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GOAT PROCESSING WITH AND WITHOUT SKIN AFFECTS PROCESSING EFFICIENCY, MEAT QUALITY, AND SAFETY

I. Kang[1*], M. D. Chao[3], S. Pokharel[1], A. M. Lammert[2], D. U. Ahn[4], E. Reynolds[1]
Departments of Animal Science[1] and Food Science & Nutrition[2], California Polytechnic State University, San Luis Obispo, California 93407, USA
Department of Animal Science and Industry[3], Kansas State University, Manhattan, Kansas 66506, USA
Department of Animal Science[4], Iowa State University, Ames, Iowa 50011, USA

*ikang01@calpoly.edu

I. INTRODUCTION

Goat meat is consumed by more people than other red-meat species in the world with no religious and cultural restrictions (Abhijith et al., 2023). In the United States (U.S.), the demand for goat meat has continuously increased for the last 30 years, driven by the growth of ethnic populations, particularly among Asian, Hispanics and African communities (Meat & Livestock Australia Industry Insight, 2019; Gillespie et al., 2013b). However, one of challenges in the goat industry is low profitability, mainly due to lower dressing yields than other livestock species (Gillespie *et al*., 2013a). Goat carcasses are very lean, with most fat deposited in visceral parts rather than in muscles, making them more susceptible to moisture loss and meat toughness. Traditionally, most Americans prefer skinless and boneless goat meat, while many immigrants in America prefer skin-on and bone-in meat (McMillin & Pinkerton, 2008). LaRoche *et al*. (2021) compared two goat processing methods (skin-on and skin-off) and found that skin-on goats had greater overall yield and higher liking score than skin-off goats, with no difference in harvest efficiency. In this study, three goat processing methods (skin-on, skin-off and skin-off-late) were evaluated for chilling efficiency, meat quality, and product safety.

II. MATERIALS AND METHODS

A total of 27 Boer goats (nine wethers per each of three replications), aged 5–6 months old with live weight of 36.2 ± 1.3 kg, were transported from the goat unit to the meat processing center at California Polytechnic State University (Cal Poly). The goats were stunned, exsanguinated, and assigned to one of the three processing methods: 1) skin-on for ethnic meat, 2) skin-off for traditional meat, and 3) skin-off-late (skin removed during fabrication) for traditional meat (**Figure 1**). After 24 h post-mortem, carcasses were fabricated into seven major cuts using the Institutional Meat Purchases Specifications. The weights of live animals, hot carcasses, chilled carcasses and final major cuts were recorded during processing. Based on these data, dressing yield, chilling yield, fabrication yield, and primal cut yield were evaluated. The shear force procedure was conducted according to the AMSA Meat Cookery and Sensory Guidelines (American Meat Science Association (AMSA), 2015). Bacteria populations were assessed after swabbing on legs using Petrifilm™ count plates for total plate count (TPC) and *Escherichia coli* (*E. coli*). Consumer sensory attributes were conducted using goat consumers (~ 80) for skin-on, skin-off, and skin-off-late meats after cooking according to the guidelines of USDA (2001). All samples were evaluated for appearance, texture, flavor, and overall acceptability using a 9-point hedonic scale (9 ~ like extremely; 1 ~ dislike extremely). A completely randomized design was used for the study, and a post-hoc analysis was performed using Duncan's multiple range test to evaluate differences among treatments ($P < 0.05$; SPSS, 2023).

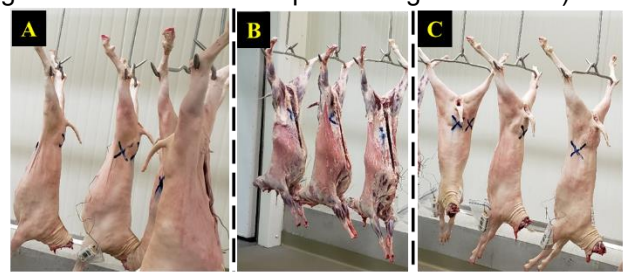


Figure 1. Goat carcasses[1] for skin-on (A), skin-off (B) and skin-off-late (C) meats
[1]Skin treatments: same as in Figure 1 (number of observations in each chilling, n = 9).

Table 1. Live weight, carcass weight, and processing time of skin-on and skin off goat carcasses

Parameter/Carcass[1]	Skin-on	Skin-off	Skin-off-late
Live weight (kg)	37.8[a]	36.4[a]	34.3[a]
Hot carcass weight (kg)	22.06[a]	18.70[b]	20.47[ab]
Cold carcass weight (kg)	20.61[a]	17.46[b]	18.80[ab]
Slaughter time from stun to evisceration (min)	56.3[a]	62.9[a]	49.9[a]
Fabrication time (min)	8.9[b]	9.9[b]	18.0[a]
Total processing time (min)	66.02[a]	72.8[a]	67.9[a]

[a-b]Means within a raw with unlike superscripts are different ($P < 0.05$).
[1]Skin treatments: same as in Figure 1 (number of observations in each chilling, n = 9).

