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Productive performance and carcass traits of Nellore x Aberdeen Angus and Nellore x Red Angus heifers under tropical conditions¤

Rendimiento productivo y características de la canal de Novillas Nelore x Aberdeen Angus y Nelore x Angus Colorado en condiciones tropicales

Desempenho produtivo e características de carcaça de Novilhas Nelore x Aberdeen Angus e Nelore x Red Angus sob condições tropicais

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Summary

Background: Angus breed strains (Black and Red) perform differently under tropical conditions. **Objective:** to evaluate differences among F1 Nellore x Aberdeen Angus and F1 Nellore x Red Angus regarding productive performance and carcass traits under tropical conditions. **Methods:** forty-one heifers were used to assess the effect of both genetic groups on productive performance and carcass traits. The performance parameters evaluated were final live body weight and average daily gain. The carcass traits were: 1) hot and cold carcass weight and cold carcass dressing percentage, 2) carcass conformation and fatting (both ranging from 1 to 5), 3) back fat thickness, 4) rib eye area, 5) cutability, and 6) total usable meat, and commercial cut yield. Animals were divided in two groups and fed *Megathyrsus maximum* grass in three pens for 28 days. After this period, animals were relocated in a feedlot system for 84 days, and weighed at the beginning and at the end. All data were subjected to analysis of variance with initial live weight as a covariate. **Results:** differences were found between groups for productive performance and carcass traits such as back fat, and rib eye area. However, no difference was observed for conformation, fatting, ease of cutability, total usable meat, and Brazilian

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commercial cuts. **Conclusion:** F1 Nellore x Aberdeen Angus heifers had increased growth performance and carcass traits under tropical conditions.

Keywords: *growth, hair coat, precocity, tropic*, *ultraviolet radiation, weight gain.*

Resumen

Antecedentes: las variedades de la raza Angus (Negro o Rojo) pueden exhibir un rendimiento diferente en condiciones tropicales. **Objetivo:** el objetivo fue evaluar las diferencias entre los grupos genéticos de bovinos Nelore x Angus F1 y F1 Nelore x Angus Colorado en cuanto al rendimiento de la canal y las características productivas en condiciones tropicales. **Métodos:** se utilizaron 41 novillas para evaluar los grupos genéticos con respecto al crecimiento y características de la canal. Como parámetros de rendimiento productivo se evaluó el peso vivo final y la ganancia diaria, y para características de la canal: 1) peso en canal caliente, fría y rendimiento, 2) conformación de la canal, 3) el espesor de grasa, 4) área del ojo del lomo, 5) cortabilidad y 6) carne total utilizable y cortes comerciales brasileños. Los animales fueron divididos en dos grupos y alimentados con pasto *Megathyrsus maximum* bajo pastoreo rotacional en tres corrales durante 28 días. Luego fueron trasladados 84 dias a un sistema de confinamiento, siendo pesados al inicio y al final del tratamiento. Todos los datos fueron sometidos a análisis de varianza con el peso vivo inicial como covariable. **Resultados:** hubo diferencias en el rendimiento productivo y características de la canal, en espesor de grasa dorsal y área del ojo del lomo. Sin embargo, no hubo diferencia en la conformación, el acabado, cortabilidad, la carne utilizable total y de los cortes brasileños. **Conclusión:** novillas F1 Nellore x Aberdeen Angus presentaron mayor rendimiento y características de la canal de crecimiento en condiciones tropicales.

Palabras clave: *aumento de peso, crecimiento, pelaje, precocidad, radiación ultravioleta, trópico.*

