Effects of early castration on carcass composition, yield and quality characteristics of meat from young reindeer (Rangifer tarandus tarandus) bulls and steers

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Abstract: Thirty male reindeer; \( n=6 \) bulls (control treatment) and \( n=4 \) steers (castrated males) were used to evaluate the effects of early castration on carcass yield and meat quality attributes. The reindeer were castrated at 2 and 13 months of age, and then slaughtered at 2 and 3 years of age. Live weights and carcass weights were significantly highest in the 3 year old bulls and steers. Dressing percentage did not differ between the 2 and 3 year old reindeer steers castrated at 2 months; however these values were higher than for 2 year old steers castrated at 13 months. Meat ultimate pH values (measured in the striploin; LD) were significantly highest in 2 year old steers castrated at 13 months and their corresponding control group of 2 year old bulls, indicating low muscle glycogen stores at slaughter. Castration had an effect on fat content with 3 year old steers having a higher fat content than bulls. No significant differences were found in any sensory attribute when the trained panel compared the meat from 2 year old reindeer bulls and steers.

Key words: carcass meat yield, castration, meat pH values, reindeer meat, sensory evaluation.

Introduction
The Alaskan reindeer industry has produced meat for subsistence and local use and has at times been an important export commodity (Stern et al., 1980). Currently, Alaskan reindeer herders manage for and slaughter adult steers (castrated males > 3 years old) (Alaska Agriculture Statistics, 1990-2006). This management system is designed to improve meat quality and increase carcass yield during winter. The steers are expected to maintain an acceptable nutritional status over the winter compared with bulls that might lose considerable body mass and muscle energy stores during the rutting season. The current method practised for castration of male reindeer on the Seward Peninsula involves that the animals are wrestled to the ground, restrained by a team of workers and castrated. Adult reindeer on the Seward Peninsula are large animals (Finstad & Prichard, 2000) and difficult to handle so this
method is labour intensive and exposes both the animal and workers to potential injury. Reindeer producers would prefer to castrate younger animals, thereby reducing labour costs and the risk of injury but they are concerned that this method may constrain future growth and negatively influence carcass yield and quality.

It is essential for reindeer meat producers, abattoir managers and wholesale distributors to have knowledge about carcass composition and the yield of primal and lower quality cuts of different animal categories to estimate potential market value. Earlier work has described carcass composition and yield of reindeer bulls, cows and calves from Nunivak Island, Alaska (Renecker et al., 2005) and adult reindeer steers (>3 years old) from the Seward Peninsula, Alaska (Wiklund et al., 2008).

The major purpose of this study was to evaluate a new animal category for the Alaskan reindeer meat market by comparing the effects of early castration (at 2 and 13 months of age) on carcass yield and meat quality attributes.

Material and methods

Animals

In this study, 30 male reindeer (n=16 bulls; control treatment and n=14 steers; castrated males) were included to evaluate the effects of early castration on carcass yield and meat quality attributes. Reindeer were slaughtered at two years of age in Group 1 (n=6 bulls) and Group 2 (n=7 steers) with steers castrated at 13 months of age. Animals were slaughtered at two years of age in Group 4 (n=5 bulls) and Group 6 (n=4 steers) but steers were castrated at two months of age. Finally, animals were slaughtered at 3 years of age Group 3 (n=5 bulls) and Group 5 (n=3 steers) with steers castrated at 2 months.

All animals came from the same reindeer herd (Noyakuk, Teller, Alaska) and were slaughtered in late winter (March) of 2005 and 2007. Animals slaughtered in 2005 (Groups 1 and 2) were herded into a fenced alley-way and shot in the field. Animals slaughtered in 2007 (Groups 3 to 6) were herded to a corral, restrained in a squeeze chute, stunned with a captive bolt and bled. The carcasses were then gutted, dressed and transported from the field slaughter site. The whole carcasses were frozen at 48 h post slaughter and transported to Fairbanks for boning at a meat processing facility. Samples for sensory evaluation (M. longissimus, LD) were collected at the time of boning from reindeer in Groups 1 and 2.

