BIA
BOLETIM DE INDÚSTRIA ANIMAL

RUMINANT PRODUCTION

PERFORMANCE AND CARCASS CHARACTERISTICS OF CATTLE WITH DIFFERENT CASTRATION PRACTICES

Mariana Moreira dos Anjos
Fundação Universidade Federal de Rondônia – UNIR, Rondônia, RO, Brazil,
https://orcid.org/0000-0003-3798-1503
Email correspondente: marianamoreiradosanjos13@gmail.com

Vagno da Silva Miler
Rondônia, RO, Brazil,
https://orcid.org/0000-0001-5763-1901

Bruno Nascimento Barboza
Fundação Universidade Federal de Rondônia – UNIR, Rondônia, RO, Brazil,
https://orcid.org/ 0000-0002-6945-011X

Edicarlos Oliveira Queiroz
Fundação Universidade Federal de Rondônia – UNIR, Rondônia, RO, Brazil,
https://orcid.org/0000-0002-5821-7152

Bruna Rafaela Caetano Nunes Pazdiora
Fundação Universidade Federal de Rondônia – UNIR, Rondônia, RO, Brazil,
https://orcid.org/0000-0002-5262-0514

Geysa Almeida Viana
Fundação Universidade Federal de Rondônia – UNIR, Rondônia, RO, Brazil,
https://orcid.org/0000-0002-3339-446X

Raul Dirceu Pazdiora
Fundação Universidade Federal de Rondônia – UNIR, Rondônia, RO, Brazil,
https://orcid.org/0000-0002-5495-4737

Received: 25/01/2023
Approved: 13/11/2023

Abstract

The aim of this research was to evaluate the performance and carcass characteristics of immunocastrated cattle, in comparison to castrated and non-castrated cattle supplemented on pasture. 36 bovines were used, distributed in a completely randomized design, in 3 treatments: non-castrated animals (ANC), animals castrated late by the surgical method (ACC) and immunocastrated animals (AIC), with 12 replicates each. Immunocastration was performed following the protocol of two doses of the immunocastrating vaccine, with an interval of 60 days, promoting a castrated effect of 120 days. The animals were kept on mixed pasture in an extensive rearing system using rotational grazing, they received mineral supplement in the first 3 months and specific feed for the fattening season in the subsequent 3 months, according to the property's standards. The total experimental period was 180 days. Data were hidden from the normality test, analysis of variance and mean comparisons were performed using the Tukey test, except for the variable degree of finishing, which was maintained at the chi-square test, at 5%. Average daily weight and total weight gains, hot and cold carcass weights and hot and cold carcass yield did not show statistical differences (P>0.05) for animals submitted to different treatments. However, the cooling loss was lower in immunocastrated animals (P<0.05), followed by surgically castrated and non-castrated animals. Immunocastrated and surgically castrated animals showed better carcass finishing (P<0.05) than non-castrated animals. The initial temperature of the carcass was lower (P<0.05) in the immunocastrated group, while for the final temperature no statistical differences (P>0.05) were verified for the animals submitted to different treatments. Final carcass pH was higher (P<0.05) in immunocastrated than in surgically castrated animals, but did not differ (P>0.05) from non-castrated animals. Immunocastrated animals, in a grazing system receiving supplementation, showed similar gains in weight and carcass weight in relation to non-castrated and surgically castrated animals, however, with lower losses to carcass cooling.

Keywords Fattening, finishing grade, Sexual dimorphism, subcutaneous fat thickness, weight gain

DESEMPENHO E CARACTERÍSTICAS DA CARCAÇA DE BOVINOS COM DIFERENTES PRÁTICAS DE CASTRAÇÃO

Resumo

Objetivou-se com este estudo avaliar o desempenho e as características da carcaça de bovinos imunocastrados, em comparação a bovinos castrados e não castrados, suplementados em pastagem. Foram utilizados 36 bovinos, distribuídos em delineamento inteiramente casualizado, em 3 tratamentos sendo: animais não castrados (ANC), animais castrados tardiamente pelo método cirúrgico (ACC) e animais imunocastrados (AIC), com 12 repetições cada. A imunocastração foi realizada seguindo o protocolo de duas doses da vacina imunocastradora, com intervalo de 60 dias, promovendo um efeito castrado de 120 dias. Os animais foram mantidos em pastagem mista em sistema de criação extensivo utilizando um pastejo rotacionado, recebendo suplemento mineral nos primeiros 3 meses e ração específica para época de engorda nos conseguintes 3 meses, seguindo o padrão da propriedade. O período experimental total foi de 180 dias. Os dados foram submetidos ao teste de normalidade, análise de variância e as comparações de médias foram realizadas pelo teste de Tukey, exceto para a variável grau de acabamento que foi submetida ao teste de qui quadrado, a 5%. Os ganhos de peso médio diário e peso total, os pesos de carcaça quente e fria e o rendimento de carcaça quente e fria não apresentaram diferenças estatísticas (P>0,05) para os animais submetidos a diferentes tratamentos. No entanto, a perda por resfriamento foi menor nos animais imunocastrados (P<0,05), seguidos dos castrados cirurgicamente e não castrados. Os animais imunocastrados e castrados cirurgicamente apresentaram melhor acabamento de carcaça (P<0,05) que os animais não castrados. A temperatura inicial da carcaça foi menor (P<0,05) no grupo de imunocastrados enquanto para temperatura final não foi verificada diferenças estatísticas (P>0,05) para os animais submetidos a diferentes tratamentos. O pH final da carcaça foi maior (P<0,05) nos animais imunocastrados que nos castrados cirurgicamente, porém não diferenciaram (P>0,05) dos não castrados. Animais imunocastrados, em sistema de pastejo recebendo suplementação, apresentaram ganhos de peso e peso de carcaça semelhantes em relação a animais não castrados e castrados cirurgicamente, no entanto, com menores perdas ao resfriamento da carcaça.

