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Carcass traits of Nellore, F_1 Simmental × Nellore and F_1 Angus × Nellore steers fed at maintenance or *ad libitum* with two concentrate levels in the diet[1]

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ABSTRACT - This trial was conducted to evaluate the quantitative carcass traits of Nellore, F_1 Simmental × Nellore and F_1 Angus × Nellore steers fed at maintenance level or *ad libitum* with 1% and 2% of the body weight in concentrate. The animals were allotted to the treatments in a completely randomized experimental design, in a 3 × 3 factorial arrangement. The animals fed the *ad libitum* diet with more concentrate had greater cold carcass weight, cold carcass yield and *longissimus* muscle area/ 100 kg of cold carcass weight when compared with animals fed the diet with low concentrate allowance. There was no difference between the *ad libitum* diets for all of the carcass cuts yields, except for top sirloin. Crossbred animals had cold carcass yield larger than the Nellore animals. F_1 Angus × Nellore animals had greater rib fat thickness and smaller *longissimus* muscle area/ 100 kg than the F_1 Simmental × Nellore cattle. The yield of commercial carcass cuts was not influenced by genetic group, except for the shoulder clod yield, which was smaller in crossbred animals compared with Nellore animals. The *longissimus* muscle area, rib fat thickness and rump fat, taken by ultrasound were influenced by the body weight of the animals. Crossbred animals fed diets with higher concentrate level produce carcasses most suitable for the requirements of the market.

Key Words: carcass yield, longissimus muscle area, tissue deposition

Introduction

With the recent challenges in the Brazilian beef industry, concepts about the production system adopted by the beef producers must be reviewed. The understanding of production standardization and reduction of the cost of interest on the capital invested in animals is necessary to improve the productivity with the quality standard required by the international market.

Even though Brazil has advantages regarding beef production compared with some other countries, the Brazilian beef chain presents productivity and economic index below the expected for an efficient beef production system. For that reason, the use of feedlot animals has increased in Brazil, as the rate of weight gain with high energy diets is greater than with roughage-based diets which reduce the time that cattle need to be fed (Duarte et al., 2011).

The Brazilian cattle herd is composed mainly of *Bos indicus* animals (Alves et al., 2004), mostly by Nellore, which present lower growth potential compared with Taurine breeds. However, Nellore cattle have more rusticity and adaptability to the tropical environment. Thus, the use of F_1 *Bos indicus* × *Bos Taurus* crossbred animals can maximize the heterosis, mainly with regard to carcass traits.

Carcass yield is economically important, as most of the inspected meat commercialized in Brazil is based on carcass weight. In this context, this study was developed to evaluate the influence of the feeding regime on quantitative characteristics of carcass of Nellore, F_1 Simmental × Nellore and F_1 Angus × Nellore.

Material and Methods

This experiment was conducted in the Laboratório Animal of the Departmento de Zootecnia of Universidade Federal de Viçosa (UFV), in Viçosa-MG, from May to September of 2007. Forty-eight steers with average age of 18 months (16 Nellore (N), 16 F_1 Simmental × Nellore (SN), 16 F_1 Angus × Nellore (AN)) were used.

Animals were submitted to a period of 30 days of adaptation to the experiment conditions and 14 days of adaptation to experimental diets prior to the beginning of the of 84 days of experiment. During the 30 days of adaptation to experimental conditions, cattle were fed the same diet with the level of concentrate at 1% of BW. After the 30 days

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of adaptation, six animals from each genetic group that were assigned to receive concentrate at levels of 2% of BW were fed concentrate at 1.5% of BW for 7 days and fed concentrate at 2% of BW for 7 days for adaptation to experimental diets. Six animals from each genetic group assigned to receive concentrate at 1% of BW and four animals assigned to be fed at maintenance were fed their treatment diets after the 30 days of adaptation to the experimental conditions.

