The Texas Journal of Agriculture and Natural Resources 27:73-83 (2014) 73

Characteristics of Nilgai Antelope Carcasses and Meat Quality

Tanner J. Machado[1*]
Cassandra M. Albert[1]
Mathew J. Schnupp[2]
David G. Hewitt[3]

[1]*Department of Animal, Rangeland, and Wildlife Sciences, Texas A&M University-Kingsville, Kingsville, TX 78363*
[2]*King Ranch, Inc., Kingsville, TX 78364*
[3]*Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville, Kingsville, TX 78363*

ABSTRACT

Nilgai antelope are a large bovid native to India that were introduced to southern Texas for recreational hunting, and are commercially harvested for exotic meat markets. The objective of this research was to determine the carcass characteristics and meat quality attributes of free ranging nilgai antelope (*Boselaphus tragocamelus* Pallas). Twenty nilgai (nine females; 11 males), of various maturity, were harvested to determine carcass characteristics. Muscle profiling of 15 different muscles was conducted to determine muscle weights, shear force, and color. Male nilgai had heavier ($P < 0.05$) live, field dressed, and carcass weights combined with a greater ($P < 0.05$) dressing percentage than the female nilgai. The male nilgai also had heavier ($P < 0.05$) carcass components, and a larger ($P < 0.05$) *longissimus* muscle area than the females. Females had lower ($P < 0.05$) shear force values for the *adductor*, *longissimus dorsi*, *supraspinatus*, *semitendinosus*, and *triceps brachii* with a trend ($P = 0.057$) for a lower shear force value for the *rectus femoris* compared to males for steaks aged 7d then frozen. There was little difference in meat color between genders.

KEY WORDS: game; nilgai; antelope; tenderness

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 are a common free-ranging exotic ungulate in South Texas. 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 1992, it was estimated that Texas had greater than 36,700 nilgai antelope (Traweek and Welch 1992). As nilgai numbers increase in South Texas, land owners seek ways to manage the impact of nilgai on their property. Since nilgai is an exotic wild game animal, it is eligible for wholesale distribution if it has been slaughtered, dressed, and processed under USDA FSIS inspection. Thus,

[*] Corresponding author: tanner.machado@tamuk.edu.

utilizing nilgai as a niche meat source could possibly be a method that land owners could use to manage nilgai populations. However, little meat-related research has been conducted on nilgai. Schulze (1985) measured dressing percentage, carcass hindquarter percentage, and carcass weight lost due to cooler shrink on 144 nilgai carcasses. Ables et al. (1973) conducted a more in depth study on three nilgai (one adult female, one sub-adult male, and one adult male) where the researchers measured carcass yields, carcass composition, and evaluated the loin, top round, 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 frankfurters.

The current study was conducted due to the lack of meat-related research on nilgai. The objectives of the study were to determine: 1) the meat yield of nilgai, and 2) the characteristics of several muscles to assist in identifying how nilgai carcasses should be fabricated to optimize the carcass utilization.

MATERIALS AND METHODS

Methodology of this study was approved by the Texas A&M University-Kingsville Animal Care and Use committee.