Resumo

Antecedentes: animais da raça Angus podem apresentar desempenho diferente de acordó com a linha (Red Angus ou Black Angus). Objetivo: objetivou avaliar os grupos genéticos bovinos F1 Nelore x Angus Aberdeen e Nelore x Red Angus quanto ao desempenho produtivo e características de carcaça em condições tropicais. **Métodos:** foram utilizadas quarenta e uma novilhas para avaliar o grupo genético em relação ao desempenho de crescimento e características de carcaça. Como parâmetros de desempenho produtivo foram avaliados o peso vivo final e ganho diário e para características de carcaça: 1) peso de carcaça quente, fria e rendimento, 2) conformação da carcaça e de acabamento, 3) espessura de gordura, 4) área de olho de lombo, 5) retalhabilidade e 6) porção comestível total e rendimento de cortes comerciais brasileiros. Os animais foram divididos em dois grupos e alimentados em pastagem de *Megathyrsus maximum* sob pastejo rotacionado em três piquetes por 28 dias e posteriomente confinados por 84 dias, onde foram pesados no início e no final do tratamento. Todos os dados foram submetidos à análise de variância com o peso vivo inicial como covariável. **Resultados:** houve diferenças em desempenho produtivo e características de carcaça, a espessura de gordura subcutânea e a área de olho de lombo. No entanto, não houve diferença para conformação, acabamento, cutabilidade e rendimento dos cortes brasileiros. **Conclusão:** novilhas Nelore x Angus Aberdeen apresentaram melhores caracterististicas de carcaça e desempenho.

Palavra chave: *cor do pelame, crescimento, ganho de peso, precocidade, radiação ultravioleta, trópico.*

Introduction

Brazil has the largest commercial cattle herd in the world, with more than 203 million heads. It ranks second in beef production in the world, with 9.5 million tons per year and is a major exporter in spite of its high domestic consumption. In 2013, the domestic market consumed 83.78% of Brazil´s cattle production (USDA-FAS, 2013).

Crossbred cattle (*Bos taurus indicus* x *Bos taurus taurus*) are an important component of beef production systems in several parts of the world, including tropical and sub-tropical regions (Chizzotti *et al*., 2007).

Precocity is valuable to increase cattle productivity in terms of performance and carcass traits (Siqueira *et al*., 2012). Crossbreeding between *B. taurus taurus*

and *B. taurus indicus* has been a common practice in the beef cattle industry for a long time, and is increasing considerably in Brazil, notwithstanding the negative impact of *B. taurus indicus* on meat quality (Machado *et al*., 2011).

Aberden Angus and Red Angus semen was used more than Nellore during 2013 in Brazil. Approximately 3.3 million semen doses of these *B. taurus taurus* breeds were commercialized in the country, versus 2.7 million doses of Nellore semen (ASBIA, 2013). Angus cattle comprise two different breeds: Aberdeen Angus and Red Angus, with black and red hair, respectively. Hair coat and skin color influence ultraviolet (UV) rays absorption, especially short frequency UV waves. Consequently, it may influence productive performance, because it is primarily through the skin that animals dissipate heat by radiation, conduction, convection and evaporation. Thus, dark skin and dark hair coat offer an effective protection against UV rays compared to light color or non-pigmented skins (Silva *et al*., 2001).

This study evaluated productive performance and carcass traits of F1 Nellore x Aberdeen Angus (NAA) and F1 Nellore x Red Angus (NRA) heifers raised under the tropical conditions of Brazil.

Materials and methods

Ethical considerations

All procedures in this trial were approved by the ethics committee for animal research (CEPA) of Universidade Federal de Mato Grosso, Brazil (code number 308/2012).

Experimental design and management of heifers

The experiment was conducted in a feedlot located in the north region of Mato Grosso State (11º51'51"S and 55º30'09"W) and animals were slaughtered in Frigobom Slaughterhouse in the same region, accredited by the state sanitary inspection service (SISE).

Criteria for selecting the Red Angus and Aberdeen Angus bulls used in this experiment were the positive expected progeny differences for final weight, conformation, and fatting traits. Forty-one crossbred heifers (20 F1 NAA and 21 F1 NRA) were used. The animals were twelve months old and the average initial body weight (BW) was 289.5 ± 26.1 kg. Animals were fed on *Megathyrsus maximum* cv. Mombaça pasture under rotational grazing in three paddocks. The heifers remained in each paddock for 9 days and received 3 kg of feedlot diet per head/day during 28 days. After this period, the animals were relocated in feedlots and during 84-day were fed *ad libitum* a diet containing 16.4% crude protein (CP) and 75.2% TDN.