Analysis of dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), and acid detergent fiber (ADF), were performed as described by Silva & Queiroz (2002). For analyzing the neutral detergent fiber (NDF) concentration, samples were treated with alpha thermostable amylase without sodium sulfite and corrected for ash residue (Mertens, 2002) and residual nitrogen compounds (Licitra et al., 1996). The non-fiber carbohydrate content (NFC) was calculated as follows: NFCap = 100 – [(% CP – %CP derived from urea + % urea) + %NDFap + %EE + %Ash]. The apparent total digestible nutrients (TDN) were calculated as (CP intake – fecal CP) + (NDF intake – fecal NDF) + (NFC intake – fecal NFC) + [2.25 × (EE intake – fecal EE)] (Sniffen et al., 1992). Digestible energy was obtained by multiplying the digestible nutrients by their respectively energetic value (NRC, 2001). The concentration of metabolizable energy was considered as 82% of the digestible energy (Coelho da Silva & Leão, 1979).

Chemical composition of the ingredients is presented in Table 1, and ingredients proportion and chemical composition of diets are presented in Table 2.

Animals were confined to individual stalls with feeders and drinkers and a total area of 30 m^2 of which 8 m^2 were covered with asbestos tiles. After analysis of the available ingredients, diets were formulated to be isonitrogenous with 12.5% CP. The animal feed intake was estimated as suggested by Valadares Filho et al. (2006) and the macro and micro minerals requirements were adjusted according to NRC (1996). Concentrates were formulated by using corn meal, soybean meal, cotton seed, soybean hull, urea/ammonium sulphate (9:1) sodium bicarbonate, magnesium oxide, salt and mineral mixture. Corn silage was used as source of roughage. All diets were formulated to contain 20% as the minimum amount of NDF. Through the experiment, the concentrate:roughage ratio was 58.7:41.3 and 24.84:75.16 for diets with concentrate levels at 1% and 2% of BW, respectively.

The experimental period was divided into 3 periods of 28 days each. At the beginning of the experiment, cattle were weighed in order to obtain the average initial body weight (BW), which was 265.6±6.4 kg for N, 325.3±4.7 kg for F_1 Simmental × Nellore and 324.6±6.0 kg for F_1 Angus × Nellore . Cattle were also weighed on days 28 and 56 of the experimental period.

Diets were fed as total mixed ration (roughage + concentrate) and cattle were fed twice daily (at 6:30 a.m. and 3:30 p.m.) allowing for up to 5-10% of orts. Animals assigned to be fed at maintenance were fed once daily with the same diet of those fed concentrate at 1% of BW. At the first experimental period cattle fed at maintenance were fed concentrate levels of 1.2% BW. However, due to a gain of weight observed in those animals, they were fed concentrate levels of 1% BW after the second experimental period.

At the end of the trial, animals were weighed after a 16-h solid fast and slaughtered by cerebral concussion followed by jugular and carotid venesection following the Normative Instruction no. 3 of 01/13/2000 (Technical Regulation of Methods for Humane Slaughtering of Livestock).

After the slaughter, the hot carcass weight (HCW) was recorded. All carcasses were refrigerated at 0 ºC for 24 h. After the postmortem chill period, cold carcass weight

Table 1 - Chemical composition of the ingredients used in the experimental diets

Item	Cotton seed	Soybean hull	Soybean meal	Corn	Corn silage	Mineral mixture
Dry matter (% DM)	91.18	88.68	88.61	88.38	28.95	-
Organic matter (% DM)	96.91	96.19	94.04	98.97	93.32	-
Crude protein (% DM)	23.92	11.85	49.46	8.91	7.13	-
Neutral detergent insoluble crude protein/crude protein (% CP)	12.79	40.10	11.68	29.72	19.55	-
Ether extract (% DM)	15.75	1.05	1.48	3.36	2.44	-
Neutral detergent fiber, NDF (% DM)	49.63	67.43	17.58	21.95	52.48	-
NDFap (% DM)[1]	45.68	61.68	11.17	18.78	49.13	-
Indigestible NDF (% DM)	20.47	6.32	2.60	3.07	19.60	-
Non fiber carbohydrates (% DM)	11.56	21.62	31.93	67.92	34.62	-
Phosphorus (% DM)	0.94	0.20	1.02	0.50	0.36	15.57
Calcium (% DM)	0.31	0.81	0.56	0.25	0.36	31.54
Magnesium (% DM)	0.29	0.27	0.35	0.11	0.11	0.66
Sodium (% DM)	0.16	0.17	0.11	0.11	0.14	0.23
Potassium (% DM)	1.17	1.31	2.13	0.47	1.28	0.40

[1] Neutral detergent fiber corrected for ash and protein.

