg, respectively), however, backfat and LMA did not differ ($P > 0.10$). These results indicated that castration of young market goats reduced growth and did not provide any distinct advantage in carcass characteristics. Elimination of castration practices will improve animal welfare.

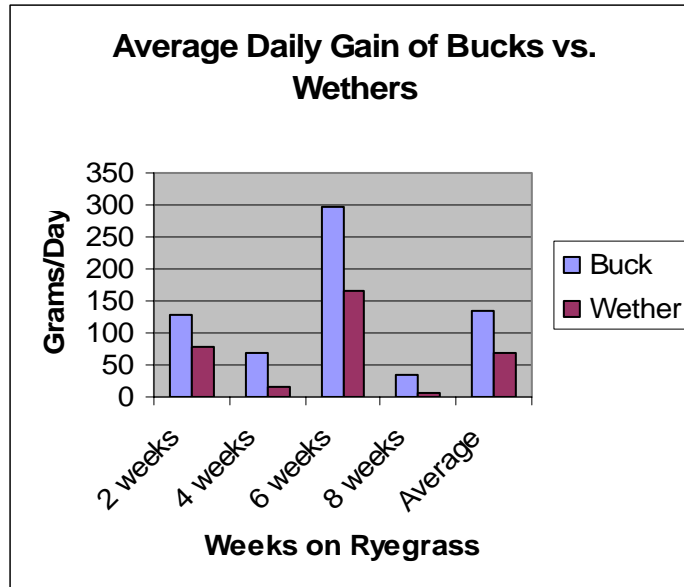


Figure 8. Average daily gain of bucks vs. wether grazing ryegrass

Table 21. Carcass traits of buck and wether goats

| Item ^{a,b} | Means at 8 Weeks Body Weight | | |
|---------------------|------------------------------|-------------------|------|
| | Buck | Wether | SE |
| HCW, kg | 21.8 | 19.5 | 0.86 |
| CCW, kg | 21.0 | 18.6 | 0.81 |
| Dressing % | 50.0 | 48.0 | 1.01 |
| 12 rib fat, cm | 0.05 | 0.03 | 0.02 |
| BWF, cm | 0.2 ^a | 0.41 ^b | 0.06 |
| KPF % | 0.23 ^a | 0.51 ^b | 0.07 |
| LMA, cm | 10.3 | 8.9 | 0.58 |

^a HCW= Hot carcass weight, CCW= Cold carcass weight, BWF= Body wall fat, KPF= Kidney pelvic fat, LMA= Longissimus muscle area.

^b Means within a row with different superscripts differ ($P < 0.05$).

D.1.4. Materials and Methods

Ryegrass Study, year 1 and 2

These experiments were conducted to determine the optimum stocking rate of goats grazing on annual Marshall ryegrass. Four approximately one-acre paddocks were prepared for grazing. Marshall ryegrass was planted on a prepared seedbed in September, 2003 and again September 2004, at a seeding rate of 30 lb/ac. Nitrogen fertilizer was applied at 100 lb N/acre at planting, and 60 lb N/acre again in February. Phosphorus and potassium were applied according to soil test. 8, 11, 14 and 17 animals (buck kids) were randomly assigned to these paddocks and start grazing on December 15, 2003 and again December 1, 2004. Animals weight and disk meter reading (DMR) were recorded every 4 weeks.

D.2.4. Results and Discussion

Tables 22, 23 and 24 summarize the performance data for different stocking rates for years 2003-2004 and 2004-2005. Based on the results of these experiments stocking rates at 8-11 goats/acre had highest animal gain per day and there was a direct relationship between ADG and DMR for ryegrass pastures. Animals performance can be affected by different years. The 2004-2005 grazing season was very wet and rainy and animals did not perform as prior year grazing season (2003-2004).