Meat pH and temperature, carcass yield and composition

Ultimate pH values and temperatures in M. longissimus (LD, at the last rib) were measured at boning using a portable pH meter (Knick Elektronische Messgeräte GmbH & Co, Germany) equipped with a Xerolyte electrode (InLab®427, Mettler Toledo, Switzerland) and a digital thermometer (Comark, DT 300, Beaverton, OR, USA).

Carcasses were split and the left side was used to determine the yield of commercial cuts as described by Wiklund et al., 2005. Definitions of the cuts presented in Table 2 are as follows: hindquarter (major part of the hind-quarter of the carcass without shank, pelvic bone, vertebrae and flank muscles but including the M. glutaeus medius, M. quadriceps femoris, M. biceps femoris, M. semitendinosus and M. semimembranosus), inside (M. longissimus with bone), outside (M. biceps femoris and M. semitendinosus), sirloin tip (M. quadriceps femoris), tenderloin (M. psoas major), striploin (M. longissimus), forequarter (neck, chuck and shoulder including M. triceps brachii, M. supra spinatus and M. infra spinatus with bone and shank), shoulder (M. triceps brachii, M. supra spinatus and M. infra spinatus with bone and shank), shoulder clod (M. deltoideus, M. teres major, M. triceps brachii capit group: longum, mediale, laterales infraspinatus) and chuck roll (M. longis-
Sensory evaluation

The work was performed at the Co-operative Extension Service, Food Product Development Kitchen (University of Alaska Fairbanks). A descriptive test, conventional profiling (ISO 6564, 1985), was carried out by a selected and trained sensory panel (ISO 8586-1, 1993) consisting of seven members. The sensory training was performed in accordance with ISO 6564 (1985). All assessments were carried out in a sensory laboratory with separate booths equipped with Compusense® five, an automated data collection system (Compusense Inc., 2004) and under normal white light (ISO 8589, 1988).

Upon thawing, the loin samples were put in a refrigerator at +3 °C for 17 h. The meat was cooked in a conventional oven at 50 °C to a core temperature of 70 °C. Internal temperature in each loin was monitored with copper-constantan thermocouples (Type T, Omega Engineering, Stamford, CT, USA) and a Barnant scanning digital thermometer (Model 692-0000, Barnant Co., Barington, IL, USA). At every session, the panel members were served meat samples from 7 to 9 animals at the same time, each sample consisting of one slice of meat. Samples were placed in plastic cups coded with three-digit numbers and were served to the panel members in randomised order, at room temperature and in two replicates. The following attributes were selected and unanimously agreed upon during panel training: smell intensity, tenderness, juiciness, gamey flavour, blood flavor, liver flavour and sweet flavour. An unstructured continuous line scale from 0 (low intensity) to 10 (high intensity) was used.

### Table 1. Carcass and meat quality characteristics (least-squares means ± standard errors) in M. longissimus (LD) from reindeer bulls (n = 14) of two ages; 2 years old (2y) and 3 years old (3y) included in the study.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Castrated at 2 months</th>
<th>Castrated at 3 months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1 (Bulls 2y)</td>
<td>Group 2 (Steers 2y)</td>
</tr>
<tr>
<td></td>
<td>n = 6</td>
<td>n = 7</td>
</tr>
<tr>
<td>Live weight, (kg)</td>
<td>80.8 ± 3.4</td>
<td>86.7 ± 3.7</td>
</tr>
<tr>
<td>Carcass weight, (kg)</td>
<td>41.0 ± 1.8</td>
<td>48.5 ± 1.2</td>
</tr>
<tr>
<td>Dressing, (%)</td>
<td>51.0 ± 1.4</td>
<td>57.9 ± 1.5</td>
</tr>
<tr>
<td>Ultimate pH (LD)</td>
<td>6.28 ± 0.09</td>
<td>5.63 ± 0.11</td>
</tr>
<tr>
<td>Temperature LD, °C</td>
<td>-0.5 ± 0.7</td>
<td>-0.9 ± 0.7</td>
</tr>
</tbody>
</table>