(CCW), 12th rib fat thickness (RFT) and 12th rib *longissimus* muscle area (LMA) were measured on the left side of each carcass. *Longissimus* muscle areas were traced on transparency for further measurement and RFT were measured at ¾ the length ventrally over the *longissimus* muscle. Carcass length was recorded by measuring the distance between the anterior edge of the first rib and the anterior edge of the aitch bone (Muller, 1980).

On the right half of each carcass, commercial cut yields were measured, separating the anterior and posterior quarters by cutting between the fifth and sixth ribs. The forequarter consisted of the chuck, shoulder and flank, and the hindquarter consisted of top sirloin and rump.

Table 2 - Ingredients proportion and chemical composition of experimental concentrates and diets

Ingredient	1%		2%	
	Concentrate	Diet	Concentrate	Diet
	Proportion			
Corn silage	58.70		24.84	
Cotton seed	12.28	5.07	12.07	9.07
Soybean hull	26.93	11.12	26.66	20.04
Urea	3.17	1.31	1.06	0.80
Ammonium sulfate	0.35	0.14	0.21	0.16
Corn	52.43	21.65	55.07	41.39
Soybean meal	2.02	0.83	2.09	1.57
Mineral mixture	0.69	0.29	0.70	0.52
Salt	0.69	0.29	0.70	0.52
Potassium chloride	0.35	0.14	0.35	0.26
Magnesium oxide	0.32	0.13	0.32	0.24
Sodium bicarbonate	0.64	0.26	0.64	0.48
Limestone	0.14	0.06	0.14	0.11
Dry matter	-	53.97	-	74.29
Organic matter	95.72	94.31	95.70	95.11
Crude protein	20.69	12.73	14.96	13.02
Ether extract	4.01	3.09	4.06	3.66
NDFap[1]	41.18	45.84	35.51	38.89
Non fiber carbohydrates	52.39	41.96	48.21	44.83
Total digestible nutrients	-	70.50	-	70.27
Digestible energy	-	3.11	-	3.10
Metabolizable energy	-	2.54	-	2.54
Phosphorus	0.56	0.44	0.57	0.52
Calcium	0.67	0.49	0.67	0.59
Magnesium	0.35	0.21	0.36	0.30
Sodium	0.55	0.31	0.55	0.45
Potassium	0.95	1.14	0.96	1.04

[1] Neutral detergent fiber corrected for ash and protein.

Ultrasound measurements of 12th rib fat thickness (RFT), *longissimus* muscle area (LMA), and rump fat thickness (P8) were taken using an Aloka 210DX real-time ultrasound unit (Corometrics Medical Systems, Wallingford, CT) equipped with a 3.5-MHz linear array probe with 17.2 cm of length.

Ultrasound measurements were evaluated by using the simple allometric model: $Y = \beta_0 \times X^{\beta_1} + \varepsilon$ were: Y = response variable (LMA, RFT or P8); X = Body weight (kg); β_0 = parameter of scalar adjustment; β_1 = allometric coefficient; and ε = random error. The data were linearized by anamorphosis, including the effects of feeding regime (1% or 2% of BW) and genetic type to the model described above. The effect of genetic type was analyzed by using Dummy variables (Draper & Smith, 1966).

The experiment was conducted in a completely randomized design in a 3 × 3 factorial arrangement. Treatments consisted of 3 genetic types (Nellore; F_1 Simmental × Nellore; F_1 Angus × Nellore) and 3 feeding regimes (cattle fed at maintenance and *ad libitum* with concentrate levels at 1 or 2% of BW) with six replicates in each *ad libitum* level and four replicates in the group of animals fed at maintenance. Statistical analyses were performed using the PROC GLM procedure of SAS (SAS Inst. Inc., 2000), with significance considered at P<0.05.

