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Carcass parameters and meat quality in meat-goat kids finished on chicory, birdsfoot trefoil, or red clover pastures

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ABSTRACT

This study was conducted during the 2009 and 2010 grazing seasons to assess carcass parameters and chevon (goat meat) quality when meat-goat kids (n = 72) were finished on pastures of red clover (*Trifolium pratense* L.; RCL), birdsfoot trefoil (*Lotus corniculatus* L.; BFT), or chicory (*Cichorium intybus* L.; CHIC). Final live weight ($P < 0.05$) and carcass weight ($P = 0.10$) were greater when goats were finished on RCL compared to CHIC with BFT being intermediate. Ribeye area, backfat thickness, body wall thickness, internal fat score, and leg score were not different ($P > 0.10$) among treatments when adjusted for the covariate of carcass weight. Finishing meat-goat kids on RCL, BFT, or CHIC impacted concentrations of fatty acids (FAs) 18:1 trans-10, 18:1 cis-11, 18:2, 18:3 polyunsaturated fatty acids (PUFAs), omega-6, omega-3, and PUFA:saturated fatty acid ratio in *longissimus lumborum* samples. Finishing meat-goat kids on CHIC, RCL, or BFT pastures produced carcass weights acceptable for most ethnic markets in the USA.

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1. Introduction

Meat goat production in the Appalachian Region of the eastern USA is a niche-market opportunity for small-resource producers supplying chevon (goat meat) to many ethnic markets. Most ethnic markets in the USA prefer lighter (18–36 kg live weight) goat kids and carcasses with little or no fat (Karanjkar, Hakim, & Patil, 2000; Singh-Knights & Knights, 2005) over heavier (>36 kg live weight) animals and carcasses (Farris, 2004). For these niche markets, the lighter weight, less finished meat-goat carcasses produced from pasture-based finishing systems with rotational stocking management are acceptable to consumers.

In the eastern USA, two challenges facing producers finishing meat goats on pasture include gastrointestinal nematode (GIN) control and selection of appropriate forage species to targeted animal weight gain, carcass traits, and meat quality. Several forages show promise to meet these challenges for meat goat production in the Appalachian Region of the USA. Red clover (*Trifolium pratense* L.) is a cool-season, short-lived perennial legume that is well adapted to the eastern USA (Taylor & Smith, 1995). Its unique feature is its ability to form protein-binding o-quinones upon tissue disruption (Jones, Hatfield, & Muck, 1995) which may improve protein utilization by grazing animals. Red clover pasture has improved resilience to GIN for improved performance (Turner, Cassida, & Zajac, 2013) by meat goats. Birdsfoot trefoil (*Lotus corniculatus* L.), a cool-season perennial legume (Beuselinck & Grant, 1995), contains condensed tannins which have reduced GIN (Molan, Waghorn, & McNabb, 1999) compared to legumes that do not contain condensed tannins. Forages containing condensed tannins typically improved protein utilization and weight gain by lambs compared to non-tannin-containing alfalfa (Wang et al., 1996). Forage-type chicory (*Cichorium intybus* L.) is a perennial forb (Hall & Jung, 2008) that contains sesquiterpene lactones and condensed tannin that may reduce GIN infection (Foster, Cassida, & Turner, 2011; Molan, Duncan, Barry, & McNabb, 2003) for improved lamb weight gain (Turner, Belesky, & Fedders, 1999).

Finishing lambs on pasture or feeding forages containing secondary metabolites impacted carcass characteristics (Bonanno et al., 2011) and meat quality (Lourenço, Van Ranst, Vlaeminck, De Smet, & Fievez, 2008). Much of the published data relate the impact of forages and plant secondary metabolites on carcass parameters and meat quality in sheep and cattle (Rochfort, Parker, & Dunshea, 2008). There is little information available on carcass parameters and meat quality when meat goats are finished on pasture using management intensive grazing systems in a temperate environment.

Therefore, the objective of this research was to assess carcass parameters and chevon quality, including meat fatty acid profiles, when meat-goat kids were finished on pastures of red clover, birdsfoot trefoil, or chicory.

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2. Materials and methods

Experimental protocols using meat goats in this grazing study were reviewed and approved by the Institutional Animal Care and Use Committee associated with the USDA, Agricultural Research Service, Appalachian Farming Systems Research Center, Beaver, WV, USA.

2.1. Pastures

The grazing experiment was conducted for two consecutive years during the 2009 and 2010 growing seasons. Pastures were located in Raleigh County, WV, USA (37°45′N, 80°58′W, 875 m elevation). Prairie bromegrass (*Bromus catharticus* Vahl.) cv. 'Lakota' pastures were interseeded with 1) birdsfoot trefoil (BFT) cv. 'Pardee'; 2) red clover (RCL) cv. 'Cinnamon Plus'; or 3) chicory (CHIC) cv. 'Oasis'. Because of the superior growth of CHIC, little (if any) prairie bromegrass established in CHIC pastures. The nine pastures represented three replicates of the three forages (RCL, BFT, and CHIC); pastures were established in a randomized complete block design. Each 0.2-ha pasture was subdivided into ten 0.02-ha paddocks for grazing management using rotational stocking, similar to Turner et al. (2013). Grazing began on 26 May until 29 Sep in 2009 and on 24 May until 20 Sep in 2010.

