Vol.46, n. 4 : pp. 609-616, December 2003
ISSN 1516-8913 Printed in Brazil

BRAZILIAN ARCHIVES OF
BIOLOGY AND TECHNOLOGY
AN INTERNATIONAL JOURNAL

Evaluation of Carcass Characteristics and Meat Chemical Composition of *Bos indicus* and *Bos indicus* x *Bos taurus* Crossbred Steers Finished in Pasture Systems

Fernanda Barros Moreira[1*], Nilson Evelázio de Souza, Makoto Matsushita, Ivanor Nunes do Prado and Willian Gonçalves do Nascimento
Universidade Estadual de Maringá; fbmoreira@sercomtel.com.br; Av. Colombo, 5790; Maringá - Paraná - Brazil

ABSTRACT

The objective of this study was to evaluate the carcass characteristics (carcass weight, carcass yield, fat thickness, loin area, marbling and colour) and chemical composition of the Longissimus dorsi muscle (moisture, ash, crude protein, fat and cholesterol) of cuts with or without fat thickness, of Bos indicus and Bos indicus x Bos taurus crossbred steers finished in millet (Pennisetum americanum L.) or star grass (Cynodon plectostachyus Pilger) pasture systems, with mineral or mineral protein supplementation. Animals were slaughtered with an average body weight of 450 kg (Bos indicus) or 470 kg (Bos indicus x Bos taurus crossbreed). There was no treatments effect on carcass characteristics and meat chemical composition of cut without fat thickness. The cuts with fat thickness of steers fed millet presented the highest fat deposition. Bos indicus steers presented higher carcass yield (57.23%) and fat thickness (4.88 mm) compared with crossbreed (53.40% and 3.05 mm). There was no breed effect on chemical composition of meat. The mean levels of cholesterol concentration were 31.41 mg/100 and 37.55 mg/100g of meat with and without fat thickness.

Key words: *Bos indicus, Bos taurus*, carcass, meat, pasture

INTRODUCTION

Brazil has the biggest commercial cattle herd in the world, with approximately 161 million animals and a production of approximately 7 million tons of carcass each year (FNP, 2001). Brazil has the great potential to become the highest bovine meat producer and exporter, but, to achieve such position, it is extremely important to control the quality of the commercialised product.

Bovine meat has excellent nutritional quality because it has protein of high biological value, associated with rich vitamin contents. It is an important source of B-complex vitamins, associated to a high content of minerals, especially iron, present in the meat in high bioavailability form (Saucier, 1999). Bovine meat contains all the essential amino acids in the right ratio to maintain the needs of the organism (Pensel, 1998).

However, bovine meat has been mentioned as one of the factors that may lead to the development of human cardiovascular diseases, obesity, hypertension and cancer, especially due to the presence of saturated fat and cholesterol. However, low fat contents (less than 5% in the muscular portion) and low cholesterol contents (less than 75 mg/100 g) have been observed in bovine meat chemical analyses, achieving from

* Author for correspondence

one third to one half of the daily recommended cholesterol intake (Jiménez Colmenero et al., 2001). Fat deposition in the carcass may vary according to feeding management (Mandell et al., 1998), breed (Rule et al., 1997), sex (Enser et al., 1998), age and finishing score of the carcass (Owens et al., 1993). Animals finished in pasture systems have presented lower fat deposition in the carcass (French et al., 2000). Differences according to breed, feeding management or sex of the animals have not been observed when the cholesterol present in the skeletal musculature is analysed (Rule et al., 1997). However, the possibility of an alteration on the intramuscular cholesterol existed, if an expressive increase in polyunsaturated acids concentration occurred.

Some studies on meat chemical composition of *Bos taurus* animals finished in feedlot or pasture could be found in the literature (Camfield et al., 1997; Rule et al., 1997; Mandell et al., 1998; French et al., 2000; French et al., 2001), but none was found of *Bos indicus* animals fed tropical pastures.

This objective of this study was to evaluate carcass characteristics (carcass weight, carcass yield, fat thickness, loin area, marbling and colour) and chemical composition of the *Longissimus dorsi* muscle (moisture, ash, crude protein, fat and cholesterol) of cuts with or without fat thickness, of *Bos indicus* and *Bos indicus* x *Bos taurus* crossbred steers, finished in millet or star grass pasture, with mineral or protein mineral supplementation.