Results and Discussion

There was no interaction (P<0.05) between feeding regime and genetic type for none of the variables evaluated.

Cattle fed at maintenance presented lower values (P<0.05) of all variables evaluated in this trial compared with cattle fed *ad libitum* (1% or 2% of BW), with the exception of LMA/100 kg, which was greater in animals fed at maintenance (Table 3). Animals fed concentrate at 2% of BW presented greater carcass yield (P<0.05) than those fed concentrate at 1% of BW. Cattle fed concentrate at 1% of

Table 3 - Means and coefficient of variation of carcass traits of beef cattle fed at maintenance and fed concentrate at 1% and 2% of body weight

Item	Feeding regime					
	Ad libitum		Maintenance	P-value		CV (%)
	1%	2%	Maintenance	Maintenance × *Ad libitum*	1% × 2%	
Cold carcass weight, kg	264.39	281.22	200.17	<0.0001	0.0059	6.8
Cold carcass yield, %	57.57	58.88	57.03	0.0139	0.0074	2.4
Carcass length, cm	130.42	133.17	126.08	0.0002	0.0621	3.2
Longissimus muscle area, cm^2	75.84	75.35	58.96	<0.0001	0.8122	8.5
Longissimus muscle area/100 kg	28.67	26.86	29.40	0.0172	0.0090	7.0
Rib fat thickness, mm	6.71	6.40	1.68	<0.0001	0.6820	41.0

CV = coefficient of variation.

BW presented greater values (P<0.05) of LMA/100kg than those from the group fed concentrate at 2% of BW. No differences were found (P>0.05) for carcass length for cattle fed concentrate at 1% or 2% of BW.

Carcass traits are influenced by growth and development of the animal, which may be defined as mass accumulation and form challenges (Berg & Butterfield, 1976). Animal growth can be affected by genetic and environmental factors, where animal nutrition plays an important role. Cattle fed at maintenance received energy enough only to maintain the vital functions, as the feed level was not enough to provide animal growth, adequate fat and muscle deposition. Thus, animals fed at maintenance presented inadequate carcass traits according to the requirements of Brazilian beef industry, such as at least 3 mm of RFT and 210 kg of carcass weight for castrated cattle (Paulino et al., 2010).

Some internal organs of the body such as liver, kidney, heart and gastrointestinal tract are responsible for up to 40% of energy requirement for maintenance of fasting cattle (Koong et al., 1985). Therefore, it is worth stressing the direct relationship between the size of internal organs and maintenance requirements of beef cattle. These tissues have high protein turnover, relatively higher than those presented by muscle tissue resulting in high cost of energy for a basal metabolism. According to Winter et al. (1976), during feeding restriction there is a reduction in the size of intern organs in relation to the BW, where the growth of liver and intestine is more affected than the growth of the animal, being a tendency to a negative allometric growth.

Marcondes et al. (2010) working with the same animals reported that animals fed at maintenance had lower (P<0.05) percentage of organs and viscera (13.63%) compared with animals fed *ad libitum* (16.21%). However, animals fed at maintenance presented lower (P<0.05) carcass yield than those fed *ad libitum*, which may be explained by the lower amount of carcass fat thickness (RFT) and lower muscle mass, evidenciated by the lower LMA (P<0.05). In addition, the carcass from cattle fed at maintenance was shorter (P<0.05) than those fed *ad libitum*, which allows inferring that the growth of animals fed at maintenance was affected.

As previously reported, the size of the gastrointestinal tract may vary according to the type of diet that the animals are fed. Cattle fed high levels of concentrate may present a lighter and shorter gastrointestinal tract than animals fed lower levels of concentrate (ARC, 1980), which was not observed in this study. Marcondes et al., (2010) in a study with the same animals observed that cattle fed *ad libitum* had the same percentage of organs and viscera in relation to empty body weight (16.21%). Thus, it can be inferred that the greater carcass yield of the animals fed *ad libitum* have occurred exclusively due to the greater (P<0.05) carcass weight of these animals (Table 3).

