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Cooking properties of Nilgai Antelope steaks, and patties with beef or pork fat inclusion

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Abstract

Nilgai antelope are a large bovid native to India that were introduced to North America and South Africa. Nilgai are free ranging in the United States and Mexico, and are commercially harvested for exotic meat markets. However, knowledge of nilgai meat characteristics is limited. The objectives of this research were to determine the impact of degree of doneness on nilgai steaks, and to determine if beef or pork fat influenced nilgai flavor and cooking properties of ground nilgai patties. Nilgai steaks tended ($P = 0.11$) to respond to cooking differently than beef steaks. When steaks were cooked to 63, 71, and 74°C, nilgai steaks cooked to 63°C were only more tender than the 74°C steaks while tenderness of beef steaks decreased with each increase in temperature. There was no difference ($P > 0.05$) in nilgai patty palatability between types of fat added, but addition of beef fat resulted in the greatest ($P < 0.05$) cooking loss. Inclusion of pork and beef fat resulted in similar ($P > 0.05$) cooked patty color.

Introduction

Nilgai antelope (*Boselaphus tragocamelus* Pallas) are endemic to India and portions of Pakistan and Nepal, and have been introduced into the United States, Mexico, and South Africa (Leslie, 2008). Nilgai were first brought to North America for stock in zoos, and in 1941 the King Ranch released eight cows and four bulls which are believed to have established free ranging nilgai in North America (Sheffield *et al*., 1983). In South Texas there has been a growing interest in utilizing nilgai as a niche meat source due to the increase in free ranging nilgai and its value as a lean meat source. Since nilgai is considered an exotic wild game animal in the United States, it is eligible for wholesale distribution if slaughtered, dressed, and processed under USDA FSIS inspection. Knowledge of nilgai meat characteristics is limited due to the lack of research conducted on nilgai meat. Ables *et al.* (1973) conducted an in depth study on three nilgai (one adult female, one subadult male, and one adult male). The researchers measured carcass yields and composition, and evaluated the loin, top and bottom round by taste panel, and Warner-Bratzler shear force. Ables *et al.* (1973) also compared nilgai loin steaks to beef loin steaks, and evaluated nilgai meat as an ingredient in wieners. One of their findings was that cooked nilgai meat was drier than cooked beef. If nilgai meat tends to result in a dry product, understanding how degree of doneness impacts juiciness of the end product will allow for better understanding of how to cook nilgai meat. Furthermore, Ables *et al.* (1973) also reported that nilgai are very lean with fat trim from the carcass ranging from 0.02% in subadult males to 1.44% in females. Fat inclusion into lean ground products often occurs to enhance palatability. However, fat inclusion impacts cooking properties and can alter meat flavor profiles. The type of fat included into meat products can result in different eating experiences as beef and pork adipose generate different flavor volatiles (Mottram *et al*., 1982). Myers *et al.* (2009) reported that increasing pork fat in pork patties increased pork flavor compared to inclusion of beef fat into pork patties. Moreover, inclusion of beef or pork fat into ground beef did not influence beef flavor, indicating that the type of fat may have different ramifications depending upon the species of the lean source (Myers *et al*., 2009).

Therefore, the research objectives were to determine the impact degree of doneness has on tenderness and moisture content of nilgai steaks, and to determine if beef or pork fat influenced nilgai flavor and cooking properties of ground nilgai patties. The research hypotheses are that tenderness and moisture content of nilgai steaks will decrease as the degree of doneness increases, and that pork fat will have a greater influence on the flavor and cooking properties

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of ground nilgai meat compared to beef fat.

Materials and Methods

Degree of doneness study

Beef strip loins *(longissimus lumborum)* were purchased for the study. The beef strip loins (*n* = 2) were from USDA Choice carcasses that were electrically stimulated, and the strip loins had been wet aged for 21 d prior to purchasing. Following purchase, beef strip loins were frozen, cut into 2.54 cm thick steaks on a band saw, individually vacuumed packaged and frozen (-20°C) until analysis. Fabrication of nilgai steaks occurred by cutting 2.54 cm thick steaks from the longissimus thoracis et lumborum muscle of nine female nilgai. The nilgai steaks were individually vacuum packaged, aged for 7 d, and then frozen (-20°C) until analysis.

The beef and nilgai steaks were assigned to three degree of doneness treatments (63, 71 and 74°C). The steaks from the beef strip loins were randomized, and nine beef steaks were assigned to the three degrees of doneness treatments. The nilgai steaks were randomized within each individual with each degree of doneness treatment having two steaks from the same longissimus (6 steaks/individual; 2 steaks/individual/temperature).