The diet formulation and chemical composition are summarized in Tables 1 and 2, respectively. All animals were weighed at the beginning (D0), at the end (D84) of the experiment, and at 28-day intervals. The diet was balanced to meet the NRC (1996) requirements and was supplied freely at 7 a.m and 4 p.m in the form of complete diet. Leftovers were collected the following morning and feed allowance was adjusted daily to allow 5% leftovers. Concentrate and silage samples were collected every 14 days, forming a compound sample. The samples were dryed in a forced-air oven at 65°C for 72 hours and ground using a 1 mm mesh. Dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined according to Silva and Queiroz (2002).

Table 1. Composition of the experimental diet.

Ingredients	DM (%)
Corn	51.00
Millet	35.00
Soybean meal	10.00
Urea	1.00
Premix[1]	3.00
Total	100.00

[1]Per kg/Premix: Vitamin A, 200,000.00 IU; Vitamin D3, 50,000.00 IU; Vitamin E, 1,500.00 IU; Ca (min-max), 190.00 to 220.00 g; P, 60.00 g; S, 20.00 g; Mg, 20.00g; K, 35.00 g; Na, 70.00 g; Co, 15.00 mg; Cu, 700.00 mg; Cr, 10.00 mg; Fe, 700.00 mg; I, 40.00 mg; Mn, 1,600.00 mg, Se, 19.00 mg; Zn, 2,500.00 mg; F, 600.00 mg.

Table 2. Chemical composition of concentrate and roughage diets.

Items	
Crude protein, %	16.45
Crude fiber, %	5.03
Crude ash, %	3.24
Ca, %	0.65
P, %	0.45
TDN, %	75.20
Vitamin A, UI/kg	6.000.00
Se	0.57
Vitamin D, UI/kg	1,500.00
Vitamin E, UI/kg	45.00
Mg, g/hg	0.60
S, g/kg	0.60
Cu, mg/kg	21.00
Zn, mg/kg	75.00
Mn, mg/kg	48.00
Co, mg/kg	0.45
I, mg/kg	1.20
Fe, mg/kg	21.00
Na,	0.21
K, g/kg	1.05
Cr, mg/kg	0.29
Cl, %	0.30
Monensin sodium, mg/kg	30.00

Traits measured

Prior to slaughter, animals were weighed for final live body weight (FLBW) and average daily gain (ADG). Slaughter was done in a commercial slaughterhouse facility by cerebral concussion and sectioning of the jugular vein, followed by removal of hides and evisceration without electrical stimulus. Carcasses were chilled for 24 h in refrigeration chambers at 2 to 3 °C and re-weighed for cold carcass weight (CCW) and carcass dressing percentage (CDP) determination.

Carcasses were divided in halves, and a subjective evaluation was made for conformation. The carcass conformation scores evaluated were: concave (1), sub-rectilinear (2), rectilinear (3), sub-convex (4), and convex (5). The fatting carcass score evaluated: total absence of fat or lean (1), little fat with 1 to 3 mm (2) average fat with 3 to 6 mm (3) uniform fat with 6 to 10 mm (4), and excessive fat with more than 10 mm (5).

Rib eye area (REA) and back fat thickness (BFT) were evaluated after cooling on the cross section of muscle *longissimus thoracis,* between the 12^{th} and 13^{th} ribs (Muller and Primo, 1987). The BFT was measured using calipers. The REA was drawn on tracing paper for subsequent calculation of surface area (cm^2).

Cutability (CUT), total usable meat (TUM), and Brazilian commercial cuts yield (BCC) were measured using REA, BFT and hot carcass weight (HCW), with regression equations developed by Felício and Allen (1982):

$$CUT\ \% = 52.06 - 0{,}019 \times HCW - 0.365 \times BFT + 0.094 \times REA$$

$$TUM\ \% = 72.92 - 0.020 \times HCW - 0.489 \times BFT + 0.119 \times REA$$

$$BCC\ \% = 60.33 - 0.015 \times HCW - 0.462 \times BFT + 0.110 \times REA$$

Statistical analysis

Data (final weight, ADG, HCW, CCP, BFT, REA, fatting conformation, CUT, TUM, and BCC) were subjected to analysis of variance (ANOVA) using R Software (R Development Core Team, Version 2.14.02, 2011). Live weight (LW) was used as a covariate, and the significance level was set at 5%.

The statistical model used was:

$$Y_{ij} = \mu + Ti + b\ (X_{ij} - X) + e_{ij}$$

Where:

Y_{ij}: value observed in animal j, in treatment i, adjusted to LW initial.