Table 22. Average daily gain for goats and disc meter readings (DMR, inches) of ryegrass pastures at different stocking rates for 105 days (2004).

| Stocking Rates | Initial | | Final | | ADG | ADG |
|----------------|---------|-----|---------|-----|---------|-------|
| | BW(lbs) | DMR | BW(lbs) | DMR | lbs/day | g/day |
| 17 | 51 | 7.7 | 68 | 2.7 | 0.16 | 74.4 |
| 14 | 50 | 7.0 | 72 | 2.8 | 0.21 | 96.3 |
| 11 | 49 | 8.2 | 89 | 5.4 | 0.39 | 174.7 |
| 8 | 50 | 5.9 | 87 | 5.4 | 0.35 | 160.4 |

DMR= disc meter reading, ADG= average daily gain, BW= body weight.

Table 23. Average daily gain for goats and disc meter readings (DMR, inches) of ryegrass pastures at different stocking rates for 103 days (2005).

| Stocking Rates | | <u>Initial</u> | | <u>Final</u> | | <u>ADG</u> | <u>ADG</u> |
|----------------|---------|----------------|---------|--------------|--|------------|------------|
| Goats/acre | BW(lbs) | DMR | BW(lbs) | DMR | | lbs/day | g/day |
| 17 | 56.9 | 7.3 | 65.1 | 3.2 | | 0.08 | 36.4 |
| 14 | 53.3 | 6.8 | 63.6 | 4.6 | | 0.10 | 45.6 |
| 11 | 50 | 8.1 | 72.5 | 4.8 | | 0.22 | 100.1 |
| 8 | 52.9 | 7.8 | 86.1 | 5.7 | | 0.32 | 145.5 |

DMR= disc meter reading, ADG= average daily gain, BW= body weight.

Table 24. Average daily gain for goats on ryegrass pastures at different stocking rates and DMR for years 2004 and 2005.

| Stocking Rates | <u>ADG</u> | <u>DMR</u> |
|----------------|------------|------------|
| Goats/acre | (g/day) | inches |
| 17 | 55.4 | 3.0 |
| 14 | 71.0 | 3.7 |
| 11 | 137.4 | 5.1 |
| 8 | 153.0 | 5.5 |

DMR= disc meter reading

ADG= average daily gain

D.3. Impact of Results/Outcome

Based on preliminary study with mimosa, goats with average body weight of 15 to 20 kg perform superior to those with less body weight (10 to 15 kg). Smaller animals tend to have harder time to reach mimosa plants and utilize branches 6 to 8 ft. in height. Four to five goats per acre rotationally grazing mimosa gained on average 80 grams per day. Based on chemical composition (high protein, low fiber), animals browsing on mimosa should gain more; however, due to its nature and imbalance in energy to protein ratio, optimum animal performance can only

reached with proper supplementation. More research on stocking rate and supplementation is needed to improve animal's performance.

Based on preliminary study with Marshal ryegrass, intact males gain faster than wethers. Therefore practice of castration maybe eliminated for market goats. Ryegrass pastures stocked with 8 to 11 goats per acre resulted in higher ADG; however, optimum gain per acre may be achieved at different stocking rate. More research is needed to evaluate most economical stocking rate per acre.

Objective E. Compare productivity of goats on ryegrass with that of cattle.

E.1. Materials and Methods

Two grazing experiments were conducted at the E. V. Smith Research Center of Auburn University, at Shorter, south-central Alabama. Marshall ryegrass was planted on a prepared seedbed in September, 2004, at a seeding rate of 30 lb/ac. Nitrogen fertilizer was applied at 100 lb N/acre at planting, and 60 lb N/acre again in February. Phosphorus and potassium were applied according to soil test. The goat experiment involved four 1-acre pastures which were stocked initially with 8, 11, 14 and 17 head. Stocking rates were not replicated. Mortalities resulted in minor modification to these stocking rates. Grazing started on December 1, 2004, and continued for 149 days. The cattle experiment involved six 2-acre pastures with three stocking rates (1, 1.5 and 2 head/acre), each replicated twice. Grazing started on December 8, 2004, and continued for 147 days. Animals were dewormed several days prior to initiation of grazing and weighed approximately every 28 days. They consisted of intact males in the goat experiment and steers in the cattle experiment. Initial weights were 53.7 lb/head and 556 lb/head for goats and cattle, respectively. Stocking rates are expressed as head/ac, liveweight/ac and metabolic weight ($\text{weight}^{0.75}$)/ac for comparison across animal species. Average daily gain is expressed in lb/head and lb/100 lb of metabolic weight. Data for the goat experiment were analyzed by regression analysis, and data from the cattle experiment were analyzed by means of ANOVA.