The greater values (P<0.05) of LMA/100 kg observed in animals fed at maintenance may be related to higher proportion of muscle tissue found on the carcass of those animals (65.11%) compared with those fed *ad libitum* (60.5%).

Feed-restricted cattle can minimize the use of energy by reducing the size of organs and viscera (Sainz & Bentley, 1997) as well as modulating the growth of muscle fibers by increasing the frequency of oxidative fibers, which has greater efficiency of energy metabolism than glycolytic fibers (Lefaucher, 2010). Since the intake of metabolizable energy is restricted in animals fed at maintenance, the energy available for fat deposition is critical. Several genes related to structural proteins and enzymes have their expression reduced when the animal is submitted to a feed-restriction, as the energy is mostly used for maintenance of vital functions rather than tissue deposition. According to Faulconnie et al. (2001), feed-restricted animals present a reduction of expression of the lipoprotein lipase, responsible for lipid deposition into the adipocytes. This is a possible explanation for the production of carcass with larger amount of muscles and lower amount of fat in feed-restricted animals.

The lower values of LMA/100 kg observed in animals fed concentrate at 2% of BW compared with those fed concentrate at 1% of BW may be related to the excess of available energy that is converted to adipose tissue, consequently reducing the proportion of muscle tissue in the carcass.

According to Owens et al. (1993) the excess of nutrients is converted into lipids, excreted or catabolized. Cattle fed lower levels of concentrate had greater proportion of muscle tissue in the carcass.

The lack of differences (P>0.05) for carcass length among *ad libitum* feeding regimes may be explained by the similar growth presented by the animals fed concentrate at 1% or 2% of BW (1.24 and 1.32 kg/day respectively). The similarity in growth rate implies that those animals had similar deposition of bone tissue in the carcass. On the other hand, the lower value of carcass length (P<0.05) of the animals fed at maintenance compared with those fed *ad libitum* may have occurred due to the stabilization of growth of bone tissue as a consequence of the feed-restriction during a critical early growth phase.

Differences were observed for weight and length of carcass (P<0.05) where Nellore animals had lower weight and length of carcass than Simmental × Nellore and Angus × Nellore animals (Table 4). However, no differences were observed ($P>0.05$) between F_1 Simmental × Nellore and F_1 Angus × Nellore cattle for those variables (Table 4). With regard to carcass yield, no differences were found ($P>0.05$) among genetic groups (Table 4). Animals from the Nellore group presented lower values ($P<0.05$) of LMA than crossbred animals. Similar values of LMA/100 kg ($P>0.05$) were observed between Nellore and crossbred animals (Table 4). Nonetheless, differences were observed ($P<0.05$) for LMA/100 kg of carcass where F_1 Simmental × Nellore animals presented greater values than F_1 Angus × Nellore cattle, which presented greater RFT values ($P<0.05$) (Table 4).

Feijó et al. (1997), in a study with Simmental × Nellore cattle observed an increase of carcass length of crossbred animals. Vaz & Restle (2001) have found greater values of carcass length in crossbred animals, evidentiating the heterosis of the characteristic.

Differences in carcass yield between genetic types are commonly seen when the time of slaughter is determined by the evaluation of carcass finishing score (Euclides filho et al., 1997), as the some animals can presented the desired finishing score at heavier weights and consequently greater carcass yield. Thus, animals with lighter BW at maturity may present high carcass finishing score and consequently higher carcass yield. However, this was not observed in this study since the time of slaughter was determined by the number of days in feedlot.