Nilgai Fabrication. Twenty nilgai antelope (*Boselaphus tragocamelus* Pallas) (nine females; 11 males) of various maturity were utilized in the study. Nilgai were harvested in May 2011 on the King Ranch in South Texas. The nilgai were rendered unconscious via gunshot to the head from a helicopter. The time from the helicopter initiating the chase to the time the nilgai were rendered unconscious ranged from two to five minutes. Immediately following, the live weight and field dressed weight (weight of eviscerated carcass before skinning) was recorded. All field dressed carcasses were placed in a cooler (3ºC) located on the ranch within one hour postmortem. The female carcasses were in the ranch cooler approximately two hours before they were transported to the Texas A&M University-Kingsville meat lab. Once the female carcasses arrived at the university meat lab they were skinned, Achilles suspended by one leg, and placed in a 2ºC cooler. The time of placement of the skinned female carcass into the cooler ranged from four to six hours postmortem with all skinned carcasses exhibiting the onset of rigor mortis prior to placement in the cooler. The male carcasses remained in the cooler located on the ranch suspended by one leg until the following day when they were transported to the university meat lab for skinning. For both females and males, the leg (left or right) used for Achilles suspension was randomized. After chilling for 24 h, each nilgai carcass was split down the midline of the vertebral column into two sides. The side that was already suspended remained suspended from the Achilles, while the other side was suspended from the aitch bone (pelvic). The left side of each carcass was fabricated beginning 48 hr postmortem, and fabrication of all left sides was completed by 7 d postmortem (two female and two male sides fabricated per day). The muscles removed from the left side of each carcass were cut into steaks with color evaluation occurring the day of fabrication. The steaks were vacuum-packaged, stored at 2 ºC, and frozen (-20 ºC) 7 d postmortem for Warner-Bratzler shear force analysis at a later date. Fabrication of the right sides occurred to determine carcass yields and muscle weights, and began 8 d postmortem with two female and two male sides fabricated per day.

Fabrication of nilgai carcass sides was conducted as follows. Each side of the nilgai carcass was fabricated into three initial sections: shoulder, torso, and hind leg (Figure

1). The shoulder was removed by cutting through the *pectoralis profundi*, following the natural seam to the dorsal end of the scapula. The hind leg was removed by a cut along the caudal side of the aitch bone, through the hip joint while cutting on a path that was a continuation of the aitch bone. The remainder of the side was classified as the torso.

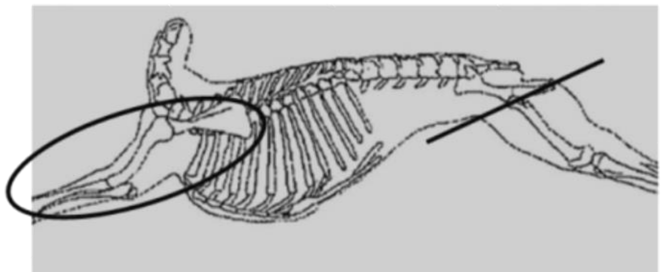

Figure 1. Fabrication diagram of the shoulder, torso, and hind leg.

Weights were recorded for each section, and the summation of the weights for all sections from both sides was used to determine the chilled carcass weight. Following fabrication of the three sections, individual muscles were removed and weights were recorded. Muscles removed from the three sections were as follows: 1) shoulder (*infraspinatus, supraspinatus,* and *triceps brachii*); 2) hind leg (*adductor, biceps femoris, gracilis, rectus femoris, semimembranosus, semitendinosus, vastus intermedius, vastus lateralis,* and *vastus medialis*); and 3) torso (*gluteus medius, longissimus dorsi, psoas major, spinalis dorsi, tensor fasciae latae*, and *trochanter major*). Skeletal bones were removed from the sections and weighed with the remainder of the meat collected as trim. To determine the *longissimus* muscle area (LMA), a cut surface was derived at a point half the distance of the length of the *longissimus* and perpendicular to the external surface. The exposed area was measured and the LMA for each side was averaged to obtain one LMA per carcass.

Steak Fabrication and Color Measurement. Steaks (2.5 cm thick) were cut across the grain at the midpoint of the length of each muscle for Warner-Bratzler shear force analysis. The number of steaks per muscle varied depending upon the size of the muscle to ensure that at least six cores could be obtained from the cooked steaks. The steaks were allowed to bloom for 20 minutes and colorimeter readings were taken. Color values for L*, a*, and b* were measured on one steak per muscle using a MiniScan EZ Diffuse LAV (HunterLab, Hunter Associates Laboratory, Inc., Reston, VA) that had a diffuse geometry, 10 degree observer angle, D65 illuminant, a pulse xenon halogen lamp, 20 mm diameter viewed area, and a 25 mm diameter port size. Steaks were vacuum-packaged, aged for 7 d at 2 ºC, and then frozen (-20 ºC).