E.2. Results and Discussion

Based on periodic fecal egg counts, goats required minimal treatment for GI parasites (data not shown). On the basis of liveweight, at the initiation of grazing one steer was equivalent to 10.4 goats (556/53.7). However, on the basis of metabolic weight, one steer was equivalent to

5.8 goats (115/19.8). Consequently, when comparing the highest stocking rate of the two experiments, cattle had a higher value in terms of liveweight/ac, but a lower value in terms of metabolic weight/ac (Tables 25 and 26). Since feed intake is expected to be more closely related to metabolic weight, it was considered useful to express both stocking rate and weight gain in terms of metabolic weight. In terms of liveweight/acre, the range in stocking rates was greater for the cattle experiment (556 vs. 451 lb/acre), but in terms of metabolic weight/acre it was greater for the goat experiment (167 vs. 115 lb/acre). However, there was considerable overlap in stocking rates between the experiments, regardless of how stocking rate was expressed.

While there appeared to be a general decrease in ADG with increased stocking rate in the goat experiment, this was not significant ($r=0.80$; $P > 0.10$) probably due mainly to the fact that there were only two error df in the analysis (Table 25). In the cattle experiment ADG was higher ($P < 0.1$) at the intermediate stocking rate than at the high and low stocking rates (Table 26).

Because cattle and goats were evaluated on separate experiments, results cannot be compared statistically. However, when simply compared numerically on the basis of the highest values recorded for each species, ADG in lb/100 lb metabolic weight and gain/ac were 35% and 28% greater for cattle, respectively. Also it should be noted grazing season 2004-2005 was very wet and goats seemed to be more affected by wet weather than cattle. Comparison based on 2003-2004 grazing season maybe more favorable for goats.

Table 25. Average daily gain (ADG) and gain/ac for goats grazed on ryegrass at several stocking rates (SR) with stocking rates expressed as head/acre (SR1), lb live weight/acre (SR2) and lb metabolic weight/acre (SR3) and ADG expressed as lb/head (ADG1) or lb/100 lb metabolic weight (ADG2).

| | | | | |
|-----------------------------------|------|------|------|------|
| SR1 (head/acre) | 8.0 | 10.4 | 13.6 | 16.4 |
| SR2 (lb liveweight/acre) | 430 | 558 | 730 | 881 |
| SR3 (lb metabolic weight/acre) | 158 | 206 | 269 | 325 |
| ADG1 (lb/head) | 0.31 | 0.20 | 0.22 | 0.18 |
| ADG2 (lb/100 lb metabolic weight) | 1.59 | 1.02 | 1.13 | 0.92 |
| Gain/ac (lb) | 370 | 310 | 446 | 440 |

Table 26. Average daily gain (ADG) and gain/ac for cattle grazed on ryegrass at several stocking rates (SR) with stocking rates expressed as head/acre (SR1), lb liveweight/acre (SR2) and lb metabolic weight/acre (SR3) and ADG expressed as lb/head (ADG1) or lb/100 lb metabolic weight (ADG2).