The lower carcass weight of Nellore cattle may be explained by the values of carcass length and carcass gain (0.640 kg/d) compared with crossbred animals (0.860 kg/d). Crossbred animals presented greater values of BW gain than Nellore animals, leading to heavier carcasses. Even though SN cattle are considered animals with greater frame size compared with F_1 Angus × Nellore cattle, carcass length did not differ ($P>0.05$) between those groups. This may have occurred due to the similar ($P>0.05$) carcass gain (0.860 kg/d) between those groups. In addition, considering that Angus cattle have a small frame size, the crossbreeding with Nellore animals may have led to an increase in the size of these animals compared with those from the F_1 Simmental × Nellore group. Taurine breeds have been intensively selected to produce beef, and thus present high muscle yield in the carcass when compared with purebred *Bos indicus* cattle (Morales et al., 2002). According to Barbosa (1999), Nellore cattle have less growth rate compared with Taurine cattle. Thus, it can be inferred that Nellore animals present late deposition of fat compared with crossbred animals, which might explain the lower values of RFT observed on the carcass of those animals.

Camfield et al. (1997) observed lower deposition of subcutaneous fat tissue in carcass of animals that present greater BW at maturity, which may explain the lower RFT of the carcass from F_1 Simmental × Nellore animals. As there is a direct relationship in the proportion of muscle:fat tissues in the carcass, it was expected that F_1 Simmental × Nellore cattle would present greater amount of muscle in the carcass compared with F_1 Angus × Nellore cattle.

Cattle fed concentrate at 2% BW presented heavier commercial cuts ($P<0.05$) than animals fed concentrate at 1% BW, with exception of chuck and forequarter, which was similar between those treatments ($P>0.05$). Animals fed at maintenance had lower ($P<0.05$) weight of cuts than animals fed *ad libitum*. The yield of chuck, top sirloin and forequarter did not differ ($P<0.05$) between animals fed at maintenance and *ad libitum*. Animals fed at maintenance had greater yield ($P<0.05$) of round, shoulder and hindquarter, and lower yield of plate ($P<0.05$) than animals fed *ad libitum*. Cattle fed concentrate at 2% of BW had greater yield ($P<0.05$) of top sirloin than those fed concentrate at 1% of BW (Table 5).

Animals were fed at maintenance aiming to maintain the BW without changes in the carcass weight. Consequently, lower weight of commercial cuts was observed in animals fed at maintenance compared with those fed *ad libitum*.

The RFT is positively correlated to the amount of fat on the carcass and inversely correlated to commercial cuts

Table 4 - Means and coefficient of variation (CV) of carcass traits of Nellore (NE), F_1 Simmental × Nellore (SN) and F_1 Angus × Nellore (AN) cattle

Item	Genetic type			P-value		CV (%)
	SN	AN	NE	NE × Crossbred	SN × AN	
Cold carcass weight, kg	269.78	271.99	222.17	<0.0001	0.6118	6.8
Cold carcass yield, kg	58.01	57.82	57.95	0.7971	0.6942	2.4
Carcass length, cm	132.94	133.28	123.44	<0.0001	0.8268	3.2
Longissimus muscle area (LMA), cm^2	78.49	74.26	61.56	<0.0001	0.0797	8.5
LMA/100 kg	29.24	27.40	27.88	0.3971	0.0113	7.0
Rib fat thickness, mm	4.62	6.37	3.81	0.0181	0.0342	41.0

Table 5 - Means and coefficient of variation (CV) of weight and yield of commercial cuts of beef cattle fed at maintenance and fed concentrate at 1% and 2% of body weight

Item	Feeding regime			P-value		CV (%)
	Ad libitum		Maintenance			
	1%	2%	Maintenance	Maintenance × *Ad libitum*	1% × 2%	
			Commercial cuts ½ carcass (kg)			
Chuck	29.62	29.35	21.51	<0.0001	0.8727	18.2
Round	34.73	36.54	28.74	<0.0001	0.0374	7.4
Top sirloin	21.46	23.47	17.45	<0.0001	0.0015	8.3
Shoulder	21.23	22.50	17.84	0.0351	<0.0001	8.4
Plate	15.58	16.99	10.16	<0.0001	0.0273	12.5
hindquarter	56.18	60.01	46.18	<0.0001	0.0060	7.1
Forequarter	50.85	51.84	39.35	<0.0001	0.5881	11.3
			Commercial cuts yield (% cold carcass weight)			
Chuck	24.29	22.82	22.59	0.4650	0.2643	16.8
Round	28.61	28.45	30.09	0.0002	0.6817	4.0
Top sirloin	17.62	18.25	18.25	0.2865	0.0376	4.9
Shoulder	17.5	17.54	18.69	0.0033	0.9565	6.3
Plate	12.80	13.17	10.58	<0.0001	0.3527	9.6
hindquarter	46.22	46.70	48.34	0.0002	0.3133	3.0
Forequarter	39.46	40.35	41.28	0.8768	0.2662	9.4

