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Effect of Feeding System on Meat Goat Growth Performance and Carcass Traits[1]

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Summary

This research sought to evaluate the effect of diet on meat-goat-growth performance, carcass traits, and fatty acid profiles of the meat product. Fifty-six meat-goat kids were allocated to one of two feeding systems. The control treatment (FORAGE; n = 27) was a forage-only system that was composed of grazing and chopped hay. The treatment group (GRAIN; n = 28) was fed one percent of their BW grain mix in addition to the FORAGE diet. Animals were fed to a target end weight of 36.4 kg. Animals on the GRAIN treatment had higher ADG and fewer days on feed ($P < 0.05$). Dietary treatment did not impact ($P > 0.10$) dressing percent, tenderness, or fat-cover score. Animals on GRAIN had more desirable carcass-selection scores ($P < 0.01$). The percentage of saturated fatty acids, unsaturated fatty acids, MUFA, PUFA, omega-6, and omega-3 fatty acids in longissmus muscle ($P > 0.10$) was not impacted by diet. Animals on GRAIN tended to have a higher omega-6: omega-3 ratio ($P = 0.06$). Feeding low levels of concentrates to meat goats increased ADG and reduced days on feed without impacting dressing percentage, fat- cover score, tenderness and fatty acid composition of the meat product. When evaluating the production costs of both systems, the benefits of increased rate of gain and fewer days on feed may not offset the added cost of production.

Key Words: Meat Goat, Growth Performance, Carcass Traits, Fatty Acids

Introduction

Meat-goat inventory in the United States has been increasing over the past decade (USDA, 2007). As the inventory of meat goats increase in the United States, so does the need for more information regarding basic production principles. Meat-goat producers are challenged to ensure packers have a consistent supply of animals. Many producers are working together to form marketing cooperatives to develop a consistent, reliable meat-goat supply. Consistent product quality is needed for a marketing cooperative to be successful.

Feeding system impacts growth and subsequent carcass traits. Increasing concentrates in meat-goat diets results in increased live-harvest weights, as well as increased carcass weights (Ryan et al., 2007; Haddad, 2005; Urge et al., 2004). Goats fed high-concentrate diets appear to have more muscling (Johnson and McGowan, 1998). However, the cost benefit of feeding additional concentrates has not been fully explored in goat-production systems and needs to be evaluated.

Recent literature suggests that the ability to replace saturated fatty acid (SFA) content with monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) has beneficial effects on human health (Williams, 2000). Little is known about the nutritional value of goat meat for human consumption. Banskalieva et al. (2000) summarized literature addressing fatty acid composition of goat meat. In a limited dataset, these authors demonstrated goat meat possesses desirable fatty acids compared with meat of other ruminant livestock. More research is needed to explore the various factors that may influence fatty acid profiles of goat-meat products.

In building a market for a product, it is imperative to evaluate that product thoroughly and have a clear vision of what that product provides. Diet can have a major impact on growth and carcass traits. Therefore, the objective of this research was to evaluate the effect of feeding systems on meat-goat-kid growth performance, carcass traits, and fatty acid profiles of the meat product.

Materials and Methods

Fifty-six meat-goat kids were allocated to one of two feeding systems. Seventeen producers provided goats; each producer's goats were split across the two finishing systems. Goats were predominantly Boer breeding. Twenty-five goats were fullblood or high-percentage Boer breeding, and 31 goats were Boer F1 crosses, as defined by the breeder. Diet treatment was stratified across breed composition and gender. The control treatment was a forage-only system (FORAGE; n = 27), that was composed of grazing irrigated pasture during the summer through early fall and then chopped hay during the late fall and winter. Irrigated pasture was comprised of primarily orchard grass (*Dactylis glomerata*), ryegrass (*Lolium perenne*), tall fescue (*Schedonorus phoenix* (Scop.) Holub), and white clover (*Trifolium repens*). The test treatment was the same as the FORAGE system; however, animals were fed one percent of their BW a pelleted, commercially available, goat grain mix (GRAIN; n = 28). The grain contained the following minimum nutrient concentrations: 16 percent CP; 2.5 percent crude fat; and 6.0 percent CF (Bar Ale, Inc., Williams, Calif.). Grain was offered to animals once per day, in the morning. Both treatments had ad libitum access to water and a trace-mineral supplement. Average-initial weight for FORAGE was 22.92 kg with a range in weight from 15.87 kg to 28.57 kg. Average-initial weight for GRAIN was 23.04 kg with a range of 19.05 kg to 29.02 kg. All animals were dewormed and vaccinated for *Clostridial* diseases upon initiation of the trial. During the grazing period, four animals in the FORAGE group died due to heavy parasite infestation. All anthelmintics (albendazole, moxidectin, and ivermectin) were administered as per the consulting veterinarian's recommendation.

