

# Comparison of meat quality characteristics, growth, and feed efficiency of intact and castrated post-pubertal bovine males

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## Abstract

Yearling Red Angus or Black Angus bulls (n = 24; initial BW = 1,336 ± 25.1 lb; (606 ± 11.4 kg); average 16 mo of age) were used to evaluate the effects of castration and use of growth promoting technology (STR) on performance, carcass traits, and meat quality characteristics when compared to intact (BULL) post-pubertal male cattle. The STR treatment included administration of a combination 120 mg trenbolone acetate + 24 mg estradiol growth-promoting implant on d 0 and feeding ractopamine hydrochloride the last 28 d on feed. Cattle were individually fed a corn-based finishing diet for 62 d and harvested at a commercial abattoir. Intact bulls had greater average daily gain (4.08 vs 3.19 lb or 1.85 vs 1.45 kg/d; *P* = 0.02) and feed:gain ratio (8.54 vs 10.97; *P* = 0.02) than STR. There were no treatment differences for dry-matter intake, quality or yield grade, hot carcass weight, back-fat thickness, or dressing percent (*P* < 0.05). Longissimus muscle area was greater in BULL compared to STR carcasses (16.6 vs 15.0 in<sup>2</sup> or 106.9 vs 96.8 cm<sup>2</sup>; *P* < 0.01). Warner-Bratzler Shear Force was not affected (*P* > 0.05) by treatment. Intact bulls had improved performance with no differences in carcass characteristics, tenderness, or sensory panel measurements compared to STR treatment.

**Key words:** beef, bulls, carcass, castrated, meat quality

## Résumé

Des taureaux de l'année de race Red ou Black Angus (n = 24; poids initial = 1,336 ± 25.1 lb (606 +/- 11.4 kg); moyenne de 16 mois d'âge) ont été utilisés pour évaluer l'effet de la castration et de l'utilisation de technologie pour promouvoir la croissance (STR) sur la performance, les caractéristiques de la carcasse et la qualité de la viande en comparaison avec des bovins mâles non-castrés post-pubères.

Dans le traitement STR, on a administré un implant avec 120 mg d'acétate de trenbolone et 24 mg d'estradiol au jour 0 et ajouté du chlorhydrate de ractopamine dans la nourriture lors des derniers 28 jours. Les bovins recevaient une portion individualisée d'un régime de finition à base de maïs pendant 62 jours et ont été abattus dans un abattoir commercial. Par rapport aux taureaux STR, le gain moyen quotidien (4.08 v. 3.19 lb (1.85 v. 1.45 kg)/j; *P* = 0.02) de même que la conversion alimentaire (8.54 v. 10.97; *P* = 0.02) étaient plus élevés chez les veaux non-castrés. Il n'y avait pas de différence entre les deux groupes de taureaux pour la consommation de matière sèche, la qualité ou le grade de rendement, le poids de la carcasse chaude, l'épaisseur du gras dorsal ou le pourcentage d'habillage (*P* > 0.05). L'aire du muscle longissimus était plus élevée chez les carcasses de taureaux non-castrés que STR (16.6 v. 15.0 pouces<sup>2</sup> (106.9 v. 96.8 cm<sup>2</sup>); *P* < 0.01). La force nécessaire au cisaillement de Warner-Bratzler n'a pas été affectée par le traitement (*P* > 0.05). Les taureaux non-castrés avaient une meilleure performance que les taureaux STR et il n'y avait pas d'impact sur les caractéristiques de la carcasse, la tendreté ou les mesures d'un panel sensoriel.