Warner-Bratzler shear force

Steaks were tempered for 24 h at 4°C prior to cooking on an electric grill (George Foreman, Model GRV120GM, Salton Inc., Lake Forest, IL). The steaks were cooked to the targeted treatment degrees of doneness and peak internal temperature was recorded for each steak using a digital hand held thermometer (model 221-071, ThermoWorks, Lindon, UT). After cooking, the steaks were cooled for 24 h at 4°C before subjected to shear force procedures outlined by AMSA (1995). The cooked steaks had cores removed parallel to the muscle fiber orientation, and each core was sheared once on a Warner-Bratzler shear machine (G-R Electric Manufacturing Co., Manhattan, KS). For the nilgai steaks, the measurements of the peak internal temperature and shear force values from the two steaks per individual were averaged to obtain a single temperature and shear force value. The peak shear force values for the beef steak were averaged to obtain a single shear force value for each steak. The sheared cores and the remainder of the cooked steak were collected, vacuum packaged and then frozen (-20°C) for percent moisture analysis.

Associated cooking loss and percent moisture

To determine the associated cooking loss, weights of steaks were recorded prior to cooking, five minutes after steaks were removed from the grill and prior to Warner-Bratzler shear force analysis (24 h after cooking). Initial cooking loss was calculated from the raw and cooked weight, and the cooler loss was calculated from the cooked weight and the weight prior to Warner-Bratzler shear force analysis.

Percent moisture analysis was conducted on the remnants of the Warner-Bratzler shear force steaks. The frozen cooked samples were thawed for 24 h at 4°C, homogenized in a food chopper (model 72500RY, Hamilton Beach Brands, Inc., Southern Pines, NC), and a representative sample of 7 g was used to determine percent moisture. The representative samples were placed in a 43 mm aluminum dish, covered with Whatman filter paper grade 1, weighed, dried at 100°C for 24 h and allowed to cool for 1 h in desiccators, and weighed again to determine the percent moisture.

Ground nilgai study

Nilgai lean trimmings were assigned to three different treatments. The treatments were as follows: 1) 100% nilgai (NG), 2) 85% nilgai with 15% pork fat (NP), and 3) 85% nilgai with 15% beef fat (NB). The pork fat was derived from subcutaneous fat of boston butt roasts (Institutional Meat Purchase Specification item number 406), and beef fat was derived from subcutaneous fat of briskets (Institutional Meat Purchase Specification item number 120). The raw product for each treatment was coarse ground through a 9.5 mm plate, mixed, and fine ground through a 4.8 mm plate. The final ground product was formed into 114 g patties using a 12 cm diameter plastic die. The raw patties were then crust frozen by placing the patties in a freezer at -20°C on trays, single layered, for approximately 40 minutes. The crust frozen patties were then vacuum sealed in bags and frozen (-20°C) until analysis. All raw patties were tempered (4°C) 24 h before cooking. Prior to cooking, a thermocouple was inserted into the geometric center of the patty, and internal temperatures were monitored using a digital hand held thermometer (model 221-071, ThermoWorks, Lindon, UT). All patties were cooked on an electric griddle (Model 0704512, National Presto Ind., Inc., Eau Claire, WI) until the temperature reached half of the desired cooking temperature, then flipped and cooked to 71°C. Once the patties reached the desired temperature they were removed from the grill.

Trained sensory panel

Once each patty was cooked it was placed in a glass dish and loosely covered with aluminum foil, and the dish was placed in a humidified heated holding cabinet (Model PHTT-6, Food Warming Co. Inc., Crystal Lake, IL) for five minutes at 160°C and 50% humidity. Upon removal from the warming oven, each patty was cut into eight equal wedges and promptly served to the panelist. Seven trained panelists were asked to score samples for juiciness, meat texture, and nilgai flavor intensity using an eight point descriptive scale (AMSA, 1995). Off-flavor was determined on a scale of 1 to 4 with 1 being extreme off-flavor and 4 being no off-flavor. There were a total of three sessions; two sessions on the first day and one session on the second day, with each session containing 13 samples. For each session the first sample served was 100% nilgai. The remaining 12 samples were balanced for treatments and the serving order was randomized. Panelist evaluated the nilgai samples in individual booths under a red incandescent light. The data collected from the first sample of each session was removed prior to statistical analysis. The panelists' scores were averaged to obtain one value for each sample within each evaluation category.

