Goat Leg and Loin Enhancement by Electrical Stimulation and Injection to Improve Sensory Characteristics

T. S. Hively[1], R. K. Miller[1], W. S. Ramsey[1], D. B. Griffin[1]

[1]Texas A&M University, College Station, TX

ABSTRACT

Goat is an increasingly utilized species. To reduce meat quality variability, electrical stimulation and marination were evaluated. Fed Boer cross goats (n = 36) were slaughtered according to industry practices. Goats were paired with counterparts of approximately equal live weight, with one goat assigned to electrical stimulation (ES) following evisceration while the other goat served as control (NES). At 24 hr, carcasses were ribbed, graded, evaluated for objective color and fabricated into leg and loin primals. Right primals were assigned to non-injected control, while left primals were assigned to one of two injection treatments at approximately 10% green weight: 1) water, 2% potassium lactate, 0.4% sodium tripolyphosphate and 0.2% sodium diacetate or 2) water, 1% salt and 0.4% sodium tripolyphosphate percent in the final product. Primals were weighed before and after injection to determine percent uptake. At 48 hr, primals were cut into 1-inch chops, vacuum-packaged and randomly assigned to 1, 7, 14, 21 or 28 d shear. Facings from NES legs were reserved for microbial analysis (total APCs). Shear force, objective (L*, a* and b* values), subjective color and discolor (1 = extremely dark red, no discoloration, 8 = extremely bright red, total discoloration), purge (%) and pH of leg and loin chops on each d were measured. Chops were allowed to bloom 20 min before subjective and objective color evaluation. Two to eight cores, 1.27-cm in diameter, were removed per chop parallel to muscle fiber orientation for shear force evaluation. ES did not significantly affect carcass quality grade. Leg facing total APCs were not significantly affected by marination. ES leg chops did not differ significantly among L*, a*, subjective color, pH and purge measures (P = 0.07, 0.82, 0.97, 0.33, 0.70 and 0.25, respectively. NES b* was significantly lower (3.22 vs. 3.80, P < 0.01) and ES shear values were significantly lower (3.26 vs. 3.77, P < 0.01). ES loin chops did not differ significantly among L*, b* and pH (P = 0.78, 0.05 and 0.91, respectively). NES a* and subjective color were significantly lower (12.25 vs. 13.14, P < 0.01 and 4.02 vs. 4.25, P < 0.01, respectively) and subjective discolor, purge and shear were significantly higher (2.28 vs. 1.85, P < 0.01; 31.89 vs. 24.99, P < 0.01 and 4.49 vs. 3.56, P < 0.01, respectively). Control, 1 and 2 leg chops did not differ significantly among L*, a*, b*, subjective color and discolor (P = 0.90, 0.71, 0.27, 0.89 and 0.40, respectively). Control pH was significantly lower than both 1 and 2 (5.90 vs. 6.05 and 6.04, P < 0.01, respectively) and 1 purge was significantly lower than 2 (5.92 vs. 7.20, P < 0.01). Control shear was significantly higher than 2, and 2 was significantly higher than 1 (4.39, 3.33, 2.84, P < 0.01, respectively). Control, 1 and 2 loin chops likewise did not differ significantly among L*, a*, b*, subjective color and discolor and purge (P = 0.43, 0.32, 0.07, 0.41, 0.83 and 0.32, respectively). Control pH was significantly lower than both 1 and 2 (5.73 vs. 587 and 5.90, P < 0.01, respectively). Control shear was significantly higher than 2, 2 was significantly higher than 1 (4.77, 3.93, 3.37, P < 0.01, respectively). Storage day did not significantly affect a* for leg chops (P = 0.74). All other measures were significantly different with aging (P < 0.01). Storage day likewise significantly affected all loin chop measure (P < 0.01).