Palavras-chave Dimorfismo sexual, engorda, espessura de gordura subcutânea, ganho de peso, grau de acabamento.

INTRODUCTION

The consumer market has been going through changes. The consumers are more demanding in terms of food characteristics and quality and they have increased the demand for food originating from production systems with sustainability goals as well as those that promote the well-being of animals. In the context of agro-industrial chains, this change has provided an increasing demand for product diversification (MALAFAIA et al., 2019), which characterizes a development scenario.

The new scenario requires product offers that meet market requirements (MORGAN et al., 2016). Considering that Brazil is in a prominent position in the production of animal protein, it is necessary that production systems be adapted to market requirements. For this purpose, some practices in beef cattle farming have been evaluated, considering the new market demands and the productivity rate by the production system.

A large part of Brazilian cattle farming is done on pasture, with breeds selected according to soil and climate characteristics in each region. It is also important to point out the practice of raising whole males, with or without late castration, at around 18 to 24 months of age and slaughter between 30 and 36 months of age. (AMATAYAKUL-CHANTLER et al., 2013).

When comparing non-castrated animals with castrated animals in a conventional manner, the former show a higher efficacy when converting food into muscles, due to testosterone in the testicles, which acts on the anabolism of endogenous nitrogen. And, because this is not associated with a traditional surgical castration, it becomes a method which is ethically accepted in the view of a large part of consumers. (ANDREO et al., 2013).

However, there are some difficulties in raising intact males for meat production, which are related to reactive and sexual behavior (COETZEE, 2013) and the deficiency in carcass fat deposition (MOREIRA et al., 2015). In order to minimize the factors mentioned, castration is performed. In addition to keeping them less reactive, it affects the meat quality, which shows a better fat deposition and increased marbling. (MARTI et al., 2017; MOREIRA et al., 2015).

Due to the necessity of finding alternatives that enable the use of good

characteristics for meat production shown by intact males and associated with the characteristics of castrated males, an alternative method has appeared, which occurs through the immunization against the Gonadotropin Releasing Hormone (GnRH), which is called immunologic castration (ANDREO et al., 2013).

The vaccine proposed for the sterilization in strategic time aims to gain a better performance by the intact animal, while it controls undesired behavior and influences the quality of the carcass and meat (AMATAYAKUL-CHANTLER et al., 2013). However, further information is necessary about its effect on animal performance and in different systems of beef cattle farming. Thus, the aim has been to evaluate the performance and characteristics of the carcass of immunocastrated bovines, surgically castrated bovines, and the non-castrated ones, which were raised in a pasture production system.

MATERIALS AND METHODS

The research product related to the experimental tests was approved by the Ethical Committee in the Use of Animals – CEUA under protocol 035/2018, at Universidade Federal de Rondônia - UNIR.

The experiment was performed at a private property located in the municipality of Mirante da Serra – RO, Brazil, located at 223 m altitude, 11° 1' 38'' South latitude, 62° 40' 43'' West longitude. An area with 27.22 hectares was used, which was divided into nine 3.02 hectares paddocks. The animals were raised in a pasture mixed with these types of grass: *Panicum maximum* cka Mombaça, *Brachiaria brizantha* cka Marandu and *Brachiaria humidícola* cka Humidícola, in a rotational management system. In these paddocks, the animals had free access to troughs with water and supplementary food.

The experiment lasted a period of 180 days of evaluation. The variables were studied in 36 male bovines, mixed-breed bovines (Nelore x Dutch x Guzerá) with an average age of 24 months and initial weight of 385 ± 9,59 kg. The animals were divided by chance in 3 treatments: non-castrated animals (NCA), animals castrated late by surgical method (CCA) and immunocastrated animals (ICA), with 12 repetitions each.

During the period, two commercial supplementations were used, a mineral supplement for the initial stage and a specific feed for the fattening period, according to the property's standards. The supplementations are shown on Table 1. The mineral

supplement used was provided at ease for a period of 3 months with an estimated consumption of 150g per animal a day. As for the energetic supplementation, for a period of 3 months, the last 3 months of evaluation. It was provided once a day and the estimated consumption was 1kg per animal a day in the first month of supply, followed by an estimated consumption of 2kg per animal a day in the second month of supply, and an estimated consumption of 3kg per animal a day in the third month of supply.