#### Statistical analysis

The statistical analyses were carried out with the Statistical Analysis System (SAS Institute, 2003) using the GLM and MIXED procedures. The model for comparing carcass characteristics and composition, meat ultimate pH and temperature included the fixed effect of treatment group. Significance was defined as

\[ P \leq 0.01; \quad ** = P \leq 0.001. \]
Table 2. Carcass yield and composition (least-squares means ± standard errors) in reindeer bulls (n = 16) and steers (n = 14) of two ages; 2 years old (2y) and 3 years old (3y) included in the study.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Castrated at 13 months</th>
<th>Castrated at 2 months</th>
<th>Degree of sign.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1 (Bulls 2y n = 6)</td>
<td>Group 2 (Steers 2y n = 7)</td>
<td>Group 3 (Bulls 3y n = 5)</td>
</tr>
<tr>
<td>Side weight (SW), (kg)</td>
<td>23.1 ± 0.8</td>
<td>21.7 ± 0.8</td>
<td>25.7 ± 0.9</td>
</tr>
<tr>
<td>Hindquarter, (kg)</td>
<td>9.2 ± 0.3</td>
<td>8.5 ± 0.3</td>
<td>9.1 ± 0.3</td>
</tr>
<tr>
<td>Hindquarter, (% of SW)</td>
<td>39.7 ± 0.6</td>
<td>39.1 ± 0.5</td>
<td>35.4 ± 0.6</td>
</tr>
<tr>
<td>Inside, (kg)</td>
<td>1.7 ± 0.05</td>
<td>1.5 ± 0.04</td>
<td>1.5 ± 0.05</td>
</tr>
<tr>
<td>Inside, (% of SW)</td>
<td>7.4 ± 0.2</td>
<td>7.0 ± 0.2</td>
<td>5.9 ± 0.2</td>
</tr>
<tr>
<td>Outside, (kg)</td>
<td>1.0 ± 0.04</td>
<td>0.9 ± 0.04</td>
<td>1.0 ± 0.04</td>
</tr>
<tr>
<td>Outside, (% of SW)</td>
<td>4.5 ± 0.1</td>
<td>4.4 ± 0.1</td>
<td>3.8 ± 0.1</td>
</tr>
<tr>
<td>Sirloin tip, (kg)</td>
<td>1.3 ± 0.04</td>
<td>1.2 ± 0.04</td>
<td>1.2 ± 0.04</td>
</tr>
<tr>
<td>Sirloin tip, (% of CW)</td>
<td>5.7 ± 0.1</td>
<td>5.5 ± 0.1</td>
<td>4.9 ± 0.2</td>
</tr>
<tr>
<td>Tenderloin, (kg)</td>
<td>0.3 ± 0.02</td>
<td>0.3 ± 0.02</td>
<td>0.4 ± 0.02</td>
</tr>
<tr>
<td>Tenderloin, (% of CW)</td>
<td>1.5 ± 0.06</td>
<td>1.5 ± 0.06</td>
<td>1.5 ± 0.06</td>
</tr>
<tr>
<td>Striploin, (kg)</td>
<td>0.8 ± 0.04</td>
<td>0.8 ± 0.04</td>
<td>0.9 ± 0.05</td>
</tr>
<tr>
<td>Striploin, (% of SW)</td>
<td>3.3 ± 0.1</td>
<td>3.5 ± 0.1</td>
<td>3.4 ± 0.2</td>
</tr>
<tr>
<td>Forequarter, kg</td>
<td>9.9 ± 0.4</td>
<td>9.4 ± 0.4</td>
<td>11.0 ± 0.4</td>
</tr>
<tr>
<td>Forequarter, (% of SW)</td>
<td>42.8 ± 0.7</td>
<td>43.5 ± 0.6</td>
<td>42.6 ± 0.8</td>
</tr>
<tr>
<td>Shoulder, (kg)</td>
<td>4.4 ± 0.2</td>
<td>4.2 ± 0.2</td>
<td>5.2 ± 0.2</td>
</tr>
<tr>
<td>Shoulder, (% of SW)</td>
<td>19.0 ± 0.3</td>
<td>19.4 ± 0.3</td>
<td>20.1 ± 0.4</td>
</tr>
<tr>
<td>Shoulder clod, (kg)</td>
<td>1.7 ± 0.09</td>
<td>1.6 ± 0.08</td>
<td>2.2 ± 0.1</td>
</tr>
<tr>
<td>Shoulder clod, (% of SW)</td>
<td>7.2 ± 0.3</td>
<td>7.5 ± 0.3</td>
<td>8.8 ± 0.4</td>
</tr>
<tr>
<td>Chuck roll, (kg)</td>
<td>1.4 ± 0.1</td>
<td>1.4 ± 0.1</td>
<td>1.6 ± 0.1</td>
</tr>
</tbody>
</table>
For the trained panel work, the model included the random effects animal and panel member, as well as the fixed effect of treatment group.