Cooking characteristics of nilgai patties

Eleven patties per treatment were utilized to determine cooking time, color change due to cooking, cooking loss, and surface area shrink due to cooking. Frozen raw patties were tempered for 24 h at 4°C prior to cooking. One hour before cooking, the raw patties were removed from vacuum packages, and placed on trays in the cooler. All evaluations of raw patties were conducted immediately prior to cooking, and all cooked evaluations occurred five minutes after patties were removed from the grill. Colorimeter values for L^*, a^*, and b^* were measured using a MiniScan EZ Diffuse LAV (HunterLab, Hunter Associates Laboratory, Inc., Reston, VA) that had a 20 mm diameter viewed area, and a 25 mm diameter port size. The colorimeter was calibrated with PVC film covering color standards. Colorimeter readings were measured with PVC film touching the patty, and three different surface locations were measured on each patty. Cooking loss and surface area shrink were calculated as a percent change from raw patty values.

Statistical analysis

The statistical analysis of the steaks was conducted using GLM procedures of SAS (SAS Inst. Inc., Cary, NC). Shear force, percent moisture, cook loss, and cooler loss were analyzed using species, degree of doneness and their interaction as fixed effects. The statistical analysis of the ground nilgai for the trained taste panel, cooking time, cooking loss and surface area shrink was conducted using GLM procedures of SAS with treatment as a fixed effect. The statistical analysis of patty color was conducted using a repeated measures analysis model of MIXED procedures of SAS with treatment as a fixed effect. Least square means were separated using the PDIFF option with differences detected at the $P < 0.05$ level.

Results and Discussion

Degree of doneness-percent moisture

Previous research in beef (Cover *et al.*, 1962a,b; Cross *et al*., 1976; Luchack *et al*., 1998; Yancey *et al*., 2011), pork (Boles *et al*., 1991; Wood *et al*., 1995; Rincker *et al*., 2008; Moeller *et al*., 2010) and lamb (Smith *et al.,* 1968; Maddock *et al*., 2004) have demonstrated that toughness increases in *longissimus* samples as internal temperature increases. Similar results were demonstrated in the current study. Cooking steaks to 63°C resulted in the most ($P < 0.05$) tender steaks, and cooking to 74°C resulted in the least ($P < 0.05$) tender steaks (Table 1). There was a degree of doneness by species interaction trend ($P = 0.11$) for shear force (Table 2). Beef tenderness decreased with each increase in temperature which agrees with past research, and confirms the method used to determine nilgai degree of doneness. While the nilgai steaks cooked to 63°C were only more tender than the 74°C steaks. There is limited data published with regards to how degree of doneness influences game meat. Rincker *et al.* (2006) evaluated beef, reindeer and caribou steaks and reported that with a limited number of samples there was a numerical increase in shear force for reindeer and beef steaks, but a decrease in shear force for caribou steaks when steaks were cooked from 65 to 75°C. In the current study, the results suggest that the nilgai steaks were resistant to toughening as internal temperature increased. A similar response has been reported between domestic swine breeds. Crawford *et al.* (2010) reported that chops from Berkshire pigs resisted toughening when cooked to higher temperatures compared to Landrace pigs.

Research has demonstrated that during the cooking process moisture loss increases as degree of doneness increases (Luchack *et al*., 1998; Wheeler *et al*. 1999; Smith *et al*., 2011). This response was also seen in the current research when evaluating weight loss due to cooking. As degree of doneness increased, weight lost during cooking increased ($P < 0.05$) for both nilgai and beef (Table 1). However, when cooked nilgai and beef steaks were analyzed for percent moisture by drying a representative sample at

Table 1. Least square means for degree of doneness and species for Warner-Bratzler shear force and associated cooking losses

	Degree of Doneness					Species			
	63°C	71°C	74°C	SEM	P-value	Nilgai	Beef	SEM	P-value
WBSF[a], kg	1.95[x]	2.26[y]	2.50[z]	0.076	< 0.001	1.98	2.48	0.062	< 0.001
Initial Cook Loss[b], %	14.57[y]	18.70[z]	20.47[z]	0.748	< 0.001	19.88	15.94	0.611	< 0.001
Cooler Loss[c], %	3.64	2.21	2.67	0.548	0.180	3.90	1.78	0.448	0.002
Moisture, %	50.53	50.16	50.99	0.685	0.694	45.29	55.82	0.560	< 0.001