yield. In addition, fat deposition occurs differently in the different parts of the body of the animal (Berg & Butterfield, 1976). Fat deposition in cattle typically follows the order in which perirenal fat is deposited first, followed by intermuscular, subcutaneous and finally by the intramuscular fat (Sainz & Hasting, 2000). As in any other tissue, adipose development occurs both by hyperplasia and hypertrophy. In the finishing phase, lipocytes that have been developed earlier (intermuscular, perirenal and mesenteric) complete their hyperplasic development and become depots for fat. However, subcutaneous and intramuscular deposits continue to produce new adipocytes, as they accumulate fat (Sainz & Hasting, 2000).

In addition, similarly to bones and adipose tissue, muscle tissue also grows allometrically. Therefore, at birth there is greater development of members and during the post-natal period these muscles present lower growth rate compared with the rest of the muscles (Butterfield & Berg, 1966). It may explain the differences and similarities observed for commercial cuts yield between animals fed at maintenance and *ad libitum* (Table 5).

Nellore animals had lighter commercial cuts ($P<0.05$) than crossbred animals. With the exception of the yield of shoulder from carcass of Nellore animals, no effects ($P>0.05$) of genetic type on commercial cuts were detected (Table 6).

May et al. (1992) reported that carcass from European breeds presents greater commercial cuts yield compared with carcass from Zebu cattle, which was not observed in this study, with the exception of yield of shoulder. In this study, the lack of effects of genetic type, mainly for proportions of forequarter and hindquarter probably have occurred due to castration of the animals.

In general, differences in proportion of forequarter and hindquarter is commonly seen in non-castrated animals, as in these animals there is greater action of male hormones (testosterone). Due to the lack of action of testosterone, castrated animals present similar proportion of forequarter and hindquarter regardless of the genetic type (Berg & Butterfield, 1976).

According to Costa et al. (2002), the minimum amount of RFT to avoid cold shortening and consequent decrease in beef tenderness is 3 mm. In the Brazilian carcass grade system the lean maturity is evaluated by visual assessment of fat content and fat distribution in the carcass. To be classified as “medium”, carcass must present 3 – 6 mm of RFT. With the exception of animals fed at maintenance, carcass of all animals presented the minimum amount of RFT to be classified for lean maturity as medium.

No differences were found ($P>0.05$) between genetic types for LMA, RFT and P8 assessed throughout the performance trial. The increase of LMA and fat deposition was affected ($P<0.05$) by BW, while for the concentrate level there was a trend ($P<0.10$) for increase of LMA (Table 7). Concentrate level did not affect ($P>0.05$) fat deposition through the animal growth (Table 7).

Animals fed concentrate at 2% BW had a tendency ($P<0.10$) to increase LMA throughout the feedlot period compared with animals fed concentrate at 1% BW. This increase in LMA probably occurred due to a better efficiency of metabolizable energy utilization, which can be related to

Table 6 - Means and coefficient of variation (CV) of weight and yield of commercial cuts of Nellore (NE), F_1 Simmental × Nellore (SN) and F_1 Angus × Nellore (AN) cattle

