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ANIMAL PRODUCTION

Carcass characteristics of feedlot-finished Nellore heifers slaughtered at different weights

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ABSTRACT. Carcass and meat characteristics of 48 Nellore heifers at 24 to 30 months of age, with an initial weight of 263.4 ± 13.9 kg, were evaluated. The experiment was set up as a completely randomized design with four treatments, which consisted of four slaughter-weight classes, namely <340, 340-370, 370-400, or >400 kg. Back fat thickness was not influenced ($p > 0.05$) by slaughter weight in any of the forms it was expressed (mm or %), averaging 5.3 mm. Loin eye area in cm^2 increased ($p < 0.05$) with the increase in slaughter weight. Animals slaughtered at a live weight (LW) of more than 400 kg showed better ($p < 0.05$) carcass conformation than the other experimental groups (9.8 points). Heifers slaughtered at over 400 kg LW had a more compact ($p < 0.05$) carcass (1.65 cm kg^{-1} cold carcass). The marbling degree of meat was lower ($p < 0.05$) in the animals slaughtered at less than 340 kg LW. In conclusion, cull heifers must not be slaughtered at a LW of less than 340 kg and slaughter weights greater than 400 kg have positive implications on important carcass characteristics, notably conformation and marbling.

Keywords: beef cattle; carcass yield; conformation; marbling; slaughter weight.

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Introduction

In Brazil, 7.72 million head of cattle were slaughtered in the first trimester of 2017 (Anuário da Pecuária Brasileira [ANUALPEC], 2018). In the same period, 3.4 million females were slaughtered, which corresponds to 46.6% of the total, demonstrating the relevance of female cattle for meat production in the country (ANUALPEC, 2018). The ‘cull female’ category includes cows and heifers, which are destined for slaughter due to reproductive failures, physical defects, inferior livestock potential, or low yield (Andreotti et al., 2015). According to Pacheco et al. (2013), the slaughter of cull cows represents an important source of income for producers and stands out as a relevant share of the slaughter of beef cattle in Brazil.

At present, the carcass weight constitutes the main criterion in establishing the price paid for cattle by slaughterhouses in Brazil, which seek and pay more for animals with heavier carcasses. In general, slaughterhouses prefer heavier animals because they allow for a more efficient operation of the industry, since lighter carcasses require the same labor and processing time (Vaz, Restle, Pádua, Fonseca, & Pacheco, 2013).

The carcass weight can be elevated by increasing the animal weight at slaughter, since these two characteristics are positively correlated (Missio et al., 2013b). However, as stated by Missio et al. (2013a), increasing the slaughter weight to values greater than the minimum required by slaughterhouses undermines the efficiency of the production system due to the proportional increase in non-carcass components, which culminates in decreased biological efficiency of transformation of consumed feed into weight gain. This is a consequence of changes occurring in the weight gain profile as the animal reaches maturity, the stage characterized as the moment at which maximum muscle mass has been achieved or the weight above which weight gain consists mainly of adipose tissue (National Research Council [NRC], 2000). This effect has consequences on the economic efficiency of feedlot finishing systems, considering that gains above that point require a higher energy intake for deposition of a greater proportion of adipose tissue.

The quantitative and qualitative aspects of beef cattle carcasses are determined by a set of characteristics such as weight, conformation, yield, fat cover, and marbling. These characteristics can be influenced by the stay in the feedlot and by alterations in the roughage-to-concentrate ratio of the diet (Rezende et al., 2012). In addition to those factors, several studies have shown significant alterations in carcass characteristics as a result of changes in the slaughter weight of confined cows or males. However, little scientific information exists on the impact of slaughter weight on characteristics of the carcass of Nellore heifers. The present study was thus undertaken to examine the carcass characteristics of cull heifers slaughtered at different weights.