Warner-Bratzler Shear Force. Steaks were derived from both female (n = 4 sides Achilles suspended; n = 5 sides Pelvic suspended), and male (n = 6 sides Achilles suspended, n = 5 Pelvic suspended). Steaks evaluated for tenderness had been previously aged 7 d, and then frozen (-20 ºC). Prior to shear force analysis, steaks were tempered for 24 h at approximately 2 ºC before being cooked on an electric grill (model GRV120GM, George Foreman, Miramar, FL). The steaks were cooked to a targeted peak internal temperature of 71 ºC, and the peak internal temperature was recorded for each steak using a digital handheld thermometer (model 221-071, ThermoWorks, Lindon, UT). Shear force values were determined for steaks using the procedures of AMSA (1995). After cooking, steaks were cooled for 24 h at 2 ºC, and cores (1.27 cm diameter) were removed from each steak parallel to the muscle fiber orientation. The cores were then individually sheared with a Warner-Bratzler shear machine (G-R Electric Manufacturing Co., Manhattan, KS). The peak internal temperature and shear force values for the multiple steaks per individual were averaged to obtain a single temperature and shear force value for each individual.

Statistical Analysis. Individual muscle weights are reported on a carcass side basis, and obtained by averaging the muscle weights from both sides of the carcass. Analysis of live weight, carcass characteristics, and individual muscle weights was conducted using GLM procedures of SAS (SAS Inst. Inc., Cary, NC) with carcass as the experimental unit and gender as the fixed effect. Analysis for shear force and color was conducted using MIXED procedures of SAS with carcass as the experimental unit. The fixed effects were gender, suspension method, muscle and their interaction with individual within gender, suspension, and muscle as a random effect. Analysis of shear force included individual steak as a repeated measure, and peak internal temperature was utilized as a covariate. Least square means were separated using PDIFF option with differences detected at the $P < 0.05$ level.

RESULTS AND DISCUSSION

Weights and carcass yields. The weight ranges and carcass characteristics for both males and females are reported in Table 1. Live, field dressed, and carcass weights, along with percent bone and muscle, are comparable to those reported by Ables et al. (1973). When evaluating the values reported by Ables et al. (1973) for the single adult female and the single sub-adult male, all weights fell within the ranges reported in this study (Table 1). However, the values reported for the single adult male by Ables et al. (1973) were 258 kg for live weight, 178 kg for field dressed weight, and 136 kg for carcass weight which were heavier than the maximum for males in this study (Table 1). In the current study, the large bull nilgai that were designated for hunting were not harvested resulting in male weights that are conservative.

As with other species, various factors can influence the weight of nilgai, including age. Lochmiller and Sheffield (1989) recorded live weights of male nilgai with 1.5-year-old males having an average weight of 115.0 ± 3.4 kg to 6-year-old males weighing 268.0 ± 7.0 kg. Schulze (1985) conducted a larger nilgai study that evaluated 67 males and 56 females with an age range of less than a year old to 10 years old. Schulze (1985) reported nilgai weights after the nilgai were bled out with weights ranging from 80 to 276 kg for males and 60 to 200 kg for females. When the author evaluated how age influenced weight, the weights were not statistically different ($P > 0.05$) once the males were older than four years, and once the females were older than two years. Schulze (1985) also reported a seasonal variation in live weights for males but not females with males being heavier ($P < 0.05$) in autumn versus spring. The nilgai evaluated in this research were of various ages and harvested during the spring.

When comparing genders (Table 2), male nilgai had heavier ($P < 0.05$) live, field dressed, and carcass weights combined with a greater ($P < 0.05$) dressing percentage than the female nilgai. Another antelope species similar in weight to nilgai is kudu. Male kudu have greater live weight, carcass weight, and dressing percentage than females (Hoffman et al. 2009). In the current study, the male nilgai had heavier ($P < 0.05$) carcass components (data not shown) and a larger ($P < 0.05$) LMA than the females. However, this did not result in an increase in percent muscle since muscle as a percentage of carcass weight was similar ($P > 0.05$) between the two genders. The similarity in percent muscle could possibly be explained by the fact that the females had a greater percentage of hind leg compared to the males, and thus offsetting the larger LMA found in the males. Subcutaneous and intermuscular adipose were not accounted for in this study, because both genders had very little to no adipose to dissect from the carcasses. Adipose content could vary depending upon season of harvest, but in general they are lean. Ables et al. (1973) reported that fat trim on the female carcass was 1.44%, the sub-adult male 0.02% and the adult male 0.21% of the carcass weight.