## Introduction

Bull breeding soundness evaluations (BSE) are often performed as a critical component of beef cow-herd management.<sup>3,26,3</sup> Carrol et al evaluated 10,940 bulls for breeding soundness evaluating sperm motility, sperm concentration, and sperm morphologic characteristics and reported that approximately 9.5% of bulls failed the BSE and were recommended to be culled.<sup>5</sup> More recently, Troxel et al reported approximately 20% of beef bulls tested for breeding soundness were deemed unsatisfactory potential breeders.<sup>23</sup> Currently, there are approximately 31.2 million beef cows and 2.2 million bulls in the US.<sup>25</sup> The BSE failure rate suggests several hundred thousand bulls will enter the beef market

on an annual basis, and a portion will be young bulls with the potential to be fed and sold to produce saleable meat of USDA Choice or Select quality grade.

Castration of male cattle is a common procedure practiced worldwide, but is more common in the US than in many countries. Behavioral benefits from castration include reduced aggressiveness<sup>13</sup> and sexual activity by reducing testosterone levels.<sup>22</sup> In addition, castrated animals maintain a lower muscle pH, thereby producing fewer “dark cutters”.<sup>13,21,22</sup> Bulls have greater feeding performance and efficiency than steers;<sup>6,9,10</sup> however, a bull’s ability to gain efficiently and produce a leaner carcass, with more value to the packer and retailer, is over-shadowed by the perception that meat from bulls is less tender than meat from steers.<sup>10,18</sup>

Castration methods, either surgical or use of rubber banding, and age at castration influence the potential stress on the animal, resulting in animal welfare and animal performance concerns.<sup>7</sup> Bretschneider reported a greater ( $P < 0.05$ ) stress response in cattle that were castrated > 6 months of age compared to ≤ 6 months of age, regardless of castration method.<sup>4</sup> Furthermore, Knight et al evaluated castration method and age at castration on growth rate and meat quality of post-pubertal bulls and reported that post-pubertal castrates (17 mo of age) had weight loss for 4.5 months following castration.<sup>14</sup> Similarly, Fisher et al reported lower growth rate in 14-month-old cattle castrated by surgical or rubber banding methods compared to intact males.<sup>8</sup> Post-pubertal castration has been shown to prolong wound formation and decreased performance<sup>8</sup> as cattle age beyond puberty, or 10 months of age.<sup>2,16</sup> Therefore, castration of post-pubertal bulls to improve meat quality should be re-evaluated due to animal welfare concerns and decreased animal performance. The objective of this study was to evaluate the effects of castration and use of growth promotion technologies in post-pubertal bulls on feeding performance, carcass traits, and meat quality characteristics compared to intact post-pubertal bulls.

## Materials and Methods

All experimental procedures in this study were conducted in accordance with a protocol approved by the Kansas State University Institutional Animal Care and Use Committee (No. 3390).

### *Animals and experimental design*

The study was conducted at Kansas State University from June through August 2014. Purebred Red Angus and Black Angus bulls ( $n = 30$ ; initial bodyweight (BW) = 1,336 ± 25.1 lb (606 ± 11.4 kg); average age = 16 mo) were used in a randomized complete block design to evaluate the effects of castration of post-pubertal bulls on feeding performance, carcass traits, and meat quality characteristics. Bulls deemed unfit for sale as breeding animals because they failed a BSE were sourced from seed-stock producers in Nebraska, Kan-

sas, and Oklahoma. Bulls were transported to the Kansas State University Juniata Facility in Manhattan, KS, and were provided long-stemmed hay and water ad libitum on arrival at the facility for the first 24 h.