Material and methods

The experiment was conducted in the experimental feedlot at the Livestock Section of the Technological Center of the Agro-industrial Cooperative of Rural Producers of Southeast Goiás (COMIGO), located in Rio Verde - GO, Brazil (17º46'13.50" S and 51º02'08.23" W; 846 m altitude). The experiment was approved by the Ethics Committee of Animal Use at the Federal University of Goiás (protocol 076/2015).

Forty-eight Nellore cull heifers from the same herd (average live weight 263.4 ±13.9 kg; 24 to 30 months old) were used in the study. The experimental groups corresponded to four slaughter-weight classes, namely <340, 340-370, 370-400, and >400 kg, with 12 animals per group.

Heifers were kept in feedlot facilities consisting of collective 10 × 7.7-m^2 stalls equipped with collective troughs measuring 1.15 linear meters per animal and automatically refilled drinkers. At the onset of the experiment, the animals were weighed post-fasting, dewormed, and acclimated to diets and facilities for 14 days before the actual commencement of the trial, which lasted 97 days, totaling 112 days. Diets were formulated in accordance with the requirements suggested by the NRC (2000), to provide an estimated average weight gain of 1.2 kg day^{-1}. The feed consisted of 90% concentrate plus 10% corn silage as the only roughage source (Table 1). The concentrate was composed of ground corn, soybean hulls (in mash form), soybean meal, and a mineral mixture, and was supplied along with the roughage twice daily, in the morning and in the afternoon (07:00h and 17:00h, respectively).

Slaughter weight (SW) was measured on a digital scale immediately before the heifers were taken to a slaughterhouse certified by the Federal Inspection Service (SIF), after a fasting period of 12h. After slaughter, the carcasses were identified to determine the hot carcass weight (HCW), which was measured at the end of the slaughter line immediately after bleeding, evisceration, and removal of hides, head, and feet. Cold carcass weight was obtained after the carcass chilled for 24h in a cold room at 0 ±1°C. Hot carcass yield (HCY) was calculated by dividing HCW by SW and multiplying the result by 100.

After 24h of chilling, the following measurements were taken from the right half of the carcass: carcass length – measured with a measuring tape from the cranial border in the mid-portion of the first rib up to the cranial border of the pubic bone; hind-leg length - measured from this pubic bone to the tibiotarsal joint; round thickness – measured with a compass with one of the tips fixed at the outermost part of the inside round (topside) and the other at the external side of the hind leg; fore-leg length: obtained with a measuring tape, from the tuberosity of the olecranon up to the distal extremity of the humerus; fore-leg circumference: measured in the mid-portion of the humerus, involving the muscles that cover the region. Carcass compactness was calculated as HCW divided by carcass length.

The weights of the primal cuts *hindquarter*, *forequarter*, and *short ribs* were obtained from the right half of the carcass after the carcasses was chilled for 24h at 0 ± 1°C, and their percentage was expressed relative to the cold carcass weight. The hindquarter cut corresponded to the back region of the carcass, which was separated from the forequarter between the 5th and 6th ribs at a distance of approximately 22 cm from the spine. The forequarter cut included neck, shoulder, forelegs, and five ribs. Short ribs comprised six ribs, which were separated at approximately 22 cm from the spine, and abdominal muscles.

Table 1. Chemical composition and proportion of ingredients used in the diets.

Variable	Nutrient (% DM)				
	DM	CP	NDF	ADF	EE
Corn silage	36.60	7.86	51.20	33.10	3.24
Ground corn	87.20	8.34	4.06	3.33	3.55
Soybean hulls	91.00	12.70	69.60	42.3	2.34
Soybean meal	90.50	46.40	9.12	6.04	3.87
Mineral mixture*	96.00	0.00	0.00	0.00	0.00

Dry matter (DM); crude protein (CP); neutral detergent fiber (NDF); acid detergent fiber (ADF); ether extract (EE); *13.56% phosphate; 50.53% calcite; 9.86% micro-mineral mixture; 24.65% white salt; 0.81% virginiamycin; 0.59% ionophore.