Table 1. Live weight and carcass characteristics for male and female nilgai.

	Mean	SD	Minimum	Maximum
Male				
Live weight, (kg)	202.5	34.94	147.4	254.0
Field dressed weight[1], (kg)	139.0	23.67	98.4	171.5
Chilled carcass weight, (kg)	104.7	17.52	76.2	126.2
Dressing percentage[2], (%)	51.8	2.96	48.4	59.8
Longissimus muscle area, (cm^2)	46.3	6.58	34.2	54.8
Carcass components[3] (% of carcass)				
Shoulder	17.4	0.59	16.6	18.2
Hind leg	28.9	2.30	26.6	32.5
Torso	53.7	2.67	49.7	56.8
Bone	21.2	1.58	18.7	23.7
Muscle	78.8	1.58	76.3	81.3
Female				
Live weight, (kg)	168.5	15.57	152.0	197.3
Field dressed weight[1], (kg)	105.4	8.43	96.2	118.8
Chilled carcass weight, (kg)	81.9	5.91	73.9	90.4
Dressing percentage[2], (%)	48.8	2.85	45.0	54.5
Longissimus muscle area, (cm^2)	38.5	4.19	32.9	47.1
Carcass components[3] (% of carcass)				
Shoulder	16.3	0.54	15.2	17.0
Hind leg	31.7	0.96	30.4	33.5
Torso	52.0	1.26	50.3	54.5
Bone	20.5	3.77	14.1	24.9
Muscle	79.6	3.77	75.1	85.9

[1] Weight of eviscerated carcass before skinning
[2] Dressing percentage = (chilled carcass weight ÷ live weight)*100
[3] Carcass components = (component weight ÷ chilled carcass weight)*100

Table 2. Least squares means (± standard error) for live weight and carcass characteristics for each gender of nilgai.

	Female	Male	P-value
Live weight, (kg)	168.5 ± 9.35	202.5 ± 8.45	0.0147
Field dressed weight[1], (kg)	105.4 ± 6.17	139.0 ± 5.58	0.0008
Chilled carcass weight, (kg)	79.6 ± 4.62	104.7 ± 4.18	0.0008
Dressing percentage[2], (%)	47.6 ± 1.44	51.8 ± 1.30	0.0416
Longissimus muscle area, (cm^2)	38.5 ± 1.88	46.3 ± 1.70	0.0065
Carcass components[3] (% of carcass weight)			
Shoulder	16.9 ± 0.49	17.4 ± 0.44	0.4591
Hind leg	32.9 ± 1.01	28.9 ± 0.92	0.0102
Torso	50.3 ± 1.45	53.7 ± 1.31	0.0966
Bone	21.2 ± 1.02	21.2 ± 0.92	0.9552
Muscle	78.9 ± 1.02	78.8 ± 0.92	0.9567

[1] Weight of eviscerated carcass before skinning
[2] Dressing percentage = (chilled carcass weight ÷ live weight)*100
[3] Carcass components = (component weight ÷ chilled carcass weight)*100

Table 3. Least squares means (± standard error) for muscle weights representing one carcass side[1] for each gender of nilgai.

