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Article

Comparison of surgical castration at birth *versus* immunocastration on carcass and meat traits in growing Holstein males

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Abstract:

Castration of male cattle affects carcass and meat traits. An evaluation was done of the effect of surgical castration at birth and immunocastration on carcass and meat traits in 7-8-mo-old male Holstein calves (average weight= 240.8 kg). Animals in the surgical castration treatment were castrated 24 h after birth, while those in the immunocastration treatment were administered doses of the Bopriva vaccine at 1, 21, 101 and 181 d of growth. Live weight was recorded in both groups at 21, 101 and 181 d, and carcass and meat traits were quantified after slaughter. The surgically-castrated animals exhibited higher average weight (P<0.05), and higher weight at slaughter. Cold carcass weight, hot carcass weight, ribeye area and subcutaneous fat thickness were all higher in the surgically-castrated animals (P<0.05). No differences between treatments were found in meat pH and sheer force (P>0.05), but the b*, C* and H* values were higher in the IC animals (P<0.05). Castration at birth resulted in better average carcass weight and meat traits than immunocastration, but animal welfare must be considered when using surgical castration.

Key words: Inmunocastration, Holstein males, Carcass evaluation.

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Introduction

Castration is a common management tool in beef production. It provides benefits such as reduction of aggressive and sexual behavior which facilitates safer handling. This in turn promotes better carcass quality due to subcutaneous fat deposition and less carcass damage from mounting or aggression in the finishing pen; all these favor animal welfare[1-5]. Surgical castration is the norm but requires additional work and cost, causes prolonged pain in the animal[6,7], and can lead to infections and bleeding[8] or death in some cases[9]. Immunocastration is a non-surgical technique intended to preserve animal welfare when in intensive finishing pens[10]. Immunocastrated males produce an antibody against GnRh that consequently reduces testosterone concentrations[11] and physical activity[12].

Holstein males have been increasingly included in growth pens as a production alternative. This breed differs from traditional meat-producing breeds in its friendly and playful temperament, but can become very aggressive if not castrated[13]. Immunocastration has been

tested in different breeds, with different vaccination programs, diets and implant programs[14-17]. Immunological castration programs need to be evaluated in different production systems (breeds, diets, implants); for instance, Holstein beef cattle in commercial production where final weights greater than 550 kg are required for slaughter. The present study objective was to compare the effects of surgical castration at birth *vs* immunocastration on carcass and meat traits in growing Holstein males.

Material and methods

Geographical location

The study was done in the city of Mexicali, Baja California, Mexico (32°32'00" N; 115°12'41" W). The region has a dry desert climate with an average temperature of 34.7 °C (-5 °C winter; 50 °C summer), average rainfall of 37 mm, and average relative humidity of 50 %[18].

Study design

The experimental animals were 720 Holstein males of the same origin, 7 to 8 mo' age on arrival at the growth facility, with a 240 kg average live weight. Two treatments were applied: surgically-castrated (SC) males (T1) and immunocastrated (IC) males (T2). The animals were randomly assigned to the treatments, with 90 animals per pen and four pens per treatment. Those in the T1 treatment were castrated 24 h after birth at a dairy farm.

Handling after reception at growth facility

Twenty-four hours after arriving at the growth facility the animals were vaccinated, wormed, and an implant applied (contains trenbolone acetate, estradiol and tylosin). The animals in T2 were immunocastrated by subcutaneously administering 1 ml Bopriva® (Laboratorios Zoetis, Salud Animal, Mexico) at four times after arrival: 24 h (d 1), and on d 21, 101 and 181 of the experiment). The SC animals were administered 1 ml saline solution on the same days. Live weight (LW) was recorded for each animal on days 1, 21, 101 and 181 of the experiment and before slaughter. The animals were fed twice a day, following a six-diet

program widely used in northern Mexico which consists of wheat hay, Sudan grass, tallow, DDGS (dry distiller's grains with solubles) and a mineral premix.