Table 1. Composition of mineral and energetic supplements provided to the animals according to the evaluation period.

Nutrients	Guarantee levels	
	Mineral supplement	Energetic supplement
Raw Protein (min.), g/kg	100.0	160.0
NNP equivalent in PB (max.). g/kg	80.0	45.0
Calcium (max.), g/kg	120.0	20.0
Calcium (min.), g/kg	75.0	13.0
Phosphorus (min.), g/kg	35.0	2.5
Sodium (min.), g/kg	110.0	4
Magnesium (min.), g/kg	6	-
Sulfur (min.), g/kg	10.0	2.7
Copper (min.), g/kg	0.7	0.027
Manganese (min.), g/kg	0.25	0.022
Zinc (min.), g/kg	2.5	0.15
Cobalt (min.), mg/kg	50.0	2.5
Iodine (min.), mg/kg	40.0	7.0
Fluoride (max.), g/kg	0.35	-
Salinomicyn(min.), mg/kg	720.0	30.0
Organic Chromium (min.), mg/kg	5.0	-
Selenium (min.), mg/kg	8.0	0.3
Organic Selenium (min.), mg/kg	3.0	
Ethereal Extract (min.), g/kg	-	43.0
Raw Fiber (max.), g/kg	-	35.0
Mineral Matter (max.), g/kg	-	70.0
Humidity (max.), g/kg	-	120.0

As for the demonstrative unit for the experiment, the 36 animals were separated by chance and then sub-divided, they were weighed and identified according to their sub-group. The immunocastration of ICA group was performed with 400 µg of a combination of GnRH and carrier protein via subcutaneous route. The first dose of vaccine was given on D0 (first day of experiment) and the second dose was given on D60 (sixth day of experiment), in compliance with the interval period suggested by the company for a period of 120 days, that is, to the 180th day of the

experiment. None of the vaccinated animals showed any adverse reactions due to the subcutaneous route of the Anti-GnRH vaccine.

The bovines on CCA group were castrated on D0 day by using the open orchiectomy technique through the removal of the scrotum apex, with the help of a local anesthetic for a mixed technique (infiltrative and perineural) according to the methodology proposed by Massone (2003).

The bovines were weighed 7 times during the experiment without a previous fasting, from 7 to 8 o'clock. The first time occurred on the first day (D0) and the last time on the last day (D180) of the experiment. The other 5 weighing were distributed monthly among the experimental months (on 30th, 60th, 90th, 120th, and 150th day). When they reached the 180th day of the experiment, the animals were taken for slaughter. The animals were boarded at around 10 a.m. and they headed to the slaughterhouse, which lies at around 290 km from the property. The transportation lasted 4 hours and 40 minutes. The slaughter occurred within the period established in accordance with current legislation.

Average daily weight gain (DWG), total weight gain (TWG), hot carcass weight (HCW) and cold carcass weight (CCW), cooling loss (CL) and finishing were determined. For their base, DWG was obtained from the difference between the final weight and the entry weight divided by the total time of the experiment in days; TWG was obtained from the difference between the final weight and the entry weight; HCW was obtained at the end of the slaughter line, before entering the cooling chamber; CCW was obtained after cooling the carcass for 24 hours in a cooling chamber at 0+1^{o}C; the hot carcass yield (HCY) was obtained by dividing the HCW by the live slaughter weight and multiplying by 100; the cold carcass yield (CCY) was obtained by dividing the cold carcass weight by the live slaughter weight and multiplying by 100; Cooling loss (CL) was obtained by the difference between HCW and CCW, divided by HCW and multiplied by 100; the finishing degree was assessed by a trained professional on a scale of 1 to 5, with 1 for no finish, 2 for poor finish (1 to 3 mm of fat thickness), 3 for medium finish (above 3 to 6 mm of fat thickness), 4 for uniform finish (above 6 to 10 mm of fat thickness) and 5 for excessive finish (above 10 mm of fat thickness); initial and final carcass temperatures were measured before entry and after 24 hours in a cooling chamber at 0+1^{o}C; and muscle pH was determined by making an incision in the Longissimus muscle, between the 12th and

13th ribs, using a portable digital pH meter (pH Classic: Akso, São Leopoldo - Rio Grande do Sul, Brazil) with penetration probes, after cooling.

The experimental design used was completely randomized (CRD), with 3 treatments and 12 replicates. For the statistical evaluation, the normality test (Shapiro Wilk), analysis of variance, comparison of means using the Tukey test and chi-squared test for the finishing degree variable, at 5% significance level, were carried out using the SAS (2001) computer program.

RESULTS AND DISCUSSION

The animals submitted to treatments did not show any significant differences (P>0.05) for the initial weight, final weight, TWG and DWG (Table 2).