MATERIALS AND METHODS

The experiment was carried out between the months of November and February in a private farm located in Centenário do Sul, Paraná State, Brazil (22°51'south latitude, 51°33' longitude W-GR).

Seventeen steers were used, 7 *Bos indicus* (Nelore) and 10 *Bos indicus* x *Bos taurus* crossbreed assigned to 3 finishing pasture systems: millet (*Pennisetum americanum* L.) + mineral salt supplementation – MMS (1 ½ Nelore x ½ Limousin, 3 ½ Nelore x ½ Girolando and 2 Nelore); star grass (*Cynodon plectostachyus* Pilger) + mineral salt supplementation – GMS (2 ½ Nelore x ½ Limousin, 1 ½ Nelore x ½ Girolando and 2 Nelore) and star grass + protein mineral salt supplementation – GPS (2 ½ Nelore x ½ Limousin, 1 ½ Nelore x ½ Girolando and 3 Nelore). The initial animals average weight was 413 kg.

The animals were maintained for 70 days (1st slaughter) or 83 days (2nd slaughter). The slaughter occurred when the animals achieved approximately 450 kg (*Bos indicus*) or 470 kg (crossbreed) of body weight.

During grazing time, ten forage samples were collected from each pasture, each 28 days, being further homogenised for each treatment, in order to analyse crude protein and ethereal extract content described by Silva (1990) and the *in vitro* dry matter digestibility according to Tilley and Terry (1963) methodology, adapted for the use of artificial rumen, developed by ANKOM®, as described by Holden (1999). The total digestible nutrients content (TDN) and the metabolizable energy were estimated from *in vitro* dry matter digestibility (NRC, 1996).

The animals were slaughtered in an abattoir 80 km away from the farm. Before going to the abattoir, the animals were submitted to a previous 10-hour solids and liquids fasting and then had their weight measured. Shortly after the slaughter, the carcasses were identified and measured in order to evaluate the weight and yield of the hot carcass. The carcasses were chilled for 24 hr at 2°C before the *Longissimus dorsi* muscle samples were collected from the area between the 12th and 13th rib, and then immediately taken to analysis of loin area, fat thickness, marbling and colour, as described by Müller (1987).

After these analyses, the samples were frozen for future chemical analysis. Two months later, the samples were thawed at ambient temperature and separated in two portions. All fat thickness was removed from one of the samples, and only the *Longissimus dorsi* muscle was analysed. The fat thickness of the other sample was maintained and analysed along with the muscle portion. These two cuts were ground and the moisture, ash, crude protein and fat contents were analysed according to the AOAC methodology (1980).

The cholesterol extraction was made according to the method described by Al-Hasani et al. (1993). The cholesterol quantification was made by a Shimadzu 14A chromatograph, equipped with flame ionisation detector and fused silica capillary column (25 cm x 0.25 mm and 0.20 μm of SE-30). The temperatures of the injector, column and detector were of 260, 300 and 300°C, respectively.

The gas fluxes were 1.5mL/min for the carrier gas (H_2), 25mL/min for the make-up gas (N_2); 300 mL/min and 30 mL/min for the flame gases, synthetic air and H_2, respectively. The split used was of 1/150. The peak areas were determined by the CG-300 Computing Integrator and the cholesterol identification was made according to the patterns determined by Sigma (USA). The statistical analysis was made using the Statistical and Genetic Analysis System (SAEG, 1983).

Table 1 - Crude protein (CP), ethereal extract (EE), *in vitro* dry matter digestibility (IVDMD), total digestible nutrients (TDN) and metabolizable energy (ME) of dry matter of grass and supplement used in different treatments.

Food	CP (%/DM)	EE (%/DM)	IVDMD (%/DM)	TDN (%/DM)	ME (Mcal/kg DM)
Millet	12.41	0.54	72	74	2.68
Star grass	7.41	0.87	47	48	1.74
Protein supplement[1]	38.00	5.27	-	53	1.83

[1]soybean meal, cracked corn, urea and mineral premix

RESULTS AND DISCUSSION

The contents of crude protein, ethereal extract, *in vitro* dry matter digestibility, TDN and metabolizable energy of forage and mineral protein supplement are shown in Table 1. Millet presented the higher levels of crude protein, *in vitro* dry matter digestibility, TDN and metabolizable energy, when compared to star grass. Millet is a type of tropical forage of excellent nutritional value and should be used in cattle feeding process.