Carcass conformation was determined on the right half of the carcass, after 24h of chilling in a cold room, by a subjective assessment, following the methodology described by Müller (1987). By this method, the muscle expression of the carcass is estimated using a 18-point scale with emphasis on the hindquarter, where the cuts of highest commercial value are located.

Marbling was evaluated on a transverse section of the *Longissimus dorsi* muscle made at the 12th rib of the left half of the carcass. This variable was assessed subjectively according to the number and size of granules of intramuscular fat, for which scores of 1 to 18 were assigned (1 to 3 = traces; 4 to 6 = slight; 7 to 9 = little; 10 to 12 = medium; 13 to 15 = moderate; 16 to 18 = abundant), described by Müller (1987).

Physiological maturity was assessed by the methodology described by Müller (1987), which is based on the study of the degree of ossification of the cartilages present in the spinous processes of the thoracic and lumbar vertebrae and between the sacral vertebrae.

Back fat thickness was measured at three points of the *Longissimus dorsi* muscle from the left half of the carcass, using a caliper. Values were expressed in millimeters, after the arithmetic mean of the three measurements was calculated. Loin-eye area (LEA) was also measured on the *Longissimus dorsi* muscle from the left half of the carcass, by making a transverse section between the 12th and 13th ribs and outlining it on tracing paper. The area was then determined as square centimeters of the image using AUTOCAD® software.

Meat color and texture were determined subjectively after 24h of carcass chilling, on a transverse section of the *Longissimus dorsi* made at the 12th rib of the left half of the carcass, after exposing the muscle to constant oxygenation and luminosity for 30 min. The color was classified on a scale of 1 to 5 (1 = extremely dark meat; 5 = extremely light meat). Texture was assessed based on the granulation of muscle fiber bundles on the exposed surface of the sectioned muscle, with scores ranging from 1 (extremely thick) to 5 (extremely fine) (Müller, 1987). The final pH of the carcass was determined at the *Longissimus dorsi* muscle from the left half of the carcass, using a digital pH meter 24h after the carcasses was chilled in a cold room at 0 ± 1ºC.

The experiment was set up as a completely randomized experimental design with four treatments (weight classes). Data were subjected to analysis of normality and homogeneity of variances. After these assumptions were met, the data were subjected to analysis of variance, with differences between the means detected by Tukey's test at $\alpha = 5\%$, using SAS statistical software (Statistical Analysis System [SAS], 2004). The following mathematical model was applied:

$$Yij = \mu + \beta i + \alpha ij$$

where y_{ij}= dependent variable; μ= overall mean; β_i= effect of treatment i; and α_{ij}= residual experimental error.

Results and discussion

The increasing slaughter weights led to higher ($p < 0.05$) hot and cold carcass weights (Table 2). These findings were expected, given the high correlation found between these variables (0.85; $p = 0.001$). All experimental groups showed carcass weights consistent with those required by most slaughterhouses in Brazil (180 to 230 kg), except for the group slaughtered at less than 340 kg, whose HCW was 178.3 kg. These animals were liable to devaluation upon sale, as this is the main criterion for the composition of the price paid by commercial slaughterhouses in Brazil (Pascoal et al., 2011). High correlations between slaughter weight and carcass weight have been described by various authors in experiments investigating carcass characteristics of cattle slaughtered at different weights.

Slaughterhouses give preference to heavier animals because smaller animals take a similar processing time, which results in a higher operating cost per kilogram of processed carcass. Moreover, lighter animals have lighter non-carcass components with commercial value, notably hides and internal organs, generating less revenue for the industry. Another noteworthy factor is uniformity in the size and weight of secondary cuts, since large differences in carcass weight result in non-uniform secondary cuts, undermining the sale to more-demanding, better-paying markets.

