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ANIMAL PRODUCTION

Quantitative carcass traits of Holstein calves, finished in different systems and slaughter weights

Características quantitativas da carcaça de bezerros da raça holandesa terminados em diferentes sistemas de terminação e pesos de abate

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ABSTRACT

The objective of this experiment was to evaluate carcass characteristics Holstein calves finished on feedlot or pasture with supplementation and slaughter weights. The feedlot calves were fed with commercial concentrate and corn silage in the ratio of 40:60. The experimental design was completely randomized in a factorial 2x4 (two finishing systems x four slaughter weights). The animals were different slaughter weights 140, 180, 220 and 260kg of body weight). The finishing system had no influence on the weight carcass hot and cold, yield, and losses carcass, but the feedlot animals showed higher fat thickness and better conformation. With the increase in the slaughter weight, there was a linear increase in the hot carcass weight and cold carcass yield, conformation, metric measurements and weight of commercial cuts. The percentage of hind decreased with the increase in the slaughter weight, whereas fat thickness showed a quadratic response. The finishing system showed carcass yield similar. The carcass characteristics improve with the increase in the weight, but the percentages were similar.

Key words: *conformation,carcass yield, fat thickness,veal.*

RESUMO

O objetivo deste experimento foi avaliar as características da carcaça de bezerros holandeses terminados em confinamento ou em pastagem com suplementação e abatidos com diferentes pesos de abate. Os animais confinados foram alimentados com volumoso e concentrado comercial, na proporção de 40:60, sendo a silagem de milho utilizada como volumoso. O delineamento experimental foi o inteiramente casualizado, em arranjo fatorial 2x4 (dois sistemas de terminação x quatro pesos de abate). Os animais foram abatidos à medida que atingiam os pesos de abate pré-determinados (140, 180, 220 e 260kg). O sistema de acabamento não teve influência sobre o peso e rendimento de carcaça quente e fria e as perdas de carcaça, mas os animais confinados apresentaram maior espessura de gordura. Animais confinados apresentaram melhor conformação, comparados com os terminados em pastagem. À medida que aumentou o peso de abate, houve crescimento linear para peso de carcaça quente e fria, rendimento de carcaça quente e fria, conformação, medidas métricas e peso dos cortes comerciais da carcaça. O percentual do corte traseiro decresceu com o aumento do peso de abate, enquanto que a espessura de gordura apresentou resposta quadrática. Os sistemas de abate apresentaram rendimento de carcaça semelhante. As características da carcaça melhoram com o aumento do peso de abate, mas, em percentagem, são semelhantes.

Palavras-chave: *conformação, espessura de gordura, rendimento de carcaça, vitelo.*

INTRODUCTION

Brazil has shown steady growth in the production of meat and milk. In 2011, domestic production presented a growth of 5.5% compared to the previous year (IBGE, 2011). According to data from the Food and Agriculture Organization, the country is the second largest producer of beef and the fifth largest producer of milk, with about 31 billion liters (FAO, 2011).

Quality of Holstein beef, in terms of palatability characteristics, is not different from beef derived from beef breed steers of comparable age and gross composition. Sensory characteristics of Holstein beef are resilient to a wide range of dietary and management factors (SCHAEFER, 2005). Therefore the production of Holstein beef may be an

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alternative, provide that food and animal management are appropriate for the growth.

In the Brazil beef derived from Holstein steers are not usually produced as in other countries. For the production of young bulls, one must consider the slaughter weight and finishing degree of the carcass. The carcass weight usually sought by animal in slaughterhouses is above 230kg. However, when the animals are young (baby teeth), carcasses are being accepted with lower weight (over 180kg), due to lighter carcass weights being associated with younger animals and therefore better quality meat (SANTOS et al., 2008; COSTA et al., 2002). These animals with weight less may be younger finished, increasing the slaughter rate of the property and owner income.

Yet, in the production of beef Holstein there are not studies that demonstrate the effect of slaughter weight on carcass traits. The slaughter of these animals with low weight can cause problems, especially in the finishing carcass, but it can be an alternative to a niche market that prefers light meat. The objective of this study was to evaluate the effect of the finishing system and slaughter weight on the quantitative characteristics of Holstein carcass calves.