| | | | |
|-----------------------------------|------|------|-------|
| SR1 (head/ac) | 1.0 | 1.5 | 2.0 |
| SR2 (lb liveweight/ac) | 556 | 834 | 1,112 |
| SR3 (lb metabolic weight/ac) | 115 | 173 | 230 |
| ADG1 (lb/head) | 2.25 | 2.53 | 1.94 |
| ADG2 (lb/100 lb metabolic weight) | 1.93 | 2.16 | 1.66 |
| Gain/ac (lb) | 331 | 558 | 570 |

E.3. Impact of Results/Outcome

Based on this preliminary assessment, an optimal range of stocking rates for approximately 50-lb goats appeared to be in the 10 to 14 head/ac range. Cattle appear to be more productive than goats on ryegrass pastures. After 149 days, goats weights were higher than optimum (around 100-110 lbs), thus two sets of goats may be finished on the same pasture per season to reach ideal market weight of 70-80 lbs.

IV. IMPACT OF RESULTS

A combination of mimosa in the summer and annual Marshall ryegrass in the winter is likely to provide an outstanding year-round forage system for goat production by limited resource farmers in the southern US. However, more data is needed to develop the best management practices for this system, and to clearly demonstrate its superiority over typical systems currently being used. Altering canopy structure by pruning stems to about 2 ft and allowing only limited re-growth prior to defoliation may be more effective in achieving more uniform partial defoliation. Preliminary data confirmed that mimosa provides an excellent alternative feed for summer and current production system using perennial grasses does not provide sufficient nutrients for optimum growth. Mimosa may not have anthelmintic property, however, browsing in summer may also reduce the infestation of GI parasites (major problem in Southeast), when goats spend less time grazing close to the ground where the larvae of these pathogens are present

in large quantities. Mimosa appears more nutritious, indicated by chemical analysis, rather than animal performance. The chemical composition of mimosa warrants higher gains; however, either an imbalance in energy to protein ratio or presence of compounds such as condensed tannins may be the hindering factor. Quality of meat from mimosa was comparable to those produced under different systems. However, it contained more omega 3 fatty acids and along with pasture fed animals had longer shelf life. Annual ryegrass as winter pasture for goats is very promising; however, 8-11 goats per acre maybe sufficient, for maximum yield, and requires intensive management.

V. ECONOMIC ANALYSIS

Series of experiments were conducted (explained in detail in above chapters) to evaluate most appropriate year-round production system for goats in southeastern U. S. Production systems utilizing feedlot style was compared to those mainly based on summer pasture (common bahiagrass pasture), winter pasture (Marshall ryegrass) or browse (mimosa). Animals on feedlot style or Marshall ryegrass grew faster (about 150 g/goat /day) and reached expected slaughter date in less time when compared to other systems (about 80 g/goat/day and 46 g/goat/day for mimosa and bahiagrass, respectively). Their (Animals on feedlot and Marshall ryegrass) carcass quality also appeared to be superior to other systems (not a significant different).

For feedlot system (CONC), mimosa browse system (MB) and bahiagrass pasture system (BG) 16 animal data were used, 8 Boer crosses and 8 more than 75% Boer kids. More 75% Boer kids were about \$10 more in value when purchased. Prices of goats were actual prices paid. Few assumptions were made to compare these systems economically. Price of live goat is set at \$1.00 per lb regardless of weight. Heavier animals are usually sold for less \$ /lb. Higher prices will bring more profit. Dressing percentages is set at 50% and price for processing the meat is set at \$0.6 per lb. More processing cost will lower the profit. Prices of fertilization, medication and feed were based on actual prices paid. Price of goat meat cut is set at \$3.00 per lb. Higher prices will result in higher profit. Costs associated with establishing mimosa browse or pasture is not included. We probably can graze two sets of animals for winter grazing on ryegrass pasture, each for 60 to 70 days that may result in more profit.

Profit and losses of feedlot system, summer pasture system, mimosa browse and winter pasture are presented in Tables 27, 28, 29 and 30 with the summary presented in Table 31. Preliminary results on input-output for mimosa browse are very promising when compared to

reported results for similar size goats kept indoors and consuming more than 40% grain in their diet. However, economically (when input-output to the system was calculated), Marshall ryegrass was superior followed by mimosa browse when compared to other two systems. Commonly used bahiagrass pasture even with supplementation cannot support economically viable production system.