[a] Warner-Bratzler shear force
[b] Calculated from the raw weight and cooked weight 5 min after cooking
[c] Calculated from cooked weight 5 min after cooking and cooked weight following 24 h rest in cooler
[x, y, z] Within a row, means without a common superscript differ (P < 0.05)

Table 2. Least square means for each species at different degree of doneness for Warner-Bratzler shear force and associated cooking losses

	Nilgai			Beef				
	63°C	71°C	74°C	63°C	71°C	74°C	SEM	P-value
WBSF[a], kg	1.82	1.98	2.15	2.07	2.53	2.84	0.107	0.110
Initial Cook Loss[b], %	16.21	20.83	22.62	12.93	16.57	18.33	1.058	0.863
Cooler Loss[c], %	5.36	2.74	3.59	1.91	1.68	1.75	0.775	0.299
Moisture, %	44.74	45.13	46.01	56.31	55.19	55.97	0.969	0.654

[a] Warner-Bratzler shear force
[b] Calculated from the raw weight and cooked weight 5 min after cooking.
[c] Calculated from cooked weight 5 min after cooking and cooked weight following 24 h rest in cooler

Table 3. Least square means for sensory characteristics of ground nilgai as affected by fat inclusion

	100% Nilgai	85% Nilgai; 15% Beef fat	85% Nilgai; 15% Pork Fat	SEM	P-value
Nilgai Flavor Intensity[a]	5.33[y]	4.17[z]	4.27[z]	0.170	< 0.001
Juiciness[a]	3.92[y]	4.95[z]	5.36[z]	0.155	< 0.001
Texture[a]	3.96[y]	4.36[z]	4.60[z]	0.124	0.004
Off-Flavor[b]	3.19	3.13	3.37	0.118	0.342

[a] 1 = Extremely bland, dry, crumbly; 8 = Extremely intense, juicy, rubbery
[b] 1 = Extreme off-flavor; 4 = No off flavor
[y, z] Within a row, means without a common superscript differ (P < 0.05)

100°C, there was no difference (P > 0.05) in moisture content for all degrees of doneness.

Ground nilgai

Trained sensory panel

Nilgai is a very lean meat source for which fat is often added into ground products to increase palatability of the product. Research has shown that addition of beef or pork trim, as a source of fat, increases the palatability of venison ground meat patties (Brittin *et al*., 1981). The results of the current study (Table 3) agree with Brittin *et al.* (1981) as inclusion of beef or pork fat increased (P < 0.05) juiciness and reduced (P < 0.05) crumbliness of the patties. It was also observed that nilgai flavor intensity was reduced (P < 0.05) with the inclusion of beef and pork fat, potentially due to the reduction of lean tissue in the patties. However, the inclusion of pork fat did not influence nilgai flavor as hypothesized since there was no difference (P > 0.05) between the ground nilgai patties with the inclusion of pork fat versus inclusion of beef fat for nilgai flavor intensity, juiciness, or texture (Table 3).

Nilgai patty cooking characteristics

The results from the current study indicate that fat type impacted cooking loss of the ground nilgai in this study (Table 4). The addition of beef fat resulted in the greatest (P < 0.05) cooking loss (34.5%) compared to NG (31.5%) and NP (30.2%) patties. The increased cook loss due to beef fat inclusion is in agreement with Miller *et al.* (1987) as the researchers reported that ground beef patties with 20% beef fat had greater (P < 0.05) cook loss compared to beef patties with 20% pork fat. Although the NP had 15% more fat compared to NG, the difference in fat content between NP and NG patties was not great enough to impact cooking loss as cooking loss was similar (P > 0.05). This is in agreement with Reitmeier and Prusa (1987), Berry (1992) and Troutt *et al.* (1992b). Reitmeier and Prusa (1987) reported that fat level did not influence (P > 0.05) cooking loss in pork patties with fat ranging from 4 to 23 percent, and Berry (1992) reported no difference (P > 0.05) in cooking loss for beef patties with fat ranging from 0 to 20%. Troutt *et al.* (1992b) reported that ground beef patties with 5, 10, 15, and 20% fat had similar (P > 0.05) cooking loss, and once fat level reached 25%

Table 4. Least square means for cooking properties of ground nilgai as affected by fat inclusion

	100% Nilgai	85% Nilgai; 15% Beef Fat	85% Nilgai; 15% Pork Fat	SEM	P-value
Cooking time, sec.	791	997	957	74.0	0.131
Cook loss, % of weight	31.5^{y}	34.5^{z}	30.2^{y}	1.03	0.018
Patty shrink, % of area	39.9	36.7	37.1	1.29	0.179

