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**Report Prepared for the Alberta Elk Association**

# **The Evaluation of Meat Yield and Quality in Elk**

**Wayne Robertson, Allan Schaefer, Stan Landry, Don Brereton**

Agriculture & Agri-Food Canada, Lacombe Research Centre,  
6000 C & E Trail, Lacombe, Alberta, T4L 1W1

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## **Introduction**

The current research project was undertaken to evaluate velvet-antler removal methods, velvet-antler assessment methods and venison yield and quality. An earlier report (Cook *et al.*, 2000) presented results of the assessment of management procedures in the harvesting of velvet antler. This report presents new information on carcass and meat quality of elk of different ages, evaluation of a method for improving tenderness and means of estimating carcass value.

In the beef industry, it is recognized there is a direct relationship between animal age and tenderness, and in general, increased age is associated with decreased tenderness. With increasing animal age, there is an increase in the amount of cross-linking both within and between molecules of collagen (connective tissue), and the collagen becomes less susceptible to enzymes and is less soluble on heating (Lawrie, 1979). North American beef grading systems take into account the relationship between animal age and tenderness, and graders assess maturity based on the degree of ossification of various parts of the skeleton. The Canadian beef grading system recognizes two maturity classes and only those carcasses from the youthful maturity class qualify for the high quality grades. Because of differences between early and late-maturing breeds, it is difficult to give an exact age for the breakpoint between youthful and mature carcasses, but some carcasses from 36 month old animals would not qualify for the Canada A grade series. The USDA beef grading regulations specify 5 maturity levels, and only carcasses from the two most youthful levels qualify for the top grades. Approximate ages corresponding to Maturity Class A is 9 to 30 months and to Maturity Class B is 30 to 42 months (Tatum, 1997). There have been no reported research results examining the relationship between animal age and tenderness in elk, and therefore it was of interest to seize the opportunity provided by this study to examine the meat quality of 2, 3 and 4 year old elk. It was also an opportunity to determine the effect of animal age on yield of valuable cuts and total meat yield of elk carcasses, and to begin to develop a data base of information pertaining to composition of elk carcasses.

Previous research at the Lacombe Research Centre on the meat quality of elk and whitetail deer had identified a concern with respect to lack of consistency of meat quality, specifically tenderness. High voltage electrical stimulation (470 V) of beef carcasses has been shown to be very effective in reducing shear values (Aalhus *et al.*, 1992). New Zealand researchers reported improvements in tenderness of venison using low voltage stimulation (Drew *et al.*, 1988; Chrystall and Devine, 1983). However, results from the Lacombe studies of whitetail deer failed to demonstrate any benefits of high voltage electrical stimulation of the carcass on shear values (unpublished data). Among the perceived mechanisms of electrical stimulation in improving tenderness is the earlier onset of rigor mortis and the subsequent prevention of cold shortening or cold-induced toughening which may occur when pre-rigor muscle is chilled too rapidly. Earlier studies of venison quality of whitetail deer, then, also examined the effect of reducing the rate of chilling on tenderness. High temperature conditioning (10°C for the first 24 or 48 h post-mortem) was found to be very effective in attenuating shear values of deer venison compared to conventionally chilled carcasses (1°C), particularly in the rib eye muscle. However, carcass weight losses during chilling due to drip and evaporation were prohibitively high in the conditioned sides. In the current study, it was decided to investigate the effects of a moderate high temperature conditioning regime (6 to 7°C) on tenderness of elk rib steaks.

## **Materials and Methods**

A total of 26 males (2, 3 and 4 year olds) were used in this study. All animals were obtained from Canadian Rocky Mountain Ranch, and were transported to the Lacombe Research Centre abattoir the morning of the day of slaughter. The two slaughter dates were August 22, 2000 and August 29, 2000. *Need something about pre-slaughter Nutricharge trtmt.*

A final live weight was obtained immediately prior to slaughter of the animals. Live weights were not obtained on three animals which were uncooperative and were dispatched in the holding area ahead of the live animal scale. Carcass side weights were

recorded following dressing of the carcass. Alternating between left and right sides, carcass sides were assigned to conventional chilling (CC) or a moderate high temperature conditioning (HTC) treatment. Average temperature of the coolers was 1.7°C and 6.2°C for the CC and HTC sides, respectively. All sides were pasteurized in a hot water (85°C) pasteurizer for 8 seconds prior to chilling.