μ: overall average.

T_i: *i* treatment, where *i* = 1 (NAA) and 2 (NRA).

b: linear regression coefficient of the trait against LW initial.

X_{ij}: initial weight of the *j* animal in the *i* treatment.

X: average initial weight.

e_{ij}: error associated with the *ij* observation.

Results

Productive performance results such as corrected initial live body weight, FLBW, ADG, and feed intake are summarized in Table 3. Initial live body weights of NAA and NRA were adjusted so as not to affect the other parameters. Final live weight was higher for NAA (411.62 kg) in comparison to NRA animals (380.55 kg; $p<0.05$). Such values influenced other NAA parameters, such as ADG where NAA animals obtained 1.45 kg whereas the NRA animals obtained 1.08 kg ($p<0.05$).

Table 3. Productive performance parameters of F1 Nellore x Aberdeen Angus (NAA) and F1 Nellore x Red Angus (NRA) heifers finished in feedlot under tropical conditions.

Item	Genetic group			
	NAA	SEM*	NRA	SEM
No. of heifers	20	-	21	-
Duration (days)	84	-	84	-
Initial live body weight, kg	289.51[a]	27.30	289.51[a]	25.2
Final live body weight, kg	411.62[a]	24.10	380.55[b]	24.6
Average daily gain, kg	1.45[a]	0.29	1.08[b]	0.21

*SEM: standard error of the mean.

[a,b]Means followed by different superscripts within the same row differ according to the Fisher's test ($p<0.05$).

NAA: Nellore x Angus Aberdeen.

NRA: Nellore x Red Angus.

The CCW was greater ($p<0.05$) for NAA compared to NRA heifers (210.38 kg and 192.65 kg, respectively; the BFT was also greater ($p<0.05$) for NAA compared to NRA heifers (5.66 mm and 4.09 mm, respectively). The REA was 67.5 cm^2 for NAA and 61.87 cm^2 for NRA ($p<0.05$; Table 4).

According to Table 4, CDP did not differ ($p>0.05$) among genetic groups; it was 51.11% for NAA and 50.62% for NRA, and no statistical difference ($p>0.05$) was found between genetic groups for conformation and fatting criteria. Conformation was subconvex in all NAA animals.

The CUT, TUM, and BCC values did not differ ($p>0.05$) for NAA and NRA; values were 56.23 and 56.2% for CUT, 73.86 and 74.3% for TUM, and 65.05 and 65.17% for BBC, respectively.

Table 4. Carcass traits of F1 Nellore x Aberdeen Angus (NAA) and F1 Nellore x Red Angus (NRA) heifers finished in feedlot under tropical conditions.

Item[1]	Genetic group			
	NAA	SEM*	NRA	SEM
No. of heifers	20	-	21	-
CCW, kg	210.38[a]	12.80	192.65[b]	11.50
CDP, %	51.11[a]	1.20	50.62[a]	1.40
Conformation[1]	4.00[a]	0.00	3.90[a]	0.30
Fatting[2]	2.80[a]	0.52	2.60[a]	0.48
BFT, mm	5.66[a]	1.60	4.09[b]	1.20
REA, cm^2	67.50[a]	5.50	61.87[b]	4.90
CUT, %	56.23[a]	1.0	56.20[a]	0.70
TUM, %	73.86[a]	1.4	74.3[a]	0.80
BCC, %	65.05[a]	1.2	65.17[a]	0.90

*SEM: Standard error of the mean.

[a,b]Means followed by different superscripts within the same row differ according to Fisher's test ($p<0.05$). [1]Conformation: concave (1), sub-rectilinear (2), rectilinear (3), sub-convex (4), and convex (5).

[2]Fatting Score: lean (1), little fat with 1 to 3 mm (2) average fat with 3 to 6 mm (3) uniform fat with 6 to 10 mm (4) and excessive fat with more than 10 mm (5). CCW = Cold carcass weight, CDP = Carcass dressing percentage, BFT = Backfat thickness, REA = Ribeye area, CUT = Cutability, TUM = Total usable meat, BCC = Brazilian commercial cuts yield.

NAA: Nellore x Angus Aberdeen.