INTRODUCTION

Goats are an efficient converter of low quality feed into animal protein (Verma et al., 1996) with some breeds frequently producing twins or kidding more than once a year (Smith et al., 1978). Given the demand for low fat, healthful meat sources, consumers are willing to try new types of meat (Johnson et al., 1995), which has probably contributed to the excess demand over supply (Glimp, 1996).

However, the US goat industry has historically been a low-labor enterprise with little emphasis on animal productivity (Oman et al., 1999) or selection for meat production traits, resulting in highly variable market weights and carcass traits (Glimp, 1996).

These factors may contribute to some of the negative perceptions of goat, as well as research demonstrating that aged Spanish goat was considered unacceptable in comparison with young Spanish goat (Smith et al., 1978) and overbroiled goat loin was considered unacceptable in comparison to overbroiled beef, pork and lamb (Smith et al., 1974). Goat meat additionally has a lack of flavor associated with a lack of tenderness, as well as a perception that adult male goat meat has an unattractive flavor and color (Madruga et al., 2000).

The objectives of this research were to examine the potential benefits of electrical stimulation and non-meat ingredients to enhance palatability and reduce variability among goat loin and leg chops, as determined by Warner-Bratzler shear force, objective and subjective color, microbial level, purge and pH.

MATERIALS AND METHODS

- Boer cross goats (n = 36) were paired with counterparts of approximately equal live weight (one goat assigned to electrical stimulation and the other goat served as control)
- at 24 hr, carcasses were ribbed, graded, evaluated for objective color and fabricated into leg and loin primals
- right primals were assigned to non-injected control
- left primals were assigned to one of two injection treatments at approximately 10% green weight:
  - 1) water, 2% potassium lactate, 0.4% sodium tripolyphosphate and 0.2% sodium diacetate
  - 2) water, 1% salt and 0.4% sodium tripolyphosphate
- at 48 hr, primals were cut into 1-inch chops, vacuum-packaged and randomly assigned to 1, 7, 14, 21 or 28 d
- control leg facings were reserved for microbial analysis (total APCs)
- purge (%), pH, objective color (L*, a* and b* values), subjective color and discolor (1 = extremely dark red, no discoloration, 8 = extremely bright red, total discoloration), and shear force of leg and loin chops on each d were measured
- chops were allowed to bloom 20 min before subjective and objective color evaluation.
- 2 to 8 cores, 1.27-cm in diameter, were removed per chop parallel to muscle fiber orientation for shear force evaluation

Table 1. Overall means, standard deviations, minimum and maximum values for carcass traits of goats (n = 36).

Traits	Mean	Standard deviation	Minimum	Maximum
Live wt., kg	45.31	8.38	29.09	60.00
Hot carcass wt., kg	24.07	5.50	13.63	33.00
Dressing %	52.67	3.33	44.60	59.80
Longissimus lumborun muscle area, cm^2	1.99	0.47	0.85	2.75
USDA Yield Grade	1.82	0.87	0.90	3.90
Lean maturity	183.14	32.25	130.00	250.00
Skeletal maturity	182.22	23.07	150.00	230.00
Overall maturity	182.64	25.84	140.00	240.00
USDA Quality Grade	587.61	51.64	500.00	666.00

Table 2. Main effect least squares means for raw characteristics of goat legs subjected to 2 electrical stimulation treatments (NES=not electrically stimulated or ES=electrically stimulated) and 3 injection treatments (control=no injection, 1=2% potassium lactate, 0.2% sodium diacetate and 0.4% sodium tripolyphosphate and 2=1% salt and 0.4% sodium tripolyphosphate).