III. RESULTS AND DISCUSSION

Live goat weights ranged from 31.3 to 43.6 kg with no significant difference among the treatment groups ($P > 0.05$). After stun and evisceration, hot skin-on carcasses (22 kg) were significantly higher than skin-off carcasses (18.7 kg) ($P < 0.05$), with skin-off-late carcasses (20 kg) being intermediate. Cold carcass weights followed the similar trend

after chilling (P < 0.05) (**Table 1**). The slaughter times from stun to evisceration were 56.3, 62.9 and 49.9 min for the skin-on, skin-off and skin-off-late goats, respectively, which was not significant different each other (P > 0.05). The dressing yield of skin-on and skin-off-late carcasses was significantly higher than the skin-off carcasses due to the skin (P < 0.05) (**Table 2**), which supports the previous results (Webb, 2014). Low dressing yield and profitability remain major challenges for meat goat producers (Gillespie *et al.*, 2013a). Loveday (2024) reported that skin-off goat yields are lower than those of beef and pork. No significant difference was observed in chilling yield, regardless of skin presence (P > 0.05) (**Table 2**), suggesting moisture loss during carcass chilling was not significantly affected by the presence of skin, aligning with the results of LaRoche *et al*. (2021). Higher fabrication yields were observed for the skin-on and skin-off carcasses than skin-off-late carcasses, which eliminated the skin before fabrication (P < 0.05).

Total plate count and *E. coli* were assessed on goat carcasses in the four processing steps of singeing, evisceration, chilling, and fabrication. There was no significant difference for TPC and *E. coli* on goat carcasses, regardless of skin processing method. Similarly, there was no significant difference for TPC and *E. coli* difference on goat carcasses, regardless of processing step (**Table 3**).

Goat samples were evaluated for appearance, flavor, texture, tenderness, juiciness, aftertaste, and overall liking. Results indicated that skin-off and skin-off-late goats (traditional meat) received higher scores for sensory attributes than skin-on goats (ethnic meat) (P < 0.05), except the juiciness (**Table 4**). These results were expected due to the chewiness of skin after dry cooking rather than steamy moisture cooking that are usually practiced for ethnic dishes. Additional reason for the lower scores in the skin-on goat is the nonethnic sensory panel members who are not familiar with skin-on meat.

Table 2. Carcass chilling yield, dressing yield, primal cut yield, and fabrication yield of skin-on and skin off goat carcasses

Parameter/Carcass[1]	Skin-on	Skin-off	Skin-off-late
Dressing yield (%)	59.38[a]	51.96[b]	55.51[a]
Neck yield (%)	5.91[a]	5.25[ab]	4.80[b]
Breast yield (%)	11.01[a]	10.78[a]	9.65[a]
Shoulder yield (%)	20.15[a]	21.53[a]	21.67[a]
Rack yield (%)	12.57[a]	12.67[a]	12.43[a]
Loin yield (%)	10.66[a]	11.06[a]	9.82[b]
Leg yield (%)	27.97[a]	28.67[a]	28.84[a]
Shank yield (%)	7.97[a]	8.43[a]	8.17[a]
Chilling yield (%)	95.0[a]	94.8[a]	94.4[a]
Fabrication yield (%)	85.50[a]	85.92[a]	77.52[b]

[a-b]Means within a raw with unlike superscripts are different (P < 0.05).
[1]Skin treatments: same as in Fig. 1 (n = 9).

Table 3. Populations of total plate count (TPC) and *Escherichia coli* (*E. coli*) on goat carcasses

Parameter/Carcass[1]	Skin-on	Skin-off	Skin-off late
	Total plate count (log CFU/g)		
After Singeing	2.87	2.75	2.81
After Evisceration	2.75	2.82	2.46
After Chilling	1.98	3.25	2.24
After Fabrication	2.78	2.72	1.80
	E. eoli (log CFU/g)		
After Singeing	0.78	0.77	0.67
After Evisceration	0.60	0.44	0.22
After Chilling	0.67	0.56	0.67
After Fabrication	0.56	0.56	0.44

[a-d]Means within a column and a raw with no common subscript are different (P < 0.05).
[1]Skin treatments: same as in Fig. 1 (n = 9).

Table 4. Sensory properties of goat meat processed by skin-on, skin-off, and skin-off-late methods

Parameter/Carcass[1]	Skin-on	Skin-off	Skin-off-late
Appearance	4.98[b]	6.65[a]	6.56[a]
Flavor	5.71[b]	6.20[a]	6.20[a]
Tenderness	5.22[b]	6.31[a]	5.97[a]
Juiciness	5.79[a]	6.21[a]	6.02[a]
Overall	5.43[b]	6.36[a]	6.18[a]

[a-b]Means within a raw with no common subscript are different (P < 0.05) based on a 9-point hedonic scale (9 ~ like extremely; 1 ~ dislike extremely).
[1]Skin treatments: same as in Figure 1 (n = 9).

IV. CONCLUSION

Traditionally, goats are processed skin off for traditional consumers and skin on for ethnic consumers. Skin-on goats offer higher dressing yield, fabrication yield, meat tenderness than skin-off goats. Skin-off-late goats provide no inferior meat to skin-off goats with the flexibility for skin-on and skin-off meats during fabrication. Further research is needed for sensory attributes with steamy moisture cooking.

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