MATERIALS AND METHODS

The experiment was carried out in the experimental area of the Dois Vizinhos campus of the Universidade Tecnologica Federal do Paraná (UTFPR), located in the southwest region of Parana state, from July 2011 to April 2012. We used 43 Holstein calves, steers, aging 58+1,3days and average weight of 57+1,6kg, which were randomly divided into two finishing systems: feedlot or pasture. Within each system, they were distributed into four groups with stipulated weight (140, 180, 220 and 260kg of body weight).

The adjustment period to the facilities and employee management system lasted 15 days. At weaning, the animals received injectable ADE vitamin, they received albendazole treatment and were weighed after a fasting period of 16 hours. The animals were neither castrated nor dehorned and were vaccinated against foot-and-mouth disease according to the official calendar. The control of parasitic infections was performed by application of Ivermectin to 1% in all animals on the day of entry stage of the experiment; new applications being made every 28 days, during the periodic weighings.

Twenty-three animals were kept in individual stalls and fed a diet consisting of corn silage with 10.4 and 60.5% of crude protein (CP) and total digestive nutrients (NDT) respectively mixed with commercial concentrate pellet with 19% CP and 70% TDN, in a ratio of 40:60. The diet was formulated based on nutritional requirements established by the NRC (2001), for an expected daily weight gain of 1.0kg. The twenty remaining animals were finished on oat (***Avena sativa***) intercropped with ryegrass (***Lolium multiflorium***) with 26% CP and 56% TDN from 07/09/11 to 10/05/11, African Star (***Cynodon nlemfuensis***) with 14% CP and 52% TDN from 10/06/11 to 12/06/11 and millet (***Pennisetum glaucum***) with 22% CP and 56% TDN from 12/07/11 to 04/12/12, and they received concentrate supplementation at 1% of body weight, with the same composition of ration fed to feedlot plus free access to water and mineral salt. The grazing system used was continuous with supply control in 10% of body weight, enabling the selection of more nutritious parts to the animals. The forage mass of pasture was measured every 28 days. The pasture CP and NDT value were obtained simulated grazing.

The feeding of the feedlot animals was split into two meals a day. Half of it was given at 9 o'clock and the remaining at 4 o'clock. It was maintained to a spare margin of 10% of the food offered, being the remains of the previous day weighed to estimate consumption. The weighing were taken every 28 days with a 16-hour-fasting of food and water and, as the animals of each treatment reached their slaughter weight, they were slaughtered in a slaughterhouse installed at UTFPR - Dois Vizinhos campus. Right before being slaughtered, each animal was weighed and presented the following average slaughtered 144.6, 179.5, 227.5 and 260.5kg of body weight.

After the slaughter, the two half - carcasses were washed, identified and weighed before being taken to the cooling chamber in order to obtain the hot carcass weight. After the cooling period for 24 hours at a temperature of -2°C, the carcasses were reweighed to obtain the cold carcass weight and check the yields of the hot and cold carcasses and losses due to cooling. Still using the two half-carcasses, the conformation was evaluated according to the method described by MÜLLER (1987). The left half carcass was separated into primary retail cuts: front, side and hindquarter. Each piece was weighed for subsequent calculation of their percentage in relation to the whole carcass.

In the right half carcass characteristics the measures were evaluated: carcass length (taken from the cranial edge of the first rib and the medial edge of the pubic bone) , leg length (corresponding to the distance between the anterior edge of the pubic bone and the tibio-tarsius), arm length (measured from radio carpiana joint up to the end of the olecranon), cushion thickness (measured between the lateral and medial aspect of the upper cushion, with the aid of a compass) and mid-arm circumference (determined by the perimeter of the medial region of the same), according to MÜLLER (1987). Between the 12^{th} and 13^{th} rib there was a horizontal cut in order to expose the *Longissimus dorsi*, to trace its outline on vellum, being the area of the figure subsequently determined with the help of graph paper; the thickness of subcutaneous fat was obtained by the average of three observations in the same place.

