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Carcass merit and meat quality in Suffolk lambs, Katahdin lambs, and meat-goat kids finished on a grass–legume pasture with and without supplementation

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ABSTRACT

The experiment evaluated traditional U.S. sheep (Suffolk), hair sheep (Katahdin), and meat goat (Boer crossbred; Goat) carcass and meat quality parameters when finished on pasture with and without supplemental whole cottonseed (*Gossypium hirsutum* L.). Supplemented animals had greater ribeye area ($P < 0.01$), body wall thickness ($P < 0.001$), and lean quality score ($P < 0.05$) than unsupplemented animals. Whole cottonseed increased fatty acids (FA) 18:1 trans-10, 18:1 trans-12, 18:2, and Omega6:Omega3 ratio and decreased FA 18:1 trans-11, 18:3, and Omega3 in *longissimus* muscle (LM). Katahdin LM had greater ($P < 0.001$) intramuscular fat compared to Suffolk and Goat. Goat LM had less ($P < 0.001$) FA 14:0, 18:0, 18:1 t11, 18:3, 20:3n − 6, and saturated FA when compared to Suffolk or Katahdin. Carcass weights from pasture-finished sheep and goats would be acceptable for most ethnic markets in the USA. Omega6:Omega3 ratios in chevon and lamb were within the guidelines for meats that can improve human diets and health.

1. Introduction

Opportunities exist to produce lamb meat and chevon (goat meat) in the USA for American consumers from diverse immigrant cultures for which these are the preferred meats, such as Hispanic, Caribbean, Muslim, Greek, Italian, Chinese, and Korean. The sheep (*Ovis aries*) and meat goat (*Capra aegagrus hircus*) industries are being developed and implemented on small-scale farms in the Appalachian Region of the USA to help supply meat for these ethnic markets. In recent years, there has also been an increased interest in hair sheep production as these sheep breeds perform well in low-input production systems with acceptable growth and carcass attributes when consuming low to moderate quality forages and they do not need to be shorn (Jones, 2004). Katahdins are a composite hair sheep breed developed in the Northeastern USA (Wildeus, 1997) and a breed gaining in popularity in the humid, eastern hill-land pasture region of the USA. Boer (Casey & Van Niekerk, 1988) and Kiko (Batten, 1987) meat goat breeds have been introduced to the USA to improve carcass composition when reared as purebred or in crossbreeding systems with dairy-goat breeds or Spanish-type goats.

Numerous forage types and qualities are used in small ruminant production systems. Orchardgrass (*Dactylis glomerata* L.) is a major pasture cool-season grass in the eastern USA (Hoveland, 1992). Red clover (*Trifolium pratense* L.) grows well on fertile and moderately acidic soils, thrives with management using rotational stocking (Taylor & Smith, 1995), and has higher ruminally undegraded protein when compared to alfalfa (*Medicago sativa* L.) (Jones, Hatfield, & Muck, 1995). White clover (*Trifolium repens* L.) is predominately grown for use as grazed forage throughout the USA (Pederson, 1995). Red and white clovers are legumes that help provide high levels of dietary protein for grazing livestock.

In a humid temperate environment, grazed forages traditionally are limiting in digestible energy; therefore, ruminants finished on pasture consistently produce leaner carcasses when compared with finishing in a feedlot on high grain diets. Supplemental hays, grains, and by-product feedstuffs provide added digestible energy and protein and can help satisfy dietary requirements to improve nutrient-use efficiency for maximal performance by grazing livestock. A by-product of the cotton ginning industry in the USA, feeding whole cottonseed (*Gossypium hirsutum* L.) as a supplement in forage-based systems can provide additional digestible energy, thereby improving growth rate and efficiency in small ruminant species (Luginbuhl, Poore, & Conrad, 2000). Whole cottonseed may

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impact fat deposition and fatty acid profiles in meat (Paim et al., 2014). Whole cottonseed contains gossypol, a toxic secondary plant compound. The potential for gossypol toxicity in ruminants is low because rumen fermentation detoxifies by binding free gossypol with soluble proteins (Reiser & Fu, 1962). Effects of gossypol on meat flavor are unknown, but Rhee, Ziprin, & Calhoun (2001) reported that cottonseed meal (contains gossypol) was apparently an effective anti-oxidant in cooked, ground meats of beef and chevon.

Non-traditional and ethnic markets supplying meat for ethnic groups in the USA accept smaller and leaner carcasses than traditional commodity markets, allowing for additional flexibility in marketing grass-finished sheep and goats. Diet (Johnson, Doyle, & Long, 2010) and breed of animal (Burke & Apple, 2007; Oman, Waldron, Griffin, & Savell, 1999) influence performance, carcass traits, and meat chemistry; therefore, studies to understand diet, livestock species, and breed-type can contribute scientific data to support on-farm and consumer decision making.

The objective of the present study was to evaluate and compare breed types including a traditional crossbred sheep (Suffolk), a common hair sheep (Katahdin), and a crossbred Boer meat goat (Goat) for carcass composition, meat quality and muscle chemistry, including fatty acid (FA) profiles, when grazing animals were finished on pasture with and without supplemental feed in a humid, temperate environment.

2. Materials and methods

2.1. Animals and treatments

This experiment was conducted from 2006 to 2008 at the USDA, ARS, Appalachian Farming Systems Research Center located in Beaver, WV, USA. All experimental procedures using animals were reviewed and accepted by the Agricultural Research Service, Appalachian Farming Systems Research Center, Institutional Animal Care and Use Committee in accordance to the Federation of Animal Science Societies' Guide for the Care and Use of Agricultural Animals in Research and Teaching.