Muscle pH and temperature was measured at 50 min post-mortem in the loin eye (longissimus lumborum, LL) at the 1<sup>st</sup> lumbar vertebra. The pH and temperature measurements were made by insertion of a spear type electrode and stainless steel thermocouple through the overlaying silverskin. Temperature loggers were used to track temperature decline at the center of the LL and the deep hip in two CC sides and two HTC sides.

Following chilling the carcass sides were knife-ribbed between the 12<sup>th</sup> and 13<sup>th</sup> ribs. Muscle color was measured on the exposed face of the rib eye muscle (longissimus thoracis, LT) at the 12<sup>th</sup> rib after a 20 min bloom period using a Minolta CR300 reflectance meter. CIE L\*, a\* and b\* values were recorded. Hue and chroma (saturation) were calculated using the a\* and b\* values. Three fat thickness measurements were made of the subcutaneous fat over the rib eye at the ¼, ½ and ¾ positions, and averaged. The minimum thickness of fat in the 4<sup>th</sup> quadrant (distal to the chine bone) was also recorded. The rib eye area was measured using a transparent grid ruled in 1 cm squares and a GR measurement was made (total tissue depth 7 cm from the end of the rib eye). Finally, muscle pH and temperature measurements were made by insertion of the electrode and thermocouple in the exposed face of the LT.

Carcass sides were re-weighed to determine loss due to evaporation and drip during cooling. The CC sides were cut out to determine yield of cuts and total meat yield. A 13 to 15 cm portion of the LT anterior to the 12<sup>th</sup> rib was collected from both CC and HTC sides. A 20 mm thick chop was cut from the 12<sup>th</sup> rib end, weighed, placed on an absorbent pad in a retail display tray and over-wrapped with oxygen-permeable film. The steak was held for 48h at 4°C, blotted dry and re-weighed to determine drip loss. The

steaks used for determination of drip loss were then vacuum packaged and held at  $-1^{\circ}\text{C}$  for an additional time to provide a total of 7 d aging, then frozen for subsequent use in determining the effect of end point cooking temperature on shear value (tenderness). The remaining portion of the sample collected was also vacuum packaged, held at  $-1^{\circ}\text{C}$  to provide a 7 d aging period, and frozen for subsequent evaluation to determine the effect of pre-slaughter nutritional therapy and HTC on shear value.

### *Shear values.*

The chops from the drip loss procedure were used to determine the effect of end point cooking temperature on shear values in order to establish the best temperature for cooking the main body of samples for the experiment. The drip loss chops were assigned to one of three end point temperatures with both CC and HTC sides assigned to the same treatment. As much as possible samples were assigned so as to account for pre-slaughter treatment and animal age. The chops were thawed for 48 h at  $1^{\circ}\text{C}$ , and then grilled on a Garland grill (Model ED30B, Condon Barr Food Equipment Ltd., Edmonton, AB). Temperature at the center of the chops was monitored using spear tip thermocouples connected to a data logger. The chops were cooked on one side to  $35^{\circ}\text{C}$ , turned and cooked to three different end points: 63, 67 and  $71^{\circ}\text{C}$ . An ice/water bath was used to arrest the cooking process, and then the chops were held overnight at  $4^{\circ}\text{C}$ . Three cores of 19 mm diameter were removed from each chop parallel to the muscle fibers. Degree of doneness was noted as the cores were removed. The cores were sheared at right angles to the muscle fibers in a Warner-Bratzler shear cell attached to an Instron Materials Testing System. Cross head speed was 200 mm/min. The peak shear force required to shear through the cores was recorded.