The ethereal extract percentage of the two forages was low, with values inferior to 1% of dry matter. However, the protein mineral supplement used presented the highest ethereal extract value. The contribution of the ethereal extract of the supplement on the diet was of low magnitude due to the low consumption of the protein mineral supplement obtained during the experimental period (200g/animal/day).

A difference ($P>0.05$) among treatments (millet + mineral salt (MMS), star grass + mineral salt (GMS) and star grass + protein mineral salt (GPS)) was not observed on slaughter weight, carcass weight, carcass yield, fat thickness, marbling and colour of animals meat (Table 2). However, the animals submitted to the GMS treatment presented larger loin area ($P<0.05$) when compared to the animals submitted to the MMS and GPS treatments.

In order to compare the meat of animals maintained in different production systems, as well as to evaluate the effect of the genetic group on meat quality, similar finishing scores of the carcasses are necessary, once differences in the finishing score may result in alterations on meat composition. In this way, Nelore animals were slaughtered with an average weight of 450 kg and crossbred animals with an average weight of 470 kg, so that the finishing score for each treatment was similar, as well as for the different genetic groups, once crossbred animals need higher body weight in order to achieve the same finishing score as Nelore animals.

Carcass yield presented an average value of 54.9%. This value is inferior to the one obtained by Prado et al. (2000), where non castrated males (½ *Bos indicus* x ½ *Bos taurus*), finished in feedlot, presented a carcass yield of 57.1%, but is superior to the value of 52.3% obtained by Leme et al. (2000), for non-castrated males (½*Bos indicus* x ½ *Bos taurus*) animals. This means that variations according to animal genetics, its diet or even the cleaning process in slaugher house exist.

The largest loin area (*Longissimus dorsi*) was observed for the animals fed the GMS treatment. This could be attributed to the number of crossbred animals in relation to the Nelore animals. The genetic group affected this parameter ($P<0.01$). The effect that was observed on the treatment would actually be related to the effect of the genetic group on the loin area but not the treatment itself. Nelore animals present smaller loin area than crossbred (½ *Bos indicus* x ½ *Bos taurus*) animals (Table 2). This could explain the largest loin area observed for the GMS treatment.

There was no treatment effect ($P>0.05$) on fat thickness, measured between the 12^{th} and 13^{th} rib (Table 2). The values found were similar to the ones observed by Restle et al. (1996), for castrated animals, ½ Nelore ½ Charolais, finished in pasture, with an average fat thickness of 3.5 mm.

Analysing the subjective evaluations of colour and marbling, differences among the treatments were not observed (P>0.05), presenting colouring varying from red to blood red and slight marbling (Table 2). Restle et al. (1996) observed meat colouring among slightly dark red to red and slight marbling for animals in similar conditions. However, it is important to point out that these evaluations are subjective, which makes the comparison of results difficult, since the evaluator was a different person for the experiments that were compared.

Table 2 - Slaughter weight (SW), carcass weight (CW), carcass yield (CY), loin area (LA), fat thickness (FT), marbling (M) and colour (C) of Nelore and crossbred steers finished in different pasture systems.

Treatments	**SW (kg)**	**CW (kg)**	**CY (%)**	***LA (cm²)***	**FT (mm)**	**M (points)[4]**	**C (points)[5]**
MMS[1]	466	255	54.78	68.53b	4.01	2.85	4.60
GMS[2]	467	251	53.82	75.78a	4.37	2.25	4.26
GPS[3]	463	259	56.14	65.46b	3.12	2.62	4.37
SE (%)	3.81	4.03	5.47	4.71	40.81	43.52	9.00
Bos indicus	453b	259	57.23a	66.38b	4.88a	2.30	4.55
Crossbreed	473a	252	53.40b	71.82a	3.05b	2.84	4.27
SE (%)	3.31	4.43	6.00	7.98	40.98	43.79	9.05

[1]Millet + mineral salt; [2]Star grass + mineral salt; [3]Star grass + protein and mineral salt; [4]Points from 1 (no marbling) to 5 (excess marbling); [5]Points from 1 (dark) to 5 (blood red); Averages in the same column, followed by different letters are different by Tukey test (P<0.065).

Table 3 - Moisture, ash, crude protein (CP) and fat percentages and cholesterol concentration (mg/100g muscle) of fresh meat with or without fat thickness of steers finished in different pasture systems.

