Ciência Rural
ISSN: 0103-8478
cienciarural@mail.ufsm.br
Universidade Federal de Santa Maria
Brasil

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Ciência Rural, vol. 42, núm. 5, mayo, 2012, pp. 875-881
Universidade Federal de Santa Maria
Santa Maria, Brasil

Ciência Rural, Santa Maria, v.42, n.5, p.875-881, mai, 2012
ISSN 0103-8478

Carcass and meat characteristics of crossbred steers submitted to different nutritional strategies at growing and finishing phases

Características da carcaça e da carne de novilhos mestiços submetidos a diferentes estratégias nutricionais na recria e terminação

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ABSTRACT

*This study was carried out to evaluate the effects of different nutritional strategies at growing and finishing phases on carcass and meat characteristics from 24 crossbred steers predominatly Holstein, slaughtered at 15 months of age and with 395.00kg of body weight. At the growing phase, the animals were maintained on **Brachiaria brizantha** pasture with two levels of supplementation in amounts equivalent to 0.5 or 1.0% of body weight. Subsequently, the animals were finished in feedlot with diets composed of 50 or 80% of concentrate. The high level of the concentrate at the finishing phase increased significantly (P<0.05) the hot carcass yield (50.16 vs. 48.62%). The lowest level of supplementation at the growing phase resulted in higher (P<0.05) percentage of carcass fat (25.61 vs. 23.39%) but it did not influence the percentage of muscle and bone. The high level of supplementation at the growing phase provided higher (p<0.05) meat tenderness, required less shear force (4.72 vs. 6.66kg cm^{-3}) and lighter red meat (3.88 vs 2.89 points). The high feeding level during the growing phase was more interesting because it affected positively some important carcass and meat characteristics, especially tenderness.*

Key words: *rib eye area, color, marbling, fat thickness, carcass yield.*

RESUMO

*Objetivou-se com este estudo avaliar os efeitos de diferentes estratégias nutricionais na recria e terminação sobre as características da carcaça e da carne de 24 bovinos mestiços com predominância Holandês, abatidos com 15 meses de idade e 395,00kg de peso vivo. Na fase de recria, os animais foram mantidos em pastagem de **Brachiaria brizantha** com dois níveis de suplementação energética em quantidade equivalente a 0,5 ou 1,0% do peso vivo. Posteriormente, os animais foram terminados em confinamento com dietas compostas por 50 ou 80% de concentrado. Constatou-se efeito significativo (P<0,05) do nível de concentrado na terminação sobre o rendimento de carcaça quente em favor do nível alto (50,16 vs 48,62%). O menor nível de suplementação na recria resultou em maior (P<0,05) percentual de gordura na carcaça (25,61 vs 23,39%), mas não influenciou os percentuais de músculos e ossos. O nível alto de suplementação na recria proporcionou carne mais macia, requerendo menor força de cisalhamento (4,72 vs 6,66kg cm^{-3}) e de coloração vermelha mais clara (3,88 vs 2,89 pontos). O nível alimentar alto na recria mostrou-se mais atrativo por ter efeitos positivos sobre algumas características importantes da carcaça e da carne, notadamente a maciez.*

Palavras-chave: *área de olho de lombo, cor da carne, espessura de gordura subcutânea, maciez, marmoreio, rendimento de carcaça, textura.*

INTRODUCTION

There is an estimation that around 5 million male calves, usually crossbred (Holstein x Gir), are born annually in the state of Goias, Brazil. This state has the second largest dairy herd in the country (IBGE, 2008) and in most of the dairy farms males represent a problem, because these animals require great amount of milk at the beginning of their development. Great part of 7.5 million male dairy calves (IBGE, 2008) born annually in

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Received 08.31.11 Approved 12.01.11 Returned by the author 03.24.12
CR-5934

Brazil is slaughtered on the first days of age or they are sold for irrelevant prices. When these animals remain at the farms they are usually raised with defficient feed management, leading to high mortality rates or resulting in slow development, affecting carcass and meat quality due to slaughtering at old age. Therefore the objective was to study the effects of different feeding plans on quantitative and qualitative characteristics of carcass and meat of dairy crossbred bovines according to the levels of energy ingestion during growing and finishing phases.