Table 27. Economic Analysis of Feedlot System

| | | | |
|---|--|---------|---------|
| Animals | 16 Castrated Goats | | |
| Initial BW | 21 Kg | | |
| Age | 4-5 months | | |
| Breed | Boer/Spanish | | |
| Feed | 40% Dairy pellets, 40% Soybean Hulls, 20% BG Hay | | |
| Period | 100 days | | |
| PURCHASES | | | |
| Goats >75% Boer | 8 | \$50/h | \$400.0 |
| < 75% Boer | 8 | \$40/h | \$320.0 |
| Dairy pellets | | | \$201.7 |
| Soy hulls | | | \$101.8 |
| Bermudagrass Hay | | | \$ 50.4 |
| Medicated feed | | | \$ 17.8 |
| Cydetin | | | \$ 4.2 |
| Co-Ral Dust | | | \$ 9.9 |
| Clostridium C &D with Tetanus | | | \$ 3.2 |
| TOTAL | | | \$1109 |
| INCOME If sold live 80lbs @ \$1/lb | | | \$1280 |
| PROFIT | | | \$171 |
| Profit/goat | | | \$10.7 |
| INCOME if slaughtered @ 50% dressing | | | |
| Total meat & bone | | 640 lbs | |
| @\$3.00/lb | | | \$1,920 |
| @.6/lb processing | | | \$ 384 |
| Net | | | \$1,536 |
| PROFIT | | | \$ 427 |
| Profit/goat | | | \$ 26.7 |
| Feed Cost | | | \$ 392 |
| Feed Cost/goat | | | \$ 22 |
| Medication Cost | | | \$ 17 |
| Medication Cost/goat | | | \$ 1.1 |

Table 28. Economic Analysis of Grazing System (Summer)

| | | | |
|---|---|-----------------|----------------|
| Animals | 16 | Castrated Goats | |
| Initial BW | 21 | Kg | |
| Age | 4-5 | months | |
| Breed | Boer/Spanish | | |
| Feed | Bahaiagrass Pasture, Dairy pellets, 100-200 g/head/ day | | |
| Period | 134 | days | |
| PURCHASES | | | |
| Goats > 75%Boer | 8 | \$50/h | \$400 |
| < 75%Boer | 8 | \$40/h | \$320 |
| Lime | | \$26/ton | \$ 65 |
| Fertilizer 16-16-16 | | \$240/ton | \$120 |
| Medicated feed | | | \$ 17.8 |
| Cydetin (twice) | | | \$ 8.3 |
| Co-Ral Dust | | | \$ 9.9 |
| Clostridium C &D with Tetanus | | | \$ 3.2 |
| Ivermectin | | | \$ 8.8 |
| Valbazin | | | \$ 3.0 |
| Panacur | | | \$ 6.7 |
| Dairy Pellets @ 3.5 lbs/d for 54 d | | | \$23.8 |
| Dairy Pellets@ 7.0 lbs/d for 52 d | | | \$45.9 |
| Dairy Pellets @ 10.6 lbs/d for 28 d | | | \$37.1 |
| Bermuda grass Hay | | | \$10.1 |
| Bahaigrass pasture | | | |
| TOTAL | | | \$1080 |
| INCOME If sold live 65 lbs @ \$1/lb | | | \$1040 |
| PROFIT- LOSS | | | \$ - 40 |
| Profit- Loss /goat | | | \$ -2.5 |
| INCOME if slaughtered @ 50% dressing | | | |
| Total meat | | 520 | lbs |
| @\$3.00/lb | | \$1,560 | |
| @.60/lb processing | | \$ 312 | |
| Net | | \$1,248 | |
| PROFIT | | \$ 168 | |
| Profit/goat | | \$ 10.5 | |
| | | | |
| Feed Cost | | \$ 320 | |
| Feed Cost/goat | | \$ 20 | |
| Medication Cost | | \$ 40 | |
| Medication Cost/goat | | \$ 2.5 | |