Item	Genetic type			P-value		CV (%)
	Crossbred		Purebred			
	SN	AN	NE	Crossbred × Nellore	SN × AN	
			Commercial cuts ½ carcass (kg)			
Chuck	28.11	30.55	23.81	0.0014	0.1857	18.2
Round	35.86	35.63	30.23	<0.0001	0.9576	7.4
Top sirloin	22.74	22.33	18.55	<0.0001	0.6865	8.3
Shoulder	21.71	21.98	18.88	<0.0001	0.5963	8.4
Plate	15.64	15.88	12.74	<0.0001	0.7332	12.5
hindquarter	58.60	57.96	48.78	<0.0001	0.8301	7.1
Forequarter	49.83	52.53	42.68	<0.0001	0.1686	11.3
			Commercial cuts yield (% cold carcass weight)			
Chuck	22.45	24.48	23.02	0.8231	0.1765	16.8
Round	28.79	28.52	29.39	0.0893	0.6202	4.0
Top sirloin	18.22	17.91	17.90	0.4524	0.3955	4.9
Shoulder	17.45	17.62	18.38	0.0207	0.4721	6.3
Plate	12.44	12.60	12.11	0.1927	0.8625	9.6
hindquarter	47.01	46.50	47.28	0.3406	0.3434	3.0
Forequarter	39.90	42.10	41.40	0.6430	0.1454	9.4

Table 7 - Descriptive levels of probability for error type I (P-value) associated to effects evaluated for ultrasound measurements of *longissimus* muscle area (LMA), rib fat thickness (RFT) and rump fat thickness (P8)

Comparisons between genetic type	P-value		
	LMA	RFT	P8
Nellore × F_1 Simmental × Nellore	0.6003	0.9975	0.6212
Nellore × F_1 Angus × Simmental	0.7848	0.5665	0.3873
F1 Simmental × Nellore × F1 Angus × Nellore	0.4473	0.5907	0.7409
Direct effects			
Body weight	0.0004	0.0178	0.0224
Concentrate level	0.0929	0.6144	0.6023
Interaction effects			
Body weight × 1%	0.5819	0.8660	0.7578
Body weight × 2%	0.8096	0.5734	0.5073
Concentrate level ×Body weight	0.1022	0.5978	0.5610
Concentrate level ×F_1 Simmental × Nellore	0.7399	0.3412	0.1379
Concentrate level ×F_1 Angus × Simmental	0.5731	0.9925	0.1359

the characteristics of the diet such as its metabilizability (Coelho da Silva & Leão, 1979).

According to Luchiari Filho (2000) the adipose tissue is the most variable tissue in the carcass. Fat deposition occurs primarily in the hindquarter and forequarter, following the vertebral column. As fat deposition goes through the body, there is a tendency of the subcutaneous fat deposition to follow the ventral portions of the carcass (Belk et al. 1991). In addition, fat deposition between the 12th and 13th ribs is lower than deposition on rump until it reaches 5 mm of thickness (Tait et al., 2005). It might explain the lack of differences of fat deposition on P8 between treatments (Table 7).

The growth of muscle and fat tissue is described by an allometric curve. Thus, the maximum rate of growth occurs in different periods, as those tissues present differences in growth and development.

During the animal growth the muscle deposition increases quickly due to the release of growth protein hormones (Cervieri et al., 2005). At puberty, the muscle tissue reaches the maximum growth and decreases until reaching the plateau at maturity. In the following phase the finishing period begins, in which the fat deposition is intensified reducing the rate of growth.

The alterations that occur in the pattern of tissue deposition are determined by the greater production of reproduction hormones and the decrease in levels of growth protein hormones (Berg & Butterfield, 1976). After that, the weight gain is determined mainly by the fat deposition instead of muscle tissue.

Is noteworthy that growth does not occur linearly and that the body composition is changed throughout the animal lifespan. Assessment of LMA, and fat thickness at the 12th rib and P8 are important to detect the variations in tissue deposition allowing the adoption of strategies of production to obtain carcass with characteristics that meet the specific requirement of different markets.

Conclusions

The use of high energy diets for crossbred animals provides heavier carcasses with greater finishing score. Ultrasound measurements allow the evaluation of carcass tissue deposition, with possibility of prediction of the moment in which cattle present better quality of carcass traits.

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