Carcass traits and retail display-life of chops from different goat breed types[1]

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ABSTRACT: Four groups of goats, Boer × Spanish, straightbred Spanish, Spanish × Angora, and straightbred Angora were slaughtered at a constant age according to accepted industry procedures. At 24 h postmortem, various carcass yield and quality measurements were taken. At 48 h postmortem, one side from each carcass was fabricated into major wholesale cuts for dissection into percentage lean, bone, and fat. Rib chops from the opposite side were fabricated, packaged, and displayed in a retail case. Trained panelists evaluated the rib chops over 4 d of retail display for lean color, surface discoloration, and overall appearance; packages were opened and analyzed for off-odor on d 4. When slaughtered at constant ages, Angora goats had lighter ($P < .05$) live and hot carcass weights than all other breed types, and Boer × Spanish goats had heavier ($P < .05$) live and carcass weights than Spanish goats. Live and carcass weights for Boer × Spanish and Spanish × Angora goats did not differ ($P > .05$). Carcasses from Angora goats had considerably smaller ($P < .05$) longissimus muscle areas than all other breed types. Carcasses from Spanish goats had lower ($P < .05$) carcass conformation scores than carcasses from Boer × Spanish goats but did not differ ($P > .05$) from carcasses of the other two breed types. Carcasses from Angora goats had smaller ($P < .05$) leg circumferences than the carcasses from Boer × Spanish and Spanish × Angora breed types. In general, carcasses from Boer × Spanish and Spanish goats possessed higher ($P < .05$) percentages of lean and lower ($P < .05$) percentages of fat for the side than did carcasses from Spanish × Angora and Angora goats. When the Spanish × Angora carcasses were compared to the Angora carcasses, it seemed that the addition of the Spanish breeding tended to increase lean and decrease fatness for most side or primal comparisons. There were no ($P > .05$) breed type or breed type × day effects for lean color, surface discoloration, overall appearance or off-odor; however, day of display did influence ($P < .05$) these traits. Crossing Spanish with Angora goats may be an option to improve carcass characteristics over that of straightbred Angora.

Key Words: Angora, Goat, Goat Breeds, Goat Feeding, Goat Meat

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Introduction

Two events in 1993 influenced U.S. goat production: 1) the importation of Boer goats into the United States and 2) the repeal of the National Wool Act and the subsequent phase-out of wool and mohair incentive payments to producers. The latter event already has had a major impact on Angora goat producers, especially in Texas, where 86% of the nation's Angora goats and 91% of the nation's mohair are produced (NASS, 1994). According to Jones and Wyse (1993), this policy decision could result in a loss of 3,000 jobs and a decline in personal income of $75 million in a 41-county region of Texas.

Historically, selection in Angora goat breeding has been based primarily on fiber quantity and quality, and relatively little emphasis has been placed on carcass traits. Boer goats, which are native to South Africa, have a high meat-yield potential (Van Niekerk and Casey, 1988); however, the influence of Boer goats in a crossbreeding system has not been investigated thoroughly. Some Angora goat producers are looking for an alternative outlet for their stock, and cross-breeding with meat-type Spanish, Boer, or Boer-cross goats could be a feasible management practice to enhance muscle production in terminal-cross offspring.

From conversations with producers and retailers we have learned that meat from Angora goats is often discriminated against because it is believed to have a shorter retail display-life than meat from other breeds. However, there has been no published research that

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supports this observation. Much of the research in the area of meat goats has focused on breeding, reproduction, productivity, and other live-animal aspects. Only limited research has focused on the final product of meat goats (Smith et al., 1978; Riley et al., 1989; Hogg et al., 1992). The objective of this study was to determine the effects of breed type on carcass characteristics and retail display-life of different goat breed types slaughtered at a constant age.

Materials and Methods

Thirty-six kids representing Boer × Spanish (n = 12), straightbred Spanish (n = 12), Spanish × Angora (n = 6), and straightbred Angora (n = 6) goats were obtained from the Texas Agricultural Experiment Station (TAES) at San Angelo. All goats were born in March and April 1994 and were left as intact males (as is the case for most male goats). Kids were raised on pasture until weaning at approximately 3 mo of age. After weaning, kids were given ad libitum access to an 80% concentrate, either 12.5% or 15% CP diet. Kids were assigned randomly within sire group to CP levels. Preliminary analyses showed no effect due to protein level. The Boer × Spanish and Spanish kids were a subset of those used in a breed comparison trial (Waldron et al., 1996). The kids in this study were chosen to be representative of each of the sires.