Table 29. Economic Analysis of Browse System

| | | | |
|---|--------------|-----------------|---------|
| Animals | 16 | Castrated Goats | |
| Initial BW | 21 | Kg | |
| Age | 4-5 | months | |
| Breed | Boer/Spanish | | |
| Feed | Mimosa, Corn | 100 g/h/d | |
| Period | 134 | days | |
| | | | |
| PURCHASES | | | |
| Goats >75% Boer | 8 | \$50/hd | \$400.0 |
| <75% Boer | 8 | \$40/hd | \$320.0 |
| Corn 100g/hd/d | | | \$ 49.6 |
| Medicated feed | | | \$ 32.7 |
| Cydectin | | | \$ 4.2 |
| Co-Ral Dust | | | \$ 9.9 |
| Clostridium C &D with Tetanus | | | \$ 3.2 |
| Valbazin | | | \$ 3.0 |
| TOTAL | | | \$822.6 |
| | | | |
| INCOME If sold live 70lbs @ \$1/lb \$1120 | | | |
| | | | |
| PROFIT | | | \$ 297 |
| Profit/goat | | | \$ 18.6 |
| | | | |
| INCOME if slaughtered @ 50% dressing | | | |
| | | | |
| Total meat | | 560 | lbs |
| @\$3.00/lb | | | \$1,680 |
| @.60/lb processing | | | \$ 336 |
| Net | | | \$1,344 |
| | | | |
| PROFIT | | | \$ 521 |
| Profit/goat | | | \$ 32.5 |
| | | | |
| Feed Cost | | | \$ 82.3 |
| Feed Cost/goat | | | \$ 5.1 |
| Medication Cost | | | \$ 20.3 |
| Medication Cost/goat | | | \$ 1.3 |

Table 30. Economic Analysis of Grazing System (winter)

| | | |
|--------------------------------------|-------------------------|----------|
| Animals | 30 Wether/Bucks | |
| Initial BW | 30-35 Kg | |
| Age | 6-7 Months | |
| Breed | Boer/Spanish | |
| Feed | Marshall Ryegrass | |
| Period | 55 days | |
| PURCHASES | | |
| Goats | Boer cross 30 @ \$50/hd | \$400.0 |
| Medicated feed | | \$ 32.7 |
| Cydetin | | \$ 7.8 |
| Co-Ral Dust | | \$ 9.9 |
| Clostridium C &D with Tetanus | | \$ 6.0 |
| Marshall Ryegrass | | \$ 43.9 |
| N 80lb/acre | | \$ 243.2 |
| TOTAL | | \$1843.6 |
| INCOME if sold live 100 lbs @ \$1/lb | | |
| | | \$3000 |
| PROFIT | | \$1156.4 |
| Profit/goat | | \$ 38.5 |
| INCOME if slaughtered @ 50% dressing | | |
| Total meat | 1500 lbs | |
| @\$3.00/lb | | \$4,500 |
| @.60/lb processing | | \$ 900 |
| Net | | \$3,600 |
| PROFIT | | \$1,756 |
| Profit/goat | | \$ 58.5 |
| Feed Cost | | \$ 320 |
| Feed Cost/goat | | \$ 10.7 |
| Medication Cost | | \$ 23.8 |
| Medication Cost/goat | | \$ 0.8 |

Table 31. Summary of system comparisons (\$/goat)

| | Feedlot | Bahiagrass | Browse | Ryegrass |
|-----------------------|---------|------------|--------|----------|
| Feed cost | 22 | 20 | 5.1 | 10.7 |
| Medication cost | 1.1 | 2.5 | 1.3 | 0.8 |
| Total cost | 69 | 67.5 | 51.4 | 61.4 |
| Profit if sold live | 10.7 | -2.5 | 18.6 | 38.5 |
| Profit if sold retail | 26.7 | 10.5 | 32.6 | 58.5 |

VII. PUBLICATIONS

Shoemaker, C. E. 2006. Performance, carcass characteristics, and meat quality of Boer cross goat kids raised under different production systems. PhD dissertation, Auburn University. In preparation.