Data were subjected to analysis of variance was conducted using the GLM procedure of SAS (2002) and when statistical difference analysis was performed, the polynomial regression to the third grade for slaughter weight, and comparison of means for finishing systems at 5% of significance. The mathematical model used in this work was:

$Y_{ijkl} = \mu + IW_k + TS_i + SW_j + (TS * SW)_{ij} + E_{ijkl}$

In which Y_{ijkl} = dependent variables, μ = mean of all observations; IWI_k = effect of the k-th initial weight; TS_i = effect of the ith termination system (pasture and feedlot); SW_j = effect of the j-th slaughter weight; $(TS * SW)_{ij}$ = interaction between finishing system and slaughter weight; E_{ijkl} = random residual error.

RESULTS AND DISCUSSION

No significant interaction was observed (P>0.05) between finishing system and slaughter weight therefore the results will be discussed separately.

As the weights were pre-stipulated, there was no difference (P> 0.05) for the slaughter weight between the finishing systems (Table 1). The finishing period was variable, depending on the system and the animals finished on pasture took an average of 221 days and 153 days of feedlot to achieve the weights pre-stipulated and this difference was a result of the average daily weight gains of finishing systems, 0.710kg day^{-1} for pasture and 0.941kg day^{-1} for feedlot.

Table 1 - Means and standard errors for quantitative carcass traits, metric measurements and weight and percentage of retail cuts of Holstein calves finished in different finishing systems.

Variables	Finishing systems		CV (%)	P-value
	Feedlot	Pasture		
Quantitative Carcass traits				
Slaughter weight , kg	201.02 ± 1.85	205.20 ± 1.99	4.22	0.1468
Hot carcass weight, kg	101.87 ± 1.21	100.38 ± 1.65	5.33	0.4924
Cold carcass weight, kg	98.08 ± 1.26	97.72 ± 1.36	5.98	0.8540
Hot Carcass yield, %	50.32 ± 0.51	48.96 ± 0.70	4.75	0.1489
Cold carcass yield,%	48.48 ± 0.47	47.49 ± 0.50	4.52	0.1765
Loss in cooling, %	3.63 ± 0.23	3.49 ± 0.32	30.91	0.7407
Fat thickness, mm	0.82 ± 0.09	0.48 ± 0.10	65.65	0.0235
Metric measurements				
Conformation, points *	6.16 ± 0.36	4.84 ± 0.38	29.90	0.0212
Cushion thickness, cm	17.24 ± 0.25	17.21 ± 0.27	6.82	0.9442
Arm perimeter, cm	28.80 ± 0.44	28.03 ± 0.48	7.30	0.2671
Loin eye area, cm²	38.30 ± 1.58	41.15 ± 1.71	18.47	0.2462
Carcass length, cm	107.18 ± 1.05	107.09 ± 1.13	4.54	0.9526
Leg length, cm	56.23 ± 0.59	57.90 ± 0.64	4.83	0.0737
Arm length, cm	33.10 ± 0.50	33.57 ± 0.54	7.04	0.5455
Weight and percentage of retail cuts				
Front, kg	36.98 ± 0.69	36.91 ± 0.74	8.69	0.9476
Front, %	37.71 ± 0.45	37.92 ± 0.48	5.53	0.7596
Sidecut kg	12,46 ± 0.32	12.25 ± 0.34	11.99	0.6697
Sidecut, %	12.61 ± 0.26	12.53 ± 0.28	9.66	0.8409
Rear kg	48.52 ± 0.93	48.13 ± 1.00	8.91	0.7828
Rear, %	49.67 ± 0.45	49.53 ± 0.48	4.20	0.8467

* 1-3: lower; 4-6: bad; 7-9: regular; 10-12: good; 13-15: very good; 16-18: higher.

The hot and cold carcass weight and the yield of hot and cold carcass were similar between the finishing systems. The main factor affecting carcass yield is the diet in which the animals that were fed fibrous diets had higher contents of the gastrointestinal tract and, consequently, lower carcass yield. REZENDE et al. (2012), suggested that the main factor affecting the increase in carcass yield is the reduction in the weight of the gastrointestinal contents due to the increase of the concentrate diets, for those with a higher proportion of grains had higher digestibility. In the present study the animals in the pasture supplemented 1% of the weight of the same concentrate containment and were kept on pasture with high nutritional quality. Animals kept on pasture presented heavier gastrointestinal tract, however when expressed in 100kg of empty body showed not significant difference (Table 1).