Traits	L*	a*	b*	Subjective color	Subjective discolor	pH	% purge
ES	0.0693[a]	0.8196[a]	0.0009[a]	0.9648[a]	0.3339[a]	0.6979[a]	0.2517[a]
NES	40.61	15.37	3.22[b]	4.15	2.48	5.99	6.36
ES	41.23	14.67	3.80[c]	4.15	2.33	6.00	6.76
Injection	0.8976[a]	0.7122[a]	0.2721[a]	0.8904[a]	0.4042[a]	0.0001[a]	0.003[a]
Control	41.03	16.52	3.34	4.13	2.31	5.90[b]	
1	40.88	13.83	3.60	4.18	2.36	6.05[c]	5.92[b]
2	40.85	14.72	3.59	4.15	2.54	6.04[c]	7.20[c]
Storage day	0.0001[a]	0.7400[a]	0.0008[a]	0.0174[a]	0.0001[a]	0.0001[a]	0.0001[a]
7	44.35[b]	13.45[c]	2.97	3.96[c]	1.54[b]	6.10[c]	5.94[b]
14	45.20[b]	14.51[c]	3.88	4.37[b]	3.41[c]	5.98[d]	6.98[c]
21	43.65[b]	14.31[c]	3.75	4.32[b]	2.60[d]	6.12[c]	6.68[c]
28	30.48[c]	17.82[d]	3.43	3.92[c]	3.81[c]	6.00[d]	6.64[c]
RMSE[f]	2.52	22.62	1.26	0.88	1.28	0.23	1.68

[a] *P*- value from analysis of variance tables for each compression percentage.
[b, c, d] Different superscripts within main effect indicate significant differences (*P* < 0.05).
[f] Root mean square error from analysis of variance table.

Table 3. Main effect least squares means for cooked characteristics of goat legs subjected to 2 electrical stimulation treatments (NES=not electrically stimulated or ES=electrically stimulated) and 3 injection treatments (control=no injection, 1=2% potassium lactate, 0.2% sodium diacetate and 0.4% sodium tripolyphosphate and 2=1% salt or 0.4% sodium tripolyphosphate).

Traits	Warner-Bratzler shear force
Electrical stimulation	0.0002[a]
NES	3.77[b]
ES	3.26[c]
Injection	0.0001[a]
Control	4.39[b]
1	2.84[c]
2	3.33[d]
Storage day	0.0001[a]
1	4.74[b]
7	3.29[c]
14	3.37[c]
21	3.17[c]
28	3.02[c]
RMSE[e]	1.33

[a] *P*- value from analysis of variance tables for each compression percentage.
[b,c,d] Different superscripts within main effect indicate significant differences (*P* < 0.05).
[e] Root mean square error from analysis of variance table.

Table 4. Main effect least squares means for raw characteristics of goat loins subjected to 2 electrical stimulation treatments (NES=not electrically stimulated or ES=electrically stimulated) and 3 injection treatments (control=no injection, 1=2% potassium lactate, 0.2% sodium diacetate and 0.4% sodium tripolyphosphate and 2=1% salt or 0.4% sodium tripolyphosphate).

Traits	L*	a*	b*	Subjective color	Subjective discolor	pH	% purge
ES	0.7791[a]	0.0001[a]	0.04935[a]	0.0457[a]	0.0060[a]	0.9009[a]	0.0001[a]
NES	43.16	12.25[b]	2.88[b]	4.02[b]	2.28[b]	5.84	31.89[b]
ES	43.24	13.14[c]	3.17[c]	4.25[c]	1.85[c]	5.83	24.99[c]
Injection	0.4302[a]	0.3186[a]	0.0721[a]	0.4049[a]	0.8256[a]	0.0001[a]	0.3230[a]
Control	43.43	12.73	3.11	4.08	2.12	5.73[b]	
1	43.11	12.87	3.19	4.25	2.04	5.87[c]	29.18
2	43.05	12.49	2.78	4.07	2.03	5.90[c]	27.70
Storage day	0.0001[a]	0.0009[a]	0.0005[a]	0.0153[a]	0.0001[a]	0.0001[a]	0.0001[a]
1				4.06[b,c,d]	0.14[b]	5.89[b]	
7	42.75[b]	12.69[b]	2.60[b]	3.88[b,c]	1.25[c]	5.84[b]	26.43[b]
14	42.90[b]	13.28[c]	2.90[b,c]	4.00[b,c]	2.71[d]	5.85[b]	30.01[c]
21	42.78[b]	12.60[b]	3.43[d]	4.31[b,e]	2.52[d]	5.92[b]	30.01[c]
28	44.36[e]	12.21[d]	3.19[c,d]	4.42[e]	3.71[e]	5.68[c]	27.32[b]
RMSE[g]	2.12	1.35	1.03	0.90	1.23	0.22	7.12