The LT portions retained for the purpose of determining the effect of pre-slaughter nutritional therapy and HTC on tenderness were also thawed for 48 h at  $1^{\circ}\text{C}$ . Two chops of 25 mm thickness were fabricated from the 11<sup>th</sup> rib end, cooked to  $67^{\circ}\text{C}$  and sheared as

described above. Three cores were removed from each chop, providing 6 cores in total for shear value determination.

## **Results and Discussion**

### *Animal age*

The effects of animal age on carcass characteristics are presented in Table 1. As one would expect, live weight increased with age of the animal. Average weight of the 3 year olds was approximately 25 kg heavier than 2 year olds, while there was a larger weight difference between 4 and 3 year old animals of 47 kg. Hot carcass yield expressed as a percentage of final live weight prior to slaughter also increased with age, and the 4 year old elk in this trial had significantly higher hot carcass yields compared to the 2 year old animals ( $P<0.05$ ). Rib eye area, measured at the 12<sup>th</sup> rib, and the thickness of tissue at the GR site increased along with carcass weight. There was also a tendency for older animals to have higher levels of finish (subcutaneous fat), although the differences were not statistically significant.

Results of the cut out are presented in Table 2. Total cuts refers to the combined weight of specific cuts and specialty items (e.g. osso buko). Total meat yield includes all cuts, stew meat and 85% lean trim. Carcasses from the 4 year old animals had a lower yield of total cuts than carcasses from either 2 or 3 year old animals ( $P<0.05$ ) but higher yields of stew meat and 85% trim so that total meat yield was not significantly affected by animal age. There was a higher proportion of bone in the carcasses of 2 year olds compared to either 3 or 4 year old elk, and a lower proportion of readily dissectable fat although this latter difference was not statistically significant. Differences in the yield of individual cuts or specialty items between the age groups were not of a magnitude to be statistically significant with the exception of the peeled sirloin tip which represented a smaller proportion of the carcass in 4 year olds than in 2 year olds ( $P<0.05$ ).

Animal age had no effect on rate or extent of pH decline in the LL muscle (Table 3). Nonetheless, the 4 year old animals produced meat which was slightly darker (lower L\* values) than either 2 or 3 year olds ( $P < 0.05$ ). Darker muscle color in carcasses from older animals is not unique to elk, and is seen in beef carcasses as well. The difference observed in this trial of less than one full unit would have minimal, if any, impact on acceptability of the product. Furthermore, the average 24 h pH values are not indicative of “dark cutting”, and there were no incidences of LT muscle pH greater than 6.0 in this trial, which is generally regarded as the critical ultimate pH for dark cutting in beef carcasses. It is of interest to note the decline in shear value indicating that meat from 4 year old animals was more tender than the same cut from 2 year old animals ( $P < 0.05$ ), with 3 year olds intermediate between the other two in tenderness. The variation of shear value within the six cores from each animal was also significantly less in 4 year olds compared to either 2 or 3 year olds (standard deviation of 1.655, 1.551 and 0.999 in 2, 3 and 4 year olds, respectively).

#### *Pre-slaughter Nutri-charge™ treatment*

There were very few differences in carcass characteristics (Table 4) or meat quality (Table 5) which could be attributed to pre-slaughter treatment of the animals. Control and treated animals had identical hot carcass yields expressed as a percentage of final live weight recorded immediately prior to slaughter, and identical carcass weight losses during cooling. While total percentage yield of cuts and specialty items were not different, the total yield of meat including stew meat and 85% lean trim was 1.5% greater in carcasses from treated animals compared to that of control animals ( $P < 0.05$ ).

Nutri-charge™ treatment had no effect on muscle color of the LT at 24 h post-mortem, and drip loss of rib eye steaks were similarly unaffected. While initial muscle pH was similar between carcasses from control and treated animals, pH measured at 24 h post-mortem was slightly higher in carcasses from treated animals ( $P = 0.011$ ). There were no

statistically significant differences in shear values of grilled rib eye steaks obtained from carcasses of control or treated animals.