There was no difference between finishing systems for losses to cooling. According to SANTOS et al. (2008), carcasses with higher fat thickness coverage have lower loss during cooling, but in this experiment the fat thickness was not enough to protect the carcass in any treatment.

The fat thickness was greater ($P<0.05$) for feedlot animals (0.82 vs 0.48mm for feed lot and pasture, respectively), which was already expected due to the higher energy intake from the diet, because the dry matter intake was 3,5 and 3,0% body weight for feedlot and pasture respectively. The fat thickness obtained in the present study did not reach the minimum recommended by most slaughterhouses (3mm), due to low slaughter weights. RODRIGUES FILHO et al. (2003) evaluated the carcasses of Holstein calves slaughtered at 215kg body weight and found that the fat thickness of subcutaneous fat in animals fed a quality of elephant grass as forage and 75% concentrate was higher than in those fed diets with lower energy concentration (4.05 to 2.78mm, respectively). The fat thickness is important to protect the carcasses of the harmful effects of intense and sudden cooling to which carcasses aresubmitted in slaughterhouses. Cooling can promote the shortening of muscle fibers, dehydration, drying and browning the meat, causing the depreciating it. However, calves are more devoid of animal fat and it is considered one of the differentiating attributes of such lean beef (OLIETE et al., 2005).

The feedlot animals showed superiority of 27.3% in carcass conformation compared to animals kept on pasture (Table 1). The conformation can be regarded as qualitative factor because the animals have higher muscle hypertrophy provide cuts with better appearance for the demanding consumers, or as a quantitative factor, due to the fact that carcasses with better conformation tend to have higher edible portion and a lower proportion of bone.

The cushion thickness and arm perimeter, which are also measures that reflect the development and expression of muscle carcass showed similarity ($P>0.05$) between finishing systems. The measures of carcass development as leg and arm length did not differ ($P>0.05$) between finishing systems (Table 1). These results can be explained by the similarity of slaughter weights and carcass for both finishing systems. MENEZES et al. (2010) evaluating the carcass of steers fed on different feeding systems also found metric similarity for the metric characteristics of the carcass.

The loin eye area (LEA) was not influenced by the finishing system. This measure is used as an indicator of carcass composition because there is a positive correlation between LEA and edible portion (RODRIGUES et al., 2001). REZENDE et al. (2012) evaluating Holstein cattle slaughtered at 395 kg, also found no difference in eating plans in growing and finishing for the loin eye area, obtaining average values of 51.46cm². DUCKETT, et al., (2013), found superiority for all quantitative carcass traits who compared finishing systems (feedlot x pasture). However, the amount of the concentrate used was 82% of the diet. Therefore the supplementation on pasture can be an alternative to create of Holstein calves.

Analyzing weights and percentages of retail cuts (Table 1), it appears that the front, side and hindquarter, showed no significant difference between finishing systems. RODRIGUES FILHO et al. (2003) in a study with dairy steers slaughtered at 215kg body weight, found mean values of 38.85 and 61.09% for the front and total rear yield (Sidecut + rear), respectively, similar to those obtained in this study.

The weights of hot and cold carcass increased linearly ($P<0.01$) with the increase of the slaughter weight of animals (Table 2). This difference in carcass weight can be explained by the similarity ($P>0.05$) on carcass yield between the hot and cold carcass weight. It is highly affected by the fasting period before slaughtering, making it difficult to compare the results of authors who used different periods of fasting. According to FERNANDES et al. (2004), the selected animals for cutting have carcass yields 7% higher than those of dairy. In the present experiment the carcass yield ranged from 48.18 to 51.32%, while the cold carcass yield ranged from 46.59 to 49.46%.

Table 2 - Means and standard errors for quantitative carcass traits of Holstein calves according to different slaughter weights.