Specific aspects of pasture and animal management have been previously reported by Turner, Belesky, Zajac, and Dowd (in press). In brief, the grazing experiment was conducted for three consecutive years (2006 to 2008) during the growing season each year. Suffolk crossbred lambs (n = 36), Katahdin lambs (n = 36), and Boer with Kiko influence crossbred (at least 75% Boer breeding) meat-goat kids (n = 36) were used in 2006 and 2007 while Boer × Kiko (F_1) goat kids (n = 36) were used in 2008. All animals were born during a 2-week period in March and weaned 28 June each year. Prior to the start of the grazing, all animals were castrated, vaccinated (plus booster vaccination) for protection from enterotoxemia and tetanus, and dewormed with a combination of orally administered anthelmintics. After the initial deworming, only individual animals were administered anthelmintics when their FAMACHA© score was 3 or greater (Kaplan et al., 2004) as evaluated every 14 d.

Thirty-six of each breed were weighed and assigned to six groups. Each grazing group contained eighteen animals (6 Suffolk, 6 Katahdin, and 6 Goat; all wethers) and was assigned to graze one of the six pastures. All pastures were a mixed sward of orchardgrass, red clover, and white clover. Each pasture was 0.61 ha in size (29.5 animals/ha) and was subdivided into three 0.2-ha paddocks for management with rotational stocking. A group of lambs and kids grazed pastures together. Three groups of animals (n = 54) were supplemented (SUP) with whole cottonseed at 0.5% body weight (BW) daily throughout the study, whereas the remaining three groups of animals (n = 54) were not offered any supplement (UNSUP). Animals were weighed every 14 d and supplement allocation adjusted after each weigh period. Animals had access to water and mineral feeders at all times during the grazing study. Grazing began on 29 June and continued until the end of the grazing season (about 1 Oct) each year.

2.2. Measurements

Around 1 October each year, animals were penned overnight without access to pasture and live weight of the animals before slaughter (shrunk BW) was recorded; animals were then transported to a packing plant (84 Packing Company, Eighty Four, PA, USA) and processed using Halal protocols. Carcasses were stored overnight for 12 h in a walk-in cooler maintained at 1.1 °C prior to recording chilled carcass weights (CCW). Carcasses were ribbed between the 12th and 13th ribs. Backfat thickness was measured over the center of the *longissimus lumborum* muscle from the right and left sides of the carcass and averaged. Left- and right-side *longissimus* circumference was traced on acetate paper, and mean ribeye area (REA) determined (Mousel et al., 2012). Body wall thickness (BWALL) was measured (11.4 cm lateral to the midline between the 12th and 13th ribs) with a caliper on both carcass sides, recorded, and subsequently averaged. Leg score (subjective score based on proportion of carcass weight that is in the hind leg), lean quality score (subjective score of flank firmness and lean flanking), and carcass conformation score (subjective score of overall carcass; superior are wide, thick, heavy muscled; poorer are thin and thinly muscled) were evaluated using the USDA (1982) standards (1 to15; 1 = low Cull, 15 = high Prime) and recorded by one trained specialist in 2006–2008.

In all years, a sample of the *longissimus lumborum* muscle was collected from the right carcass side of a subset of carcasses [twelve from each of the six pasture groups (a total of n = 72) which represented four animals each from the three breeds in each of the six groups each year], vacuum-packaged, and subsequently frozen at −20 °C until analyzed.

After thawing, raw samples were trimmed of external fat, ground (Hobart model 4822, Hobart Co., Troy, OH, USA) three times, and subsampled for determination of ash, crude protein (CP), and intramuscular fat (IMF) as ether-extractable lipid. Total ash content was determined as the residue after combustion at 550 °C for 15 h. Total N was determined by Kjeldahl procedures (AOAC, 1999) using the Büchi Digestion Automat K-438 and Büchi Distillation Unit B-324 (Büchi Laboratory Equipment, Flawil, Switzerland); CP was calculated as % total N × 6.25. The IMF content was determined using Ankom procedures (Am 5-04; AOCS, 2004). Ash, total N, and IMF procedures were completed in duplicate on individual samples, and individual values were then averaged prior to statistical analysis.

In 2006 only, ground meat samples were used to determine individual fatty acids (FA) in the total lipid fraction. Extraction of FA from the total lipid fraction followed procedures as outlined by Cherian, Selvaraj, Goeger, and Stitt (2002).

Following extraction from the lipid fraction, individual FAs were quantified by gas–liquid chromatography (Hewlett Packard 5890A Gas Chromatograph, Avondale, PA, USA). Conditions were as follows: injector temperature 245 °C, flame ionization detector 255 °C, hydrogen carrier gas at 0.8 ml/min, detector make up gas (N_2) at 20 ml/min, injector split ratio 100:1. The initial column temperature of 100 °C was programmed at 6 °C/min to 170 °C for 50 min, then 8 °C/min to 220 °C for 20 min. The column was a CP-SIL88 capillary column (100 m × 0.25 mm × 0.2 m film thickness; Varian, Inc., Palo Alto, CA, USA). The detector signal was collected by a Hewlett-Packard controller, analyzed, and summarized by the ChemStation program (Hewlett-Packard, Agilent Technologies Inc., Waldbronn, Germany).

2.3. Calculations and statistical analyses

Dressing percentage was calculated as CCW divided by shrunk BW × 100. The REA:CCW ratio was calculated to provide an additional