	Female, (kg)	Male, (kg)	P-value
Shoulder			
Infraspinatus	0.61 ± 0.039	0.76 ± 0.035	0.0109
Supraspinatus	0.54 ± 0.035	0.70 ± 0.031	0.0030
Triceps brachii	0.85 ± 0.068	1.20 ± 0.061	0.0015
Hind leg			
Adductor	0.67 ± 0.032	0.73 ± 0.029	0.1742
Biceps femoris	2.05 ± 0.103	2.36 ± 0.093	0.0349
Rectus femoris	0.84 ± 0.028	0.91 ± 0.025	0.0654
Semimembranosus	1.99 ± 0.077	2.27 ± 0.069	0.0156
Semitendinosus	0.71 ± 0.038	0.81 ± 0.034	0.0588
Vastus lateralis	1.02 ± 0.034	1.14 ± 0.030	0.0208
Vastus medialis	0.32 ± 0.019	0.36 ± 0.017	0.1349
Torso			
Gluteus medius	1.24 ± 0.055	1.41 ± 0.050	0.0461
Longissimus dorsi	2.64 ± 0.154	3.23 ± 0.139	0.0110
Psoas major	0.72 ± 0.042	0.83 ± 0.038	0.0696
Trochanter major	0.60 ± 0.036	0.66 ± 0.033	0.2607

[1] Muscle weights from each of the two carcass sides were averaged to obtain one value per carcass.

When evaluating the weights of the selected muscles (Table 3), eight of the 14 muscles were heavier ($P < 0.05$) in males than females, and the *rectus femoris*, *psoas major*, and *semitendinosus* tended ($P < 0.10$) to be heavier in males. Only the *adductor*, *trochanter major*, and *vastus medialis* were similar ($P > 0.10$) between genders. The results of the muscle weights can aid in explaining the differences seen between the two genders with regards to the shoulder and hind leg sections as a percentage of the carcass weight. All of the muscles from the males that were removed from the shoulder were heavier ($P < 0.05$) than the females, and thus the shoulder section represented a greater ($P < 0.05$) portion of the carcass for the males compared to the females. At the same time, only one-third of the muscles removed from the hind leg were statistically (P < 0.05) heavier for the males than the females, and since the females had lighter (P < 0.05) carcasses with comparable weights for muscles from the hind leg, it resulted in the hind leg representing a greater (P < 0.05) percentage of the carcass weight for the females. Although Schulze (1985) fabricated the nilgai carcasses differently than the current study, the researcher also reported a difference between genders for carcass proportions with the hindquarter percentage for females being greater (P < 0.05) than the males. Female impalas, another antelope species, also have a larger (P < 0.05) percentage of hind leg than males (Hoffman 2000).

Warner-Bratzler shear force and color. The results of this research would indicate that the majority of nilgai steaks are considered acceptable for tenderness when utilizing tenderness thresholds identified for beef. Miller et al. (2001) reported consumers considered beef with shear force less than 3.0 kg as tender, and shear force greater than 4.6 kg as tough. Of the 15 nilgai muscles evaluated for tenderness, only the *infraspinatus* and *supraspinatus* had shear force values that were greater than 4.6 kg (Table 4).

Table 4. Least squares means (± standard error) for Warner-Bratzler shear force[1] of 15 muscles for gender.

	Female, (kg)	Male, (kg)	P-value (Gender)
Shoulder			
Infraspinatus	4.54 ± 0.342^{a}	5.12 ± 0.309^{b}	0.2291
Supraspinatus	4.29 ± 0.336^{ab}	6.23 ± 0.306^{a}	0.0006
Triceps brachii	2.53 ± 0.176^{efg}	3.13 ± 0.159^{ef}	0.0227
Hind leg			
Adductor	2.86 ± 0.196^{ef}	3.53 ± 0.176^{de}	0.0221
Biceps femoris	4.00 ± 0.229^{abc}	4.27 ± 0.214^{c}	0.3963
Rectus femoris	2.39 ± 0.128^{fg}	2.75 ± 0.112^{fg}	0.0566
Semimembranosus	2.75 ± 0.196^{efg}	3.07 ± 0.189^{ef}	0.2658
Semitendinosus	3.13 ± 0.205^{de}	3.84 ± 0.183^{cd}	0.0192
Vastus lateralis	3.65 ± 0.168^{cd}	3.77 ± 0.153^{cd}	0.6116
Vastus medialis	2.72 ± 0.202^{efg}	2.86 ± 0.179^{f}	0.6063
Torso			
Gluteus medius	2.49 ± 0.238^{efg}	2.66 ± 0.215^{fg}	0.5898
Longissimus dorsi	2.28 ± 0.140^{g}	2.69 ± 0.127^{fg}	0.0425
Psoas major	2.59 ± 0.102^{efg}	2.28 ± 0.095^{g}	0.0415
Serratus ventralis[2]	3.70 ± 0.199^{bcd}	3.99 ± 0.158^{cd}	0.2557
Trochanter major	2.39 ± 0.301^{fg}	2.84 ± 0.270^{f}	0.2790