Variables	--------Slaughter weight (Kg)--------				CV(%)	-----P-value[1]-----	
	144,6	179.7	227.5	260.5		L	Q
HCW,kg[2]	70.02±2.36	88.60 ± 1.82	111.76±1.89	134.13±1.79	5.33	<.0001	0.1969
CCW,kg[3]	67.72±1.77	85.47±1.77	109.06±1.96	129.34±1.86	5.98	<.0001	0.3497
HCY, %[4]	48.18±1.00	49.81±0.77	49.24 ± 0.80	51.32 ± 0.76	4.75	0.1497	0.3783
CCY, %[5]	46.81±0.48	46.59± 0.48	48.05±0.54	49.46±0.51	4.52	0.0697	0.6199
LC, %[6]	3.87±0.46	4.37±0.35	2.57±0.37	3.44±0.35	30.91	0.1363	0.0714
FT, mm[7]	0.20±0.13	0.60±0.13	0.97±0.14	0.82±0.14	65.65	0.0523	0.0360

HCW: Hot Carcass Weight, CCW: Cold carcass weight, HCY: Hot Carcass Yield, CCY: Cold Carcass Yield, LC: Loss in Cooling, FT: Fat Thickness.

[1]L and Q-order effects on the linear and quadratic increase in the slaughter weight.

[2]HCW=-11.36786+0.08582*0.52950*IW+SW(r^2=0.96).

[3]CCW=-14.27465+0.11850*0.51689*IW+SW(r^2=0.96).

[4]HCY=49.63.

[5]CCY=47.72.

[6]LC=3.56.

[7]FT=-5.20222+0.00887+0.05171*IW*-0.00011851*SW^2(r^2=0.25).

This low carcass yield is negative for the production of this type of animal, since slaughterhouses that do not have different marketing of meat may penalize this type of carcass. However, it is observed that there is a tendency ($P<0.06$) to raise the cold carcass yield with the increase of the carcass, owing to vital organs present more development in the early stage of the life of the animal, and as age advances, the rate of growth of muscle tissue, mainly from adipose tissue, is greater, from the internal organs to represent a smaller proportion of empty body weight.

Fat thickness showed a quadratic behavior ($P<0.05$), increasing up to 218kg in the slaughter weight, and decreasing thereafter. The literature provides positive results for the fat thickness in the carcass when it raises the slaughter weight of animals (COSTA et al., 2002; ARBOITTE et al., 2004). However, these experiments older animals were used at the desired point of slaughter by the slaughterhouses (over 3mm fat thickness). In the present experiment, when the animals weighed around 227kg, they were about 9 months old, it means close to puberty. As they were whole animals, the speed of the fat deposit may have declined at that stage, showing a quadratic behavior. Uncastrated animals have greater development of muscle tissue by hormonal testicular testosterone production due to generating higher protein anabolism, and completing the maturity and fat deposition late when compared to castrated ones (CATTELAM et al., 2011).

Another point that draws attention is the high coefficient of variation (65.65%) observed for that trait. However, this is explained by the animals of both finishing systems being grouped within the slaughter weights, remembering that fat thickness showed a significant difference for the finishing system used (Table 1).

All the features that express the muscularity of the carcass responded linearly ($P<0.05$) to the increase of the slaughter weight (Table 3); what was already expected since the animals were in the growth stage, characterized by increase in weight, length, height and circumference due to age. The conformation of the carcass, which represents the degree of musculature, especially in the posterior region of the carcass, shows that the higher the slaughter weight the better the conformation of the carcass ($P<0.05$).

There was an increase ($P<0.01$) in the absolute weights of commercial cuts with increasing in the slaughter weight of the animals (Table 3). When the commercial cuts were expressed in percentage of weight, there was no variation with the increase in the slaughter weight. According to OSÓRIO (2012), with the advance of maturity it occurs a decrease in the proportion of muscles in regions of higher commercial value, which was noticed in numbers ($P=0.0524$). A greater proportion of rear is desirable, since this part of the carcass has the noblest and most valuable cuts (COSTA et al., 2002).

CONCLUSION

The finishing system on pasture with supplementation showed carcass yield similar to the feedlot one. However, the time for finishing animals on

Table 3 - Means and standard errors for the metric and weight and percentage of retail cuts of the carcass of Holstein calves according to slaughter weight.