2.2. Meat-goat kids

Seventy-two meat-goat kids (wethers), at least 75% Boer breeding and 6-mo of age, were used each year in 2009 and 2010. Goat kids were randomly assigned, based on initial BW (mean 22.7 ± 0.4 kg in 2009, and mean 22.6 ± 0.4 kg in 2010), to nine groups. Each group contained 8 animals and groups were randomly assigned to the nine pastures. Prior to the start of grazing, animals were vaccinated and boostered against tetanus and enterotoxemia (Bar Vac® CD/T, Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO, USA) and dewormed to control GIN with a combination of three orally administered commercial anthelmintics: benzimidazole (Valbazen® 15 mg kg BW^{-1}); tetrahydropyrimidine (Prohibit®, 8 mg kg BW^{-1}); and macrocyclic lactone (Ivomec®, 400 μg kg BW^{-1}) (Turner et al., 2013) with any subsequent dewormings based on individual animal need using the FAMACHA© system (Kaplan et al., 2004). Based on preliminary data and FAMACHA© scores, meat-goat kids grazing RCL were administered less dosing events of anthelmintics compared to those grazing BFT and CHIC (Turner, Cassida, and Zajac, unpublished data). Animals had access to water and a commercial mineral mixture containing major macro- and micro-minerals and vitamins A, D, and E formulated for goats (Southern States, Beckley, WV, USA) during the grazing season. Body weight was recorded throughout the grazing season.

2.3. Carcass

Gut fill can influence body weights; we shrunk the animals overnight (no pasture/forage access, but access to water) to remove a gut fill effect for a better relative comparison of final live BW which was recorded prior to transporting animals to a packing plant in Eighty Four, PA, USA. In 2009 and 2010, harvest of animals followed Halal (Grandin & Regenstein, 1994) protocols with the exception that heads were removed. Collection of carcass parameters [cold carcass weight (CCW), ribeye area (REA), backfat thickness, body wall thickness (BWALL) and leg, lean quality, and conformation scores] and a *longissimus lumborum* muscle sample followed procedures as outlined by Turner, Cassida, and Zerby (2014). In 2009 and 2010 the same trained specialist subjectively determined leg score, lean quality score, and overall conformation score using the USDA (1982) standards (1 to15; 1 = low Cull, 15 = high Prime). In addition, the intraperitoneal (IP) fat was estimated subjectively by the same trained specialist and recorded as 1 = least and 5 = most for each carcass. Dress out was calculated using the CCW divided by final live BW then multiplied by 100 to express as a percentage. Along with REA and conformation score, the REA:CCW ratio was calculated to also estimate meatiness of the carcasses.

2.4. Longissimus lumborum samples—proximate analyses and fatty acid profiles

A sample of loin meat (*longissimus lumboroum*) was collected from the right side of a subset of carcasses in 2009 (n = 36) and 2010 (n = 36). Samples were vacuum-packaged and frozen at −20 °C until analyzed for proximate components [ash, crude protein (CP), and intramuscular fat (IMF) concentrations] and fatty acid (FA) profiles. Proximate analyses, extraction of total fat, and FA profiles of meat samples followed procedures as outlined by Turner, Cassida, and Zerby (2014).

The FAs were grouped into functional groups which included: monosunsaturated FA (MUFA), polyunsaturated FA (PUFA), saturated FA (SFA), omega-6 FA, omega-3 FA, and desirable FA (Turner, Belesky, Cassida, & Zerby, 2014). Ratios of MUFA:PUFA, PUFA:SFA and omega-6:omega-3 were also calculated.

2.5. Statistical analyses

The final live BW, overall ADG, carcass parameters, meat proximate analyses, and FA profile data were analyzed using PROC MIXED in SAS (SAS Institute, Inc., Cary, NC, USA) as a randomized complete block (based on the blocked field layout for the pasture treatments) with repeated years. In the linear model, year, pasture treatment, and year × treatment were designated as fixed effects, while the random effects were replicate, replicate × treatment, and replicate × year pooled with replicate × year × treatment. Pairwise comparisons among means were done using t-statistics at $P < 0.05$, with $P \leq 0.10$ considered a trend. Cold carcass weight was used as a covariate on carcass traits. Variables with a significant ($P < 0.05$) covariate were REA, backfat thickness, BWALL thickness, leg score, and conformation score. For these traits, least square means adjusted for CCW are also presented.

3. Results

There were no year × pasture treatment interactions ($P > 0.10$) for any of the parameters.

3.1. Final body weight, overall weight gain, and carcass parameters

There was a year effect for overall liveweight gain in that ADG (g/d ± SEM) was less ($P < 0.05$) in 2009 (52.7 ± 3.5) compared to 2010 (65.2 ± 3.5). In addition, dress out percentage (53.0 vs 50.5 ± 0.4), backfat thickness (1.08 vs 0.74 ± 0.07 mm), and IP fat score (2.8 vs 1.8 ± 0.2) were greater ($P < 0.01$) in 2009 compared to 2010 while BWALL thickness (0.92 vs 1.12 ± 0.03 cm) was less ($P < 0.01$) in 2009 than 2010.

Final live BW and CCW were greater ($P < 0.05$) for goat kids finished on RCL compared to CHIC; BFT was intermediate (Table 1). Dress out percentage was greater ($P < 0.10$) when goat kids were finished on CHIC compared to BFT; RCL was intermediate. The REA ranged from 8.7 to 9.8 cm^2 and BWALL thickness ranged from 0.93 to 1.06 cm. When adjusted to a common carcass weight difference, REA and BWALL thickness were similar among meat-goat kids finished on the three pastures. The REA:CCW ratio, lean quality score, and conformation score were not different ($P > 0.10$) when goat kids were finished on the three herbages. The leg score followed a similar trend ($P < 0.10$) as final BW; however, the covariate of CCW was significant ($P < 0.001$) for these factors (plus conformation score) and adjusted means were not different among treatments (Table 2). Backfat thickness and IP fat scores were higher for goats finished on RCL compared to CHIC while those finished on BFT were intermediate. Backfat thickness and IP fat scores when adjusted for CCW were not different ($P > 0.10$) among pasture finishing treatments.