### *High temperature conditioning*

While the difference in mean temperature between the conventional cooler and the HTC cooling regime was only 4.5°C, it was sufficient to reduce the rate of cooling in the LL muscle during the first ten hours post-mortem (Figure 1). Additionally, from approximately 6 h post-mortem through to 24 h post-mortem, a temperature differential of 4 to 4.5°C was maintained at the center of the muscle between control and HTC sides. The effects of cooler temperature on carcass shrink and meat quality of the rib eye muscle are presented in Table 6. Unlike experiments in which whitetail deer carcasses were held at 10°C for periods of 24 or 48 h, the HTC sides of the more heavily muscled elk carcasses held at 6°C for 24 h did not suffer any greater cooler weight losses during chilling than their conventionally chilled counterparts. The LT muscles of the HTC sides were brighter (P=0.0001), had a more highly saturated color (P=0.014), and lower 24 h pH (P=0.004) compared to the contra-lateral control sides. Drip losses were not affected by chilling treatment.

It is generally accepted that consumers who have no training in assessing sensory attributes of meat would be unlikely to detect differences in tenderness of meat samples differing in shear value by less than one unit (1 kg) (L.E. Jeremiah, personal communication). A rather moderate high temperature conditioning regime employed in this study reduced the average shear value of grilled elk steaks by 0.9 kg (P=0.009). Average or mean values can be misleading, particularly where the number of samples is small such as is the case in this study, where two or three high values can skew the results in favor of one factor over the other. Therefore it is important to consider how the differences in average shear values arose. Figure 2 presents the individual animal differences between CC and HTC sides. In eleven of 26 cases (42%) the average shear value of the CC side was more than 1 kg higher than the HTC side, while in only 1 of 26

cases (4%) did the average shear value of the HTC side exceed that of the CC side by more than 1 kg. Furthermore, seven of 26 (27%) CC sides had average shear values which were more than 2 kg higher than their contra-lateral HTC sides. The HTC treatment also reduced the within animal variation (standard deviation) in shear value from 1.760 in control samples compared to 1.043 in HTC samples ( $P=0.005$ ). In summary, then, the trial provided evidence of the efficacy of even a moderate high temperature conditioning treatment for optimizing tenderness. Shear values in general, for this experiment, were much lower than previous results obtained at Lacombe. This may be due, in part, to improved pre-slaughter handling and lairage, degree of aging of the muscle samples, different cooking methods, and the lower end point temperature used for cooking in the current study. A significant portion of the difference in shear values is likely due to handling of samples prior to cooking. In previous studies, the muscle samples were cooked from the fresh state, while in the current study the samples were frozen and slow thawed. Drew *et al.* (1988) found venison samples which had been frozen and thawed were often considerably more tender than non-frozen ones, with improvements in tenderness ranging from 10 to 40%, depending on species and muscle.

#### *Cooking end point temperature*

Various research reports describe cooking venison for tenderness evaluations by immersion in a hot water bath for a specified period of time (Drew *et al.*, 1987, Chrystall *et al.*, 1983), rather than cooking to a specified end point temperature. Prior to cooking the main body of samples in this experiment, the drip steaks were used to establish the end point temperature which would provide consistently lower and less variable shear values. The results of this part of the study should be evaluated in the context that it was done solely to establish the most suitable end point temperature for the rest of the trial, and was not a properly designed experiment although care was taken to distribute samples from different ages and treatments as evenly as possible among the three temperatures chosen. Nonetheless it is of interest to note (Table 7) that average shear values of steaks cooked to 67°C were approximately 1 kg lower than the average shear

values of steaks cooked to either 63°C or 71°C. In addition, the within steak variation (standard deviation) of the samples cooked to the intermediate end point temperature was 27% lower than the variation found for steaks cooked to the lower or higher temperature. Therefore the end point temperature selected for the experiment was 67°C. The steaks cooked to 63°C were visually assessed as being blue rare to rare, those cooked to 67°C as being rare to medium rare, and those cooked to 71°C as being medium to medium well.