Serum testosterone levels

Ten animals were randomly selected from each pen to measure serum testosterone levels; each was identified with an additional earring. Blood samples were taken on the same days as Bopriva application. A final sample was taken at slaughter at the bleeding station in the slaughterhouse production line. Approximately 5 ml blood were extracted from the coccygeal vein. The samples were centrifuged at 3,500 rpm (TRIAC centrifuge, Clay Adams, Model 0200, New Jersey, USA) to obtain the serum and stored at -20 °C until analysis. Testosterone concentration was measured using the ELISA (Bovine) Testosterone Kit (Abnova Corporation, Taipei City, Taiwan), following manufacturer instructions.

Slaughter

The animals were killed at 242 d after attaining a 607.85 ± 12.89 kg average weight. On the day of slaughter the animals were herded by a wrangler on horseback about 1.5 km to the slaughterhouse. Here they were kept in rest pens with access to water for approximately 5 h. They were slaughtered in a Federal Inspection Type (Tipo Inspeccion Federal - TIF) slaughterhouse, following established procedures (NOM-033-SAG/ZOO-2014).

Carcass evaluation

The carcasses from both treatments were stored at 2 °C for 24 h. Sample cuts were made between rib 12 and 13 to collect carcass data. A total of 120 carcasses per treatment (T1 and T2) were made available by the slaughterhouse for carcass trait data collection: hot carcass weight (HCW); cold carcass weight (CCW); back fat thickness (BFT); kidney, pelvic and heart fat (KPH); marbling; ribeye area (REA), pH and color (L*, a*, b*, C* and H*). Back fat deposition was measured in mm using a metric ruler[19]. Ribeye area was evaluated using a plastic template following the Iowa State University method. Estimated KPH was determined subjectively and expressed as a percentage of HCW, and marbling was estimated with a seven-level scale (traces, light, small, modest, moderate, slightly abundant and moderately abundant)[20].

Meat quality

Meat samples (approx. 1,000 g each) were taken 48 hours after slaughter from the *Longissimus dorsi* muscle of ten randomly selected carcasses from each pen in both treatments (total samples 80). These were vacuum-packed, refrigerated and sent to the Animal Quality Products Laboratory of the Veterinary Science Research Institute of the Autonomous University of Baja California. The pH was measured with a potentiometer (Hannah Instruments, Inc., pH 101). Color values (L*, a*, b*, C*, H*) were measured on the surface of the *Longissimus dorsi* muscle cut using a spectrophotometer (Minolta CM-2002, Minolta Camera, Co., Ltd., Japan). The specular component included (SCI) mode was used with illuminant D_{65}, and a 10° observer; L* is the brightness index, a* is red intensity and b* is yellow intensity. Shear force (SF) was quantified using previously cooked pieces of meat extracted perpendicular to the muscle fibers with a 1 cm diameter punch and placed in a texturometer (Lloyd Instruments, England) equipped with Warner-Bratzler blades. All measurements were done in triplicate.

Statistical analyses

Total variation was analyzed with a linear model:

$Y_{ij} = \mu + \tau_i + \xi_{ij}$ with i = 1, 2 and j = 1, 2, . . ., r

Where:

$\mathbf{Y_{ij}}$ are meat pH, color and SF values as response variables;

$\boldsymbol{\mu}$ is the general mean, τ_i is the fixed effect of treatment (surgically-castrated vs. immunocastrated);

$\boldsymbol{\xi_{ij}}$ is the residual random effect [$\xi_{ij} \sim NI(0, \sigma_e^2)$].

When the treatments were a source of significant variation ($P \leq 0.05$), a Tukey was applied to compare the treatments' mean values; this was done with the GLM procedure in the SAS statistics package (SAS Inst. Inc., Cary, NC)[21]. Mean serum testosterone levels were compared between treatments and over time (days 1, 21, 101 and 181, and at bleeding) with a mixed linear model:

$Y_{ijk} = \mu + \tau_i + A_{k(i)} + D_j + (\tau D)_{i\,j} + \xi_{ijk}$ with i = 1, 2 ; j = 1, 2, ..., 5, and k = 1, 2, …, r

Where:

Y_{ijk} is testosterone concentration of the k-th animal taken at j-th time and belonging to the i-th treatment, as a response variable;

μ is the general mean, τ_i is the fixed effect of treatment;

$A_{k(i)}$ is the random effect of animal within treatment [$A_{k(i)} \sim NI(0, \sigma_a^2)$],

D_j is the fixed effect of time, in days, $(\tau D)_{i\,j}$ is the effect of the treatment × time interaction;

ξ_{ijk} is the residual random effect [$\xi_{ij} \sim NI(0, \sigma_e^2)$].