MATERIAL AND METHODS

The experiment was carried out from February to December 2008, at the school-farm of the Animal Production Department of Universidade Federal de Goiás (UFG), located in Goiania, Goias, Brazil, with 721 meters, latitude 16º 35' South and longitude 49º 17' West. Were evaluated the quantitative and qualitative carcass and meat characteristics of 24 castrated crossbreed steers from the same dairy herd. During the growing phase, from 6 to 11months of age, the animals were kept in rotational grazing on ***Brachiaria brizantha*** receiving two levels of energetic supplementation, medium (M) and high (H), corresponding to, respectively, 0.5 and 1.0% of live weight. At such phase, the supplement was composed of ground corn grain with the addition of mineral mixture formulated according to the requirements suggested by NRC (1996). After this period, from 11 to 15 months of age, the animals were prevously adapted to the diets (Table 1) and finished in feedlot in individual stalls. They were fed isonitrogenated diets of medium (M) and high (H) energetic density due to the inclusion of 50 or 80% of concentrate in the dry matter (DM) of the total diet, resulting in four feed strategies: HH – Diet with high energy level from the growing to finishing phase; MH – Diet with medium energy level at growing phase and high energy level at finishing phase; HM – Diet with high energy level at growing phase and medium energy level at finishing phase e MM - Diet with medium energy level at both growing and finishing phases.

The animals were weighed after 12 hours of fasting, right before the animals shipment. Hot carcass weight was obtained at the end of the slaughter line, after the animal was slaughtered, bled, eviscerated, skinned, and had the head and limbs removed. Cold carcass weight was obtained after cooling for 24 hours in a cooling chamber at 0±1ºC. The percentage of hot and cold carcass yield was obtained by dividing the hot or cold carcass weight by the live weight and multiplying it by 100.

Left-half carcass was cut between 12th and 13th ribs to expose the *Longissimus dorsi* muscle (LDM). The outline of the exposed muscle was drawn on vegetal paper and then digitalized by the software AUTOCAD®, to estimate the ribeye area expressed in

Table 1 - Chemical composition and percentage of ingredients on the basis of the dry matter of experimantal diets during finishing phase in feedlot.

% Nutrients	Concentrate		Roughage	Total Diet	
	Medium	High		Medium	High
DM	85.90	85.75	25.56	55.73	79.75
CP	24.77	17.91	7.63	16.20	16.57
NDF	13.69	13.38	59.20	36.44	17.99
ADF	7.14	4.60	38.60	22.87	8.26
EE	2.63	2.21	1.90	2.27	2.22
ASHES	7.45	4.45	3.81	5.63	4.68
TDN*	-	-	-	69.00	80.00

% Ingredients	Level of concentrate in the feedlot diet	
	Medium	High
Sorghum Silage	50.00	20.00
Grounded Corn	29.00	66.40
Soybean Meal	18.50	11.60
Urea	0.50	0.40
Mineral/Ionophores**	2.00	1.60

DM (dry matter), CP (crude protein); NDF (neutral detergent fiber); ADF (acid detergent fiber); EE (ether extract); TDN (Total digestive nutient); *Estimated; **Phosphate 13.56%; Calcite 50.53%; micro-mineral nucleus 9.86%; White salt 24.65%; Virginiamycin 0.81%; Ionophore 0.59%.

cm^2. The fat thickness on the LDM was measured with the aid of a caliper in three different spots, whose mean provided the subcutaneous fat thickness. Furthermore, the exposed LDM was used for the subjective evaluations of color and marbling after air exposure, under continuous luminosity, for 30 minutes, according to methodology by MÜLLER (1987).

A section including 10th, 11th, and 12th ribs was withdrawn (section HH), in which the physical separation of the components (bone, muscle and fat) was carried out, with the purpose of estimating their percentage in the carcass according to equations described by HANKINS & HOWE (1946). The portion of the *Longissimus dorsi* muscle withdrawn from this peace was identified, wrapped in plastic film and immediatly frozen at -18ºC for posterior laboratorial evaluation.

Shear force was determined in the 2.5-cm-thick steaks, roasted in the oven and then cooled for 24 hours at 7ºC. Eight cylinders of $^1/_2$ square inch per steak area were extracted perpendicularly to the fiber, in a Warner-Bratzler *Meat Shear* device. The reading of the necessary force for shearing the muscle fibers was carried out, considering the means after despising maximum and minimum values.