### *Potential for yield grading*

Table 8 presents the cut out data for all 26 animals, showing the variation obtained in yield of individual cuts, total cuts and total meat yield for carcasses from animals ranging in age from 2 to 4 years. While these carcasses had relatively low levels of dissectable fat compared to typical beef carcasses (Jones *et al.*, 1987), there was still a range of 5 to 6% in yield of total cuts and total meat yield suggesting a range in carcass value. Based on the average hot carcass weight of 200 kg, the 5% range in total cuts would represent an additional 10 kg of valuable cuts and specialty items, which is of significant economic value. Consequently, and particularly if carcasses with a wider range of conformation and fatness are presented for slaughter, it may be important to begin to lay the foundation for a yield grading system. Simple carcass measurements were made using a ruler and transparent grid, and various regression models developed to predict percentage yield of total cuts (Table 9) and total meat yield (Table 10). Accuracy of the regression models is expressed in the coefficient of determination ( $R^2$  value). A higher  $R^2$  value indicates that the model explains a greater proportion on the variation in the variable being predicted, in this case yield percentage. Precision is typically expressed as the standard deviation of the difference between the predicted value and the actual value established by cut out. In this study, models combining a single fat thickness measurement, the GR measurement and hot carcass weight were able to explain approximately 70% of the variation in yield of total cuts and/or total meat yield. The standard deviation of the difference in predicted and actual yield was 0.74% and 0.84% for total cuts and total meat yield, respectively. A slight improvement in prediction accuracy and precision was achieved by adding rib eye

area to the model for prediction of cut yield but not for prediction of total meat yield. These values can be compared to similar types of equations used to predict lean yield in beef carcasses which typically have  $R^2$  values in the order of 0.50 to 0.58, and residual standard deviations of approximately 3% (Jones *et al.*, 1989). Much greater accuracy and precision can be achieved using image analysis, such as has been accomplished using the Lacombe Computer Vision System for prediction of salable yield in beef carcasses, but this type of technology will be economically prohibitive for the grading of small numbers of elk carcasses, in the near term.

It should be stressed that the number of carcasses which were cut out in this trial is grossly insufficient to establish robust regression equations for prediction of yield. It should also be recognized that the preferred method for evaluating models is to establish the model on one set of carcasses and test it against another set of carcasses. However, the results do indicate that simple carcass measurements may be used successfully to predict yield, and hence carcass value.

### *References*

Aalhus, J.L., Jones, S.D.M., Tong, A.K.W., Jeremiah, L.E., Robertson, W.M. and Gibson, L.L. 1992. The combined effects of time on feed, electrical stimulation and aging on beef quality. *Can. J. Anim. Sci.* **72**: 525-535.

Chrystall, B.B. and Devine, C.E. 1983. Electrical stimulation of deer carcasses. *New Zealand Journal of Agricultural Research*, Vol. 26, 89-92.

Cook, N., Schaefer, A., Robertson, W., Church, T., Church, J. and Ritten, R. 2000. The evaluation of meat yield and quality and the attenuation of transport, handling and velvet stress in elk. Interim report prepared for the Alberta Elk Association, October, 2000.

Drew, K.R., Crosbie, S.F., Forss, D.A., Manley, T.R. and Pearse, A.J. 1988. Electrical stimulation and ageing of carcasses from red, fallow and New Zealand elk-type male deer. *J. Sci. Food Agric.* **43**: 245-259.

Jones, S.D.M., Tong, A.K.W. and Robertson, W.M. 1987. The effects of carcass grade and sex on the lean content of beef carcasses. *Can. J. Anim. Sci.* **67**: 205-208.

Jones, S.D.M., Tong, A.K.W. and Robertson, W.M. 1989. The prediction of beef carcass lean content by an electronic probe, a visual scoring system and carcass measurements. *Can. J. Anim. Sci.* **69**: 641-648.

Lawrie, R.A. 1979. *Meat Science*, Third Edition. Pergamon Press, Oxford, England. Pp. 328 – 330.

Tatum, D. 1997. *Beef Facts: Beef Grading*. National Beef Cattlemen's Association. Chicago, Ill 60611, 4 pp.

Table 1. Effect of animal age on carcass characteristics.