After 130 d on feed, kids were shipped to the Rosenthal Meat Science and Technology Center at College Station. They were held overnight without feed before slaughter the next morning following standard protocol. All kids were approximately 9 mo of age at the time of slaughter. Live weights (after the overnight period without feed) and warm carcass weights (with kidney and pelvic fat removed) were collected.

Carcass Evaluation

Carcasses were chilled at 2°C, and at approximately 24 h postmortem the carcasses were ribbed between the 12th and 13th ribs. The following measurements were taken on each carcass: longissimus muscle area at the 12th rib; actual and adjusted (visually adjusted for variations in fat thickness over the leg, loin, rack, and shoulder) 12th rib fat thickness; body wall thickness (measured 5.1 cm from the ventral edge of the longissimus muscle); leg circumference (across the stifle area of the leg, encompassing both legs); and carcass length (measured from the point of the hock to the point of the shoulder, anterior to the scapula-humerus joint). Scores for marbling (longissimus muscle at the 12–13th rib interface), flank streaking, maturity, color, and buckiness (based on a 5-point scale, where 1 = no buckiness and 5 = extremely bucky) also were assigned by experienced TAES personnel to each carcass. Although no official goat carcass grading standards exist, USDA (1992) lamb carcass standards were used for marbling and flank streaking and skeletal and lean maturity evaluations. Carcass conformation scores were assigned based on muscle shape and thickness of the leg, loin, rack, and shoulder as described by Oman et al. (1999).

Carcass Component and Retail Display Evaluation

At approximately 48 h postmortem, the carcasses were split longitudinally on a band saw. One side from each carcass (alternating between left and right sides) was dissected into knife-separable components of lean, fat (s.c. fat, intermuscular fat, and internal fat), and bone (including large ligaments) to determine physical composition. Percentages of lean, bone, and fat were obtained for the side, shoulder, rack, shortloin, sirloin, and leg, and were based on chilled side or primal weights.

The rack from the opposite side of each carcass was fabricated into six chops 1.92 cm thick. Two sequential chops were placed on a plastic foam tray and packaged with oxygen-permeable polyvinyl chloride overwrap film (oxygen transmission rate of 6,500 cc/m^2 per 24 h at 0% relative humidity). Three packages of rib chops from each carcass were placed in an open-top retail case (model DM8, Tyler Refrigeration, Niles, MI) under 1,614 lx of GE "Natural" fluorescent light (model no. F40N; 24-h continuous lighting) simulating retail conditions in a meat market (2°C setting with two defrost cycles). Packages were placed randomly in the case to allow for even distribution to account for variations in temperature and light throughout the retail case. Trained panelists (n = 3) scored the chops on d 0, 1, 2, 3, and 4 of retail display for lean color (15 = bright, youthful reddish-pink; 1 = extremely brown), surface discoloration (15 = no surface discoloration [0%]; 1 = total surface discoloration [100%]), and overall appearance (15 = extremely desirable; 1 = extremely undesirable). Because no scale for goat lean color exists, a scale for lean color was developed before the study based on variations from the lean color scale for lamb described by Wanstedt (1982). Surface discoloration and overall appearance scales also followed those used by Wanstedt (1982). On d 4, each package was opened and analyzed for off-odor (10 = no off-odor; 1 = abundant off-odor) by the panelists (Wanstedt, 1982).

Statistical Analyses

For the carcass traits and composition analyses, breed type served at the main effect in the model. These comparisons were made on a constant-age basis. Due to the variation in mature size of the breed types used in this study, the use of body weight as a linear covariate would not be appropriate.

For the retail display analysis, breed type, day, and breed type × day were the main effects, and panelist served as a blocking effect. All data were analyzed using PROC GLM (SAS, 1991) using the LS MEANS and PDIFF (pairwise *t*-test) options.

