# GROWTH PERFORMANCE AND CARCASS TRAITS OF YOUNG NELLORE BULLS SUPPLEMENTED WITH OR WITHOUT ADDITION OF LIPIDS

## *DESEMPENHO E CARACTERÍSTICAS DE CARCAÇA DE NOVILHOS NELORE SUPLEMENTADOS COM OU SEM ADIÇÃO DE LIPÍDIOS*

**Clóvis Carlos SILVEIRA FILHO[1]; Carlos Augusto de Alencar FONTES[1]; Elizabeth Fonsêca PROCESSI[1]; Laila Cecília Ramos BENDIA[1]; Paulo Roberto Silveira PIMENTEL[2]; Ronaldo Lopes OLIVEIRA[2]; Leilson Rocha BEZERRA[3]; Isabelle Batista SANTOS[4]; Tiago Cunha ROCHA[4*]**

1. State University of North Fluminense Darcy Ribeiro, Department of Animal Science, Campos dos Goytacazes, Rio de Janeiro, Brazil. 2. Federal University of Bahia, Department of Animal Science, Salvador, Bahia, Brazil; 3. Federal University of Piauí, Campus Professora Cinobelina Elvas, Department of Animal Science, Bom Jesus, Piauí, Brazil; 4. State University of the Tocantina Region of Maranhão, Imperatriz, Maranhão, Brazil. tiagoticuro@yahoo.com.br

**ABSTRACT:** The aim of research was to evaluate the performance and characteristics of the carcasses of Nellore young bulls in grazing supplemented with or without addition of lipids. Twenty–eight young bulls, 301 ± 5.8 kg in body weight, which four constituted the reference group and the twenty-four remnants were used in the experiment and randomly distributed into four groups according to treatment: only *Panicum maximum* cv. Mombasa grass; Mombasa grass with concentrated supplementation based on soybean meal; Mombasa grass with concentrate containing lipids from soybean oil; and Mombasa grass with concentrate containing lipids derived from soybean grains. The total dry matter intake of the animals fed only Mombasa grass did not differ from the average intake of the three treatments supplemented with concentrate. There were no differences (P>0.05) between Mombasa grass and diets with concentrate, supplementation with or without lipid and lipids sources in the carcass traits, gastrointestinal tract, organs and loin eye area. Nellore bulls receiving concentrate increased subcutaneous fat thickness compared with bulls that received only Mombasa grass. Nellore young bulls fed Mombasa grass only, supplemented with or without addition of lipids were similar regarding growth performance and carcass traits.

**KEYWORDS:** Beef cattle. Mombasa grass. Soybeans. Soybean oil.

## INTRODUCTION

Cattle production in tropical countries is generally associated with grazing of cultivated pastures and low production costs (CARVALHO et al., 2016), however, variations in the quantity and quality of fodder offered may compromise the performance of the animals (SANTANA et al., 2017). Supplementation of cattle raised on pasture is a common practice used to improve animal performance, reduce slaughter age, and improve carcass traits (SAN VITO et al., 2015).

Supplementation of beef cattle with lipids during the growth phase may be an attractive way to improve the efficiency of beef production (SAN VITO et al., 2018). Lipid supplements, when added to feed, causes an increase in the net energy consumed, resulting in an increase in production because the increased energy consumed improves production efficiency and consequently can improve produce carcasses with better finishing characteristics (GOUVÊA et al., 2016; SEGERS et al., 2015; PHOEMCHALARD; URIYAPONGSON, 2015).

Thus, it was hypothesized that Nellore bulls supplemented with the addition of lipids could exhibit increased performance and improved carcass characteristics young Nellore bulls in grazing. This study aimed to evaluate the effect of supplementation with or without the addition of lipids in the feed of Nellore bulls on animal performance and carcass characteristics.

## MATERIAL AND METHODS

### Ethical considerations and the location of the experiment

This study was performed in strict accordance with the recommendations in the Guide for the National Council for Animal Experiments Control and approved by the Committee on the Ethics of Animal Experiments of the State University of North Fluminense, Rio de Janeiro State, Brazil (Permit Number: 168–2012).