Cows slaughtered at live weights (LW) between 370-400 kg had a higher ($p = 0.034$) HCY than the group of animals slaughtered at more than 400 kg, which did not differ from the others (Table 2). Differences in carcass yield between animals of the same breed and at similar ages can be explained by differences pertaining to gastrointestinal weight and/or content, fasting period, weight of non-carcass components, trimming procedure performed on the slaughter line, or fat cover, which stems from increased fat deposition in the carcass (Kuss et al., 2009). In the present study, these effects were not measured. However, it is assumed that the animals slaughtered at a LW higher than 400 kg would have some non-carcass component with an increased weight, since this group showed higher carcass weights but lower yields. In a meta-analytical approach of carcass and meat characteristics of cull cows slaughtered at distinct weights and with varying amounts of fat cover, Rodrigues et al. (2015) described that the HCY of cows classified as 'heavy' at slaughter (52.9%) was lower than that of cows classified as 'light' (56.9%). Those authors explained that the cows slaughtered at a heavier weight had more excess fat trimmed off their carcass than lighter cows, causing the carcass yield to be lower in the former group.

Back fat thickness was not influenced ($p > 0.05$) by the studied factor in any of the forms this variable was expressed, averaging 5.3 mm and 2.7% in relation to the cold carcass weight. This result suggests that the carcasses had an adequate fat cover in all slaughter-weight classes (Table 2). A backfat layer thicker than 3 mm is desirable, as slows down the decline of internal muscle temperature, preventing the muscle fibers from shortening due to cold, which greatly compromises the tenderness of meat. According to Missio et al. (2010), this characteristic is influenced by several factors, one of which is the time spent in the feedlot. In this way, no difference was expected for this trait, since the animals spend the same time confined.

Missio et al. (2013b) examined carcass characteristics of cull cows slaughtered at different weights and obtained different results, reporting that an increase in slaughter weight from 401 to 522 kg prompted a linear increase in back fat thickness, which rose from 1.11 to 4.79 mm. Similarly, Kuss et al. (2005) studied carcass characteristics of cull cows of different genetic groups finished at different weights and found that those slaughtered at 566 kg LW produced a thinner back fat than those slaughtered at 465 kg (7.5 vs. 4.4 mm). However, in the present experimental conditions, the similar back fat thicknesses across the treatments indicates that increases in slaughter weight—within the studied range—were not sufficient to provide gains in the subcutaneous fraction of body fat. This hypothesis was reinforced by Rezende et al. (2012), who stated that body fat deposition in cattle follows a chronological order during the animal's lifespan, with intermuscular fat being the first fat fraction to be deposited in the carcass, followed by visceral, subcutaneous, and, lastly, intramuscular fat. Likewise, Camargo et al. (2008) observed similar fat covers in feedlot-finished ½ Guzerat × ¼ Simbrasil × ¼ Nellore heifers slaughtered at different weights. Those authors attributed the results to the hypothesis that the animals of the studied genetic groups have limited fat-deposition ability. Thus, increasing the slaughter weight would not be an efficient method to increase subcutaneous fat deposition.

Among the main characteristics associated with muscle development in the carcass are conformation, LEA, round thickness, and fore-leg circumference. Loin-eye area, which is the most commonly used objective measurement, increased ($p < 0.05$) with the increasing slaughter weights (Table 3), and the correlation between these variables was 0.62 ($p = 0.001$). However, when LEA was expressed relative to 100 kg of LW, this difference was no longer present. Round thickness and fore-leg circumference, which are also estimates of tissue development, also raised with the slaughter weight. The correlations between these two variables and slaughter weight were 0.65 and 0.63 ($p = 0.001$), respectively. Rodrigues et al. (2015) described that round thickness was similar ($p = 0.5204$) across the different slaughter-weight classes of cull cows, with values ranging between 25.9 cm (heavy) and 24.9 cm (light). The authors argued that although HCW and conformation were distinct between the slaughter-weight classes, these differences were not sufficient to change the objective measurement of carcass muscularity. In this way, the animals slaughtered at a weight heavier than 400 kg showed better ($p < 0.05$) conformation than those in the other weight classes, which did not differ from each other (Table 3).