Table 1. Least squares means (and standard errors) of carcass yield and quality measurements stratified by breed type

Carcass measure	Boer × Spanish	Spanish	Spanish × Angora	Angora
Live wt, kg	38.2 ± 1.4[e]	33.5 ± 1.4[f]	36.5 ± 2.0[ef]	28.0 ± 2.0[g]
Hot carcass wt, kg	21.7 ± .7[e]	19.0 ± .7[f]	20.1 ± 1.0[ef]	14.5 ± 1.0[g]
Longissimus muscle area, cm^2	12.5 ± .7[e]	11.5 ± .7[e]	11.5 ± .5[e]	9.3 ± .5[f]
Fat thickness, 12th rib, cm	.12 ± .01[e]	.07 ± .01[f]	.13 ± .02[e]	.12 ± .02[e]
Adjusted fat thickness, 12th rib, cm	.16 ± .02[ef]	.11 ± .02[f]	.23 ± .03[e]	.22 ± .03[e]
Body wall thickness, cm	1.32 ± .09	1.40 ± .09	1.55 ± .12	1.40 ± .12
Carcass conformation score[a]	11.4 ± .8[e]	8.3 ± .8[f]	10.7 ± 1.1[ef]	9.0 ± 1.1[ef]
Carcass length, cm	107.0 ± 1.1[e]	104.9 ± 1.1[e]	102.6 ± 1.6[f]	94.0 ± 1.6[g]
Leg circumference, cm	54.9 ± .6[e]	52.6 ± .6[ef]	53.2 ± .9[e]	47.7 ± .9[f]
Lean maturity score[b]	1.4 ± .15	1.5 ± .15	1.9 ± .21	1.4 ± .21
Skeletal maturity score[b]	1.4 ± .08	1.5 ± .08	1.5 ± .12	1.5 ± .12
Marbling score[c]	3.4 ± .23[ef]	3.1 ± .23[f]	4.1 ± .32[e]	4.1 ± .32[e]
Flank streaking score[c]	3.6 ± .17[f]	3.4 ± .17[f]	4.3 ± .24[e]	4.2 ± .24[ef]
Buckiness score[d]	4.4 ± .3[e]	4.0 ± .3[e]	4.8 ± .4[e]	3.2 ± .4[f]

[a]Means based on a 15-point pictorial scale (Oman et al., 1999), where 1 = very angular, narrow, and thin; 15 = extremely thick and bulging.

[b]Means based on USDA (1992) skeletal and lean maturity scores for lamb, where 1.0 = A^{00} and 2.0 = B^{00}.

[c]Means based on USDA (1992) marbling and flank streaking scores, where 1.0 = Practically $Devoid^{00}$, 2.0 = $Traces^{00}$, 3.0 = $Slight^{00}$, 4.0= $Small^{00}$, and 5.0 = $Modest^{00}$.

[d]Means based on a 5-point scale, where 1.0 = no buckiness and 5.0 = extremely bucky.

[e,f,g]Means in the same row with different superscript letters differ ($P < .05$).

Results and Discussion

Presented in Table 1 are least squares means for various yield and quality measurements for the four goat breed types. When slaughtered at constant ages, Angora goats had lighter ($P < .05$) live and hot carcass weights than the other breed types, and Boer × Spanish goats had heavier ($P < .05$) live and carcass weights than Spanish goats. Live and carcass weights for Boer × Spanish and Spanish × Angora goats did not differ ($P > .05$). Carcasses from Angora goats had considerably smaller ($P < .05$) longissimus muscle areas than all other breed types. Carcasses from Spanish goats had less ($P < .05$) mean 12th rib fat thickness than the other breed types and when adjusted for variations in fat thickness over the carcass had less ($P < .05$) than Spanish × Angora and Angora carcasses. Nutritional management of goats can significantly affect carcass traits (Johnson and McGowan, 1998; Oman et al., 1999). The high body weights of the kids in this study were due to the breed types and high-concentrate diet consumed ad libitum for 130 d before slaughter.

Carcasses from Spanish goats had lower ($P < .05$) carcass conformation scores than carcasses from Boer × Spanish goats but did not differ ($P > .05$) from carcasses of the other two breed types (Table 1). Boer × Spanish and Spanish goats possessed longer ($P < .05$) carcasses than did Spanish × Angora goats, which had longer ($P < .05$) carcasses than did Angora goats. Carcasses from Angora goats had smaller ($P < .05$) leg circumferences than the carcasses from Boer × Spanish and Spanish × Angora breed types. No differences ($P > .05$) were observed among breed types for skeletal and lean maturity. Angora carcasses had higher ($P < .05$) marbling scores than meat-type carcasses but were not different ($P > .05$) from Spanish × Angora carcasses. Spanish × Angora carcasses had higher ($P < .05$) flank streaking scores than the carcasses from Boer × Spanish and Spanish goats but were not different ($P > .05$) from Angora carcasses. Angora goat carcasses had the lowest ($P < .05$) buckiness scores (less "bucky") than did the other breed types.