$^{y, z}$ Within a row, means without a common superscript differ (P < 0.05)

Table 5. Least square means for colorimeter values of ground nilgai as influenced by fat inclusion

	100% Nilgai	85% Nilgai; 15% Beef Fat	85% Nilgai; 15% Pork Fat	SEM	P-value
Raw					
L*	42.30^{x}	46.30^{y}	48.69^{z}	0.442	< 0.001
a*	$6.97y^{zy}$	6.31^{y}	7.77^{z}	0.382	0.038
b*	9.19^{y}	10.61^{z}	11.54^{z}	0.382	0.001
Hue Angle	52.91^{y}	58.91^{z}	56.32^{z}	1.104	0.002
Chroma	11.56^{y}	12.38^{y}	13.96^{z}	0.487	0.005
a* / b*	0.76^{z}	0.61^{y}	0.67^{y}	0.028	0.003
Cooked					
L*	43.77^{z}	39.91^{y}	40.78^{y}	0.687	0.001
a*	5.81	5.24	5.78	0.259	0.233
b*	9.69^{z}	7.51^{y}	8.62^{yz}	0.580	0.042
Hue Angle	58.67^{z}	53.93^{y}	55.36^{yz}	1.297	0.042
Chroma	11.37	9.20	10.42	0.603	0.053
a* / b*	0.62	0.74	0.70	0.036	0.056
Change in Values, (Cooked – Raw)					
L*	1.47^{y}	-6.40^{z}	-7.91^{z}	0.761	< 0.001
a*	-1.16	-1.07	-1.99	0.393	0.203
b*	0.50^{y}	-3.10^{z}	-2.92^{z}	0.626	< 0.001
Hue Angle	5.76^{y}	-4.98^{z}	-0.97^{z}	1.458	< 0.001
Chroma	-0.20^{y}	-3.18^{z}	-3.55^{z}	0.685	0.003
a*/b*	-0.14^{z}	0.13^{y}	0.03^{y}	0.040	< 0.001

$^{y, z}$ Within a row, means without a common superscript differ (P < 0.05)

an increase (P < 0.05) in cook loss was reported.

The type of fat in ground nilgai patties did not (P > 0.05) influence cooking time (Table 4), but the patties with the least amount of fat (NG) tended (P = 0.13) to take less time to cook compared to NB and NP in this study. The results contradict previous research conducted with ground beef. Troutt *et al.* (1992a) and Liu and Berry (1996) reported that lower fat levels in ground beef required additional time to cook. Whereas, Berry (1998) reported no difference in cooking time between ground beef patties with fat levels of 5-25% utilizing beef with a high pH.

There was no difference (P > 0.05) in patty surface area shrink between fat types or with patties that did not include added fat (Table 4). Previous research has demonstrated that increased fat level in meat patties results in increased patty diameter reduction (Berry, 1993; Jeong *et al.*, 2004). However, the results of the current study are in agreement with Troutt *et al*. (1992b) as they reported similar (P > 0.05) patty diameter in ground beef patties ranging in fat levels from 5 to 30%.

Color values for ground nilgai patties are presented in Table 5. Fat inclusion in this study resulted in raw patties that were lighter (L^*; P < 0.05), and yellower (b^*; P < 0.05) with NP being the lightest (L^*; P < 0.05). Raw NG had the greatest (P < 0.05) red color (hue angle and a^*/b^*). These results are not unexpected as increasing the quantity of fat into patties causes a reduction of lean tissue per patty. The color results for the cooked patties were potentially impacted by the differences in cooking times as the patties with fat included had longer cooking times allowing for an increase in browning. Thus, the cooked patties with fat were darker (L^*; P < 0.05) compared to 100% nilgai. The color change during cooking resulted in patties with added fat becoming darker (L^*; P < 0.05) with reduced (P < 0.05) yellowness (b^*) compared to 100% nilgai. Patties with added fat had a greater (P < 0.05) reduction in color intensity (chroma) during cooking compared to 100% nilgai. The reduction in color intensity due to cooking and increased inclusion of fat has also been reported in ground beef patties (Troutt *et al.*, 1992b).

Conclusion

Based on the results of the study, cooking nilgai longissimus steaks to a higher degree of doneness will cause greater cook loss and tougher steaks. Therefore, it is recommended to cook nilgai to a lower degree of doneness. In the current study, the use of beef and pork fat generated similar sensory characteristics. However, inclusion of beef fat into ground nilgai resulted in greater cook loss.

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