	Moisture	**Ash**	**CP**	**Fat**	**Cholesterol**
Treatments			**Meat without fat thickness**		
MMS[1]	74.38b	0.99b	21.14	1.61	37.17
GMS[2]	74.71ab	1.03ab	20.79	1.87	39.24
GPS[3]	75.42a	1.11a	20.58	1.36	35.99
SE (%)	0.59	5.04	7.70	37.87	16.79
			Meat with fat thickness		
MMS[1]	64.17b	0.87	18.43	15.22a	30.26
GMS[2]	67.58ab	0.92	20.07	7.83b	33.72
GPS[3]	69.29a	0.97	19.18	6.29b	30.24
SE (%)	3.77	11.86	10.87	34.91	22.40

[1]Millet + mineral salt; [2]Star grass + mineral salt; [3]Star grass + protein and mineral salt; [4]Means in the same column followed by different letters are different by Tukey test (P<0.065).

When comparing Nelore and crossbred steers carcass yield, the first ones presented higher carcass yield (P<0.05). Literature presents similar or higher values of carcass yield of crossbred animals when compared to Nelore (Perotto et al., 2000; Restle et al., 2000). However, it is important to point out that part of the crossbred animals used in this experiment were crossbred from dairy cattle (Girolando) and beef cattle (Nelore). Dairy animals present lower carcass yield when compared to animals exclusively destined to meat production (Leme et al., 2000). This could justify the lower carcass yield of crossbred animals obtained in this research.

The Nelore carcass yield was superior to the value of 54% presented by Jorge et al. (1990) and Leme et al. (2000). This researches, in spite of being obtained from non-castrated animals, will probably not differ from castrated animals, once the results indicate that there is no difference between carcass yield of non-castrated and castrated animals (Restle et al., 2000). These differences may be due to the cleaning process of the abattoir.

The loin area of crossbred animals was larger (P=0.065) when compared with Nelore (Table 2). The values were similar to the ones obtained by Leme et al. (2000): 61.3 cm^2 for Nelore animals and 71.7 cm^2 for crossbred animals and by Perotto et al. (2000): 53.7 cm^2 for Nelore animals and 69.72 cm^2 for crossbred animals. These are the results for non-castrated animals, finished in feedlot.

The fat thickness of Nelore steers was higher than the one of the crossbred steers. Regardless the genetic group, it is possible to observe that the fat thickness was of more than 3mm. This is the minimum value demanded by brazilian meat industry, so that there is not any damaging of the carcass quality during the cooling and commercialisation processes. The finishing score resulted in the highest fat thickness value observed for Nelore steers, once Nelore presents a finished carcass at lower weight than crossbred animals. Perotto et al. (2000) observed that non-castrated animals (½ *indicus* x ½ *taurus*) achieved a finishing score of 3 mm of fat in the 12^{th} rib, with weights above 500 kg, and non-castrated Nelore animals achieved the same finishing score at 450 kg of body weight.

Analysing castrated animals, it is possible to observe that crossbred animals present a finishing score of 3 mm of fat at 470 kg and Nelore steers a finishing score of 4.88 mm of fat at 450 kg (Table 2). Jorge et al. (1999) observed a fat thickness of 2.97 mm for non-castrated Nelore animals finished in feedlot, with slaughter weight of 450 kg. Non-castrated animals present smaller fat thickness deposition (Restle et al., 2000), which explains the difference observed in the data.

During the chemical composition evaluation of the muscle without fat thickness, it is possible to observe that animals submitted to the MMS treatment present lower moisture and ash contents (P<0.05) when compared with animals submitted to the GPS treatment, and GMS treatment presented intermediate values. On the other hand, crude protein, fat and cholesterol contents were similar (P>0.05) for 3 treatments (Table 3).

These values were similar to the ones found by French et al. (2001) for crossbred Limousin x Charolais animals, maintained in pasture: 73% of moisture, 1.3% of ash, 22.6% of crude protein and 2.5% of fat. French et al. (2000) obtained values of 4.4% of fat for castrated *Bos taurus* animals finished in pasture. Mandell et al. (1998) observed fat contents of 2.7% for Limousin animals finished in pasture and slaughtered with 4 mm of fat thickness. Enser et al. (1998) observed fat contents of 2.8% in the *Longissimus dorsi* muscle of castrated *Bos taurus* animals finished in pasture.