Shoemaker, C. E., C. R. Kerth, S. G. Solaiman, W. R. Jones and K. R. Willian. 2006. Development of multiple regression equations for predicting Caprine carcass composition and cutability using carcass traits and rib section composition. In preparation.

Solaiman, S., C. Shoemaker and D. Bransby. 2006. Year-round production systems for goats in Southeastern U.S. Agriculture Research Director's Bi-annual Meeting, Atlanta, GA. Abstract.

Bransby, D., S. Solaiman, C. Shoemaker and S. Sladden. 2006. Goat production from annual ryegrass in Alabama. In: Proceedings, Annual Forage and Grassland Congress meeting.

Shoemaker, C. E., S. G. Solaiman, C. R. Kerth, W. R. Jones, D. I. Bransby and K. R. Willian. 2005. Growth, carcass traits and fatty acid profiles of percentage Boer wether goat kids raised under different production systems. 51th International Congress of Meat Science and Technology, Baltimore, MD.

- Solaiman, S. G. 2005. Assessment of the current meat goat industry in the United States. In the Proceedings of the USDA 4th National Small Farm Conference. Greensborough, NC.
- Solaiman, S. G. 2005. Meat Goat Industry Outlook for Small Farms in Alabama and Surrounding States. Tuskegee University, Publication No. 112-705.
- Shoemaker, C., S. Solaiman, C. Kerth, W. Jones, and D. Bransby. 2005. Growth and carcass traits of percentage and crossbred Boer wether goat kids raised under different production systems. *J. Anim. Sci.* 83(Suppl. 1): 277.
- Hopkins-Shoemaker, C. E., S. G. Solaiman, B. Blagburn, D. Bransby, and C. R. Kerth. 2004. Evaluation of Albizia julibrissin (Mimosa) for internal parasite control in goats. *J. Anim. Sci.* 82 (Suppl. 1). Abstract.
- Hopkins-Shoemaker, C. E., S. G. Solaiman, C. R. Kerth, W. R. Jones and D. Bransby. 2004. Growth performance and carcass characteristics of castrated or intact male Boer x Spanish goats grazing annual Marshal ryegrass. *J. Anim. Sci.* 82 (Suppl. 1). Abstract.
- Bransby, D. I., S. G. Solaiman, C. R. Kerth, R. Noble, S. Sladden and S. Durbin. 2003. Defoliation patterns of goats browsing mimosa. Proceeding, American Forage and Grassland Council.

VIII. OUTREACH/FARMERS ADOPTION

Presentations at Local Goat Day

- Solaiman, S. G. 2005. Current industry assessment of the goat meat industry and future outlook for Alabama and U.S. Tuskegee University Goat Day.
- Solaiman, S., C. Shoemaker, D. Bransby, C. Kerth and R. Noble. 2004. Year-round foraging for goat production. Tuskegee University Goat Day.
- Solaiman, S., C. Shoemaker, D. Bransby, C. Kerth and R. Noble. 2004. Year-round foraging for goat production. Alabama A & M University.
- Solaiman, S. G. 2003. Selective strategies for feeding goats. Tuskegee University Goat Day.

Buck Sale

The first Tuskegee University Buck Sale event took place in April, 2004. Five top young bucks raised on ryegrass grazing study were placed on sale and were auctioned during the Tuskegee University Goat Day. A presentation on ryegrass study was made prior to the sale. All five were sold to highest bidders at the auction with an average \$150 per buck. See attached for the pictures and descriptions.