Received: 14/05/18
Accepted: 20/11/19


http://dx.doi.org/10.14393/BJ-v36n2a2020-42273

## Animals, experimental treatments, grass and pens

Twenty-eight Nellore young bulls were used in the experiment, with an average weight of 300.6 ± 5.8 kg and an average age of 15 months, of which, four were the reference group and were slaughtered at the beginning of the experiment, in order to obtain the weight of empty initial body and initial hot carcass weight. Then the remaining twenty-four animals were randomly distributed into four groups of six animals. Four groups were allocated at random to each replicate area of each of the following treatments: Control – only Mombasa grass (*Panicum maximum)*; Soybean Meal (Mombasa grass with concentrated supplementation based on soybean meal); Soybean Oil (Mombasa grass with concentrated containing lipids from soybean oil); and Soybean Grain (Mombasa grass with concentrate containing lipids derived from soybean grains).

The experimental area was divided into two 4.5-hectare blocks (replicate areas) equipped with an irrigation sprinkler system grid and divided into 18 paddocks of 0.25 ha. Due to the reduced rainfall in the period, pasture irrigation was performed at intervals of seven days. The Mombasa grass was fertilized by the application of 100 kg N and 50 kg $K_2O$/ha/year and fractionated after each grazing cycle, depending on the weather conditions (temperature, rainfall and solar radiation). The animals were adapted to the experimental procedures and supplementation.

Mombasa grass was managed under a rotational grazing system, with periods of occupation and rest of two and 34 days, respectively, representing a grazing cycle of 36 days, the experiment totalized 180 days (5 cycles). A variable stocking rate (put and take) was adopted to maintain the supply of biomass of green leaf blades at 4 kg DM/100 kg body weight of the animals.

The supplements were offered in an individual stall (10.2 $m^2$) with masonry feeders and automatic water troughs. In the adaptation period, the animals were weighed, treated for internal and external parasites (IVOMEC GOLD®, MERIAL, SÃO PAULO, BRAZIL) and received subcutaneous administration of vitamin A (1,500,000 IU per head).

## Experimental feeds and chemical analyses

Mombasa grass intake was allowed *ad libitum*. The ingredients of the concentrated supplements were homogeneously mixed and fed into the trough in the ratio of 0.75 kg concentrate/100 kg of BW in DM and once per day at 9:00 h, before the animals were returned to the Mombasa grass, where they remained the rest of the day. Assuming *ad libitum* forage intake and the total dry matter intake corresponding to 2.5 kg per 100 kg body weight per day, the diet would consist of 0.75 kg of concentrate and 1.75 kg of roughage per 100 kg body weight, corresponding to the ratio of forage: concentrate of 70:30 in DM. The diets were formulated based on the composition of DM in order to meet the requirements of the bulls according to the NRC (2000) for gain of 1.0 kg per day. Animals in the control treatment were subjected to the same handling, receiving only mineral supplements during the period in the stall.

Samples of orts and feces were pre-dried at 55 °C for 72 h, ground with a Willey mill (TECNAL, PIRACICABA CITY, SÃO PAULO STATE, BRAZIL) with a 1-mm sieve, stored in air-tight plastic containers (ASS, RIBEIRÃO PRETO CITY, SÃO PAULO STATE, BRAZIL), and sealed properly until laboratory analysis for the levels of the DM (Method 967.03 - AOAC, 1990), ash (Method 942.05 -AOAC, 1990), CP (Method 981.10 - AOAC, 1990), and EE (Method 920.29 - AOAC, 1990). NDF content has determined according to the methodology proposed by Van Soest et al. (1991) with changes proposed in the Ankon device manual (ANKON TECHNOLOGY CORPORATION, MACEDON, NEW YORK, US). The proportion of ingredients and the chemical composition are shown in Table 1.

## Intake

The individual intake of the supplement was determined daily by noting the quantities offered and the orts. The grass intake was estimated in second and fourth grazing cycles, using dual-indicator methodology (chromium oxide and indigestible neutral detergent fiber - iNDF). The content of the internal indicator (iNDF) was determined by *in situ* incubation of feed and feces over a period of 240 h.

Each animal received 10 g of chromium oxide divided into two 5-g portions, wrapped in paper cartridges and administered by gavage at 09:00 and 17:00 h for 13 days. In the last seven days, feces were collected in the moment of supply of chromium oxide. Using simulated grazing, we collected representative samples of the forage consumed during the collection of fecal samples. Chromium was measured by the colorimetric method, which included nitro-perchloric digestion (KIMURA; MÜLLER, 1957) and a UV - visible spectrophotometer reading at 440 nm (Spekol UV device visible).