During the grazing period, both treatments grazed the same pasture, separated with temporary fencing. Dry matter availability was estimated weekly using the GrassMaster probe (Novel Ways Electronic Product Development; Hamilton, NZ). Animals were rotated when approximately 50 percent of the forage DM was consumed. Forage DM availability did not drop below 2016 kg DM/ha. Pasture-clip samples were collected prior to grazing for forage-quality analysis. Samples were collected each time animals were moved (approximately 7d to 10 d). Pasture samples were composited by month for analysis. When the animals moved from pasture to a chopped-hay diet, a grab sample was collected each time hay was chopped for the animals. Four different hay mixes (Table 1) were used during the chopped-hay portion of the project. Hay mixes 1 and 4 were 50-percent-alfalfa hay and 50-percent-grass hay; hay mixes 2 and 3 were 50-percent-alfalfa hay and 50-percent-oat hay. Forage-chemical composition (Table 1) was evaluated using near infrared reflectance spectroscopy (FOSS in North America, Eden Prairie, Minn.).

Animals were fed to a target ending weight of 36.4 kg. All goats were weighed

Table 1. Forage quality (DM basis).

Nutrients, % forage DM	July Pasture	August Pasture	Hay Mix 1[a]	Hay Mix 2[b]	Hay Mix 3[b]	Hay Mix 4[a]
CP	12.90	13.27	17.10	20.01	17.88	20.39
ADF	39.41	38.01	36.30	29.99	31.95	31.06
NDF	57.83	60.33	51.66	44.82	44.61	42.12
Ca	0.621	0.497	0.956	1.140	1.088	1.336
P	0.323	0.340	0.338	0.350	0.327	0.313
RFV[c]	94	91	109	136	133	143

[a] Hay mix was 50:50 alfalfa hay and grass hay. Mix 1 was fed September/October and mix 4 was fed February/March.
[b] Hay mix was 50:50 alfalfa hay and oat hay. Mix 2 was fed October/November and mix 3 was fed December/January.
[c] Relative Feed Value – calculated from ADF and NDF values

every two weeks to monitor for desired ending weight. Due to harvest facility management, animals had to go to harvest in lots. When a group of animals averaged the desired ending weight, that group of animals was sent to harvest. Carcass measurements included hot-carcass weight (kg), dressing percentage (%), subcutaneous fat-cover score, and carcass-selection score. Subcutaneous fat-cover score was evaluated on a scale of one to three (1.00 to 1.99 = minimal fat cover; 2.00 to 2.99 = moderate fat cover; 3.00 to 3.99 = excessive fat cover; McMillin and Pinkerton, 2006). Carcass-selection score was also evaluated on a scale of one to three (1.00 to 1.99 = heavy muscling; 2.00 to 2.99 = moderate muscling; 3.00 to 3.99 = light muscling; McMillin and Pinkerton, 2006).

Longissimus muscle samples were collected from a subset (approximately 40 percent) of each treatment group. Samples were obtained from matching locations (post-12th rib) and then frozen until the lipid and Warner-Bratzler shear force analyses (Savell et al., 1994). Lipid samples were extracted from goat-meat samples in triplicate using the chloroform-methanol procedure of Folch et al. (1957), as modified by Realini et al. (2005). Extract was converted to fatty acid methyl esters (Duckett et al., 2002). Fatty acids were quantified by incorporation of an internal standard, methyl nonadecanoate ($C_{19:0}$) into each sample before methylation. The fatty acid methyl esters were analyzed using a Varian 3800 gas chromatograph (Agilent Technologies, Santa Clara, Calif.), and separated using a 100-m capillary column (0.25-mm i.d. and 0.20-µm film thickness, SP 2560; Supleco, Bellefonte, Pa.). Individual fatty acids were identified by comparison of retention times with standards (obtained from Sigma-Aldrich, St. Louis, Mo.).

Growth data, hot-carcass weight, and Warner Bratzler Shear Force data were analyzed as a completely randomized design (PROC MIXED; SAS Inst. Inc., Cary, N.C.); the model included the fixed effect of dietary treatment. A one-sample proportion t-test was used to determine if ending weight differed from the desired end weight of 36.4 kg. Carcass-selection score and fat cover were analyzed using hot-carcass weight as a covariate (PROC MIXED; SAS Inst. Inc., Cary, N.C.). Hot-carcass weight was not significant ($P = 0.08$) in the model for carcass-selection score and was removed from the model. However, hot-carcass weight was a significant covariate ($P < 0.01$) for carcass-fat-cover score; therefore adjusted least squares means are reported. Fatty acid data were analyzed as a split plot using PROC MIXED (SAS Inst. Inc., Cary, N.C.). Fixed effects in the model included diet, preparation, and the subsequent interaction. Random effects in the model included goat (diet) and goat*preparation (diet).