NRA: Nellore x Red Angus.

Discussion

Productive performance

Ferreira *et al*. (2009) conducted an experiment to evaluate technical and economic parameters of steers among three genetic groups: Charolais x Nellore, NRA, and NAA. They observed 1.33 kg ADG for NAA, and 1.31 kg for NRA; higher than found in the

present study. Furthermore, they found no difference between the two genetic groups for this trait in animals raised in a tropical environment similar to this study. Most literature reports were conducted in temperate environments (Laborde *et al.*, 2001) or compared sires from *Bos taurus taurus* x *Bos taurus indicus* breeds, thus making it difficult to establish comparable baselines or to discern causes.

The CDP did not differ ($p<0.05$), although it has been previously established that CDP increases with increasing slaughter weight (Kempster *et al.,* 1988; More and Keane, 1990). The present study found no difference between the two genetic groups in this regard.

Restle *et al.* (2001), working with Charolais and F1 ¾ Charolais + ¼ Nellore cows found similar values (51.1% and 51.6%) for dressing percentage, respectively. This data agree with Marques *et al*. (2000), who studied crossbred heifers in feedlots with different energy sources and obtained 50.1% average carcass yield. Higher carcass yield values were observed by Costa *et al.* (2002), who found an average yield of 54.0% for castrated Red Angus bulls. In general, these comparisons show that cows have a lower carcass yield compared to bulls.

Carcass quality

According to Table 4, no statistical difference ($p>0.05$) was found among genetic groups for conformation and fatting criteria. All NAA animals presented subconvex conformation. This data is in agreement with the experiment by Igarasi *et al.* (2008), who found that subconvex conformation was the most frequent in young NRA steers and the majority of carcasses had uniform fat cover.

According to Table 4, BFT in NAA was higher ($p<0.05$) compared to NRA animals, and most carcasses complied with the minimum Brazilian meat industry standards (3 millimeters) required to avoid cooling problems (i.e.: cold shortening; Felício, 1997).

The REA was statistically higher ($p<0.05$) in NAA compared to NRA animals. This difference could be attributed to CCW of NAA animals due to the positive correlation between REA and muscularity (Luchiari, 2006).

The BFT in the present study was higher than results reported by Vaz and Restle (2003), who found 2.55 mm BFT for two year old F1 Nellore x Charolais cattle at 247.7 kg CCW. BFT results were higher because these animals are smaller than Charolais and therefore accumulate fat at a young age (early maturity). Similar BFT results (4.85 mm) were reported by Igarasi *et al*. (2008) in NRA bulls. However, REA was higher (73.78 cm^2) in the experiment by Igarasi *et al*. (2008). This can be explained by the fact that bulls reach maturity later than cows, causing them to gain more muscle than fat.

MacNeil and Northcutt (2008) reported a similar trend in Angus, with heifers having greater intramuscular fat (4.46%) than their male counterparts (3.73%). The present 3.79% intramuscular fat is similar to the 3.26% estimate reported by Speidel *et al.* (2007). There is evidence that fat percentage may have potential as a pregnancy rate indicator in heifers (Evans *et al.* 2004).

However, REA and BFT results do not agree with Pizzuti *et al*. (2007) who found no difference on carcass physical composition between Aberdeen Angus and Red Angus steers. Pizzuti *et al*. (2007) conducted their research in South Brazil during winter, where climate could be considered subtropical.

The genetic groups did not differ ($p>0.05$) regarding CUT, TUM, and BCC values. The CUT was the same (56.2%) for NAA and NRA. These values are higher than those reported by Polizel (2011), who obtained 51.8% cut yield in Nellore animals using the equation proposed by Cross *et al*. (1973). However, this difference may be related to the formulas used to calculate CUT.

The CUT values were also higher than those found by Mattos *et al*. (1977) in a study with Nellore cattle under extensive pasture conditions and slaughtered at 26 (52.13%) and 32 months (51.83%) of age. The same authors, in another work with castrated Nellore bulls and crossbred bulls (Mattos *et al*., 1978), found 52.29% CUT average for Nellore and 52.42% for crossbred animals slaughtered at 33 months of age. The CUT values found in this study (Table 4) are

higher than those by Mattos *et al*. (1977) and Mattos *et al*. (1978), showing that crossbred cows have higher percentage of cuts from the back, loin, rib, and shoulder. The TUM values are very similar to those by Brito and Sampaio (2001), who evaluated carcasses of ¾Canchim x ¼Nellore bulls with different protein sources after 168 days in the feedlot using the same equation proposed by Felício and Allen (1982).