[1] Steaks were aged 7d, then frozen
[2] Gender x suspension effect (P < 0.05).
[a, b, c, d, e, f, g] Means in the same column followed by a different letter differ (P < 0.05).

The results of the current study also indicate that female nilgai have an advantage in tenderness over male nilgai (Table 4). When comparing gender within the same muscle, shear force was lower (P < 0.05) for the *adductor*, *longissimus dorsi*, *supraspinatus*, *semitendinosus*, and *triceps brachii* of females than males, and there was a trend (P = 0.0566) for a lower shear force for the *rectus femoris* of females compared to males. Similarly, female fallow deer (Hutchison et al. 2010), and red deer (Purchas et al. 2010) have lower shear force than males. In contrast, males had a more tender (P < 0.05) *psoas* *major* than females (Table 4). However, this has not been the case for other antelope species, because there was no difference (P > 0.05) in shear force between male and female springbok (Hoffman et al. 2007), impala, or kudu (Hoffman et al. 2009).

Suspension method of the nilgai carcasses influenced tenderness on three muscles. Pelvic suspension resulted in lower (P < 0.05) shear force values for the *rectus femoris* (2.33 kg vs. 2.80 kg), *infraspinatus* (4.09 kg vs. 5.58 kg), and *biceps femoris* (3.73 kg vs. 4.54 kg) compared to Achilles suspension. There was also a gender by suspension interaction for the *serratus ventralis* muscle with pelvic suspension resulting in a more tender (P < 0.05) steak compared to Achilles suspension for the females but not males (female pelvic 3.20 kg, Achilles 4.20 kg; male pelvic 4.10 kg, Achilles 3.9 kg). Although previous research has shown the influence of pelvic suspension on tenderness for lamb (Bouton and Harris 1972; Thompson et al. 2005), beef (Hostetler et al. 1972; Ahnström et al. 2012), pork (Møller and Vestergaard 1986; Rees et al. 2003), fallow deer and red stags (Hutchison et al. 2010), this is the first reported for nilgai. The complete understanding of why suspension influenced tenderness on the *infraspinatus* is not known. Bouton et al. (1974) reported that the *infraspinatus* from lamb carcasses that were pelvic suspended had shorter (P < 0.05) sarcomeres. However, Bouton et al. (1973) reported that pelvic suspension had no influence (P > 0.05) on sarcomere length or shear force for the *infraspinatus* in beef carcasses.

There was little difference in meat color between male and female nilgai (Tables 5 and 6). Of the muscles selected for evaluation, the *infraspinatus* displayed the biggest difference in color between genders. The male *infraspinatus* was lighter and redder than the female (P < 0.05). The lack of color difference (P > 0.05) between genders has also been reported for kudu, impala (Hoffman et al. 2009), and wild red deer (Daszkiewicz et al. 2009). The current study is unique compared to previous research as it evaluated multiple muscles and not only the *longissimus*.

CONCLUSION

Nilgai are a free-ranging exotic antelope with high lean meat yields, and when nilgai meat is aged for 7d then frozen, it results in acceptable tenderness (less than 4.0 kg) for 12 of the 15 muscles. Female nilgai carcasses on average are lighter weight than males, but contain the same percent lean on a carcass basis with steaks that are tenderer. The results of this study provide information that can assist individuals who utilize nilgai as a meat source as the data provides expected yields from nilgai carcasses. Furthermore, the muscle weights and tenderness can be utilized by individuals in making decisions as to whether the muscles could be used for roasts or steaks.

Table 5. Least squares means (± standard error) for lightness[1] (L*) of 15 nilgai muscles for gender.