[a] *P*- value from analysis of variance tables for each compression percentage.
[b, c, d, e] Different superscripts within main effect indicate significant differences (*P* < 0.05).
[g] Root mean square error from analysis of variance table.

Table 5. Main effect least squares means for cooked characteristics of goat loins subjected to 2 electrical stimulation treatments (NES=not electrically stimulated or ES=electrically stimulated) and 3 injection treatments (control=no injection, 1=2% potassium lactate, 0.2% sodium diacetate and 0.4% sodium tripolyphosphate and 2=1% salt or 0.4% sodium tripolyphosphate).

Traits	Warner-Bratzler shear force
Electrical stimulation	0.0001[a]
NES	4.49[b]
ES	3.56[c]
Injection	0.0001[a]
Control	4.77[b]
1	3.37[c]
2	3.93[d]
Storage day	0.0001[a]
1	6.81[b]
7	3.24[c]
14	3.01[c]
21	3.01[c]
28	4.06[d]
RMSE[e]	1.43

[a] *P*- value from analysis of variance tables for each compression percentage.
[b,c,d] Different superscripts within main effect indicate significant differences (*P* < 0.05).
[e] Root mean square error from analysis of variance table.

DISCUSSION

- ***Electrical Stimulation Effects***
  - ES did not significantly affect leg chop color, pH or % purge, although ES loin chops were redder, yellower, had less discoloration, and had lower % purge.
  - ES leg and loin chops had lower WB values.
- ***Injection Effects***
  - Injected leg and loin chops did not differ in color from non-injected chops.
  - pH was higher in injected leg and loin chops.
  - % purge did not differ between the two injection treatments for the loin chops; however, leg chops injected with treatment 1had lower % purge.
  - Injected leg and loin chops had lower WB values than their non-injected controls with the greatest improvement in tenderness apparent for treatment 1 chops.
- ***Storage Day Effects***
  - With increased storage, leg chops were darker, yellower, had higher percentage of surface discoloration, had higher pH and purge %.
  - Loin chops became lighter, with slightly less red, and had a higher percentage of surface discoloration with increased storage.

CONCLUSIONS

- ES and the use of non-meat ingredients should be seriously considered as methods to improve the color and tenderness of goat meat.
- Use of these technologies would improve the overall consistency of goat meat and make it more competitive with other traditional protein sources.

LITERATURE CITED

Glimp, H. A. 1996. Meat goat production and marketing. J. Anim. Sci. 73:291-295.

Johnson, D. D., C. H. McGowan, . Nurse and M. R. Anous. 1995. Breed type and sex effect on carcass traits, composition and tenderness of young goats. Small Ruminant Res. 17:57-63.

Madruga, M. S., S. G. B. Arruda, N. Narain and J. G. Souza. 2000. Castration and slaughter age effects on panel assessment and aroma compounds of the "mestico" goat meat. Meat Sci. 56:117- 125.

Smith, G. C., Z. L. Carpenter and M. Shelton. 1978. Effect of age and quality level on the palatability of goat meat. J. Anim. Sci. 46:1229-1235.

Smith, G. C., M. I. Pike and Z. L. Carpenter. 1974. Comparison of the palatability of goat meat and meat from four other animal species. J. Anim. Sci. 39:1145-1146.

Verma, A. K., V. R. B. Sastry, D. K. Agrawal. 1996. Chevon characteristics of goats fed diets with water washed neem (*Azadirachta indica*) seed kernel cake. Small Ruminant Res. 19:55-61.