The analysis was run using the MIXED procedure with the REPEATED label in the SAS package. Analysis of repeated records, including correlations between records of the same animal and heterogeneous variances between records in time was done by evaluating the covariance structures: unstructured (US); compound-symmetry (CS); and first-order autoregressive (1AR). This was done based on the Akaike and de Schwartz criteria, choosing that with the lowest values for these two indicators. In this case the selected covariance structure was unstructured (UN). When the treatment x time interaction was a source of variation ($P \leq 0.05$) a Tukey-Kramer procedure was applied to compare the least squares means between treatments for each time increment[22].

Results and discussion

Weight gain

Animal weight was higher in T1 (surgically-castrated) ($P<0.05$) starting with the second vaccination (21 d), and remained so until slaughter (Table 1).

Table 1: Mean values ± standard error (SE) of animal weight (kg) by treatment on vaccination days until slaughter

Growth day	T1 Surgically-castrated	T2 Immunocastrated	SE	P> t
1	243.25	238.39	2.50	0.052 NS
21	278.30	269.70	2.49	0.006*
101	394.94	379.53	2.51	0.001*
181	520.80	509.52	2.54	0.001*
Slaughter	620.74	594.95	6.90	0.002*

The trend observed in the present results differs from previous studies. For example, in a study of live weight in beef cattle, at 280 days males immunocastrated with Bopriva were heavier (P<0.05) than those surgically castrated at 91 days growth[10]. In a study comparing males immunocastrated with Bopriva to other males surgically castrated between fifteen and seventeen days post-vaccination in the first group, weight did not differ (P>0.05) up to slaughter[9]. One notable difference in the present study is that the animals in T1 were castrated at birth, meaning recovery time due to infection and weight loss had no impact at seven months' age when the animals were placed in the growth pens.

Serum testosterone concentrations

Testosterone concentrations in both treatments were below 1 ng/ml on each vaccination day until slaughter, confirming the effectiveness of vaccination in suppressing serum testosterone concentrations in cattle[4,9]. The present results also support previous reports that seven months is the optimal age for immunization against GnRH and generates maximum antibody production in *Bos taurus* males[22].

Carcass and meat quality

Both HCW and CCW were higher (P<0.05) in the T1 animals (Table 2), which differs from the lack of difference in CCW reported elsewhere[14]. Values for BFT and REA differed (P<0.05) between treatments, with the highest values in T1 carcasses. No differences were observed in KPH between treatments (P>0.05). In a previous study using male Nellore breed carcasses no differences (P>0.05) were apparent in BFT and REA between SC and IC animals[14]. Results for BFT more in agreement with the present results have been reported

in SC and IC Nellore and Nellore x Angus males[15]. Previous reports of REA values are lower than those observed in the present study[15]: castrated = 81.06 ± 1.78 cm^2 *vs.* immunocastrated = 83.61 ± 1.73 cm^2. These discrepancies may respond to breed since, for example, Holstein cattle are reported to have a larger and longer body structure and a longer growth period, allowing them to develop larger carcasses than beef cattle breeds[23].

Table 2: Mean values ± standard error (SE) of carcass quality variables by treatment

Growth day	T1 Surgically-castrated	T2 Immunocastrated	SE	P> f
HCW, kg	376.60[a]	362.61[b]	4.14	0.0009
CCW, kg	374.87[a]	361.38[b]	4.09	0.0011
BFT, cm	0.65[a]	0.55[b]	0.33	0.0042
REA, cm^2	91.41[a]	86.83[b]	1.54	0.0048
KPH, %	1.49[a]	1.60[a]	0.09	0.2473

WCW = warm carcass weight; CCW = cold carcass weight; BFT = back fat thickness; REA = ribeye area; KPH = kidney, pelvic and heart fat.