	Age of animal (years)		
	2	3	4
n	6	10	10
Final live wt., kg	295.3 $a$	319.6 $a$	366.8 $b$
Hot carcass wt., kg	173.4 $a$	190.7 $a$	225.7 $b$
HCW, % of final live wt.	58.7 $a$	59.3 $ab$	60.2 $b$
Cooler shrink, %	1.63	1.53	1.46
Rib eye area <sup>1</sup> , sq. cm.	58.5 $a$	61.8 $ab$	66.5 $b$
Average fat <sup>1</sup> , mm	0.8	1.5	2.3
Minimum fat in 4 <sup>th</sup> quadrant <sup>1</sup> , mm	1.1	2.0	2.8
GR measurement <sup>2</sup> , mm	32.5	38.7	41.6

$ab$  Least square means accompanied by different letters are significantly different ( $P < 0.05$ )

<sup>1</sup> Measurements made at the 12<sup>th</sup> rib.

<sup>2</sup> GR measurement is total thickness of tissue at 7 cm from the tip of the rib eye muscle.

Table xx. Effect of animal age on carcass composition (% of side)

	Age of animal (years)		
	2	3	4
n	6	10	10
Hot carcass wt., kg	173.4 <sub>a</sub>	190.7 <sub>a</sub>	225.7 <sub>b</sub>
2 X 3 Boneless rib	3.11	3.19	3.02
Inside round	4.22	4.20	3.93
Outside round	3.61	3.56	3.43
Eye of round	1.41	1.38	1.38
Sirloin tip, peeled	4.87 <sub>b</sub>	4.67 <sub>ab</sub>	4.39 <sub>a</sub>
1 X 0 Strip loin	3.60	3.62	3.50
Top butt	2.45	2.37	2.34
Tenderloin, whole	1.55	1.50	1.50
Hind shank meat	1.88	1.85	1.76
Osso buko	2.42	2.43	2.18
<b>Total cuts</b>	29.13 <sub>b</sub>	28.77 <sub>b</sub>	27.43 <sub>a</sub>
Stew meat	6.90	8.13	8.31
85% Lean	39.39 <sub>ab</sub>	38.67 <sub>a</sub>	40.79 <sub>b</sub>
<b>Total meat yield</b>	75.42	75.57	76.53
Readily dissectable fat	8.04	9.52	9.60
Bone	16.54 <sub>b</sub>	14.91 <sub>a</sub>	13.87 <sub>a</sub>

*ab* Least square means accompanied by different letters are significantly different (P<0.05)

Table 3. Effect of animal age on meat quality traits.

	Age of animal (years)		
	2	3	4
L* (brightness)	29.0 <i>b</i>	28.8 <i>b</i>	28.2 <i>a</i>
Chroma (saturation)	18.0	17.8	17.8
Hue angle	20.3	20.3	20.5
pH initial (50 min post-mortem)	6.72	6.72	6.65
PH (24 h)	5.67	5.64	5.67
Drip loss in retail package, %	0.82	0.82	0.79
Shear value, kg	6.667 <i>b</i>	5.972 <i>ab</i>	5.428 <i>a</i>

*ab* Least square means accompanied by different letters are significantly different (P<0.05)

Table 4. Effect of pre-slaughter Nutri-charge™ treatment on carcass characteristics.

	Control	Treated	P
n	13	13	
Final live wt., kg	317.3	337.1	0.20
HCW, % of plant wt.	59.4	59.4	0.95
Cooler shrink, %	1.54	1.54	0.96
Total yield of cuts, % of side	28.6	28.3	0.57
Total meat yield, % of side	75.1	76.6	0.02

Table 5. Effect of pre-slaughter Nutri-charge™ treatment on meat quality.

	Control	Treated	P
L* (brightness)	28.8	28.6	0.41
Chroma (saturation)	17.9	17.8	0.87
Hue angle	20.3	20.4	0.91
pH initial	6.72	6.69	0.38
pH (24 h)	5.64	5.68	0.011
Drip loss in retail package, %	0.83	0.80	0.39
Shear value, kg	5.751	6.293	0.11

Table 6. Effect of cooler temperature on carcass shrink and meat quality.