Junqueira *et al*. (1998) results agree with TUM in this study. They found 75.33% TUM for F1 Marchigiana x Nellore bulls, 73.72% for F1 Marchigiana x Nellore cows, and 72.85% for ¾Marchigiana x ¼Nellore cows. Of these fractions, the amount of edible meat is the most interesting for the consumer. Estimation of this parameter is required to select animals intended for different market segments with high gradient preferences or consumption needs (Brito and Sampaio, 2001).

It is concluded that F1 Nellore x Aberdeen Angus were better than F1 Nellore x Red Angus animals with regard to performance and carcass traits when finished in feedlot under tropical conditions.

Conflicts of interest

The authors declare they have no conflicts of interest with regard to the work presented in this report.

References

Associação Brasileira de Inseminação Artificial - ASBIA. Relatórios 2013; [Access date: July 20, 2013] URL: http://www.asbia.org.br/novo/upload/mercado/relatorio2012.pdf.

Brito RM, Sampaio AAM. Efeito de fontes de proteína nas características da carcaça e avaliação do rendimento de carne aproveitável estimada por meio de equações de regressão linear múltipla em touros ¾ Canchim ¼ Nelore. Ars Veterinaria 2001; 17:64-70.

Chizzotti ML, Valadares Filho SC, Tedeschi LO, Chizzotti FHM, Carstens GE. Energy and protein requirements for growth and maintenance of F1 Nellore x Red Angus bulls, steers, and heifers. J Anim Sci 2007; 85 suppl 8:1971-1981.

Costa EC, Restle J, Vaz FN, Alves Filho DC, Bernardes RALC, Kuss F. Características da carcaça de novilhos Red Angus superprecoces abatidos com diferentes pesos. Rev Bras Zootec 2002; 31:119-128.

Cross HR, Carpenter ZR, Smith GC. Equations for estimating boneless retail cut yields from beef carcasses. J Anim Sci 1973; 37:1267-1272.

Evans HL, Willard ST, King R, Vann RC. Case study: relationship among live animal carcass traits, the estrous cycle, and synchronization of estrus in beef heifers. PAS 2004; 20:453- 459.

Felício PE. Fatores que influenciam na qualidade da carne bovina. In: Produção de Novilho de Corte. FEALQ, São Paulo, Brazil; 1997. p.79-97.

Felício PE, Allen DM. Regression equations for predicting retail yields of zebu steer carcasses. Col Ital 1982; 12:203-217.

Ferreira IC, Silva MA, Barbosa FA, Carvalho ADF, Correa GSS, Fridrich AB, Souza JER. Avaliação técnica e econômica de diferentes grupos genéticos de bovinos de corte machos superprecoces e do sistema de produção em confinamento. Arq Bras Med Vet Zootec 2009; 61:243-250

Igarasi MS, Arrigoni MB, Hadlich JC, Silveira AC, Martins CL, Oliveira HN. Características de carcaça e parâmetros de qualidade de carne de bovinos jovens alimentados com grãos úmidos de milho ou sorgo. R Bras Zootec 2008; 37:520-528.

Junqueira JOB, Velloso L, Felício PE. Desempenho, rendimentos de carcaça e cortes de animais, machos e fêmeas, mestiços Marchigiana x Nelore, terminados em confinamento. R Bras Zootec 1998; 27:1199-1205.

Kempster AJ, Cook GL, Southgate JR. Evaluation of British Friesian, Canadian Holstein and beef breed x British Friesian steers slaughtered over a commercial range of fatness from 16-month and 24-month beef production systems. 2. Carcass characteristic, and rate and effciency of lean gain. Anim Prod 1988; 46:365-378.

Laborde FL, Mandell IB, Tosh JJ, Wilton JW, Buchanan JG. Breed effects on growth performance, carcass characteristics, fatty acid composition, and palatability attributes in finishing steers. J Anim Sci 2001; 79:355-365.