**Results and discussion**

**Meat pH and temperature, carcass yield and composition**

Live weights and carcass weights were significantly highest in the 3 year old bulls (Group 3) and steers (Group 5) (Table 1). However, dressing percentage did not differ between the Groups 3, 4, 5, and 6 (2 and 3 year old reindeer) which all showed higher values compared with Groups 1 and 2. Meat ultimate pH values (measured in the striploin; LD) were significantly highest in Groups 1 and 2 compared with all other groups, indicating low muscle glycogen stores at slaughter (Table ).

The present values for live weights and carcass weights are slightly lower than values reported for older reindeer steers (> 3 years old) from the Seward Peninsula, Alaska (Wiklund et al., 2008) but higher than values found for adult Swedish reindeer (Wiklund et al., 2000) and for reindeer slaughtered on Nunivak Island, Alaska (Renecker et al., 2005). High ultimate pH values in venison (deer meat) have been related to pre-slaughter handling stress (Wiklund et al., 1996; Pollard et al., 1999) and poor nutritional status of the animals (Wiklund et al., 1996; Pollard et al., 2002). The high pH values measured in Groups 1 and 2 in the present study were probably related to a combination of pre-slaughter stress during prolonged herding and animals in lower body condition and nutritional status than the other groups. This assumption is supported by the lower dressing percentage values of animals from Groups 1 and 2 and also by the fact that pre-slaughter handling times for herding and selection of slaughter animals were similar in both years of the experiment (2005 and 2007). Adequate muscle glycogen stores at slaughter will guarantee optimal pH values in venison of about 5.5 to 5.7, as demonstrated in the meat from Groups 3 to 6 in the present study.

The two year old bulls and steers in Groups 4 and 6 consistently had the lowest weights for all hindquarter cuts, including the striploin (Table 2). Surprisingly, the weights of these hindquarter cuts from the two year old bulls and steers in Groups 1 and 2 were very similar to those of three year old animals. Comparing reindeer in Groups 1 and 2 significantly lower weights for the cuts inside and sirloin tip were recorded for the steers (Group 2) (Table 2). In contrast, for
animals castrated at two months of age there
were no differences in weights of hindquarter
cuts when comparing reindeer bulls and steers
of the same age (Table 2).

For the forequarter cuts, significantly higher
weights were registered for the three year old
bulls and steers (Groups 3 and 5) compared
with all the other groups but no difference was
found between Groups 3 and 5. The two year
old bulls and steers castrated at different ages
showed similar weights of all forequarter cuts
(Table 2). Bone content in the carcasses were
highest for the bulls in Groups 3 and 4 (two
and three years old), while the total carcass fat
content were low in all Groups (ranging from
0.4% to 1.9%) (Table 2).

Similar carcass composition values to those
of the present study for reindeer have been
reported for Swedish adult reindeer bulls
(Wiklund et al., 2000), the present figures are
also, as expected, slightly lower for all included
yield data than results reported for older Alas-
kan reindeer steers (> 3 years old) (Wiklund
et al., 2008). Castration of deer has been dem-
onstrated to affect animal live weight gain and
carcass composition, mainly the fat content
(Drew et al., 1978; Mulley & English, 1985;
Freudenberger et al., 1991). The present study
indicated no differences in whole hindquarter
weight for steers castrated at two or 13 months
of age (Groups 6 and 2 respectively), however
the reindeer in Group 2 showed higher weights
for the valuable cuts inside, outside and strip-
loin (Table 2). Castration seemed to have an
effect on fat content in the three year old ani-
imals, where steers had higher fat content than
bulls. Therefore, the present results are in
good agreement with previous published data
as well as traditional knowledge among rein-
der hearers.