Results and Discussion

Animal Performance

Animals started the trial weighing 23 kg (Table 2; $P = 0.86$). Goats were fed to the target end weight of 36.4 kg; however, ending weight differed due to diet. Goats on the GRAIN diet were approximately 4 kg heavier at harvest (Table 2; $P < 0.001$). Neither FORAGE nor GRAIN differed from the desired end weight of 36.4 kg ($P > 0.05$). The GRAIN group had fewer days on feed and a greater ADG (Table 2; $P < 0.05$) compared with the FORAGE treatment.

Average-daily-gain (g) values for animals on test were low compared to some research (Haddad, 2005; Cameron et al., 2001), yet in line with others (Mushi et al., 2009; Turner et al., 2005; Urge et al., 2004). However, the increase in ADG with the addition of grain to the diet is supported by the literature. Haddad (2005) showed increasing rate of gain in growing kids fed diets with increasing levels of concentrate. Numerous other researchers show increasing rates of gain with increasing level of concentrate in the diet (Mushi et al., 2009; Turner et al., 2005; Cameron et al., 2001).

The lower-than-desired rates of gain can likely be attributed to health problems during beginning stages of the trial. During the adaptation to the grazing component of the project, numerous animals were treated for coccidiosis and parasite infestations. In the FORAGE group, eight animals were treated; 11 animals were treated in the GRAIN group.

The majority of published literature investigated higher level of concentrates in treatment diets compared to the current project. Even small amounts of concentrates in the diet may improve rate of gain and reduce days on feed if feeding to a desired end weight.

Carcass

The GRAIN group had heavier carcasses (Table 2; $P = 0.001$), which correlates to the heavier ending weights observed in the live performance of the goats. There was no difference in fat cover between the FORAGE and GRAIN group (Table2; $P = 0.75$). How-

Table 2. Effect of feeding system on meat goat growth performance and carcass traits.

	FORAGE	GRAIN	SEM	P-value
Beginning weight, kg	22.92	23.05	0.58	0.863
Ending weight, kg	34.98	39.15	0.62	<0.001
Days on feed	246	211	11.01	0.022
ADG, g/d	49.61	81.86	4.47	<0.001
Hot carcass weight, kg	17.39	19.34	0.42	0.001
Dressing percentage	49.90	49.40	0.96	0.699
Selection score[a]	2.72	2.38	0.07	0.001
Fat cover score[b,c]	2.25	2.29	0.08	0.754
Warner Bratzler Shear Force, kg	3.48	3.13	0.45	0.559

[a] Selection score: 1.00 to 1.99 = heavy muscling; 2.00 to 2.99 = moderate muscling; 3.00 to 3.99 = light muscling (McMillin and Pinkerton, 2006).
[b] Fat cover score: 1.00 to 1.99 = minimal fat cover; 2.00 to 2.99 = moderate fat cover; 3.00 to 3.99 = excessive fat cover (McMillin and Pinkerton, 2006).
[c] Adjusted least squares means are reported, due to significant ($P = 0.008$) covariate of hot carcass weight.

ever, goats on GRAIN had a more desirable carcass-selection score, indicative of increased muscling throughout the carcass (Table 2; $P < 0.001$). There was no difference between the two diets for tenderness (Table 2; $P = 0.56$).

Mushi et al. (2009) observed increased-carcass fatness and conformation score with increased levels of concentrate in the diets of goats. Shear force in the aforementioned study tended to decline with increasing concentrate levels in the diet; however, they did not differ ($P > 0.1$; Mushi et al., 2009). When comparing Boer x Spanish and Spanish goats fed on feedlot diets to those fed on range diets, Osman et al. (1999) reported increased fat thickness and improved carcass-conformation score for goats fed in a feedlot setting compared to a range diet. The goats on a feedlot diet from Osman et al. (2009) also had heavier carcasses (38.17 kg) compared to the range-fed goats (20.51 kg; $P < 0.05$). Ryan et al. (2007) fed Boer-crossbred goats diets that consisted of range (0 percent), and 50 percent, 70 percent, and 90 percent concentrate. There was no difference in Warner Bratzler Shear Force (average 5.65 kg; $P > 0.05$) due to increased levels of concentrate in diet, which corresponds to this study. Increasing level of concentrate in the diet improved carcass-confirmation score and had no effect on shear force of the meat product. The goats in this study were fed to similar ending weights, as opposed to a specified date, thus potentially masking the difference in fat thickness observed in previously published research.