Bulls were individually weighed and vaccinated against type 1 and 2 bovine viral diarrhea virus, infectious bovine rhinotracheitis virus, parainfluenza-3 virus, bovine respiratory syncytial virus;<sup>a</sup> *Clostridium chauvoei*, *Clostridium septicum*, *Clostridium novyi* type B, *Clostridium haemolyticum*, *Clostridium sordellii*, *Clostridium tetani*, and *Clostridium perfringens* types C & D;<sup>b</sup> and administered an anti-parasitic pour-on.<sup>c</sup> Twenty-four of the 30 purebred bulls were selected based on BW uniformity. Bulls were blocked by breed, stratified by weight, and assigned randomly to treatment and pen, so that breed distribution was similar among pens. The animals were either left intact (BULL;  $n = 12$ ) or castrated and administered growth-promoting technologies (STR;  $n = 12$ ); there were 4 animals per pen. Cattle were fed in a Calan Gate<sup>d</sup> individual animal feeding system in 6 outdoor dirt-floor pens approximately 59.1 ft x 11.8 ft (18 m x 3.6 m) with 5 gates per pen. One gate in each pen was locked open to allow for ad libitum access to water while the remaining 4 gates allowed individuals to have ad libitum access to feed. Cattle were acclimated to the pens and Calan Gate feeders for 26 d prior to trial initiation.

On study d 0 all cattle were weighed prior to feeding. Animals assigned to the STR treatment were subsequently castrated using a Callicrate bander<sup>e</sup> and implanted with a combination 120 mg trenbolone acetate + 24 mg estradiol implant.<sup>f</sup> During the last 28 d of feeding, the STR cattle were fed 1.0 lb (0.45 kg)/d of a pellet containing 300 mg/lb (660 mg/kg) ractopamine hydrochloride beta-adrenergic agonist (βAA)<sup>g</sup> to provide 300 mg/hd/d of ractopamine hydrochloride. Cattle in the BULL treatment were not implanted and were fed a similar amount of a placebo pellet the last 28 d on feed. The placebo and βAA pellet consisted of corn, alfalfa meal, and liquid molasses.

Cattle were fed a dry-rolled corn-based total mixed finishing diet for 62 d (Table 1). Diet samples were taken from each individual bunk and mixed together into 1 complete sample and submitted on a monthly basis to evaluate nutrient composition. Feed was delivered daily by 0800, with residuals collected and weighed prior to feed delivery. Cattle were weighed every 14 to 17 d prior to morning feeding. On d 35, the βAA or placebo pellet was introduced and fed for the remaining 28 d. On d 63, cattle were transported approximately 280 miles (450 km) to a commercial abattoir. During the 3 h lairage, animals from the same treatment were penned together to avoid any potential pre-harvest stress due to mixing of bulls and steers.

Thirty-six h postmortem longissimus muscle (LM) samples 2 in (5.1 cm) thick were taken from the left and right side of each carcass at the 12<sup>th</sup> rib. These samples were vacuum sealed, placed on ice, and transported to the Kansas State University meats laboratory for storage at 39.2°F (4°C).

Trained personnel evaluated carcasses and provided data for quality and yield grades using the United States Standards for Grades of Carcass Beef,<sup>24</sup> LM area using video image analysis camera, back-fat thickness, and marbling scores.<sup>24</sup>

#### *Longissimus muscle preparation*

Samples were aged in the vacuum-sealed packaged for 14 d postmortem at 39.2°F (4°C). Longissimus muscle samples were divided into right and left side groups; the right side was used to conduct the Warner-Bratzler Shear Force (WBSF) test and the left side was used to perform sensory panel evaluation. Samples for the sensory panel were frozen at -40°F (-40°C) after 14 d of aging, until the evaluations were completed. Samples for the WBSF test were cut to 1 in (2.54 cm) thickness steaks and cooked in a gas-fired, forced-air-convection oven<sup>h</sup> at 325°F (163°C). Steaks were cooked to an internal temperature of 160°F (71°C) and temperature was measured using a copper-constantan thermocouple<sup>i</sup> placed in the center of the steak.