Table 2. Performance by cattle submitted to different castration methods and non-castration.

Variables	Treatments			CV, %	Probability
	Non-Castrated	Castrated	Immunocastrated		
IW, kg	392.3	394.4	407.7	9.59	0.5681
FW, kg	543.7	543.1	561.0	7.81	0.5154
GPT, kg	151.3	148.7	153.2	18.69	0.9235
DWG, kg	0.840	0.827	0.852	18.69	0.9250

Variance analysis 5% significance; CV%: coefficient of variation. IW: Initial Weight; FW: Final weight; TWG: Total Weight Gain; DWG: Average Daily Weight Gain.

The similarity in initial weight for different treatments was already expected, as the homogeneity of the animals was a selection criterion. The final weight and TWG were similar due to the similarity of DWG obtained for the animals of different sexual conditions, which did not show any interference due to the stage of the animals' body development.

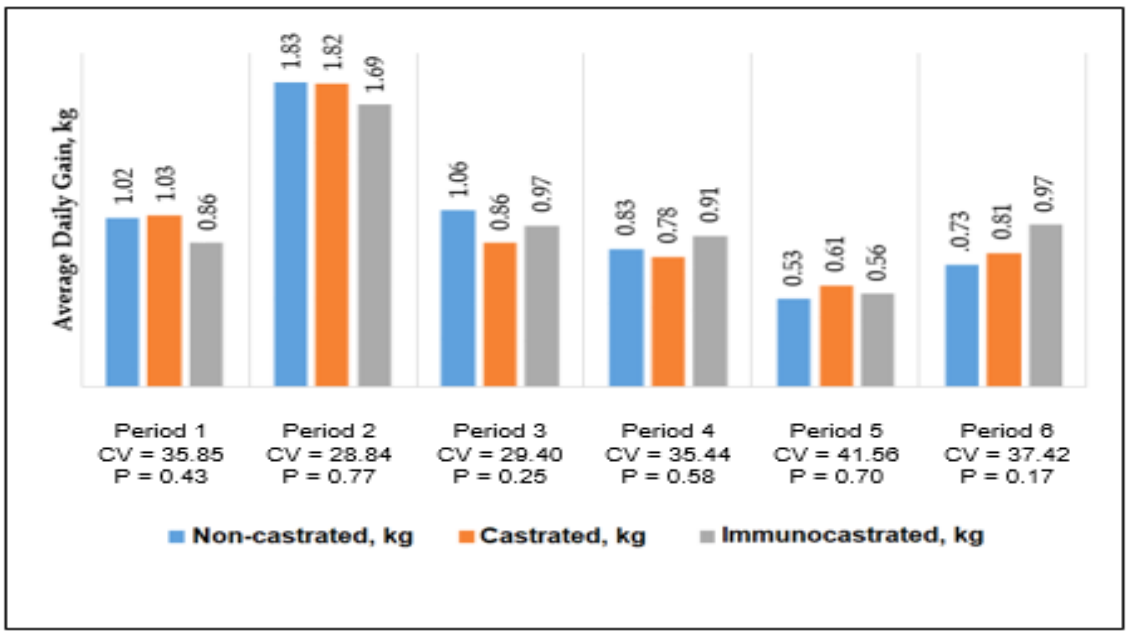
The allometric growth curve exemplifies the body development, where the skeleton develops first, followed by the muscles and then the adipose tissue (FERNANDES et al., 2019). Based on this characteristic, the animal's weight increase was obtained by increasing the proportion of muscle in the carcass, which tends to decrease and proportionally increases the accumulation of fat (SANTOS et al., 2013). The shape of these growth curves and the proportions of the carcass components vary according to genotype, sex, hormonal status and diet, with consequences for meat yield in the carcass (SANTOS et al., 2018).

Perhaps, at the beginning of the experimental period, the animals' muscle development was already close to the plateau of the growth curve, where muscle gain

slows down and the rate of fat deposition increases, as shown in Figure 1, reflecting little interference from the hormonal state on it.

Even though the current research did not detect (P>0.05) significant differences in the animals' DWG in the sexual conditions evaluated, it detected a higher pattern of DWG among the animals in period 2, followed by a reduction in gains in the following periods (periods 3, 4, and 5), followed by a slight recovery in the gain by the animals in period 6 (Figure 1), regardless of the sexual condition.

Figure 1. Average Daily Weight Gain in male cattle per period (Interval of 30 days) according to sexual condition.



Variance analysis at 5% of significance. Period 1: corresponds to days 0 to 30; Period 2: corresponds to days 31 to 60; Period 3: corresponds to days 61 to 90; Period 4: corresponds to days 91 to 120; Period 5: corresponds to days 121 to 150; Period 6: corresponds to days 151 to 180. CV = Coefficient of variation, %. P = Probability;

The effective castration effect of immunocastration occurs after the second dose of the vaccine (D60), according to the manufacturer's guidelines and reported by Marti et al. (2017), so this effect occurred after the second calculated DWG. After the same period, the animals showed a reduction in gains, in all the sexual conditions evaluated. Antonelo et al. (2017) detected greater responses to the vaccine after the second dose, with a reduction in testosterone concentrations, which characterizes castration. The same authors detected a reduction in the gain pattern between the evaluation phases (0 to 70 and 71 to 100 days), regardless of sexual condition, and justified it by the inversion in muscle adipose tissues, but the non-castrated animals stood out from the immunocastrated ones. Probably, in a similar way, in the current

research, there was a slowdown of muscle deposition caused by the plateau curve in allometric growth.