Table 2. Quantitative characteristics of the carcass of Nellore heifers slaughtered at different weights.

Variable	Slaughter-weight class				CV (%)	P value
	<340	340-370	370-400	>400		
SW, kg	322.09	355.57	372.07	423.82	4.86	<0.001
HCW, kg	178.31^{c}	197.27^{b}	209.08^{b}	223.46^{a}	17.84	<0.001
CCW, kg	174.81^{d}	191.90^{c}	203.41^{b}	220.64^{a}	4.96	<0.001
HCY, %	55.34^{ab}	55.49^{ab}	56.55^{a}	52.76^{b}	5.99	0.034
BFT, mm	4.88	4.59	5.82	5.76	16.12	0.293
BFT, %[1]	2.78	2.42	2.88	2.60	16.30	0.669
PM, points	12.18	12.27	11.66	11.35	8.03	0.066

SW = average slaughter weight; HCW = hot carcass weight; CCW = cold carcass weight; HCY = hot carcass yield; BFT = backfat thickness; PM = physiological maturity. Means followed by different letters in the row differ from each other according to Tukey's test ($p < 0.05$). 1mm 100 kg^{-1} cold carcass.

The best score of the heavier animals corresponded to an intermediary classification between "regular" and "good", with 9.79 points. According to Müller (1987), the subjective assessment of conformation estimates the degree of muscle expression in the carcass. Carcasses with better conformation are preferred by slaughterhouses, as they are associated with greater muscle hypertrophy and higher meat yield at deboning (Santos, Brondani, & Restle, 2008). Conformation presented a significant positive correlation with the other characteristics related to muscle development in the carcass, such as round thickness (0.52), LEA (0.31), and fore-leg circumference (0.33). The better conformation of the animals slaughtered at LW greater than 400 kg shows that the animals from that experimental group were depositing more muscle mass. This hypothesis was also described by Kuss et al. (2005) in a study on the carcass characteristics of cull cows of different genetic groups slaughtered at different weights in which they found that those slaughtered at 566 kg produced carcass with better conformation (10.9 points) than those slaughtered at 507 kg (9.47 points) and 465 kg (8.13 points). Rodrigues et al. (2015) described that conformation was superior in the carcasses of cows considered heavy at slaughter as compared with those considered light, the former being classified as "good minus", whereas the others were classified as "regular" and "regular minus" (10.0 vs. 8.6 points, respectively). According to those authors, conformation showed a positive correlation with slaughter weight ($p = 0.0146$; $r = 0.40$).

Carcass length was influenced by the slaughter weights (Table 3), with which it had a correlation coefficient of 0.63 ($p = 0.001$). By contrast, the lengths of fore and hind legs were not changed by the slaughter weights. This suggests that these body parts have an earlier growth, whereas the growth in carcass length goes on, which partly explains the increasing weight of the animals. Missio et al. (2013a) reported a linear response of carcass length to increasing slaughter weights in cull cows (from 401 to 522 kg). In their experiment, carcass length increased by 0.077 cm at every additional kilogram at slaughter. The authors observed, however, that hind-leg length was not changed.

Carcass compactness increased ($p < 0.05$) with the slaughter weights (Table 3). Because this characteristic relates the carcass weight to its length, increased compactness indicates that the animals deposited more tissue—muscle and fat, mainly—per unit of growth as their slaughter weight was increased.

The absolute weight of the primal cuts *forequarter*, *hindquarter*, and *short ribs* increased ($p < 0.05$) as the slaughter weight was increased, indicating a proportional development of those cuts with LW at slaughter (Table 4). Considering that the weight of primal cuts is clearly influenced by the LW of the animal, this variable is better assessed when expressed as a percentage of the carcass weight. Thus, when the weights of the forequarter and hindquarter cuts were expressed relative to 100 kg of cold carcass, this difference ceased to exist ($p > 0.05$).