By the analysis of these results, it is possible to observe that the related intramuscular fat ratio by literature was superior to the values obtained in this experiment. All the analysed results were obtained from *Bos taurus* animals and, in this particular experiment, *Bos indicus* were used. It is important to point out that experiments comparing both *Bos taurus* and *Bos indicus* under the same ambient and management conditions needs to be done.

As it can be observed for the cuts without fat thickness, the animals submitted to the MMS treatment presented lower moisture contents on meat with fat thickness (P<0.05) when compared with animals submitted to the GPS treatment, and the ones submitted to GMS treatment achieved intermediate values. In addiction, fat content was higher (P<0.05) for animals submitted to MMS treatment when compared with both other treatments. Differences were not observed (P>0.05) among the animals submitted to the GMS and GPS treatments. The treatment did not effect (P>0.05) ash, crude protein and cholesterol contents of the cuts with fat thickness (Table 3).

Millet pasture presented the highest energy value (Table 1), which made the performance of the animals better, favouring the fat deposition on the meat. In the same way, the higher fat proportion favoured smaller moisture content.

Analysing the meat without fat thickness, a higher moisture content (P<0.05) and a smaller total fat matter content (p=0.07) were observed for the crossbred steers. By other side, ash, crude protein and cholesterol contents did not present differences (P>0.05) among the two genetic groups (Table 4).

Intramuscular fat is the last one to be deposited, according to animal growth (Owens et al., 1993). In growth scale, Nelore steers probably were more advanced in maturity than crossbred steers, which can be confirmed by the fat thickness of Nelore animals (Table 2). At more advanced maturity stages, a higher deposition of intramuscular fat will occur, which explains the higher proportion of fat for Nelore steers meat. The bigger proportion of adipose tissue determined the lower moisture content, once the adipose tissue presents hydrophobic characteristic. Crossbred steers probably did not achieve weight at maturity and therefore, did not complete the intramuscular deposition.

Nelore animals, even presenting approximately 5mm of fat thickness, achieved 1.86% of intramuscular fat. This value was inferior to 2.72%, which was found by Mandell et al. (1998) analysing *Bos taurus* animals in pasture, with finishing of 4mm of fat thickness. This data suggests that *Bos indicus* animals present lower intramuscular fat deposition when compared to *Bos taurus* with the same carcass finishing score, but more researches need to be done to confirm this suggestion.

The moisture, ash, crude protein, fat and cholesterol contents of meat with the presence of fat thickness, did not present differences (P>0.05) among genetic groups (Table 4).

Table 4 - Moisture, ash, crude protein (CP) and fat percentages and cholesterol concentration (mg/100g muscle) of fresh meat with or without fat thickness of *Bos indicus* and *Bos indicus* x *Bos taurus* crossbred steers finished in different grass production systems.

	Moisture	**Ash**	**CP**	**Fat**	**Cholesterol**
Genetic group			**Meat without fat thickness**		
Bos indicus	74.28b	1.04	20.94	1.86a	35.16
Bos indicus x *Bos taurus*	75.34a	1.05	20.76	1.37b	39.64
SE (%)	0.98	7.17	6.85	33.37	15.20
			Meat with fat thickness		
Bos indicus	65.90	0.88	18.75	11.11	28.77
Bos indicus x *Bos taurus*	67.94	0.96	19.55	8.81	33.72
SE (%)	4.96	8.96	11.05	49.38	19.61

Means in the same column followed by different letters are different by Tukey test (P<0.065).

Table 5 - Moisture, ash, crude protein (CP) and fat percentages and cholesterol concentration (mg/100g muscle) of fresh meat with or without fat thickness

Meat cuts	Moisture	Ash	CP	Fat	Cholesterol
Meat without fat	74.84a	1.05a	20.84a	1.60b	37.55a
Meat with fat	66.98b	0.92b	19.18b	9.89a	31.41b
SE (%)	3.64	9.20	8.43	64.25	18.04

Means in the same column followed by different letters are different by Tukey test (P<0.065).

