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*=16 bulls (control treatment) and *n*=14 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.

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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. gluteus 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 brachi capat* group*: longum, mediale. laterales infraspinatus*) and chuck roll (M. *longis-*

simus dorsi, M. spinalais dorsi, M.subscapularis, M. rhomboideus, M. complexus, M. serratus ventralis, M. serratus dorsalis, M. longissimus costarum, M. internal intercostal).

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 ºC for 17 h. The meat was cooked in a conventional oven at 150 °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.

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

Table 1. Carcass and meat quality characteristics (least-squares means ± standard errors) in *M. longissimus* (LD) from reindeer bulls ($n = 16$) and steers ($n = 14$) of two ages; 2 years old (2y) and 3 years old (3y) included in the study.

Trait	Castrated at 13 months			Castrated at 2 months			Degree of sign.[1]
	Group 1 (Bulls 2y $n = 6$)	Group 2 (Steers 2y $n = 7$)	Group 3 (Bulls 3y $n = 5$)	Group 4 (Bulls 2y $n = 5$)	Group 5 (Steers 3y $n = 3$)	Group 6 (Steers 2y $n = 4$)	
Live weight, (kg)	$80.8^{a} \pm 3.4$	$77.8^{a} \pm 3.1$	$93.9^{b} \pm 3.7$	$76.0^{a} \pm 3.7$	$88.7^{ab} \pm 4.8$	$75.8^{a} \pm 4.1$	**
Carcass weight, (kg)	$41.0^{a} \pm 1.8$	$37.7^{a} \pm 1.6$	$53.9^{b} \pm 1.9$	$43.5^{a} \pm 1.9$	$53.8^{b} \pm 2.5$	$42.6^{a} \pm 2.2$	***
Dressing, (%)	$51.0^{a} \pm 1.4$	$48.5^{a} \pm 1.2$	$57.5^{b} \pm 1.5$	$57.4^{b} \pm 1.5$	$60.8^{b} \pm 1.9$	$56.2^{b} \pm 1.7$	***
Ultimate pH (LD)	$6.28^{a} \pm 0.09$	$6.10^{a} \pm 0.08$	$5.63^{b} \pm 0.1$	$5.58^{b} \pm 0.1$	$5.61^{b} \pm 0.1$	$5.64^{b} \pm 0.1$	***
Temperature LD, ºC	$-0.5^{a} \pm 0.7$	$-0.9^{a} \pm 0.7$	$8.4^{b} \pm 0.7$	$7.6^{b} \pm 0.7$	$8.3^{b} \pm 1.0$	$6.8^{b} \pm 0.8$	***

[1] ** = $P \leq 0.01$; *** = $P \leq 0.001$. Comparison between treatment groups, common letters in a row indicate no significant difference at $P > 0.05$.

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.