Table 3. Mean values of characteristics pertaining to the muscle expression of carcasses of Nellore heifers slaughtered at different weights.

Variable	Slaughter-weight class				CV (%)	P value
	<340	340-370	370-400	>400		
LEA, cm^2	49.08^b	50.57^b	53.08^{ab}	58.23^a	10.64	0.001
LEA, %[1]	28.11	26.35	26.05	26.39	9.47	0.217
CON, points	8.45^b	8.82^b	9.42^b	9.79^a	10.61	0.007
CL, cm	127.63^c	129.90^{bc}	130.87^b	133.53^a	1.92	<0.001
FL, cm	43.09	43.13	43.20	43.28	3.14	0.985
FC, cm	32.27^c	33.45^{bc}	33.58^{ab}	34.57^a	3.06	<0.001
HL, cm	72.40	72.13	71.75	71.64	3.84	0.898
RT, cm	23.13^c	24.50^{bc}	24.70^{ab}	26.25^a	6.05	<0.001
COM	1.37^c	1.48^b	1.55^b	1.65^a	5.09	<0.001

LEA = loin-eye area; CON = conformation; CL = carcass length; FL = fore-leg length; FC = fore-leg circumference; HL = hind-leg length; RT = round thickness; COM = compactness; means followed by different letters in the row differ from each other according to Tukey's test ($p < 0.05$).

Table 4. Primal cuts from the carcass of Nellore heifers slaughtered at different weights

Variables	Slaughter weight class				CV (%)	P value
	<340	340-370	370-400	>400		
FORE, kg	64.58^c	70.42^b	73.76^b	80.44^a	4.90	<0.001
FORE, %	36.94	36.70	36.26	36.46	3.17	0.532
SR, kg	18.90^c	22.34^b	23.44^b	26.90^a	9.20	<0.001
SR, %	10.81^b	11.64^{ab}	11.52^{ab}	12.19^a	8.68	0.019
PH, kg	91.02^d	99.92^c	106.4^b	113.7^a	4.97	<0.001
PH, %	52.07	52.07	52.31	51.53	2.93	0.753

FORE = forequarter; SR = short ribs; PH = hindquarter; means followed by different letters in the row differ from each other according to Tukey's test ($p < 0.05$).

An effect of increasing slaughter weights ($p < 0.05$) was observed on short ribs (SR), considering all forms in which this variable was expressed. According to Rezende et al. (2012), increases in the percentage of SR in heavier carcasses with a thicker backfat layer may be attributed to greater fat deposition in that area. In the present study, the correlation between fat thickness and SR weight was 0.26 ($p = 0.068$). Kuss et al. (2005) studied carcass characteristics of cull cows of different genetic groups slaughtered at different weights and observed that increasing slaughter weights (465, 507, and 566 kg) did not change the percentage of hindquarter (51.2, 50.6, and 50.6%), but reduced the forequarter (36.9, 37.3, and 35.2%) and increased SR (11.9, 12.1, and 14.1%). Vaz et al. (2013) examined the deboning revenue of secondary cuts from the carcass of bulls Nellore males slaughtered at different weights and different dentitions and found no effect of slaughter weight on the percentages of forequarter, hindquarter, or SR. Those authors concluded that irrespective of weight, the carcasses of young animals are similar regarding the yield of most deboned cuts.

The pH of the cold carcass was not changed ($p > 0.05$) by the slaughter weights. This variable was considered adequate in all experimental groups, averaging 5.6 (Table 5). This is an important parameter, as it is directly related to microbiological characteristics that determine the preservation of meat in addition to influencing losses of liquids during the chilling period and the meat color. To prevent negative effects on these characteristics, it is desirable that the pH decline occur rapidly, after the establishment of *rigor mortis*. The time to obtain an adequate pH is related to the glycogen depletion time of the muscle cell. This characteristic is determined majorly by the pre-slaughter management and animal genotype. Therefore, the similar meat pH values between the experimental groups were likely a consequence of genetic uniformity and the adoption of the same pre-slaughter management for all experimental groups.