#### *Warner-Bratzler Shear Force*

Cooked steaks were covered with polyvinyl chloride film and cooled to 35.6°F (2.6°C) for 24 h according to American Meat Science Association procedures.<sup>1</sup> Eight round cores (0.5 in; 1.27 cm) per steak were removed parallel to the long axis of the muscle fibers using a mechanical coring device.<sup>1</sup> All 8 cores from all steaks were sheared once through the middle using a Warner-Bratzler shear attachment (V-notch blade) connected to an Instron<sup>®</sup> Universal Testing Machine.<sup>1</sup>

#### *Sensory panel*

Panel members consisted of 8 graduate students and 1 faculty member. Before starting the sensory panel, panelists were trained by a meat science faculty member during

4 training sessions with 6 to 8 samples per session during which the trainees evaluated test steak samples on the following characteristics: initial juiciness, sustained juiciness, myofibrillar tenderness, connective tissue, overall tenderness, flavor identity, flavor intensity, and off-flavor. After each training sample, results were discussed within the group and a common score was given to each sample for each category.

Samples for the sensory panels were prepared by thawing the steaks at 39.2°F (4°C) for 24 h, then each steak was cut into steaks with a thickness of 1 in (2.54 cm), and cooked in a gas-fired, forced-air-convection oven<sup>h</sup> at 325°F (163°C) until the internal temperature of the steak reached 160°F (71°C), which was measured using a copper-constantan thermocouple<sup>i</sup> placed in the center of the steak. Samples were presented in a randomized order to each of the 8 to 10 panelists. Each sample was given a score (1 = extremely undesirable; 8 = extremely desirable) for each category: initial juiciness, sustained juiciness, myofibrillar tenderness, connective tissue, overall tenderness, flavor identity, flavor intensity, and off-flavor. The sensory panel was conducted over 3 d and all scores were averaged for each steak, and mean values were used for statistical analysis.

#### *Statistical analysis*

Average daily gain, average feed intake, sensory data, and carcass data were analyzed using PROC GLIMMIX procedures of SAS<sup>k</sup> with treatment included as a fixed effect and breed included as a random effect. Final weight was used as a covariate. Sensory panel scores were averaged for each individual animal and averages were used for analysis. Means were generated with the LSMEANS statement and separated using the DIFF function when the F-statistic was significant ( $P < 0.05$ ).

## Results and Discussion

#### *Cattle performance*

Results for ADG, F:G and DMI are presented in Table 2. Cattle in the BULL treatment had greater ADG ( $P = 0.02$ )

**Table 1.** Ingredient composition of study diet to evaluate the effects of castration on post-pubertal male cattle on growth, feed efficiency, and meat quality characteristics.

Ingredient*	% of DM
Dry-rolled corn	58.5
Dried distiller's grains plus solubles	21.5
Cottonseed hulls	12.3
Molasses, cane	2.5
Supplement pellet†	5.2
Chemical composition, DM basis‡	
Dry matter, %	86.6
Crude protein, %	13.8
Calcium, %	
Phosphorus, %	0.45

\*Diet fed without ractopamine hydrochloride from d 1 to 62

†Contained ground corn (90.0%), alfalfa meal (6.0%), and EZ GLO molasses (4.0%)

‡Scott Pro Optaflexx pellet, 882 mg/kg added to the batch at 0.34 kg per animal daily (Elanco Animal Health, Greenfield, IN)

**Table 2.** Least squares means illustrating the effects of castration on growth, feed efficiency, and dry matter intake in 16 mo old post-pubertal bovine males.

Item*	Treatment†			SEM‡
	BULL	STR	Prob > F	
Initial wt, lb	1327	1343	0.65	3.5
Final wt, lb	1554	1519	0.30	55.8
ADG, lb	4.08	3.20	0.02	0.463
DMI, lb	34.8	35.1	0.90	2.293
F:G	8.54	10.97	0.02	0.026

\*Least squares treatment mean

†Intact post-pubertal male bovine (BULL) or castrated via banding of post-pubertal male bovine (STR)