Variables	Slaughter weight (kg)				CV (%)	P-value[1]	
	144.6	179.7	227.5	260.5		L	Q
Metric Measurements							
Conformation,points*[2]	3.45±0.50	5.36±0.50	5.67±0.55	7.52±0.53	29.90	0.0010	0.4701
Cushion thickness,cm[3]	14.55±0.35	17.19±0.35	18.05±0.39	19.12±0.37	6.82	<.0001	0.292
Arm perimeter, cm[4]	24.42±0.62	27.28±0.62	30.34±0.69	31.61±0.66	7.30	<.0001	0.1886
Eye area, cm²[5]	32.91±2.22	36.52±2.21	42.98±2.45	46.49±2.33	18.47	<.0001	0.7887
Carcass length, cm[6]	100.16±1.47	106.39±1.47	108.15±1.62	113.84±1.54	4.54	<.0001	0.6647
Leg length, cm[7]	51.99±0.83	55.44±0.83	57.78±0.92	63.04±0.87	4.83	<.0001	0.2093
Arm length, cm[8]	30.58±0.71	31.07±0.70	34.76±0.78	36.94±0.74	7.04	<.0001	0.1302
Weight and Percentage of Retail Cuts							
Front, kg[9]	24.70±0.97	32.66±0.96	40.77±1.07	49.65±1.01	8.69	<.0001	0.3445
Front, %[10]	37.38±0.63	38.11±0.63	37.48±0.70	38.29±0.66	5.53	0.4634	0.5307
Sidecut, kg[11]	7.97±0.44	10.48±0.44	14.22±0.49	16.74±0.47	11.99	<.0001	0.7893
Sidecut, %[12]	12.13±0.36	12.24±0.36	13.09±0.40	12.84±0.38	9.66	0.0734	0.5126
Rear, kg[13]	33.28±1.30	42.74±1.30	53.76±1.43	63.52±1.36	8.91	<.0001	0.7438
Rear, %[14]	50.48±0.63	49.64±0.63	49.42±0.69	48.86±0.66	4.20	0.0524	0.7945

* 1-3: lower; 4-6: bad; 7-9: regular; 10-12: good; 13-15: very good; 16-18: higher.
[1]L e Q: order effects on the linear and quadratic increase in slaughter weight.
[2]$\hat{Y}$=-0.45664+0.01867 *IW + 0,02568 *SW (r^2=0.33); [3]$\hat{Y}$=11.70582-0.03621 *IW + 0.03836 *SW (r^2=0.72); [4]$\hat{Y}$=19.85086-0.04242 *IW + 0.05447*SW (r^2=0.57); [5]$\hat{Y}$=6.94901+0.15823 * IW + 0.11864*SW (r^2=0.42); [6]$\hat{Y}$=91.11408-0.10604 *IW +0.10613 *SW (r^2=0.45); [7]$\hat{Y}$=41.36125-0.03534 *IW + 0.08725 *SW (r^2=0.58); [8]$\hat{Y}$=17.88540+0.08197 *IW + 0.05436 *SW (r^2=0.55); [9]$\hat{Y}$=-5.99107+0.04248 *IW + 0.20117 *SW (r^2=0.92); [10]$\hat{Y}$=37.81; [11]$\hat{Y}$=-2.90749+0.00467 *IW + 0.07420 *SW (r^2=0.87); [12]$\hat{Y}$= 2.57; [13]$\hat{Y}$=-7.35303+0.13131 *IW + 0.23705 *SW (r^2=0.91); [14]$\hat{Y}$=49.60.

pasture is higher, resulting in lower fat cover and worse conformation when compared to feedlot animals.

The carcass characteristics improve with the increase in the weight, but the percentages of retail cuts and quantitative traits the carcass of Holstein calves were similar between slaughter weights.

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ETHICS COMITTE AND BIOSECURITY

We authors of the article entitled “Quantitative carcass traits of Holstein calves, finished in different systems and slaughter weights” declared, for all due purposes, the project that gave rise to the present data of the same has not been submitted for evaluation to the Ethics Committee of the University Tecnológica Federal do Paraná, but we are aware of the content of the Brazilian resolutions of the National Council for Control of Animal Experimentation - CONCEA <http://www.mct.gov.br/index.php/content/view/310553.html> if it involves animals.

Thus, the authors assume full responsibility for the presented data and are available for possible questions, should they be required by the competent authorities.

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