	Average cooler temperature		P
	1.7°C	6.2°C	
Cooler shrink, %	1.49	1.59	0.31
L* (brightness)	28.1	29.2	0.0001
Chroma (saturation)	17.4	18.3	0.014
Hue angle	20.3	20.5	0.21
pH (24 h) <sup>1</sup>	5.69	5.64	0.004
Drip loss in retail package, %	0.83	0.79	0.34
Shear value, kg	6.476	5.569	0.009

<sup>1</sup> Initial pH measured at 50 min post-mortem was 6.70 for both control (1.7°C) and high temperature conditioned (6.2°C) sides.

Table 7. Effect of end point temperature on shear value.

Average shear value, kg	End point temperature (°C)		
	63	67	71
n	18	16	18
Mean	6.890 <i>b</i>	5.997 <i>a</i>	6.986 <i>b</i>
Standard deviation	1.450	1.060	1.484

*ab* Least square means accompanied by different letters are significantly different (P<0.05)

Table 8. Carcass cut out (% of side)

	Over all animals (n = 26)		
	Mean	Minimum	Maximum
Hot carcass wt., kg	199.6	161.8	263.0
2 X 3 Boneless rib	3.12	2.58	3.52
Inside round	4.07	2.71	4.57
Outside round	3.51	2.91	4.25
Eye of round	1.39	1.14	1.64
Sirloin tip, peeled	4.60	3.93	5.18
1 X 0 Strip loin	3.56	3.15	3.94
Top butt	2.38	2.09	2.71
Tenderloin, whole	1.51	1.34	1.67
Hind shank meat	1.82	1.45	2.07
Osso buko	2.33	1.80	2.84
<b>Total cuts</b>	<b>28.29</b>	<b>25.85</b>	<b>30.74</b>
Stew meat	7.88	5.10	11.06
85% Lean	39.71	35.71	44.00
<b>Total meat yield</b>	<b>75.87</b>	<b>72.72</b>	<b>78.54</b>
Readily dissectable fat	9.21	5.68	14.40
Bone	14.91	12.22	17.76

Table 9. Utility of various carcass measurements for prediction of yield of total cuts expressed as a percentage of side weight.

Measurements included in the model	R <sup>2</sup>	+ HCW
GR measurement	0.53	0.68
Minimum fat in 4 <sup>th</sup> quadrant	0.43	0.66
Average fat	0.51	0.66
Rib eye area (REA)	0.24	0.54
Minimum fat + GR <b>(Equation 1)</b>	0.54	0.69
Average fat + GR	0.59	0.69
Minimum fat + REA	0.46	0.68
Average fat + REA	0.52	0.67
Minimum fat + GR + REA <b>(Equation 2)</b>	0.55	0.71
Average fat + GR + REA	0.59	0.72
Hot carcass weight (HCW)	0.54	

### Equation 1

Estimated yield (%) of cuts =  
 $34.603 - 0.121(\text{minimum fat, mm}) - 0.047(\text{GR, mm}) - 0.021(\text{HCW, kg})$

Standard deviation of difference (predicted – actual) = 0.74%

### Equation 2

Estimated yield (%) of cuts =  
 $33.052 - 0.144(\text{minimum fat, mm}) - 0.051(\text{GR, mm}) + 0.048(\text{REA, cm}^2) - 0.028(\text{HCW, kg})$

Standard deviation of difference (predicted – actual) = 0.71%

Table 10. Utility of various carcass measurements for prediction of total meat yield expressed as a percentage of side weight.