Amatayakul-Chantler et al. (2013) reported higher weight gains in immunocastrated animals when compared to surgically castrated animals, which is justified by the reduced stress, more consistent food intake and higher DWG of immunocastrated animals (0.79 vs. 0.75 g/day), and also considered the possibility of a positive effect of the return of low to moderate testosterone levels. Although the immunocastrated group in this research tended to show a higher DWG after the effect of the second dose, this difference was not detected in the final weight of the animals from the different treatments. This is possibly due to the composition of the animals' gains and the high healing rate of the surgical castration, which minimized pain and promoted a good post-surgical recovery, avoiding negative interference in the performance of the surgically castrated animals, which provided similar weight gains.

When evaluating different sexual conditions, Andreo et al. (2013) and De Freitas et al. (2015) reported greater weight gains in non-castrated animals, associated with the action of androgen hormones, especially testosterone, due to its positive influence on muscle growth. Immunocastration promotes a reduction in the concentration of circulating testosterone in animals (NOYA et al., 2019). However, the effect of greater development in non-castrated animals does not corroborate what was obtained in this research.

The variables AW, HCW, CCW, HCY and CCY did not show differences ($p>0.05$) according to the same sexual conditions evaluated (Table 3). The AW was affected by similar DWG, which was obtained by animals from different groups. As a

Table 3. Characteristics of cattle submitted to different castration methods and non-castration.

Variables	Treatments			CV%	Probability
	Non-castrated	Castrated	Immunocastrated		
Slaughter weight, arrobas	18.12	18.1	18.7	7.81	0.5163
HCW, arrobas	18.61	18.10	18.7	9.49	0.6746
CCW, arrobas	18.43	17.96	18.59	9.54	0.6588
HCW, kg	279.17	271.58	280.5	9.49	0.6728
CCW, kg	276.42	269.42	278.88	9.54	0.6607
HCY, %	51.31	50.08	49.93	4.79	0.3202
CCY, %	50.80	49.68	49.63	4.80	0.4145

Variance analysis at 5% of significance; CV%: coefficient of variation. HCW: hot carcass weight; CCW: cold carcass weight; HCY: hot carcass yield; CCY: cold carcass yield; CV%: Coefficient of Variation.

result, the similarities in carcass yield and AW among the sexual conditions resulted in equality in HCW.

Jacinto-Valderrama et al. (2021), when evaluating non-castrated, immunologically castrated, and immunologically castrated animals with ionophore (lasalocid) supplementation, in grazing and semi-confinement production systems, reported that in the grazing system the non-castrated animals had higher AW, however, in the semi-confinement system the AW were similar between the animals of the different sexual conditions. According to the authors, the values can be explained by a possible dietary restriction, due to the association of protein-energy supplementation at 1% of body weight and the low quality of the forage (forage seasonality), not allowing the animals to express their weight gain potential, which would result in greater gains between the categories. Although the animals in this study had access to good quality pasture and mineral supplementation (estimated consumption of 150g per animal per day in the first 3 months). Energy supplementation (consumption of less than 1% of live weight per animal per day in the last 3 months), it is believed that the nutritional intake, especially protein and energy, may have influenced the values obtained.

Similarly, Miguel et al. (2014) also found no differences in the HCW and HCY of immunocastrated Nelore cattle compared to non-castrated cattle, but Amatayakul-Chantler et al. (2013) reported higher HCW for immunocastrated Nelore cattle, justified by the possible favoring of changes in sexual or reactive behavior, which helped to maintain food intake and growth, compensating for the reduced concentrations of the natural anabolic hormone. This compensatory effect on animal behavior may have influenced the results of this study, providing good gains for immunocastrated and surgically castrated animals.

The finishing degree was influenced by the different sexual conditions (Table 4). Of the carcasses evaluated belonging to the surgically castrated and immunocastrated group, 50% of the animals had a poor finishing degree and the other 50% had a medium finishing degree, unlike the carcasses of the non-castrated animals, where 8.33% of the carcasses were classified as having no finishing degree and 91.67% as having a poor finishing degree. Although the surgically castrated and immunocastrated animals had a higher finishing degree, this was lower than that recommended rate by slaughterhouses.

Table 4. Degree of carcass finish in male cattle submitted to different methods of castration and non-castration.