Luchiari F. A produção de carne bovina no Brasil: qualidade, quantidade ou ambas? In: II Simpósio sobre Desafios e Novas Tecnologias na Bovinocultura de Corte 2006, Brasília, Distrito Federal, 1-10.

Machado Neto OR, Ladeira MM, Gonçalves TM, Lopes LS, Oliveira DM, Lima RR. Performance and carcass traits of Nellore and Red Norte steers finished in feedlot. R Bras Zootec 2011; 40:1080-1087.

MacNeil MD, Northcutt SL. National cattle evaluation system for combined analysis of carcass characteristics and indicator traits recorded by using ultrasound in Angus cattle. J Anim Sci 2008; 86:2518-2524.

Marques JA, Prado IN, Zeoula LM, Alcalde CR, Nascimento WG. Avaliação da mandioca e seus resíduos industriais em substituição ao milho no desempenho de novilhas confinadas. R Bras Zootec 2000; 29:1528-1536.

Mattos JCA, Pacola LJ, Drudi A, Ribeiro MCR, Campos BES. Estudo da carcaça de novilhos Nelore. Bol Ind Anim 1977; 34:209-216.

Mattos JCA, Pacola LJ, Lima P, Drudi A. Estudo comparativo entre carcaças de novilhos da raça Nelore e de novilhos mestiços. Bol Ind Anim 1978; 35:25-31.

More GJ, Keane MG. A comparison for live weight and carcass production of Charolais, Hereford a Friesian steer progeny from Friesians cows finished on two energy levels and serially slaughtered. Anim Prod 1990; 50:19-28.

Muller L, Primo AT. Influência do regime alimentar no crescimento e terminação de bovinos e qualidade da carne. Pesq Agropec Bras 1987; 21:445-452.

NRC, National Research Council. Nutrient Requirements of Beef Cattle. 7th ed. Washington, D.C: National Academy Press; 1996.

Pizzuti LAD, Brondani IL, Restle J, Arboitte MZ, Freitas LS, Metz PAM. Carcass physical composition of Aberdeen Angus and Red Angus steers, feedlot finished. In: Proceedings Zootec, Londrina, Paraná June 2007.

Polizel A. Uso de coproduto da produção de biodiesel como alimento para bovinos confinados. [PhD Thesis]. Universidade Estadual Paulista, Botucatu, São Paulo, 2011.

R Development Core Team, R: A Language and environment for statistical computing. Vienna, Austria, the R Foundation for Statistical Computing. ISBN: 3-900051-07-0. URL: http://www.R-project.org/2011.

Restle J, Neumann M, Alves Filho DC, Pascoal LL, Rosa JRP, Menezes LFG, Pellegrini LG. Terminação em confinamento de vacas e novilhas sob dietas com ou sem monensina sódica. R Bras Zootec 2001; 30:1801-1812.

Silva RG, Scala Júnior NL, Pocay PLB. Transmissão de radiação ultravioleta através do pelame e da epiderme de bovinos**.** R Bras Zootec 2001; 30:1939-1947.

Silva DJ, Queiroz AC. Análises de alimentos (métodos químicos e biológicos). 3th ed. Viçosa MG, Editora UFV, 2002.

Siqueira JB, Oba E, Pinho RO, Quintino HP, Eler JP, Miranda Neto T, Guimarães SEF, Guimarães JD. Heritability estimate and genetic correlations of reproductive features in Nellore bulls, offspring of super precocious, precocious, and normal cows under extensive farming conditions. Reprod Domest Anim 2012; 47:313-318.

Speidel SE, Enns RM, Brigham BW, Keenan LD. Genetic parameter estimates for ultrasound indicators of carcass. Proc West Sect Am Soc Anim Sci 2007; 58:39-42.

USDA-FAS. 2013. Beef and Veal: 2013 revised form October. Livestock and Poultry: World Markets and Trade Circular. 1-25. http://www.fas.usda.gov/dlp/livestock_poultry.asp

Vaz FN, Restle J. Ganho de peso antes e após os sete meses no desenvolvimento e nas características de carcaça e carne de novilhos Charolês abatidos aos dois anos. R Bras Zootec 2003; 32:699-708.