Least squares means for percentage carcass components are reported in Table 2. Carcasses from Boer × Spanish and Spanish goats possessed higher ($P < .05$) percentages of lean and lower ($P < .05$) percentages of fat for the side than did carcasses from Spanish × Angora and Angora goats. In general, the primal cuts from Angora carcasses were the fattest ($P < .05$) or among the fattest. When the Spanish × Angora carcasses were compared to the Angora carcasses, it seemed that the addition of the Spanish breeding tended to increase lean and decrease fatness for most side or primal comparisons. Crossing Spanish with Angora goats may be an option to improve carcass characteristics over that of straightbred Angora goats.

The values for lean percentage in Table 2 are on the lower range of values reported in the review of Warmington and Kirton (1990). The goats of the present study had greater body weight than those in most of the studies reviewed by Warmington and Kirton (1990), which may have resulted in compositional differences. In a study of carcasses from purebred Boer goats of 32 to 41 kg body weight, Van Niekerk and Casey (1988) reported a higher percentage lean and fat and a lower percentage bone than those of the Boer × Spanish carcasses we studied. Maturity and management differences between the two studies may make such comparisons invalid. Riley et al. (1989) also reported that racks from Spanish goats had a higher percentage lean and a lower percentage fat relative to Angora goats (although the size of the difference was smaller) than that presently observed. The carcass weights of the Spanish and Angora goats used by Riley et al. (1989) were approximately 15% lighter than those of the same breeds in the present study, which could account for some of the differences. The heavier weight is most likely due to the extended feeding period. The most dramatic compositional difference between the two studies was in fat percentage of the rack; Angora goats used by Riley et al. (1989) had 14.1% and the Angora goats in this study had 28%. In contrast, the Spanish goats used by Riley et al. (1989) had 13.5% fat in the rack, compared with 13.2% fat reported in this study. Although the numbers of goats in the two studies are not high, these differences suggest that composition can change dramatically within a narrow weight range because of differential rates of fat deposition that may be due to genetic or nutritional factors. Therefore, the choice of end point for carcass trait comparisons is critical. A common age comparison was used in the present study to estimate differences among the breed types when grown under the same environmental conditions (age and length of time on feed). Because of the differences among these particular breed types in growth rate over the 130 d on high-concentrate feed, comparison at a constant weight would have required either slaughtering animals at different ages, after different lengths of time on feed, or adjustment by regression procedures, which would require untenable assumptions about linear growth rates of component tissues.

Results from the display-life portion of this study are reported in Table 3. There were no ($P > .05$) breed type or breed type × day effects for lean color, surface discoloration, overall appearance or off-odor; however, day of display did influence ($P < .05$) these traits. Mean scores for lean color, surface discoloration, and overall appearance consistently declined as number of days on display increased. A significant decline was observed between d 3 and 4 for all analyses, and mean off-odor score for all chops was 5.44 ("modest" off-odor). These results are similar to those found by Henry et al. (1983), who noted differences ($P < .05$) between d-3 and d-4 muscle color, surface discoloration, and overall appearance scores of lamb rib chops from fresh or previously vacuum-packaged rib racks. Results of a beef strip loin steak shelf-life study (Griffin et al., 1982) also were similar: surface discoloration and overall appearance declined ($P < .05$) after d 3 and lean color score decreased ($P < .05$) after d 4. Both studies indicated numerical off-odor scores (10-point scales) on d 4 higher than those for the goat rib chops evaluated in the present work.

Based on the findings of this study, meat from Angora carcasses did not have display characteristics different from those of other goat breed types. It is difficult to understand what characteristics of any breed type could

Table 2. Least squares means (and standard errors) for carcass components stratified by cut and breed type