**Table 1.** Proportion of ingredients in supplements and chemical composition of diets.

| Ingredients | Treatments | | | |
|---|---|---|---|---|
| | Mombasa grass | Soybean meal | Soybean oil | Soybean grain |
| **Proportion of ingredients** | | | | |
| Mombasa grass | 99.4 | 70.0 | 70.0 | 70.0 |
| Soybean grain | - | - | - | 16.4 |
| Corn bran | - | 16.9 | 13.1 | 13.0 |
| Soybean oil | - | - | 3.09 | - |
| Mixed minerals[A] | 0.60 | 0.60 | 0.60 | 0.54 |
| Soybean Meal | - | 12.5 | 13.2 | - |
| Composition[B] | 100 | 100 | 100 | 100 |
| **Chemical composition** | | | | |
| Dry Matter | 23.1 | 28.4 | 28.5 | 28.5 |
| Crude Protein[B] | 10.0 | 14.6 | 14.6 | 14.6 |
| Ether Extract[B] | 1.00 | 1.60 | 4.50 | 4.50 |
| Neutral detergent fiber[B] | 66.0 | 52.6 | 52.2 | 52.3 |
| Total digestible nutrient[B] | 51.0 | 60.6 | 64.0 | 60.9 |
| Calcium[B] | 0.70 | 0.70 | 0.70 | 0.70 |
| Phosphorus[B] | 0.20 | 0.20 | 0.30 | 0.30 |

[A]Composition (/kg): calcium - 11 g; phosphorus - 80 g; sodium - 195 g; magnesium - 17.3 g; sulfur - 20 g; iodine - 301 mg; iron - 487 mg; selenium - 40 mg; cobalt - 100 mg; manganese – 1,000 mg; fluoride - 800 mg; copper – 1,500 mg; and zinc – 3,000 mg.
[B]Dry matter basis

The grazing simulation was performed for the harvest of forage samples in representative areas of the Mombasa grass conditions, with attempts made to graze in a way that simulated the morphological composition of the forage consumed by the cattle. Fecal samples for the estimated intake of DM were collected in the morning and evening, directly from the rectum of the animals, in amounts of approximately 200 g; these samples were placed in plastic bags, identified according to the animal and time and frozen at –10 °C.

Fecal excretion was estimated using the following formula: Dry Matter fecal kg/day = Amount provided chrome (g)/chromium fecal concentration (g/kg) x 100. The total dry matter intake was estimated according to the equation: DMI = (FE x iNDFfecal) – (DMSupl x iNDFSupl)/iNDFforage + DMSupl, where DMI = dry matter intake (g/day); FE = fecal excretion (g/day); iNDFfecal is the fecal concentration of indigestible NDF (g/g); DMSupl is the supplement dry matter (g/day); iNDFSupl is the supplement concentration of indigestible NDF (g/g); and iNDFforage is the forage concentration of indigestible NDF (g/g).

### Slaughter and carcass component determination

Nellore bulls were weighed at the beginning of the experiment (initial weight) as well as before slaughter after 16 h fasting day to obtain the final body weight (FBW) and average daily weight gain.

In the slaughtering procedure, animals were stunned with a captive bolt pistol, suspended upside down, and bled through the jugular vein. After bleeding, the animals were skinned and eviscerated. In evisceration, the gastrointestinal tract (rumen-reticulum, omasum, abomasum, small and large intestines) was weighed full and empty to determine empty body weight (EBW = weight at slaughter - contents of gastrointestinal tract - gallbladder - bladder). The empty body weight gain was calculated by the difference between the final body weight and the initial empty body weight.

Posteriorly, the head and feet were removed, and the carcasses were weighed to determine the hot carcass weight (HCW) and hot carcass yield (HCY) was calculated through the equation HCY = [HCW/ FBW] × 100. The daily gain carcass was calculated by the difference between the final hot carcass weight and the initial hot carcass weight. Then, the carcasses were placed in a cold chamber (4°C) for 24 h, after cooling, the carcasses were sectioned in the half. On the left side of the carcass, a cross section was made between the 12th and 13th ribs, exposing the Longissimus dorsi, in witch was tracked by its transparency sheet wrap Transparency A4 75 microns (P / INK-JET, KALUNGA, SÃO PAULO, BRAZIL); subsequently, this area was measured using a digital planimeter (DIGIPLAN 300/301, HERBERT KREITE, BONN, GERMANY). The subcutaneous fat thickness (mm) was measured using a precision caliper at three equidistant points in the cut region between the 12th and 13th ribs.