Trait	Castrated at 13 months			Castrated at 2 months			Degree of sign.[1]
	Group 1 (Bulls 2y n = 6)	Group 2 (Steers2y n = 7)	Group 3 (Bulls 3y n = 5)	Group 4 (Bulls 2y n = 5)	Group 5 (Steers 3y n = 3)	Group 6 (Steers 2y n = 4)	
Side weight (SW), (kg)	23.1^{a} ± 0.8	21.7^{ab} ± 0.8	25.7^{c} ± 0.9	20.4^{b} ± 0.9	25.4^{c} ± 1.2b	20.0^{b} ± 1.0	***
Hindquarter, (kg)	9.2^{ac} ± 0.3	8.5^{ab} ± 0.3	9.1^{ac} ± 0.3	7.4^{b} ± 0.3	9.6^{c} ± 0.4	7.7^{b} ± 0.4	***
Hindquarter, (% of SW)	39.7^{a} ± 0.6	39.1^{ac} ± 0.5	35.4^{b} ± 0.6	36.4^{b} ± 0.6	37.7^{c} ± 0.8	38.4^{ac} ± 0.7	***
Inside, (kg)	1.7^{a} ± 0.05	1.5^{b} ± 0.04	1.5^{b} ± 0.05	1.3^{c} ± 0.05	1.6^{ab} ± 0.07	1.3^{c} ± 0.06	***
Inside, (% of SW)	7.4^{a} ± 0.2	7.0^{ac} ± 0.2	5.9^{b} ± 0.2	6.4^{b} ± 0.2	6.3^{b} ± 0.3	6.5^{bc} ± 0.2	***
Outside, (kg)	1.0^{a} ± 0.04	0.9^{a} ± 0.04	1.0^{a} ± 0.04	0.8^{b} ± 0.04	0.9^{a} ± 0.05	0.8^{b} ± 0.05	***
Outside, (% of SW)	4.5^{a} ± 0.1	4.4^{a} ± 0.1	3.8^{b} ± 0.1	3.8^{b} ± 0.1	3.7^{b} ± 0.2	3.8^{b} ± 0.2	***
Sirloin tip, (kg)	1.3^{a} ± 0.04	1.2^{b} ± 0.04	1.2^{ab} ± 0.04	1.0^{c} ± 0.04	1.3^{a} ± 0.06	1.1^{bc} ± 0.05	***
Sirloin tip, (% of CW)	5.7^{a} ± 0.1	5.5^{a} ± 0.1	4.9^{b} ± 0.2	5.0^{bc} ± 0.2	5.2^{abc} ± 0.2	5.4^{ac} ± 0.2	**
Tenderloin, (kg)	0.3 ± 0.02	0.3 ± 0.02	0.4 ± 0.02	0.3 ± 0.02	0.4 ± 0.02	0.3 ± 0.02	n.s.
Tenderloin, (% of CW)	1.5 ± 0.06	1.5 ± 0.06	1.5 ± 0.06	1.5 ± 0.06	1.6 ± 0.08	1.5 ± 0.07	n.s.
Striploin, (kg)	0.8^{a} ± 0.04	0.8^{a} ± 0.04	0.9^{a} ± 0.05	0.6^{ab} ± 0.05	0.9^{a} ± 0.06	0.6^{b} ± 0.05	**
Striploin, (% of SW)	3.3 ± 0.1	3.5 ± 0.1	3.4 ± 0.2	3.2 ± 0.2	3.6 ± 0.2	3.0 ± 0.2	n.s.
Forequarter, kg	9.9^{ac} ± 0.4	9.4^{ab} ± 0.4	11.0^{c} ± 0.4	8.4^{b} ± 0.4	10.4^{ac} ± 0.6	8.2^{b} ± 0.5	**
Forequarter, (% of SW)	42.8 ± 0.7	43.5 ± 0.6	42.6 ± 0.8	41.2 ± 0.8	40.7 ± 1.0	40.9 ± 0.9	n.s.
Shoulder, (kg)	4.4^{a} ± 0.2	4.2^{a} ± 0.2	5.2^{b} ± 0.2	4.2^{a} ± 0.2	5.0^{b} ± 0.2	4.0^{a} ± 0.2	***
Shoulder, (% of SW)	19.0 ± 0.3	19.4 ± 0.3	20.1 ± 0.4	20.3 ± 0.4	19.7 ± 0.5	19.9 ± 0.4	n.s.
Shoulder clod, (kg)	1.7^{ac} ± 0.09	1.6^{a} ± 0.08	2.2^{b} ±0.1	1.9^{c} ± 0.1	2.2^{b} ± 0.1	1.7^{ac} ± 0.1	***
Shoulder clod, (% of SW)	7.2^{a} ± 0.3	7.5^{a} ± 0.3	8.8^{b} ± 0.4	9.3^{b} ± 0.4	8.8^{b} ± 0.4	8.7^{b} ± 0.4	***
Chuck roll, (kg)	1.4^{ab} ± 0.1	1.4^{ab} ± 0.1	1.6^{a} ± 0.1	1.4^{ab} ± 0.1	1.3^{ab} ± 0.1	1.2^{b}± 0.1	*

Table 2 cont.

Chuck roll, (% of SW)	6.3 ± 0.4	6.5 ± 0.4	6.1 ± 0.4	6.8 ± 0.4	5.3 ± 0.5	5.8 ± 0.5	n.s.
Bone, (kg)	5.9^{ac} ± 0.2	5.4^{a} ± 0.2	6.9^{b} ± 0.2	5.7^{a} ± 0.2	6.7^{bc} ± 0.3	5.3^{a} ± 0.3	***
Bone, (% of SW)	25.7^{a} ± 0.5	24.8^{ac} ± 0.4	27.0^{b} ± 0.5	28.0^{b} ± 0.5	26.4^{ab} ± 0.7	26.4^{ab} ± 0.6	**
Fat, (kg)	0.4^{a} ± 0.06	0.4^{a} ± 0.06	0.2^{b} ± 0.07	0.1^{b} ± 0.07	0.4^{a} ± 0.09	0.2^{b} ± 0.08	**
Fat, (% of SW)	1.7^{a} ± 0.2	1.9^{a} ± 0.2	0.7^{b} ± 0.3	0.4^{b} ± 0.3	1.8^{a} ± 0.4	0.9^{b} ± 0.3	***

[1] n.s. = non significant; * = $P \leq 0.05$; ** = $P \leq 0.01$; *** = $P \leq 0.001$. Comparison between treatment groups, common letters in a row indicate no significant difference at $P > 0.05$.

$P \leq 0.05$. 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 1).

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 Alaskan reindeer steers (> 3 years old) (Wiklund *et al.*, 2008). Castration of deer has been demonstrated 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 striploin (Table 2). Castration seemed to have an effect on fat content in the three year old animals, 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 reindeer herders.

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 ± standard errors) indicated intermediate values for tenderness (values from 5.9 to 6.6 ± 0.6), juiciness (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 attributes as in the present study for older Alaskan reindeer bulls and steers (> 3 years old) the results were similar, *i.e.* no significant differences 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 intermediate 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 differences in reindeer meat has been related to diet prior to slaughter, so that grazing free-ranging 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 suggested that natural grazing is an important contributor 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 previous study on Alaskan reindeer steers (Wiklund *et al.*, 2008). However, this difference is suggested 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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Effekter av tidig kastrering på slaktkroppssammansättning, styckningsutbyte och köttkvalitet hos unga renar

Abstract in Swedish / Sammanfattning: Trettio hanrenar; *n*=16 tjurar (kontrolldjur) och *n*=14 kastrater (härkar) ingick i denna studie för att utvärdera effekterna av tidig kastrering på slaktkroppssammansättning och köttkvalitetsparametrar. Renarna kastrerades vid 2 respektive 13 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 2-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.