Sensory evaluation
No significant differences were found in any
sensory attribute when comparing meat from
the reindeer bulls (Group 1) and steers (Group
2). Sensory scores (least-squares means ± stan-
dard errors) indicated intermediate values for
tenderness (values from 5.9 to 6.6 ± 0.6), juic-
iness (value 6.0 ± 0.5 for both groups), smell
intensity (values from 4.8 to 5.3 ± 0.4) and
blood flavour (values from 5.1 to 5.9 ± 0.8)
but low scores for game flavour (values from
3.7 to 3.8 ± 0.4), liver flavour (values from 3.2
to 3.6 ± 0.8) and sweet flavour (values from
3.5 to 3.9 ± 0.6). It was a tendency towards
higher scores for the attributes blood flavour
($P = 0.06$) and liver flavour ($P = 0.1$) in
the meat from the bulls compared with steers.

When comparing the same sensory attri-
butes as in the present study for older Alas-
kan reindeer bulls and steers (> 3 years old)
the results were similar, i.e. no significant dif-
f erences were demonstrated in any sensory
attribute (Wiklund et al., 2006; 2007). Sensory
scores for tenderness and juiciness in reindeer
meat (LD) have been reported to be interme-
diate to high (Wiklund et al., 2003; Renecker
et al., 2005; Rincker et al., 2006), and the results
from the present study are in good agreement
with these previous studies. Flavour differenc-
es in reindeer meat has been related to diet
prior to slaughter, so that grazing free-rang-
ing animals produced meat with more “wild”
and “gamey” flavour compared with reindeer
fed grain-based feed mixtures (Wiklund et al.,
2003; Finstad et al., 2007). It has been suggest-
ed that natural grazing is an important con-
tributor to the development of various “wild”
flavours in meat, possibly depending partly on
effects of the fatty acid composition (Wiklund
et al., 2003). The present study demonstrated
slightly higher values for the attributes blood
flavor and game flavor compared with a previ-
ous study on Alaskan reindeer steers (Wiklund
et al., 2008). However, this difference is sug-
gested to be related to the fact that animals
in the present study were slaughtered later in
the season (mid March compared with late
January) and the ‘gamey’ flavour attributes of reindeer venison have been demonstrated to increase over the slaughter season (Wiklund et al., 2006; 2007).

Conclusions
The results of this study suggest reindeer producers on the Seward Peninsula can castrate male reindeer at two and 13 months of age that will result in a slaughter animal providing good carcass yield and meat quality characteristics. In turn, the producers may realize more profit from their operations by increasing both animal welfare and labour safety and thereby reduce costs and losses to human and animal injury.

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The authors wish to thank the reindeer herder James Noyakuk of Teller, Alaska and all members of the Reindeer Research Program (RRP), University of Alaska Fairbanks for their assistance and cooperation in connection with the slaughter, butchering and collection of samples. We are also grateful to Kamolluck Trateng for her invaluable assistance during the sensory sessions with the trained panel. Financial support for this work was provided by the United States Department of Agriculture (USDA; New Crops Opportunities V, grant no. 2004-34418-15107) and by the RRP.

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Effekter av tidig kastrering på slaktkroppssammansättning, styckningsutbyte och köttkvalitet hos unga renar

Abstract in Swedish / Sammanfattning: Trettio hanrenar; n=6 tjurar (kontrolldjur) och n=4 kastrater (häkar) ingick i denna studie för att utvärdera effekterna av tidig kastrering på slaktkroppssammansättning och köttkvalitetsparametrar. Renarna kastrerades vid 2 respektive 3 månaders ålder och slaktades sedan när de var antingen 2 eller 3 år gamla. Levandevikt och slaktkroppsvikt var högst för 3 år gamla tjurar och härkar. Slaktutbytet skiljde sig inte mellan 2 och 3 år gamla härkar som kastrerats vid 2 månaders ålder, men deras slaktutbyte var högre än för de 2-åriga härkarna som kastrerats vid 13 månaders ålder. Köttets pH-värde (mätt i ytterfilén) var signifikant högst hos de 2-åriga härkarna som kastrerats vid 13 månaders ålder och deras tillhörande kontrollgrupp av 3-åriga tjurar, vilket tydde på låga nivåer av muskelglykogen vid slakt. Kastrering hade en signifikant effekt på fettinnehållet i slaktkropparna hos de 3-åriga renarna, med de högsta fetthalterna hos härkarna. Inga skillnader i ätkvalitet rapporterades när kött från 2-åriga rentjurar och härkar jämfördes.