**Statistical analyses**

Statistical analyses were performed using the following model: $Y_{ij} = \mu + T_i + R_j + TR_{ij} + \varepsilon_{ij}$, using the Nellore steer as the experimental unit, where $Y_{ij}$ = observation concerning the animal, receiving treatment i in replicate area j; μ is average; $T_i$ = treatment effect i, where i is control (Mombasa grass), soybean meal concentrate, soybean oil concentrate and soybean grain concentrate; R j = area of repeat effect, where j = 1,2; $TR_{ij}$= the interaction effect between treatment i and j replicate area; and εij = random error.

In the statistical analysis, we used the PROC GLM procedure of SAS (2004) and the means were compared by using Tukey's test (P<0.05). Treatments were compared using three orthogonal contrasts. The first comparison made among the three treatments involved supplementation with concentrate and the control treatment. The second comparison was between the treatment supplemented with or without lipids (soybean meal versus soybean oil and soybean grain), and the third comparison was between the lipids' sources in the supplementation (soybean oil versus soybean grain).

## RESULTS

**Performance and quantitative characteristics carcass**

The total dry matter intake of the animals fed only on the Mombasa grass (7.9 kg/day) did not differ (P=0.62) from the average intake of the animals in the three treatments supplemented with concentrate (8.2 kg/day) (Mombasa grass × soybean meal, soybean oil and soybean grain) (Table 2). As expected, the animals that were fed exclusively on Mombasa grass showed higher intake pasture (P=0.03). Animals that received soybean meal showed an increase in intake concentrate (P<0.01) of 34% compared with animals receiving supplementation with soybean oil and soybean grain.

**Table 2.** Intake of Nellore bulls supplemented with or without addition of lipids.

| Item | Treatments | | | | SEM[A] | *P* -value[B] | | |
|---|---|---|---|---|---|---|---|---|
| | Mombasa grass | Soybean meal | Soybean oil | Soybean grain | | MG *vs* S | SM *vs* SO+SG | SO *vs* SG |
| Dry matter intake total, kg | 7.90±0.60 | 8.80±0.60 | 7.80±0.60 | 8.00±0.60 | 1.67 | 0.62[ns] | 0.31[ns] | 0.89[ns] |
| Dry matter intake pasture, kg | 7.90±0.60 | 5.80±0.60 | 5.70±0.60 | 6.1±0.6 | 1.43 | 0.03* | 0.92[ns] | 0.76[ns] |
| Dry matter intake concentrate, kg | - | 3.00±0.20 | 2.10±0.20 | 1.90±0.20 | 0.76 | - | <0.01* | 0.44[ns] |
| Intake/100 kg body weight | 2.23±0.20 | 2.30±0.20 | 2.00±0.20 | 2.20±0.20 | 0.55 | 0.95[ns] | 0.44[ns] | 0.43[ns] |

[A]Standard Error of the Mean (SEM); [B]*P*<0.05, [ns] not significant

There were no differences (P>0.05) between Mombasa grass and diets with concentrate, concentrate with or without lipids and source of lipids in the initial body weight, final body weight, average daily weight gain, initial empty body weight, final empty body weight, daily empty body gain, gastrointestinal tract weight, organs weight, initial hot carcass weight, final hot carcass weight, daily hot carcass gain, hot carcass yield and *longissimus* muscle área (Table 3).

Subcutaneous fat thickness differed (P=0.03) among diets with concentrate. Nellore bulls receiving concentrate showed increased Subcutaneous fat thickness (61% more) compared with bulls that received only Mombasa grass. There was a tendency in supplementation with or without lipids in the concentrate (P=0.05). There was no effect in lipids sources in concentrate (P=0.12).