The experimental design was completely randomized in a 2x2 factorial arrangement, with two levels of energetic supplemetation at the growing phase and two levels of concentrate in the diet at the finishing phase in feedlot. In the variance analysis, for all studied parameters, each animal constituted an experimental unit. The differences among the averages were detected by *t* test at 5% of probability using the following mathematical model:

$$\mathbf{Y_{ijk} = \mu + a_{i(1;2)} + b_{j(1,2)} + (a*b)_{ij} + E_{ijk}}$$

In which Y_{ijk} = observations of the dependent variable correponding to the supplemetation level at growing of order i and concentrate level at finshing in feedlot of order j and repetition k; μ = average of all the observations; a_i = effect of the supplementation level of order i , being 1 = 0.5% of LW and 2 = 1.0% of LW; b_j = effect of the concentrate level at finishing of order j , being 1 = 50% of DM and 2 = 80% of DM; (a*b) = effect of the interaction between the supplementation level at grwoing phase of order i and the concentrate level at finishing phase of order j; E_{ik} = experimental error referrent to the observation of the supplementation level at growing of order i, concentrate level at finishing of order j and repetition k. The normality of data distribution was tested by Shapiro-Wilk test (SAS, 2002).

RESULTS AND DISCUSSION

The expected slaughter weight of 395.00kg was achieved at 84, 105, 126 and 126 days of feedlot for the strategies HH, HM, MH and MM, respectively. The nutritional levels at different phases had no significant effect (P>0.05) on hot and cold carcass weight (Table 2). According to PACHECO et al. (2005), the main factor that determines the carcass weight is the animal weight at slaughter, with high correlation between these two variables (r=0.93). This would explain the similarity for such variable, because the same slaughter weight was pre-determined for all the treatments.

When the animals present similar slaugther weight, differences at the carcass weight are the result of differences at carcass yield. Hot carcass yield (HCY) was higher (P=0.0594) for the animals sibmitted to the high level of concentrate during finishing phase when compared to medium level (50.16 vs 48.62%). However, such difference was not enough to produce significant difference in carcass weight.

The higher HCY of animals submitted to high level of concentrate at finishing phase occured probably as a consequence of the greater velocity and passage rate of the feed through the gastrointestinal tract at finishing, caused by the lower rate of NFD (36.44 vs. 17.99%) and the higher digestibility of the diet with high concentrate inclusion. RESTLE et al. (2001) observed that, when roughage with high passage rates are used, there are no differences regarding hot carcass yield among animals fed different levels of concentrate.

According to GESUALDI Jr et al. (2000), gastrointestinal and omasum content presents linear reduction of weight, whereas liver and internal fat present linear increase, from the raise of concentrate amount in the diet. On the other hand, MENEZES et al. (2007) observed that the increase of the gastrointestinal tract weight reduced the HCY, and the correlation between these variables was of 0.41.

Higher values of carcass yield were described by KABEYA et al. (2002), who studied Holstein/Zebu crossbred steers, with initial age of 18 months, submitted to different supplementation systems on pasture. The authors mentioned mean values of 54.08% for hot carcass yield, however, age and slaughter weight (440.00kg) were both superior than the ones of this present experiment.

There was no significant difference (P>0.05) of the nutritional levels at growing and finishing phases on the subcutaneous fat thickness (SFT). The strategies HH, HM, MH, MM presented the respective means 3.53; 2.68; 2.80 and 2.48mm (Table 2). The values

Table 2 - Averages and standard error of slaughter weight, hot and cold carcass weight and yeild, and subcutaneous fat thickness, according to the supplementation level at growing phase and to the concentrate level at finishing phase.

Supplementation at growing (%LW)	--------------Concentrate level at finishing, %--------------		Average
	80	50	
	---------------------Slaughter weight, kg---------------------		
1.0	394.26 ± 13.65	401.56 ± 14.95	397.91 ± 10.12
0.5	398.00 ± 14.95	393.66 ± 13.65	395.83 ± 10.12
Average	396.13 ± 10.12	397.61 ± 10.12	
	--------------------Hot carcass weight, kg--------------------		
1.0	201.25 ± 3.37	194.00 ± 3.69	197.62 ± 2.50
0.5	196.30 ± 3.70	192.45 ± 3.37	194.37 ± 2.50
Average	198.77 ± 2.50	193.22 ± 2.50	
	-------------------Cold carcass weight, kg-------------------		
1.0	199.05 ± 3.43	193.40 ± 3.76	196.22 ± 2.54
0.5	193.52 ± 3.76	188.63 ± 3.43	191.07 ± 2.54
Average	196.28 ± 2.54	191.01 ± 2.54	
	---------------------Hot carcass yield, %---------------------		
1.0	51.03 ± 0.81	48.39 ± 0.89	51.03 ± 0.81
0.5	49.29 ± 0.89	48.84 ± 0.81	49.29 ± 0.89
Average	50.16 ^{A}± 0.60	48.62 ^{B}± 0.60	50.16 ± 0.60
	--------------Subcutaneous fat thickness, mm--------------		
1.0	3.53 ± 0.42	2.68 ± 0.46	3.10 ± 0.31
0.5	2.80 ± 0.46	2.48 ± 0.42	2.64 ± 0.31
Average	3.16 ± 0.31	2.58 ± 0.31	
	---------------------Ribeye area, cm^2---------------------		
1.0	52.90 ± 2.55	50.08 ± 2.80	52.90 ± 2.55
0.5	50.96 ± 2.80	51.90 ± 2.55	50.96 ± 2.80
Average	51.93 ± 1.89	50.99 ± 1.89	51.93 ± 1.89