Carcass Finish Degree	Non-castrated		Castrated		Immunocastrated	
	nº	%	nº	%	nº	%
Absent	1	8.33	0	0	0	0
Scant	11	91.67	6	50.00	6	50.00
Moderate	0	0	6	50.00	6	50.00
Uniform	0	0	0	0	0	0
Excessive	0	0	0	0	0	0

Chi Square test, P<0.05. Finish Degree: points on a scale of 0 to 5, with 1 for absent finish; 2 for scant finish (1 to 3 mm of fat thickness), 3 for moderate finish (above 3 to 6 mm of fat thickness); 4 for uniform finish (above 6 to 10 mm of fat thickness) and 5 for excessive finish (above 10 mm of fat thickness).

The difference in fat deposition between the animals of the sexual conditions evaluated can be explained by the greater action of testosterone, which influences greater protein production per unit of digestible energy (CULLMANN et al., 2017) and somatotropin, which strongly acts in inhibiting lipid synthesis, facilitates lipolysis and increases the mobilization of fatty acids from fat (KOPCHICK et al., 2019). It is also believed that nutritional factors such as low total energy in the diet may have limited fat deposition.

These results are in agreement with Marti et al. (2017) who found similarities in the percentage of fat cover between surgically castrated and immunocastrated animals, but lower in non-castrated animals. Corroborating this, Andreo et al. (2016) reported higher back fat thickness and ether extract percentage and De Freitas et al. (2015) higher subcutaneous fat thickness in immunocastrated cattle than in non-castrated cattle in confinement. The authors attributed the results to the higher level of testosterone in the non-castrated animals, and the results of the present study are probably due to the same factors.

Jacinto-Valderrama et al. (2021), when evaluating animals supplemented with an ionophore (lasalocid) in two systems, noticed that although the immunocastrated animals on pasture had lower slaughter weights, they had greater fat thickness than the semi-confined animals. However, in the semi-confined system, no differences were detected between the sexual conditions for the variables mentioned. This fat cover can be evaluated as carcass finish, which results in the joint analysis of the fat thickness characteristics in the croup and rib (SANTOS et al., 2018). The results of this study can be explained by the hormonal action of higher testosterone levels (CULLMANN et al., 2017) and somatotropin (KOPCHICK et al., 2019) in uncastrated animals, which reduces early fat deposition, including subcutaneous fat.

Carcasses with insufficient finishing (less than 3mm fat thickness) may have meat quality problems such as browning, water loss and fiber shortening (SANTOS et al., 2018). The low values (points below 3, on a scale of 1 to 5) obtained for the finishing of the animals in the study demonstrate the need for the animals to spend more time in finishing or to have received a diet with a higher level of energy, which may have influenced the animals' weight gain and finishing.

Cooling losses differed ($p<0.05$) between the different sexual conditions. The carcasses of the non-castrated animals showed a greater loss on cooling than those of the immunocastrated animals, due to the greater loss of liquid during cooling caused by the lower fat content in the carcass, both of which did not differ in relation to the carcasses of the surgically castrated animals.

Table 5. Characteristics of bovine carcass submitted to castration methods and non-castration.

Variables	Treatments			CV%	P
	Non-castrated	Castrated	Immunocastrate		
CL, %	0.997[a]	0.796[ab]	0.576[b]	49.93	0.0442
Initial T°	37.81[a]	37.25[a]	34.56[b]	5.71	0.0012
Final T°	6.42	6.42	6.35	6.79	0.9107
Final pH	5.70[ab]	5.62[b]	5.75[a]	1.91	0.0280

[a,b]Means followed by different letters differ through Tukey test at 5% of significance; CV%: Coefficient of Variation. Initial T°: Carcass temperature before entering cooling chamber. Final T°: carcass temperature after 24 hours in a cold chamber; carcass pH after 24 hours in a cold chamber; CL: Cooling Loss.

The carcasses of immunocastrated animals had lower values ($p<0.05$) of initial carcass temperature after slaughter. The different sexual conditions did not affect the final temperature of the carcass (Table 5) and all were within the expected temperature range for the cooling period. This is a factor of significant importance because rigor mortis occurs during the carcass cooling period, a process that determines the final quality of the product. This can be influenced by muscle glycogen reserves, pH and carcass temperature (GOMES, 2021).

The final pH of the carcasses differed ($p<0.05$) between the different sexual conditions evaluated, but all of them were below 6.0. Immunocastrated animals had higher final pH values than surgically castrated animals, but both did not differ from non-castrated animals. Normally in cattle, the initial pH is around 7.0 and after 24 hours it drops to 5.5 to 5.9 (ALVES et al., 2019).

After slaughter, muscle glycogen is used as an energy source, leading to

accumulation of lactic acid and hydrogen ions, resulting in a reduction in pH (GOMES, 2021). Non-castrated animals are more susceptible to a reduction in muscle glycogen, leading to lower lactic acid production, which results in a higher pH (JACINTO-VALDERRAMA et al., 2021), but this characteristic was not detected in this study.