Video Production/Demonstration

A professional 22 minutes DVD production is presented to Southern SARE as a part of final report that covers the whole project and beyond. This video production encompass current status and future outlook of meat goat industry in the U.S. and especially Southeast. This video demonstrates that populations demanding goat meat are increasing in the U.S. and how meat goat production may introduce another venue for small farmers to diversify. Alternative forages and browse can provide low input feeding systems for meat goats year-round and may make goat production more profitable. However, these production systems are site specific (for southeastern U.S. only) and may not be practiced or applied to other sites without modifications. We will use this video in future as an outreach tool to introduce more producers to goat farming and how it can be profitable.

FARMERS ADOPTION

Two producers, Mrs. Carla Shoemaker and Mr. Bill Edwards are featured in the video. These producers have gradually shifted their production system to year-round foraging utilizing available browse as a part of feeding system. Mrs. Carla shoemaker has incorporated planting mimosa trees on farm for summer brows, she plants ryegrass for winter grazing and some small grain or soybean for late spring or early summer.

Having the presentation on year-round foraging during our annual goat day has excited many producers to adopt such system of grazing and reduce grain feeding. Goat prices are very marginal in Alabama and reducing feed cost may result in more profit.

IX. AREAS NEEDING ADDITIONAL STUDY

A combination of mimosa in the summer and Marshall ryegrass in the winter is likely to provide an outstanding year-round forage system for goat production by limited resource farmers in the southern U.S. However, no data are available to develop the best management practices for this system, and to clearly demonstrate its superiority over typical systems currently being used (based primarily on perennial grasses). In order to establish optimal management practices, it is necessary to know how animals defoliate forage plants. More research is needed to establish some guidelines for most profitable and efficient grazing/browsing practices for goats. Other potential browse species should be considered. Forage varieties that can feed the system in late spring/early summer as well as those for late fall and early winter must be included. Besides providing a high quality diet, browsing in summer may also reduce the infestation of GI parasites (major problem in Southeast), when goats spend less time grazing close to the ground where the larvae of these pathogens are present in large quantities. Maybe feeding mimosa for 21 days in a control study did not reduce parasite load (pharmaceutical effect); however, if it is fed for longer time may exhibit its nutraceutical effect.

Many browse species may have secondary compounds that are not desirable. Tannins or high lignin content may interfere with available energy and create an imbalance in energy-protein. Proper supplementation is needed to overcome this problem. More research in the area of optimum supplementation of browse such as mimosa is needed. It was clear based on our results that blood urea nitrogen was high in animals fed mimosa and 100 grams of corn did not provide sufficient energy to the rumen microbes to utilize additional protein in mimosa plant. Maybe more soluble carbohydrate such as molasses will provide more available energy needed. These only can be answered by future research.

Grazing studies are very time consuming with very little reward. Animal factors such as breed, size, age, prior plane of nutrition, and environmental factors such as soil, rainfall, temperature can influence the outcome of the grazing research from one year to the next. More seasons, years and replications are needed to determine proper stocking rates for different forages and browse.

Number one agricultural industry in Alabama and maybe Southeastern U.S. is timber. Proper management practices for goats on forest land and proper stocking of forest land are important to utilize goats for clearing the land and producing goat meat as value added.

More research on quality of goat meat and that from browse can demonstrate its value in health conscious Americans' diet. Major leading health problems in the U.S. are cardiovascular problems, obesity and cancer. Low fat, low cholesterol, high omega 3 fatty acids (especially from browse fed goats) will be friendly to the heart and the waist. Having higher conjugated linoleic acid as cancer fighting agent is good for health.

And finally more research on feasibility of goat meat market and marketing channels are needed. The current goat industry is very fragmented and it is in its infancy. New improved American goat breed should evolve as Kiko did from New Zealand and Boer from South Africa. I personally believe that goats, especially meat goats, are here to stay as American population demographic is changing. May be we should invest in new goat breed that is made for and in the U.S.A.

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