Measurements included in the model	R <sup>2</sup>	+ HCW
GR measurement	0.23	0.66
Minimum fat in 4 <sup>th</sup> quadrant	0.24	0.56
Average fat	0.16	0.56
Rib eye area (REA)	0.005	0.098
Minimum fat + GR <b>(Equation 1)</b>	0.26	0.70
Average fat + GR	0.23	0.73
Minimum fat + REA	0.37	0.56
Average fat + REA	0.30	0.56
Minimum fat + GR + REA <b>(Equation 2)</b>	0.44	0.70
Average fat + GR + REA	0.42	0.73
Hot carcass weight (HCW)	0.069	

### Equation 1

$$\text{Estimated total meat yield (\%)} = 72.349 - 0.260(\text{minimum fat, mm}) - 0.116(\text{GR, mm}) - 0.043(\text{HCW, kg})$$

$$\text{Standard deviation of difference (predicted - actual)} = 0.84\%$$

### Equation 2

$$\text{Estimated total meat yield (\%)} = 71.876 - 0.267(\text{minimum fat, mm}) - 0.117(\text{GR, mm}) + 0.015(\text{REA, cm}^2) - 0.041(\text{HCW, kg})$$

$$\text{Standard deviation of difference (predicted - actual)} = 0.84\%$$

Figure 1. Temperature decline in the longissimus muscle of elk carcass sides subjected to two temperature regimes.

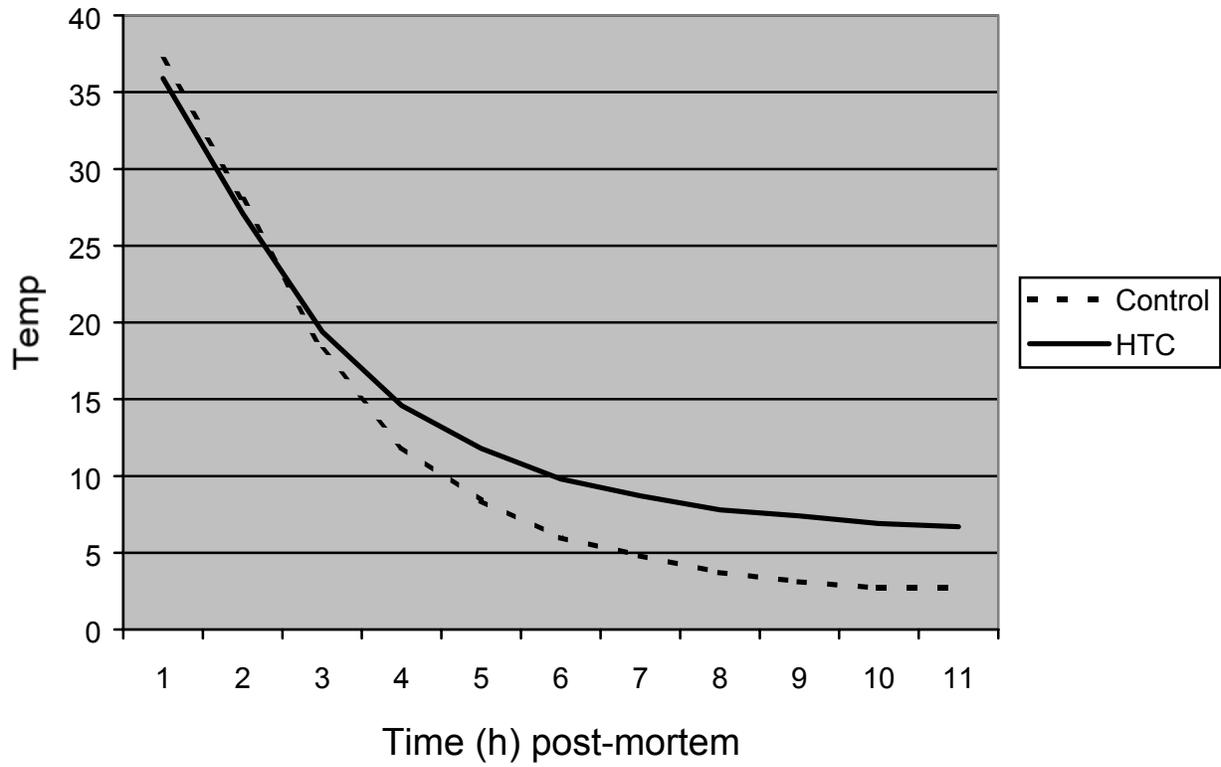


Figure 2. Individual animal differences in average shear values between CC and HTC sides (CC – HTC).