By analysing the chemical composition of the two cuts (with or without fat thickness), it its possible to observe lower (P<0.05) moisture, ash, crude protein and cholesterol contents for the meat without fat thickness, while fat contents were higher (P<0.05) for the meat with fat thickness (Table 3). It is possible to observe that the variation on chemical composition of the two cuts occurred due to the moisture content variation. When a pattern between the moisture content of the two cuts is realised, no significant differences are observed for the ash, crude protein and cholesterol proportion. The only difference is the fat proportion, once the cut with fat thickness will show higher values because it deposits two types of fat: intramuscular and subcutaneous fat.

Cholesterol concentration obtained was inferior to the values observed by Rule et al. (1997) (approximately 54mg/100g of *Longissimus dorsi* muscle). The same authors did not observe any effect of breed, nutritional planning or sex of the animal on the cholesterol concentration of the *Longissimus dorsi* muscle, suggesting that a modification of the phospholipid distribution needs to be made. It is possible to observe that studies comparing different breeds are limited to the comparison of *Bos taurus*, and not *Bos indicus* animals. The results obtained suggest that *Bos indicus* animals present a lower cholesterol distribution on the skeletal musculature when compared to *Bos taurus*, even so, more research needs to be done in order to confirm such supposition.

By the comparative analysis of the cholesterol present in bovine, ovine, swine and chicken meat, it is possible to observe that bovine meat, with or without fat thickness, presented the lowest muscle cholesterol contents (34 mg/100 g of *Longissimus* *dorsi* muscle). Swine meat presents values close to 45 mg/100 g of *Longissimus dorsi* muscle, ovine meat has values of 50 mg/100 g of *semimembranosus* muscle and chicken meat has values of 43 mg/100g of breast without skin (Chizzolini et al., 1999). These values confirm that bovine meat has excellent nutritional quality and low cholesterol contents when compared to other types of meat.

ACKNOWLEDGEMENTS

The authors are grateful to MINERPHÓS Ltda. for providing the mineral and protein supplements to carry out this experiment. We also thank the owner of the animals, Armando Vieira Moreira, for the concession of the animals and farm used in the field experiments.

RESUMO

O objetivo deste trabalho foi avaliar as características de carcaça (peso de carcaça, rendimento de carcaça, espessura de gordura de cobertura, área de olho de lombo, marmoreio e coloração) e composição química do músculo *Longissimus dorsi* (umidade, cinzas, proteína bruta, gordura e colesterol) de cortes, com ou sem gordura de cobertura, de novilhos *Bos indicus* e mestiços *Bos indicus* x *Bos taurus* terminados em sistemas em pastagem de milheto (*Pennisetum americanum* L.) ou grama estrela (*Cynodon plectostachyus* Pilger), com suplementação mineral ou protéica e mineral. Os animais foram abatidos com peso médio de 450 kg (*Bos indicus*) ou 470 kg (mestiços). Não houve efeito de tratamento sobre as características de carcaça e composição da carne com ou sem gordura de cobertura. Os cortes com gordura de cobertura de novilhos mantidos em milheto apresentaram a maior deposição de gordura. Os novilhos *Bos indicus* apresentaram maior rendimento de carcaça (57,23%) e maior espessura de gordura de cobertura (4,88 mm) comparado aos mestiços (53,40% e 3,05 mm). Não houve efeito da raça sobre a composição química da carne. A concentração média de colesterol foi de 31,41 e 37,55 mg/100 g de carne com e sem gordura de cobertura.

REFERENCES

Al-Hasani, S. M.; Hlavac, J. and Carpenter, M. W. (1993), Rapid determination of cholesterol in single and multi-component prepared foods. *Journal of Association of Official Analytical Chemists International*, **76**, 902-906.

AOAC - Association of Official Analitical Chemists (1980), *Official methods of analysis*. 14. ed. Arlington, V. A.

Camfield, P. K.; Brown Jr., A. H. and Lewis, P. K. et al. (1997), Effects of frame size and time-on-feed on carcass characteristics, sensory atributes, and fatty acids profiles of steers. *J. Anim. Sci.*, **75**, 1837-1844.

Chizzolini, R.; Zanardi, E. and Dorigoni, V. et al. (1999), Calorific value and cholesterol content of normal and low-fat meat and meat products. *Trends in food science Technology*,**10**, 119-128.

Enser, M.; Hallett, K. G. and Hewett, B. et al. (1998), Fatty acid content and composition of UK beef and lamb muscle in relation to production system and implication for human nutrition. *Meat Science.*, **49**, 329-341.

FNP (2001), *Anuário da pecuária brasileira*. São Paulo : FNP.