Cut and component	Boer × Spanish	Spanish	Spanish × Angora	Angora
Side				
Lean, %	57.8 ± .7^b	58.4 ± .7^b	55.0 ± 1.0^c	51.6 ± 1.0^d
Bone, %	26.5 ± .7	27.9 ± .7	25.5 ± .9	25.7 ± .9
Fat, %	15.7 ± .9^c	13.6 ± .9^d	19.4 ± 1.3^b	22.6 ± 1.3^b
Shoulder				
Lean, %	61.4 ± 1.1^{bc}	63.3 ± 1.1^b	58.8 ± 1.6^c	54.5 ± 1.6^d
Bone, %	21.6 ± 1.2	22.2 ± 1.2	22.1 ± 1.7	22.0 ± 1.7
Fat, %	16.9 ± .9^{cd}	14.4 ± .9^d	19.0 ± 1.3^c	23.3 ± 1.3^b
Rack				
Lean, %	54.2 ± 1.3^{bc}	56.2 ± 1.3^b	51.3 ± 1.8^{cd}	46.7 ± 1.7^d
Bone, %	29.4 ± 1.0^b	30.6 ± 1.0^b	27.4 ± 1.4^{bc}	25.3 ± 1.4^c
Fat, %	16.4 ± 1.5^{cd}	13.2 ± 1.5^d	21.3 ± 2.1^c	28.0 ± 2.1^b
Shortloin				
Lean, %	56.5 ± 1.6^b	52.8 ± 2.3^b	53.8 ± 2.3^b	46.1 ± 2.3^c
Bone, %	24.4 ± 2.0	25.3 ± 2.0	25.2 ± 2.8	25.9 ± 2.8
Fat, %	19.1 ± 1.7^c	21.9 ± 1.7^c	21.0 ± 2.4^c	28.0 ± 2.4^b
Sirloin				
Lean, %	57.2 ± 1.7^b	56.4 ± 1.7^{bc}	55.1 ± 2.4^{bc}	50.6 ± 2.4^c
Bone, %	21.0 ± 1.8	25.3 ± 1.8	21.7 ± 2.5	22.3 ± 2.5
Fat, %	21.8 ± 1.6^{bc}	18.3 ± 1.6^c	23.2 ± 2.3^{bc}	27.1 ± 2.3^b
Leg				
Lean, %	62.2 ± .6^b	62.3 ± .6^b	60.5 ± .8^b	58.6 ± .8^c
Bone, %	29.5 ± .5^{bc}	31.0 ± .5^b	28.7 ± .8^c	29.5 ± .8^{bc}
Fat, %	8.2 ± .6^{cd}	6.7 ± .6^d	10.8 ± .9^{bc}	11.8 ± .9^b

[a]Side includes major wholesale cuts and neck, shank, breast, plate, and flank.
[b,c,d]Means in the same row without a common superscript letter differ ($P < .05$).

Table 3. Least squares means for lean color[a], suface discoloration[b], and overall appearance[c] scores within day, and mean off-odor[d] score for rib chops from goat carcasses

Day	Lean color	Surface discoloration	Overall appearance	Off-odor
0	10.35[f]	13.21[f]	10.26[f]	ND[e]
2	9.63[g]	10.71[g]	9.00[g]	ND
2	8.98[h]	9.38[h]	8.34[h]	ND
3	8.85[h]	8.75[i]	8.18[h]	ND
4	7.18[i]	7.09[j]	5.96[i]	5.44

[a]Means based on a 15-point scale (15 = bright, youthful reddish-pink; 13 = moderately bright red; 11 = cherry-red; 9 = slightly dark red; 7 = moderately dark red; 5 = dark red or brown; 3 = very dark brown; 1 = extremely dark brown).

[b]Means based on a 15-point scale (15 = no surface discoloration [0%]; 13 = traces [about 7%]; 11 = slight [about 15%]; 9 = small [about 30%]; 7 = modest [about 50%]; 5 = moderate [about 70%]; 3 = slightly abundant [abount 90%]; 1 = total surface discoloration [100%].

[c]Means based on a 15-point scale (15 = extremely desirable; 13 = ery desirable; 11 = moderately desirable; 9 = slightly desirable; 7 = slightly undesirable; 5 = moderately undesirable; 3 = very undesirable; 1 = extremely undesirable).

[d]Means based on a 10-point scale (10 = no off-odor; 9 = practically no off-odor; 8 = traces of off-odor; 7 = slight off-odor; 6 = small off-odor; 5 = modest off-odor; 4 = moderate off-odor; 3 = slightly abundant off-odor; 2 = moderately abundant off-odor; 1 = abundant off-odor).

[e]Not determined.

[f,g,h,i,j]Means in the same columns with different superscript letters differ ($P < .05$).

cause the display-life to be different from others. Further research with similar findings may be required to help prove that meat from Angora carcasses does not have shorter display-life than meat from other breed types.

Implications

Goat breed type significantly affected carcass traits. Angora generally produced the least muscle traits and lightest weights. Crossing Spanish goats with Angora goats seemed to minimize the differences between the Boer × Spanish and Spanish goats and may be one alternative for improving the carcass traits and composition of Angora goats.

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