^{A,B} Averages followed by different letters differ statistically (P<0.05).

found are below the adequate patterns for the Brazilian slaughterhouses, from 3.0 to 6.0mm, except the group that recieved the high nutritional level at both phases.

PACHECO et al. (2005), finishing steers and young steers to be slaughtered with the same weight, verified significant difference at SFT favoring the young steers (6.29mm vs. 3.22mm). According to the authors, this fact was caused by a longer feeding period in the feedlot of young steers. In the present study, the animals remained in feedlot during 84, 105, 126 and 126 days for HH, HM, MH, MM, respectively. Nevertheless, the longer feedlot period of MH and MM groups was not enough to encrease SFT to the desirable level. The finishing level of the carcasses observed in this study also indicates that fat deposition occurs lately in dairy crossbred Holstein-predominant animals, hence, the animals present heavier weight at maturity, when compared with more precocious breeds such as Aberdeen angus and Jersey.

Bone percentage (BP) and muscles percentage (MP) was not affected (P>0.05) by the effects studied (Table 3). Fat percentage (FP) in the carcass was affected by the supplementation level at the growing phase (Table 3). Animals that recieved medium level of supplementation at the growing phase presented bigger proportion (P<0.05) of adipose tissue in the carcass (25.61 vs. 23.39%).

The fat percentage in the carcasses of the MH animals is probably due to lower energy requirement for maintenance, considering these animals presented lower weight at the beginning of the feedlot, resulting in greater net energy availability for fat deposition. According to DI MARCO (1998), intermuscular fat is the first fraction of adipose tissue that is accumulated in the carcass, followed by subcutaneous fat, and then by the intramuscular fat. The same author mentions that intermuscular fat represents the biggest fraction of fat in the carcass.

According to BERG & BUTTERFIELD (1979), muscle is the most important tissue because it is the most prefered by the consumer: consequently, superior quality carcass for any market should have

Table 3 - Averages and standard error of the tissues that constitute the carcass, according to the supplementation level at growing phase and to the concentrate level at finishing phase.

Supplementation at growing (%LW)	Concentrate level at finishing, %		Average
	80	50	
	Bone, %		
1.0	16.68 ± 0.60	16.15 ± 0.66	16.41 ± 0.44
0.5	15.97 ± 0.66	15.96 ± 0.60	15.96 ± 0.44
Average	16.32 ± 0.44	16.05 ± 0.44	
	Muscle, %		
1.0	60.42 ± 0.88	61.42 ± 0.96	60.92 ± 0.65
0.5	58.65 ± 0.96	60.02 ± 0.88	59.33 ± 0.65
Average	59.54 ± 0.65	60.72 ± 0.65	
	Fat, %		
1.0	23.52 ± 0.90	23.27 ± 0.98	23.39 ^{B} ± 0.66
0.5	26.29 ± 0.99	24.93 ± 0.90	25.61 ^{A} ± 0.66
Average	24.90 ± 0.66	24.10 ± 0.66	
	Relation muscle/bone		
1.0	3.64 ± 0.16	3.81 ± 0.17	3.72 ± 0.11
0.5	3.71 ± 0.17	3.79 ± 0.16	3.75 ± 0.11
Average	3.67 ± 0.11	3.80 ± 0.11	
	Relation muscle+fat/bone		
1.0	5.06 ± 0.23	5.26 ± 0.25	5.16 ± 0.17
0.5	5.38 ± 0.25	5.36 ± 0.23	5.16 ± 0.17
Average	5.22 ± 0.17	5.31 ± 0.17	
	Color (points)[1]		
1.0	3.97 ± 0.36	3.79 ± 0.40	3.88 ^{A} ± 0.27
0.5	2.79 ± 0.40	2.98 ± 0.36	2.89 ^{B} ± 0.27
Average	3.38 ± 0.27	3.38 ± 0.27	
	Marbling (points)[3]		
1.0	5.49 ± 1.34	5.61 ± 1.47	5.55 ± 0.99
0.5	7.00 ± 1.47	5.65 ± 1.34	6.33 ± 0.99
Average	6.24 ± 0.99	5.63 ± 0.99	
	Shear force, kg/cm^{3}		
1.0	4.73 ± 0.75	4.72 ± 0.82	4.72^{B} ± 0.56
0.5	6.09 ± 0.82	7.23 ± 0.75	6.66^{A} ± 0.56
Average	5.41 ± 0.55	5.98 ± 0.56	