	Female	Male	P-value (Gender)
Shoulder			
Infraspinatus	38.8 ± 0.45[g]	40.2 ± 0.41[cd]	0.0386
Supraspinatus	38.5 ± 0.57[g]	39.7 ± 0.51[de]	0.1307
Triceps brachii	38.7 ± 0.55[g]	38.8 ± 0.49[e]	0.8685
Hind leg			
Adductor	43.4 ± 1.04[a]	41.7 ± 0.94[b]	0.2538
Biceps femoris	43.4 ± 0.90[a]	41.7 ± 0.81[b]	0.1845
Rectus femoris	40.3 ± 0.75[def]	41.1 ± 0.68[bc]	0.4285
Semimembranosus	41.7 ± 0.63[bc]	40.1 ± 0.57[cd]	0.0730
Semitendinosus	42.1 ± 0.64[ab]	43.4 ± 0.58[a]	0.1666
Vastus lateralis	39.1 ± 0.71[fg]	39.9 ± 0.64[cde]	0.4292
Vastus medialis	38.1 ± 0.48[g]	39.9 ± 0.44[cde]	0.0160
Torso			
Gluteus medius	41.4 ± 0.61[bcd]	41.0 ± 0.56[bcd]	0.6450
Longissimus dorsi	40.6 ± 0.60[cde]	40.1 ± 0.54[cd]	0.5838
Psoas major	39.0 ± 0.42[fg]	39.8 ± 0.38[cde]	0.1586
Serratus ventralis	38.8 ± 0.77[g]	40.7 ± 0.61[bcd]	0.0777
Trochanter major	39.3 ± 0.51[eg]	40.6 ± 0.46[bcd]	0.0759

[1] L* (0 = black and 100 = white)
[a, b, c, d, e, f, g] Means in the same column followed by a different letter differ ($P < 0.05$).

Table 6. Least squares means (± standard error) for redness/greenness[1] (a*) of 15 nilgai muscles for gender.

	Female	Male	P-value (Gender)
Shoulder			
Infraspinatus	13.5 ± 0.46[h]	14.9 ± 0.42[ab]	0.0477
Supraspinatus	14.0 ± 0.37[fgh]	15.1 ± 0.33[ab]	0.0538
Triceps brachii	14.7 ± 0.49[efg]	14.8 ± 0.45[ab]	0.8375
Hind leg			
Adductor	16.5 ± 0.78[ab]	15.6 ± 0.70[a]	0.4073
Biceps femoris	15.8 ± 0.52[bcd]	15.7 ± 0.47[a]	0.8990
Rectus femoris	15.1 ± 0.45[cdef]	14.4 ± 0.41[bc]	0.2636
Semimembranosus	16.5 ± 0.56[ab]	15.6 ± 0.50[a]	0.2394
Semitendinosus	17.1 ± 0.49[a]	15.8 ± 0.44[a]	0.0669
Vastus lateralis	15.6 ± 0.39[bcde]	15.5 ± 0.35[a]	0.8589
Vastus medialis	13.6 ± 0.47[gh]	13.7 ± 0.42[c]	0.8557
Torso			
Gluteus medius	16.5 ± 0.37[ab]	15.5 ± 0.34[a]	0.0894
Longissimus dorsi	15.6 ± 0.53[bcde]	14.3 ± 0.48[bc]	0.0832
Psoas major	15.0 ± 0.47[cdef]	14.4 ± 0.43[bc]	0.3700
Serratus ventralis	16.2 ± 0.65[abc]	15.3 ± 0.52[ab]	0.2574
Trochanter major	14.8 ± 0.40[def]	15.1 ± 0.36[ab]	0.5981

[1] a* (positive values = red and negative values = green)
[a, b, c, d, e, f, g, h] Means in the same column followed by a different letter differ ($P < 0.05$).

REFERENCES

Ables ED, Carpenter ZL, Quarrier L, Sheffield WJ. 1973. Carcass and meat characteristics of nilgai antelope. Texas Agric. Exp. Stn. Bull. 1130.