‡Standard error of the least squares mean

compared to cattle in the STR treatment (4.08 and 3.20 lb or 1.85 and 1.45 kg/hd/d, respectively). Feed efficiency was greater ( $P = 0.02$ ) in BULL compared to STR treatments (8.54 vs 10.97). There was no difference in DMI between treatments ( $P = 0.90$ ). These results agree with Knight et al who reported decreased ADG in the finishing period of cattle castrated at 17 months of age compared to intact bulls (1.48 vs 2.18 lb or 0.67 vs 0.99 kg/hd/d, respectively).<sup>14</sup> Similarly, Fisher et al reported slower growth rates in 14-mo-old cattle castrated by surgical or rubber banding methods compared to intact males.<sup>8</sup> Post-pubertal castrates showed weight loss for 4.5 mo after castration, which was hypothesized to be due to castration-associated stress.<sup>14</sup> Additionally, Lee et al reported that implanting resulted in no advantage to weight gain in bulls greater than 12 mo of age.<sup>15</sup> Bretschneider published a review on age and method of castration on the performance of beef cattle and reported a quadratic relationship ( $P < 0.01$ ) between age at castration and weight loss during the first month after castration.<sup>4</sup> Furthermore, weight loss increased quadratically as the age of castration increased, suggesting castration performed as early as possible reduces castration-associated weight loss. Additionally, Worrell et al found that young bulls castrated at 904 lb (410 kg) were less efficient than bulls castrated at a younger age.<sup>27</sup>

**Carcass merit**

No differences ( $P > 0.05$ ) were observed between treatments for HCW, yield grade, quality grade, marbling score, dressing percent, or back-fat thickness (Table 3). Cattle in the BULL treatment had greater LM area than cattle in the STR group (16.57 vs 15.00 in<sup>2</sup> or 106.9 vs 96.8 cm<sup>2</sup>, respectively;  $P < 0.05$ ). These results agree with Knight et al in that post-pubertal castration resulted in carcasses with steer-like carcass merit characteristics.<sup>14</sup> Hunt et al evaluated the effects of implanting bulls with trenbolone acetate and estrogens to enhance performance and reported no improvements

in performance in implanted bulls.<sup>12</sup> Exogenous hormones given to steers in the form of implants have similar effects on carcass characteristics as endogenous hormones that come from testes in intact males.<sup>20</sup>

**Sensory panel**

Treatment had little effect on palatability and tenderness of the LM samples for the 2 treatments. There was no difference ( $P > 0.05$ ) found between groups for WBSF tenderness, connective tissue amount, and myofibrillar tenderness (Table 4). The remainder of the categories from the sensory panel (beef flavor intensity, juiciness, and off-flavor intensity) were also not different ( $P > 0.05$ ). Cattle from the STR treatment tended ( $P = 0.07$ ) to be more tender compared to those from the BULL treatment.

Miller and associates stated that tenderness is the most important factor influencing consumer satisfaction for beef palatability, and the ability of the consumer to evaluate tenderness levels is important in establishing the value of beef.<sup>17</sup> In the present study, WBSF tenderness and the subjective taste panel tenderness were not different between the BULL and STR treatments. Contrarily, Heaton and co-workers found that castrating bulls greater than 536 lb (243 kg) had negative impacts on carcass quality, including tenderness, juiciness, flavor, and overall acceptability.<sup>11</sup>

**Conclusions**

Under the conditions of this study, carcass traits, growth parameters, and meat quality characteristics were not improved by castrating post-pubertal bulls. Previous research has reported severe castration-associated stress resulting in decreased performance in comparable ages, breeds, and methods of castration of post-pubertal bulls. Justification for castration of post-pubertal bulls to improve carcass traits or animal performance needs further research; however, results

**Table 3.** Least squares means illustrating the effects of castration on carcass characteristics in post-pubertal bovine males.