**Table 3.** Carcass components, subcutaneous fat thickness and Longissimus muscle area of Nellore bulls supplemented with or without addition of lipids.

| Item | Treatments | | | | SEM^A | *P* –value^B | | |
|---|---|---|---|---|---|---|---|---|
| | Mombasa grass | Soybean meal | Soybean oil | Soybean grain | | MG *vs* S | SM *vs* SO+SG | SO *vs* SG |
| Initial body weight, kg | 299±10.6 | 309±10.6 | 299±10.6 | 294±10.6 | 0.47 | 0.90^ns | 0.40^ns | 0.77^ns |
| Final body weight, kg | 428±17.3 | 434±17.3 | 426±17.3 | 428±17.3 | 13.6 | 0.93^ns | 0.73^ns | 0.92^ns |
| Average daily weight gain, kg | 0.74±0.07 | 0.73±0.07 | 0.73±0.07 | 0.77±0.07 | 0.11 | 1.00^ns | 0.77^ns | 0.66^ns |
| Initial empty body weight, kg | 240±8.58 | 249±8.58 | 241±8.58 | 237±8.58 | - | - | - | - |
| Final empty body weight, kg | 358±16.4 | 377±16.4 | 363±16.4 | 367±16.4 | 0.02 | 0.55^ns | 0.53^ns | 0.82^ns |
| Daily empty body gain, kg | 0.68±0.06 | 0.74±0.06 | 0.73±0.06 | 0.73±0.06 | 0.12 | 0.43^ns | 0.87^ns | 1.00^ns |
| Gastrointestinal tract weight, kg | 3.60±0.40 | 2.80±0.40 | 2.50±0.40 | 2.90±0.40 | 0.88 | 0.11^ns | 0.79^ns | 0.46^ns |
| Organs weight, kg | 2.40±0.40 | 2.40±0.40 | 2.70±0.40 | 2.60±0.40 | 0.62 | 0.79^ns | 0.54^ns | 0.78^ns |
| Initial hot carcass weight, kg | 155±5.52 | 160±5.51 | 155±5.51 | 152±5.51 | - | - | - | - |
| Final hot carcass weight, kg | 233±10.3 | 246±10.3 | 237±10.3 | 234±10.3 | 12.1 | 0.58^ns | 0.43^ns | 0.84^ns |
| Daily hot carcass gain, kg | 0.44±0.04 | 0.49±0,04 | 0.47±0.04 | 0.47±0.04 | 0.19 | 0.44 | 0.66 | 0.92 |
| Hot carcass yield, % | 54.3±0.80 | 56.6±0.80 | 55.7±0.80 | 54.8±0.80 | 1.67 | 0.25^ns | 0.29^ns | 0.50^ns |
| Subcutaneous fat thickness, mm | 2.20±0.90 | 6.10±0.90 | 5.80±0.90 | 4.80±0.90 | 0.15 | 0.03^* | 0.05^ns | 0.12^ns |
| Longissimus muscle area, $cm^2$ | 55.3±2.60 | 58.5±2.60 | 57.5±2.60 | 53.8±2.60 | 4.51 | 0.67^ns | 0.39^ns | 0.34^ns |

^A Standard Error of the Mean (SEM); ^B P<0.05, ^ns not significant

## DISCUSSION

### Performance and quantitative characteristics carcass

The concentrate supplementation reduced (2 kg DM/day) the forage intake of Nellore bulls fed with concentrate but did not affect the DM total intake (7.9 and 8.2 kg DM/day only forage and animals supplemented with concentrate, respectively) (Table 2). This phenomenon is referred to as a substitute or pasture replacement effect because the concentrate has a higher nutritional quality due to increased protein content (DOMINGUES et al., 2015). According to NRC (2000), changes in response to intake supplementation appear to be primarily associated with the protein content of the fodder and the amount of the supplied supplement. If the forage has a low protein level, the intake is increased when a small amount of protein supplement is provided. However, when more than 1 kg of the supplement is provided, forage intake can be reduced by substitution.

The increase in supplement intake of the animals that received soybean meal was due to the lower concentration of lipids in the soybean meal concentrate treatment and to the manner in which supplementation was offered separately from the forage intake. The soybean oil and soybean grain animals exhibited restricted intake due to the higher lipid concentration in their supplements (GONZAGA NETO et al., 2015).

There was no improvement in final body weight, hot carcass or hot carcass yield with the addition of the concentrate and were similar for animals controls, the difference between these characteristics is reduced in cattle grazed on good quality pasture. The average daily gain and daily empty body gain were directly related to the final weight gain. The animals fed only Mombasa grass presented acceptable daily weight gain (0.71 kg).