Ahnström ML, Hunt MC, Lundström K. 2012. Effects of pelvic suspension of beef carcasses on quality and physical traits of five muscles from four gender-age groups. Meat Sci. 90:528-535

AMSA. 1995. Research Guidelines for Cookery, Sensory Evaluation and Instrumental Tenderness Measurements of Fresh Meat. American Meat Science Association, Chicago, IL.

Bouton PE, Harris PV. 1972. The effects of some post-slaughter treatments on the mechanical properties of bovine and ovine muscle. J. Food Sci. 37:539-543.

Bouton PE, Fisher AL, Harris PV, Baxter RI. 1973. A comparison of the effects of some post-slaughter treatments on the tenderness of beef. J. Fd. Technol. 8:39-49.

Bouton PE, Harris PV, Shorthose WR, Smith MG. 1974. Evaluation of methods affecting mutton tenderness. J. Fd. Technol. 9:31-41.

Daszkiewicz T, Janiszewski P, Wajda S. 2009. Quality characteristics of meat from wild red deer (*Cervus elaphus* L.) hinds and stags. J. Muscle Foods 20:428-448.

Hoffman LC. 2000. The yield and carcass chemical composition of impala (*Aepyceros melampus*), a southern African antelope species. J. Sci. Food Agric. 80:752-756.

Hoffman LC, Kroucamp M, Manley M. 2007. Meat quality characteristics of springbok (*Antidorcas marsupialis*). 1: Physical meat attributes as influenced by age, gender and production region. Meat Sci. 76:755-761.

Hoffman LC, Mostert AC, Kidd M, Laubscher LL. 2009. Meat quality of kudu (*Tragelaphus strepsiceros*) and impala (*Aepyceros melampus*): Carcass yield, physical quality and chemical composition of kudu and impala *Longissimus dorsi* muscle as affected by gender and age. Meat Sci. 83:788-795.

Hostetler RL, Link BA, Landmann WA, Fitzhugh Jr HA. 1972. Effect of carcass suspension on sarcomere length and shear force of some major bovine muscles. J. Food Sci., 37:132-135.

Hutchison CL, Mulley RC, Wiklund E, Flesch JS. 2010. Consumer evaluation of venison sensory quality: Effects of sex, body condition score and carcass suspension method. Meat Sci. 86:311-316.

Leslie Jr DM. 2008. *Boselaphus tragocamelus* (Artiodactyla: Bovidae). Mammalian Species. 813:1-16.

Lochmiller RL, Sheffield WJ. 1989. Reproductive traits of male nilgai antelope in Texas. The Southwestern Naturalist. 34:276-309.

Miller MF, Carr MA, Ramsey CB, Crockett KL, Hoover LC. 2001. Consumer thresholds for establishing the value of beef tenderness. J. Anim. Sci. 79:3062-3068.

Møller AJ, Vestergaard T. 1986. Effects of altered carcass suspension during rigor mortis on tenderness of pork loin. Meat Sci. 18:77-87.

Purchas RW, Triumf EC, Egelandsdal B. 2010. Quality characteristics and composition of the longissimus muscle in the short-loin from male and female farmed red deer in New Zealand. Meat Sci. 86:505-510.

Rees MP, Trout GR, Warner RD. 2003. The influence of the rate of pH decline on the rate of ageing for pork. I: interaction with method of suspension. Meat Sci. 65:791-804.

Schulze SR. 1985. *Reproductive and carcass characteristics of nilgai antelope on the King Ranch*. Thesis. Texas A&M University, College Station, Texas.

Sheffield WJ, Fall BA, Brown BA. 1983. *Kleberg Studies in Natural Resources: The Nilgai Antelope in Texas*. The Texas Agricultural Experiment Station, College Station, Texas 2M-10-83.

Thompson JM, Hopkins DL, D'Souza DN, Walker PJ, Baud SR, Pethick DW. 2005. The impact of processing on sensory and objective measurements of sheep meat eating quality. Australian Journal of Experimental Agriculture, 45:561-573.

Traweek M, Welch R. 1992. *Exotics in Texas*. Texas Parks and Wildlife Department, Austin, Texas.