Fatty Acid

Diet did not affect the percentage of saturated fatty acids, unsaturated fatty acids, MUFA, PUFA, omega-6, and omega-3 fatty acids in *longissmus* muscle of meat goats (Table 3; $P > 0.10$). Animals on GRAIN tended to have a higher omega-6: omega-3 ratio (Table 3; $P = 0.06$). Paired *longissmus* samples were used to evaluate the effect cooking had on the fatty acid profiles. There was a trend for cooking to increase the percentage of PUFA (Table3; $P = 0.07$), omega-3 (Table 3; $P = 0.10$) and omega-6 fatty acids (Table 3; $P = 0.12$).

Webb et al. (2005) compared the mean-molar percentages of various fatty acids in freeze-dried meat of goats and sheep. Relative to saturated and unsaturated fatty acids, the data for Boer goats in this study is comparable with Webb's published data. Johnson and McGowan (1998) compared production-system impact (intensive vs. semi intensive) on carcass characteristics and meat quality of young goats. The intensive system involved creep feeding the kids and maintaining concentrate feeding through slaughter. In contrast, the semi-intensive system involved concentrate supplementation of a grazing system. They reported composite samples from intensively raised goats had higher saturated and PUFA, whereas semi-intensively raised goats had higher MUFA and a higher ratio of unsaturated to saturated. Ryan et al. (2007) found that feeding concentrate diets compared with range diets increased total fatty acids. Additionally, by increasing level of concentrate in the diet, the omega-6: omega-3 ratio was increased (Ryan et al., 2007), which is in agreement with our observations. It has also been reported that feeding high levels of concentrate increases the omega-6: omega-3 ratio in lamb (Demirel at al., 2006). Increasing the amount of concentrate in goat diets does affect the omega-6: omega-3 ratio, potentially impacting human nutrition. Raes et al. (2004) stated that human nutritionists recommend a higher intake of PUFA, particularly omega-3 fatty acids. Ideally, the increased intake of omega-3 fatty acids would be at the expense of omega-6 fatty acids. Therefore, high levels of concentrate feeding of goats may negatively impact the omega-6: omega-3 fatty acid ratio from a human nutrition perspective.

Conclusions

Feeding low levels of concentrates to meat goats did increase rate of gain, and subsequently, lowered the days on feed when animals were fed to a targeted ending weight. Additionally, feeding low levels of concentrates did improve carcass muscling without impacting dressing percentage, fat-cover score, or tenderness of the meat product. There was minimal impact on fatty acid composition of the meat product with grain-fed goats. However, the resulting higher omega-6: omega-3 ratio was a shift in an undesirable direction. Research is needed to further explore the impact of feeding systems on meat-goat production and the associated costs.

Table 3. Effect of feeding system on goat meat lipid profiles.

	FORAGE		GRAIN		P-value		
	Raw	Cooked	Raw	Cooked	Diet	Prep	Diet*Prep
Saturated fatty acids, %	55.38 ± 2.22	55.14 ± 2.22	52.50 ± 2.00	53.85 ± 2.00	0.484	0.978	0.525
Unsaturated fatty acids, %	44.62 ± 2.22	45.86 ± 2.22	47.50 ± 2.00	46.15 ± 2.00	0.484	0.978	0.525
MUFA, %	40.67 ± 2.08	40.70 ± 2.08	43.31 ± 1.89	40.64 ± 1.89	0.568	0.449	0.439
PUFA, %	4.26 ± 0.66	5.16 ± 0.66	4.26 ± 0.60	5.51 ± 0.60	0.808	0.067	0.757
omega-6 fatty acids, %	3.07 ± 0.55	3.53 ± 0.55	3.30 ± 0.50	4.31 ± 0.50	0.409	0.123	0.548
omega-3 fatty acids, %	1.34 ± 0.20	1.63 ± 0.20	1.09 ± 0.18	1.27 ± 0.18	0.207	0.100	0.710
omega-6: omega-3	2.66 ± 0.45	2.35 ± 0.45	3.28 ± 0.41	3.88 ± 0.41	0.059	0.708	0.184
PUFA:SFA	0.081 ± 0.015	0.099 ± 0.015	0.087 ± 0.014	0.105 ± 0.014	0.708	0.202	0.991

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