The animal performance satisfactory can be attributed to the management of adopted Mombasa grass (rotational grazing system, irrigation, and fertilization). When forage presents good nutritional value, the amount of energy ingested in the form of concentrate may not be much higher than the reduction of energy intake in the form of fodder, and there is no significant increase in energy intake by supplemented animals (VAN SOEST, 1994). Forage availability may also partially explain the lack of response of the concentrate supplementation in grazing cattle. Pastures with low stocking rates and very high fodder can reduce the response to supplementation, as observed in some studies (DOMINGUES et al., 2015).

Furthermore, other probable reasons for the lack existence of the response to energy supplementation in this study may be related to the composition of the gain. As the subcutaneous fat thickness of animals fed exclusively on Mombasa grass was lower than the average supplemented animals, these results suggest that animals fed only with forage accumulated less energy per kg gain, which would allow them to exhibit daily weight gains and carcass weights similar to the others, even though they were ingesting less energy. On the other hand, the highest energy intake animals supplemented with or without lipids increased the subcutaneous fat thickness in the Longissimus samples, accumulating more energy per kg of gain, besides presenting better carcass finishing. In relation to supplements, soybean meal showed a tendency to increase subcutaneous fat thickness, probably due to the higher consumption of concentrate, consequently, higher energy intake.

The subcutaneous fat thickness of animals fed exclusively on Mombasa grass did not provide the desired finish to the substrate during the trial period, since the 3 to 6 mm range is considered ideal by the meat industry to protect the carcass in the cold room and to provide good sensory characteristics of the meat (FRANÇOZO et al., 2013).

The thickness of the fat of animals fed exclusively on Mombasa grass, in the range of 3 to 6 mm, is considered optimal by the meat industry to protect the carcass in the cold chamber and to provide good sensory characteristics of the meat (FRANÇOZO et al., 2013). The energy level of the grass as an exclusive food source did not provide the desirable finish to the substrate during the trial period. The addition of soybean oil increased the fat thickness in the *Longissimus* samples

There were no differences ($P > 0.05$) between treatments for empty body weight and the longissimus muscle area. With regard body weight, the animals of all treatments were slaughtered with similar weights, furthermore, they presented the same weight to the gastrointestinal tract, which also explains the similar carcass yield for the four treatments.

## CONCLUSIONS

Young Nellore bulls feeding on Mombasa grass only or supplemented with or without the addition of lipids were similar regarding growth performance. However, supplementation improves the finish of carcasses, as it deposits more subcutaneous fat thickness. A substitutive effect of the supplement is observed when the Mombasa grass is of good quality with reduced forage intake.

**RESUMO:** Objetivou-se com esta pesquisa avaliar o desempenho e as características das carcaças de novilhos Nelore em pastejo suplementados com ou sem adição de lipídios. Vinte e oito novilhos, 301 ± 5,8 kg de peso vivo, sendo que quatro constituíram o grupo de referência e os vinte e quatro remanescentes foram utilizados no experimento e distribuídos aleatoriamente em quatro grupos de acordo com o tratamento: somente *Panicum maximum* cv. capim-mombaça; capim-mombaça com suplementação concentrada à base de farelo de soja; capim-mombaça com concentrado contendo lipídios do óleo de soja; e capim-mombaça com concentrado contendo lipídios derivados de grãos de soja. O consumo total de matéria seca dos animais alimentados apenas com capim-mombaça não diferiu da ingestão média dos três tratamentos suplementados com concentrado. Não houve diferenças ($P>0,05$) entre capim-mombaça e dietas com concentrado, suplementação com ou sem lipídeos e fontes de lipídeos nas características de carcaça, trato gastrintestinal, órgãos e área de olho de lombo. Os novilhos Nelore que receberam concentrado aumentaram a espessura de gordura em comparação aos novilhos que receberam apenas capim-mombaça. Novilhos Nelore criados em capim-mombaça, alimentados apenas com capim-mombaça ou suplementados com ou sem adição de lipídeos, foram semelhantes quanto ao desempenho de crescimento e características de carcaça.

**PALAVRAS-CHAVE:** Capim-mombaça. Gado de corte. Óleo de soja. Soja.

**REFERENCES**

AOAC Official Analytical Chemists. 15.ed. Association of official methods of analysis, Washington, DC, USA, 1990.