Final pH has a direct influence on physical aspects of meat quality such as color, water retention capacity and hardness, and color is one of the main characteristics that consumers use when buying meat (GOMES, 2021). Generally, meat with a high final pH, delimited in some countries by the final pH threshold ≥6.0, is defined as Dark Cutting meat (GAGAOUA et al., 2021). Therefore, according to the data from this study, it is believed that the pH's presented in the carcasses of immunocastrated animals tend to favor color, a sensory attribute of meat.

Therefore, immunocastration is indicated as a method for castrating male cattle on pasture, with a view to their performance and carcass characteristics, as well as their better view of animal welfare. However, further observations are needed on the influence of the vaccine action period on the return of testosterone levels and the final pH of the meat.

CONCLUSION

Non-castrated, surgically castrated and immunocastrated mixed-breed animals finished on pasture and receiving supplementation for 180 days show similar weight gain, slaughter weight, carcass weight, carcass yield and final carcass temperature. However, surgically castrated and immunocastrated animals have a higher finishing degree and lower cooling loss.

REFERENCES

ALVES, L. G. C.; FERNANDES, A. R.M.; SOUZA, G. M.; CUNHA, C. M.; FOPPA, L. Bem-estar e manejo pré-abate e suas influências sobre a qualidade de carne e carcaça de bovinos de corte. **Enciclopédia biosfera**, Centro Científico Conhecer, v. 16, n. 29, 2019. https://doi.org/10.18677/EnciBio_2019A200

AMATAYAKUL-CHANTLER, S.; HOE, F.; JACKSON, J. A.; ROCA, R. O.; STEGNER, J. E.; KING, V.; HOWARD, R.; LOPEZ, E.; WALKER, J. Effects on performance and carcass and meat quality attributes following immunocastration with the gonadotropin releasing factor vaccine Bopriva or surgical castration of Bos indicus bulls raised on pasture in Brazil. **Meat Science**, v. 95, n. 1, p. 78-84, 2013. http://doi.org/10.1016/j.meatsci.2013.04.008

ANDREO, N.; BRIDI, A. M.; SOARES, A. L.; PROHMANN, P. E. F.; PERES, L. M.; TARSITANO, M. A.; GIANGARELI, B. L.; TAKABAYASHI, A. A. Fatty acid profile of beef from immunocastrated (BOPRIVA®) Nellore bulls. **Meat Science**, v. 117, p. 12-17, 2016. https://doi.org/10.1016/j.meatsci.2016.02.029

ANDREO, N.; BRIDI, A. M.; TARSITANO, M. A.; PERES, L. M.; BARBON, A. P. A. C.; ANDRADE, E. L.; PROHMANN, P. E. F. Influência da imunocastração (Bopriva®) no ganho de peso, características de carcaça e qualidade da carne de bovinos Nelore. **Semina Ciências Agrárias**, Londrina, v. 34, n. 6, p. 4121-4132, 2013. http://doi.org/10.5433/1679-0359.2013v34n6Supl2p4121

ANTONELO, D. S.; MAZON, M. R.; NUBIATO, K. E. Z.; GÓMEZ, J. F. M.; BRIGIDA, D. J.; GOMES, R. C.; NETTO, A. S.; LEME, P. R.; SILVA, S. L. Effects of immunocastration and β-adrenergic agonists on the performance and carcass traits of feedlot finished Nellore cattle. **Animal,** v. 11, n.11, p.2103-2110, 2017. http://doi.org/10.1017/S1751731117000842

COETZEE, J. F. Assessment and management of pain associated with castration in cattle. **Veterinary Clinics of North America: Food Animal Practice**, v.29, p.75-101, 2013. https://doi.org/10.1016/j.cvfa.2012.11.002

CULLMANN, J. R.; KUSS, F.; MOLETA, J. L.; LANÇANOVA, J. A. C.; SILVEIRA, M. F.; MENEZES, L. F. G.; MOURA, I. C. F.; STRAC, M. Produção de novilhos castrados ou não castrados terminados em confinamento em idade jovem ou superjovem. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia,** Belo Horizonte, v. 69, 2017. http://doi.org/10,1590/1678-4162-9100

DE FREITAS, V.; LEÃO, K. M.; NETO ARAUJO, F. R.; MARQUES, T.; FERREIRA, R. M.; GARCIA, L. L. F.; DE OLIVEIRA, E. B. **Effects of surgical castration, immunocastration and homeopathy on the performance, carcass characteristics and behaviour of feedlot-finished crossbred bulls. Semina: Ciências Agrárias**, v. 36, n. 3, p. 1725, 2015. http://doi.org/10.5433/1679-0359.2015v36n3p1725

FERNANDES, F. A.; FERNANDES, T. J.; PEREIRA, A. A.; MEIRELLES, S. L. C.; COSTA, A. C. Growth curves of meat-producing mammals by von Bertalanffy's model. **Pesquisa Agropecuária Brasileira**, v. 54, 2019. https://doi.org/10.1590/S1678-3921.pab2019.v54.01162

GAGAOUA, M.; WARNER, R. D.; PURSLOW, P.; RAMANATHAN, R.; MULLEN, A. M.; PEDROUSO, M. L.; FRANCO, D.; LORENZO, J. M.; TOMASEVIC, I.; PICARD, B.; TROY, D.; TERLOUW, E. M. C. Dark-cutting beef: A brief review and an integromics meta-analysis at the proteome level to decipher the underlying pathways. **Meat Science**, v. 181, 2021. https://doi.org/10.1016/j.meatsci.2021.108611

GOMES, M. N. B. **Manual de avaliação de carcaças bovinas.** 1º Ed. Campo Grande: Editora UFMS, 2021, 60 p.