Meat color was not influenced ($p > 0.05$) by the slaughter weights (Table 5). Results for this variable were considered satisfactory, averaging 3.28 points, which corresponds to an intermediate color between "slightly dark red" and "bright red". Yet this classification is considered well-accepted by consumers (Rezende et al., 2012). Rodrigues et al. (2015) also did not observe an effect of slaughter weight of cull cows on the color of their meat. The authors described values similar to those found in the current study (3.8-3.9 points). In their opinion, although color does not seem to influence the organoleptic aspects of meat such as palatability, juiciness, or tenderness, it is a trait of great relevance at the time of sale in retail markets. Rezende et al. (2012) declared that the amount of myoglobin in the muscle is one of the factors determining the intensity of red color in meat, and that its concentration raises as the animal ages and/or gains weight. Thus, in the present study, given the similar ages and slaughter-weight intervals studied (340 to 400 kg), it is assumed that those factors were not sufficient to darken the meat.

The texture of meat was not influenced ($p > 0.05$) by the studied factor, averaging 3.19 points, which corresponds to intermediate texture, classified between "slightly thick" and "fine" (Table 5). The genetic homogeneity and uniform age of the studied animals likely caused the similar meat texture across the experimental groups. Rodrigues et al. (2015) also did not observe an effect of slaughter weight of cows on their meat texture ($p = 0.9995$), which was classified as "slightly thick" (3 points).

The subjective assessment of the amount of intramuscular fat in the *Longissimus dorsi*, which estimates the degree of marbling of meat, revealed lower values ($p < 0.05$) for the animals slaughtered at a LW of less than 340 kg as compared with the other slaughter-weight classes, which did not differ from each other and presented results considered extremely satisfactory (Table 5). Marbling fat represents the number and size of fat granules between the muscle fibers. It is considered a key parameter to the sensory characteristics of meat, since the amount of lipids in meat is highly correlated with its palatability and juiciness (Oury, Picard, Briand, Blanquet, & Dumont, 2009). According to Vaz et al. (2012) fat is the tissue whose deposition in the animal body occurs when muscle growth declines. Accordingly, adult animals slaughtered at a heavier weight are expected to have greater fat tissue deposition, including the marbling fat fraction. Rodrigues et al. (2015) noted that marbling in the meat of cows slaughtered at different weights was similar ($p = 0.5159$), with values that ranged from 7.3 (heavy) to 6.7 (light). Those authors also stated that although the back fat thickness of the cows' carcasses was higher in those slaughtered at a heavy weight, this difference was not sufficient to alter meat marbling.

Table 5. Characteristics of meat from Nellore heifers slaughtered at different weights.

Variable	Slaughter-weight class				CV (%)	P value
	<340	340-370	370-400	>400		
pH	5.57	5.57	5.59	5.56	1.42	0.764
Color, points	2.93	3.30	3.37	3.55	17.48	0.078
Texture, points	3.05	3.30	3.18	3.23	16.50	0.729
Marbling, points*	4.72[b]	10.90[a]	9.66[a]	8.78[a]	20.39	<0.001

*Marbling: 1 to 3 = traces; 4 to 6 = slight; 7 to 9 = little; 10 to 12 = medium; 13 to 15 = moderate; 16 to 18 = abundant, as described by Muller (1987); means followed by different letters in the row differ from each other according to Tukey's test ($p < 0.05$).

Conclusion

Feedlot-finished Nellore culled heifers should not be slaughtered at a live weight lower than 340 kg, since they will have not yet reached the minimum carcass weight of 180 kg required by most commercial slaughterhouses, in addition to producing meat with less marbling. On the other hand, cull females slaughtered at a live weight higher than 400 kg have a thicker round and longer, better conformed, and more compact carcasses, indicating greater deposition of muscle and fat tissue per unit of carcass area and thus providing increased revenue.

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