[a,b] Different letter superscripts in the same row indicate significant difference (P<0.05).

Previous studies comparing SC and IC males in Holstein x Cebu[24] and Nellore cattle[10,14], found no differences (P>0.05) in BFT and REA values. No differences in CCW, BFT and REA values (P>0.05) were also observed in a study of Holstein males in which the animals were slaughtered at a lower average weight: 477 kg (SC) and 486 kg (IC)[9]. Weight at slaughter was notably higher in the present results: 600+ kg (T1) and 594 kg (T2). The differences between the present carcass quality trait values and those in previous studies[10,14,15] may be due to surgical castration schedules; in previous studies it was done some days before or contemporaneously with Bopriva application while in the present study it was done 24 h after birth, meaning the animals had fully recovered when placed in growth pens at seven months' age.

Marbling category frequency did not differ (P>0.05) between the treatments, with the largest number of carcasses in both treatments classified in the "slight" and "small" marbling categories (Table 3). These results agree with previous comparisons between carcasses from IC and SC males[25]. In another study no differences (P>0.05) were observed in intramuscular fat percentage between the carcasses of SC and IC Holstein males[9].

Table 3: Marbling classification in male Holstein carcasses by treatment

Marbling classification	T1 Surgically-castrated (n= 126)	T2 Immunocastrated (n= 126)	Pr > X^2
Traces	3	0	--
Light	67	66	0.9309
Small	46	50	0.6831
Modest	9	0	--
Moderate	1	10	--

No differences (*P*>0.05) between treatments observed in the Light and Small categories in a test of a proportional equality hypothesis.

Meat pH values did not differ (*P*>0.05) between the treatments (Table 4), with values in a normal range of 5.5 to 5.8[26]. These results coincide with the 5.57 pH at 24 h reported for Holstein cattle carcasses[27].

Table 4: Mean values ± standard error (SE) for meat physicochemical variables

Variables	T1 Surgically-Castrated	T2 Immunocastrated	SE	*P*> f
pH	5.54[a]	5.56[a]	0.04	0.7163
L*	32.14[a]	32.74[a]	0.43	0.1731
a*	11.97[a]	10.70[b]	0.33	0.0002
b*	7.93[b]	12.86[a]	0.47	0.0001
C*	14.63[b]	16.87[a]	0.48	0.0001
H*	33.23[b]	49.28[a]	1.21	0.0001
SF (N)	52.17[a]	56.38[a]	0.24	0.0919

SE = standard error; SF = shear force.

[a,b] Different letter superscripts in the same row indicate significant difference (*P*<0.05).

Most of the color values (a*, b*, C* and H*) differed (*P*<0.05) between treatments, the L* value being the one exception (*P*>0.05). No difference in L* values (*P*>0.05) has also been reported in previous comparisons of meat from SC and IM male cattle[10,15]. In addition, a lack of difference for the L*, a* and b* values was observed between the carcasses of SC males (L* = 33.9; a* = 17.1; b * = 2.6) and IC males (L* = 34.0; a * = 16.9; b* = 2.4)[9]. Although meat pH was normal in the present results, the color values observed here are similar to those reported for DFD meat (L* = 34.8; a* = 18.8; b* = 6.7)[28], suggesting that the animals had been exposed to stressors prior to slaughter.

Shear force (SF) did not differ (P<0.05) between treatments. Based on established criteria[29], meat tenderness was intermediate (tender: 22.26-35.10N; intermediate: 40.01-52.95N; hard: 57.85-70.60N). The same has been reported elsewhere[10,16], with no differences in SF between meat from SC and IC animals. Indeed, another study found no differences in SF due to sexual condition (SC males: 56.60 ± 0.36N; IC males: 53.37 ± 0.35N; whole males: 48.85 ± 0.35N)[15]. Even in males slaughtered at eleven months of age SF did not differ between SC (51.9N) and IC males (52.9N)[9].

Conclusions and implications

After more than 200 d growth, surgical castration 24 h after birth in Holstein males resulted in heavier animals with better carcass traits than males immunocastrated with Bopriva. Further research is needed to assess post castration impacts on animal welfare.

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