French, P.; O'riordan, E. G. and Monahan, F. J. et al. (2001). The eating quality of meat of steers fed grass and/or concentrates. *Meat Science*, **57**, 379-386.

French, P.; Stanton, C. and Lawless, F. et al. (2000), Fatty acid composition, including conjugated linoleic acid, of intramuscular fat from steers offered grazes grass, grass silage, or concentrate-based diets. *J. Anim. Sci.*, **78**, 2849-2855.

Holden, L. A. (1999), Comparison of methods of *in vitro* dry matter digestibility for ten feeds. *J. Dairy Sci.*, **82**, 1791-1794.

Jiménez-Colmenero, F.; Carballo, J. and Cofrades, S. (2001), Healthier meat and meat products: their role as functional foods. *Meat Science*, **59**, 5-13.

Jorge, A. M.; Fontes, C. A. A. and Paulino, M. F. et al. (1999), Desempenho produtivo de animais de quatro raças zebuínas, abatidos em três estádios de maturidade. 2. Características da carcaça. *Rev. Bras. Zootec.*, **28**, 381-387.

Leme, P. R.; Boin, C. and Margarido, R. C. C., et al. (2000), Desempenho em confinamento e características de carcaça de bovinos machos de diferentes cruzamentos abatidos em três faixas de peso. *Rev. Bras. Zootec.*, **29** : (2), 2347-2353.

Mandell, I. B.; Buchanan.Smith, J. G. and Campbell, C. P. (1998), Effects of forage vs. grain feeding on carcass characteristics, fatty acid composition, and beef quality in Limousin-cross steers when time on feed is controlled. *J. Anim. Sci.*, **76**, 2619-2630.

Müller, L. (1987), *Normas para avaliação de carcaças e concurso de carcaça de novilhos*. Santa Maria : Imprensa Universitária.

NRC - National Research Council (1996), *Nutrient requirement of beef cattle.* 7. ed. Washington : National Academy Press.

Owens, F. N.; Dubeski, P. and Hanson, C. F. (1993), Factors that alter growth and development of ruminants. *J. Anim. Sci.*, **73**, 3138-3150.

Pensel, N. (1998), The future of red meat in human diets. *Nutrition abstracts and reviews (Series A)*, **68**, 1-4.

Perotto, D., Abrahão, J. J. S. and Moletta, J. L. (2000), Características quantitativas de carcaça de bovinos zebu e cruzamentos *Bos taurus* x zebu. *Rev. Bras. Zootec.*, **29** : (Sup. 1), 2019-2029.

Prado, I. N.; Pinheiro, A. D. and Alcalde, C. R. et al. (2000), Níveis de substituição do milho pela polpa de *citrus* peletizada sobre o desempenho e características de carcaça de bovinos mestiços confinados. *Rev. Bras. Zootec.*, **29** : (Sup. 1), 2135-2141.

Restle, J.; Grassi, C. and Feijó, G. L. D. (1996), Características das carcaças e da carne de bovinos inteiros ou submetidos a duas formas de castração, em condições de pastagem. *Rev. Bras. Zootec.*,**25**, 334-344.

Restle, J.; Vaz, F. N. and Feijó, G. L. D. et al. (2000), Características de carcaça de bovinos de corte inteiros ou castrados de diferentes composições raciais charolês x nelore. *Rev. Bras. Zootec.*, **29**, 1371-1379.

Rule, D. C.; Macneil, M. D. and Short, R. E. (1997), Influence of sire growth potential, time on feed, and growing-finishing strategy on cholesterol and fatty acids of ground carcass and *Longissimus* muscle of beef steers. *J. Anim. Sci.*, **75**, 1525-1533.

Saucier, L. (1999), Meat safety: challenges for the future. *Nutrition abstracts and reviews (Series A)*, **69**, 705-708.

Silva, D. J. (1990). *Análise de alimentos e métodos químicos e biológicos.* 2. ed. Viçosa : Imprensa Universitária.

SAEG – Sistema para Análise Estatística e Genética (1983), Central de Processamento de Dados. Viçosa : UFV.

Tilley, J. M. A. and Terry, R. A. (1963), A two-stage technique for the in vitro digestion of forage crops. *J. Br. Grassl. Soc.*, **18**, 104-111.

Received: January 31, 2002;
Revised: June 19, 2002;
Accepted: October 22, 2002.