Item*	Treatment†		Prob > F	SEM‡
	BULL	STR		
HCW, lb	983	957	0.36	42.6
Dressing percentage	63.74	63.73	0.99	0.7
LMA§, in <sup>2</sup>	16.57	15.00	< 0.001	1.457
12 <sup>th</sup> rib fat depth, in	0.41	0.40	0.85	0.039
Yield grade	2.73	3.08	0.15	
Quality grade¶	Low Choice	Low Choice	0.34	
Marbling score#	502	502	0.98	

\*Least squares treatment mean

†Intact post-pubertal male bovine (BULL) or castrated via banding of post-pubertal male bovine (STR)

‡Standard error of the least squares mean

§longissimus muscle (ribeye) area

||USDA yield grade calculated from carcass measurements

¶Quality grade reported as USDA Low Choice

#Marbling score units: 400 = Small00, 500 = Modest00

**Table 4.** Least squares means illustrating the effects of castration on Warner-Bratzler Shear Force Test and sensory panel analysis in post-pubertal bovine males.

Item*	Treatment†		Prob > F	SEM‡
	BULL	STR		
Juiciness§	5.22	5.03	0.29	0.13
Overall tenderness	5.26	5.53	0.07	0.10
Beef flavor intensity¶	5.27	5.24	0.86	0.21
Connective tissue amount#	5.93	6.22	0.15	0.41
Myofibrillar tenderness**	5.23	5.42	0.45	0.18
Off flavor intensity††	7.66	7.63	0.81	0.22
Warner-Bratzler Shear Force‡‡	10.6	9.5	0.1	0.46

\*Least squares treatment mean

†Intact post-pubertal male bovine (BULL) or castrated via banding of post-pubertal male bovine (STR)

‡Standard error of the least squares mean

§8 = Extremely juicy, 7 = very juicy, 6 = moderately juicy, 5 = slightly juicy, 4 = slightly dry, 3 = moderately dry, 2 = very dry, 1 = extremely dry

||8 = Extremely tender, 7 = very tender, 6 = moderately tender, 5 = slightly tender, 4 = slightly tough, 3 = moderately tough, 2 = very tough, 1 = extremely tough

¶8 = Extremely intense, 7 = very intense, 6 = moderately intense, 5 = slightly intense, 4 = slightly bland, 3 = moderately bland, 2 = very bland, 1 = extremely bland

#8 = None, 7 = practically none, 6 = traces, 5 = slight, 4 = moderate, 3 = slightly abundant, 2 = moderately abundant, 1 = abundant

\*\*8 = Extremely tender, 7 = very tender, 6 = moderately tender, 5 = slightly tender, 4 = slightly tough, 3 = moderately tough, 2 = very tough, 1 = extremely tough

††8 = None, 7 = practically none, 6 = traces, 5 = slight, 4 = moderate, 3 = slightly abundant, 2 = moderately abundant, 1 = abundant

‡‡lb/1.26 in<sup>2</sup>

of this study strongly suggest that intact bulls should remain intact to eliminate animal welfare concerns arising from castration and castration-induced stress, leading to poorer performance when meat quality is similar between post-pubertal bulls and steers. Furthermore, continued research is needed to evaluate effects of castration on a broader population of genetics and ages of cattle to determine effects on carcass traits, animal welfare and health concerns.

### Endnotes

<sup>a</sup>Pyramid 5, Boehringer Ingelheim Animal Health, St. Joseph, MO

<sup>b</sup>Cavalry 9, Merck Animal Health, Millsboro, DE

<sup>c</sup>Cysectin, Boehringer Ingelheim Animal Health, St. Joseph, MO

<sup>d</sup>American Calan, Northwood, NH

<sup>e</sup>No-Bull Enterprises Animal Health, St. Francis, KS

<sup>f</sup>Revalor-S, Merck Animal Health, Millsboro, DE

<sup>g</sup>Optaflexx, Elanco Animal Health, Greenfield, IN

<sup>h</sup>Blodgett, Model DFG-102 CH3 G.S. Blodgett Co., Burlington, VT

<sup>i</sup>Omega Engineering, Stamford, CT

<sup>j</sup>Model 4201, Instron Corp., Canton, MA

<sup>k</sup>SAS Institute, Inc., Cary, NC

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