JACINTO-VALDERRAMA, R. A.; SAMPAIO, G. S. L.; LIMA, M. L. P.; CYRILLO, J. N. S. G.; PFLANZER, S. B. Immunocastration on performance and meat quality of *Bos indicus* (Nellore) cattle under different nutritional systems. **Scientia Agricola**. v. 78, n. 2, 2021. http://doi.org/10.1590/1678-992X-2019-0136

KOPCHICK, J. J.; BERRYMAN, D. E.; PURI, V.; LEE, K. Y.; JORGENSEN, J. O. L. The

effects of growth hormone on adipose tissue: old observations, new mechanisms. **Nature Reviews Endocrinology**, v. 16, n. 3, p. 135-146, 2019. https://doi.org/10.1038/s41574-019-0280-9

MALAFAIA, G. C.; AZEVEDO, D. B.; PEREIRA, M. A.; MATIAS, M. J. A. **A Sustentabilidade na Cadeia Produtiva da Pecuária de Corte Brasileira.** *In:* BUNGENSTAB, D. J.; ALMEIDA, R. G. de; LAURA, V. A.; BALBINO, L. C.; FERREIRA, A. D. ILPF: inovação com integração de lavoura, pecuária e floresta. Embrapa Cerrados, Brasília, 2019, 835 p.

MARTI, S.; JACKSON, J. A.; SLOOTMANS, N.; LOPEZ, E.; HODGE, A.; PÉREZ-JUAN, M.; DEVANT, M.; AMATAYAKUL-CHANTLER, S. Effects on performance and meat quality of Holstein bulls fed high concentrate diets without implants following immunological castration. **Meat Science.** v. 126, p. 36-42, 2017. http://doi.org/10.1016/j.meatsci.2016.11.013

MASSONE, F. **Atlas de anestesiologia veterinária.** 1º Ed. São Paulo: Editora Roca Ltda, 2003, 172 p.

MIGUEL, G. Z.; FARIA, M. H.; ROÇA, R. O.; SANTOS, C. T.; SUMAN, S. P.; FAITARONE, A. B. G.; DELBEM, N. L. C.; GIRAO, L. V. C.; HOMEN, J. M.; BARBOSA, E. K.; SU, L. S.; RESENDE, F. D.; SIQUEIRA, G. R.; MOREIRA, A. D.; SAVIAN, T. V. Immunocastration improves carcass traits and beef color attributes in Nellore and Nellore×Aberdeen Angus crossbred animals finished in feedlot. **Meat Science**, v. 96, n. 2, p. 884-891, 2014. https://doi.org/10.1016/j.meatsci.2013.08.030

MOREIRA, P. S. A.; LOURENÇO, F. J.; COSTA, L. C. D.; FARIA, F. F.; FARRA, A. E.; ROMERO, N. B. Desempenho produtivo e características de carcaça de bovinos Nelore submetidos a diferentes métodos de castração. **Revista Brasileira de Ciências Agrárias**, v.10, n.4, p.570-575, 2015. https://doi.org/10.5039/agraria.v10i4a5150

MORGAN, A.; WINCK, C. A.; GIANEZINI, M. A influência da rastreabilidade na cadeia produtiva brasileira de carne bovina. **Revista Espacios, v. 37, n. 26,** 2016.

NOYA, A.; RIPOLL, G.; CASASÚS, I.; SANZ, A. Effects of immunocastration performed at two live weights on the growth physiology, temperament and testicular development of feral beef bulls. **Animal Science Journal**, v. 91, n.1, p. 13307, 2020. http://doi.org/10.1111/asj.13307

SANTOS, A. C. P.; SILVA, B. C. D.; OLIVEIRA, V. S.; VALENÇA, R. L. Métodos de avaliação de carcaça e de carne dos animais através de predições *in vivo* e *post mortem*. **Revista Científica de Medicina Veterinária**, n. 30, 2018.

SANTOS, P. V. D.; PARIS, W.; MENEZES, L. F. G. D.; VONZ, D.; SILVEIRA, M. F. D.; TUBIN, J. Carcass physical composition and meat quality of holstein calves, terminated in different finishing systems and slaughter weights. **Ciência e Agrotecnologia**, v. 37, p. 443-450, 2013. https://doi.org/10.1590/S1413-70542013000500008

SAS - STATISTICAL ANALYSIS SYSTEM. **System for Microsoft Windows**: release 8.2. Cary: 2001. CD-ROM.