1= extreme dark red; 2= dark red; 3=slightly dark red; 4= light red; 5= extreme light red ; [2]Marbling: 1 to 3=traces; 4 to 6=light; 7 to 9=little; 10 to 12=medium; 13 to 15=moderate; 16 te 18=abundant; [A,B] Averages followed by different letters differ statistically ($p<0.05$).

maximum muscle quantity, minimun bone quantity and great fat quantity, which varies according to the cosumer´s preference.

There was no significant effect of the feeding plans at growing and finishing on the ribeye area (REA). Such measure is one of the parameters used to establish the carcass muscularity and it is correlated with the age of the animal (RESTLE et al., 2001), slaughter weight (COSTA et al., 2002), genetic composition (RIBEIRO et al., 2001) and sexual condition (PRADO et al. 2004). FERREIRA et al. (2000) did not verify influence of the concentrate levels at the finishing in feedlot phase on the REA of crossbred steers either.

According to MÜLLER & PRIMO (1986), deficient feeding at the growing phase damaged the muscular development of the animals, resulting in worse conformation of the carcass and smaller REA in steers maintained exclusively on pasture. RESTLE et al. (1999), studying the effects of the growth at the initial phase from three to seven months of age in beef males, verified that little growth at this period can be recovered subsequently until 24 months of age, resulting in carcasses and meat with similar characteristics to the ones of the animals that did not suffer restriction during growth.

Animals that recieved high level of supplemetnation at growing presented higher score ($P<0.05$), indicating meat with lighter red color (Table 3). Myoglobin is one of the factors which determines meat coloration, and its concentration increases with the animal´s age and weight (SHORTHOSE & HARRIS, 1991). It is likely that the longer feedlot period of the animals that recieved medium level of suppmentation at growing favored the increase of myoglobin concentration in the muscles, resulting in darker color.

Similar results were described by ARBOITTE et al. (2004), who studied the characteristics of the meat of crossbred steers slaughtered with different weights. The authors verified meat darkening when the period of feeding in feedlot increased from 84 to 121 days, with values of 4.66 and 3.83 points, respectively. MÜLLER & PRIMO (1986) studied the finishing of bovine on native or cultivated pasture and evidenced better meat coloration in animals that were better fed and slaughtered at younger age.

There was no significant effect of the nutritional plans at the different phases on the intramuscular fat score (marbling). This fact could be due to the similarity of slaughter age and the level of carcass finishing. According to DI MARCO (1998), the intramuscular fat is the last fraction of the fat tissue that is accumulated. Considering there were no significant differences for SFT, it was unlikely to find big alterations in the amount of intramuscular fat. VAZ et al. (2005), studying the addition of concentrate levels to the diet, did not verify effect of the nutritional levels on the meat marbling of Charolais/Nellore crossbred steers in feedlot, obtaining mean value of 4.75 points of intramuscular fat. BRONDANI et al. (2004) did not observe differences in the marbling score when Aberdeen Angus and Hereford steers were fed different with energy level in the diet.

Meat tenderness, measured by the shear force obained in Warner Bratzler *Shear* device, was significantly influenced ($P<0.05$) by the feeding level at growing (Table 3). Animals which recieved high supplementation level at growing presented more tender meat, regardless of the concentrate level at finishing. The meat tenderness of the animals in treatments HH and HM was similar (4.72 and 4,73kg cm^{-3}, respectively).

The greater energy intake of the animals at growing increased the speed of the muscle tissue growth, due to the higher availability of net energy for growth. According to GERRARD et al. (1987), the collagen synthesis is bigger in animals that present fast weight gain rate. BRUCE et al. (1991) state that the new collagen molecules dilute the old ones, resulting in muscles with more soluble collagen and, hence, more tender meat.

CONCLUSION

By the obtained results, it can be infered that it is possible to improve the meat quality of crossbred dairy steers, mainly the color and tenderness, through the feeding strategies searching for a more accentuated growth at the initial stage of the animal´s life.

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