CARVALHO, I. P. C. C.; FIORENTINI, G.; BERNDT, A.; CASTAGNINO, O. S.; MESSANA, J. D.; FRIGHETTO, R. T. S.; REIS, R. A.; BERCHIELLI, T. T. Performance and methane emissions of Nellore steers grazing tropical pasture supplemented with lipid sources. **Revista Brasileira de Zootecnia**, v. 45, n. 12, p. 760-767, 2016. http://dx.doi.org/doi:10.1590/S1806-92902016001200005

DOMINGUES, J. L.; NUÑEZ, A. J. C.; GOMES, R. C.; VALINOTE, A. C.; SILVA, S. L.; PEREIRA, A. S. C.; LEME, P. R.; NOGUEIRA FILHO, J. C. M. Effect of high oil corn in the diets of Nellore steers on growth performance, carcass characteristics, meat quality, and longissimus muscle fatty acid profile. **Livestock Science**, v. 174, p.31–38, 2015. http://dx.doi.org/doi:10.1016/j.livsci.2014.12.019

FRANÇOZO, M.C.; PRADO, I. N.; CECATO, U.; VALERO, M. V.; ZAWADZKI, F.; PRADO, R. M.; VISENTAINER, J. V. Growth performance, carcass characteristics and meat quality of finishing bulls fed crude glycerine-supplemented diets. **Brazilian Archives of Biology and Technology,** v. 56, n.2, p. 327–336, 2013. http://dx.doi.org/doi:10.1590/S1516-89132013000200019

GONZAGA NETO, S.; OLIVEIRA, R. L.; DE LIMA, F. H.; DE MEDEIROS, N. A.; BEZERRA, L. R.; VIÉGAS, J.; DO NASCIMENTO, N. G.; JR, DE FREITAS NETO, M. D. Milk production, intake, digestion, blood parameters, and ingestive behavior of cows supplemented with by-products from the biodiesel industry. **Tropical Animal Health and Production**, v. 47, n.1, p. 191–200, 2015. http://dx.doi.org/doi:10.1007/s11250-014-0706-2

GOUVÊA, A. A.; OLIVEIRA, R. L.; LEÃO, A. G.; ASSIS, D. Y.; BEZERRA, L. R.; NASCIMENTO JÚNIOR, N. G.; TRAJANO, J. S.; PEREIRA, E. S. Color, sensory and physicochemical attributes of beef burger made using meat from young bulls fed levels of licuri cake. **Journal of the Science of Food and Agriculture,** v. 96, n.11, p.3668–72, 2016. http://dx.doi.org/doi:10.1002/jsfa.7548

KIMURA, F. T.; MÜLLER, V. L. Chromic oxide measurement, improved determination of chromic oxide in cal feed and feces. **Journal of Agricultural and Food Chemistry,** v. 5, n. 3, p. 216-216, 1957. http://dx.doi.org/doi:10.1021/jf60073a008

NRC - Nutrient Requirements of Beef Cattle, 7th ed. National Academy Press, National Research Council, Washington, USA, 2000. 359 p.

PHOEMCHALARD, C.; URIYAPONGSON, S. Effect of cassava bioethanol by-product and crude palm oil in Brahman x Thai native yearling heifer cattle diets: II. Carcass characteristics and meat quality. **Tropical Animal Health and Production** v.49, n. 8, p. 1–3,0 2015. http://dx.doi.org/doi:10.1007/s11250-015-0902-8

SAN VITO, E.; LAGE, J. F.; RIBEIRO, A. F.; SILVA, R. A.; BERCHIELLI, T. T. Fatty acid profile, carcass and quality traits of meat from Nellore young bulls on pasture supplemented with crude glycerin. **Meat Science**, v. 100, p. 17-23, 2015. http://dx.doi.org/doi:10.1016/j.meatsci.2014.09.008

SAN VITO, E.; GRANJA-SALCEDO, Y. T.; LAGE, J. F.; OLIVEIRA, A. S.; GIONBELLI, M. P.; MESSANA, J. D.; DALLANTONIA E. E.; REIS R. A.; BERCHIELLI, T. T. Crude glycerin as an alternative to corn as a supplement for beef cattle grazing in pasture during the dry season. **Semina: Ciências Agrárias**, v. 39, n. 5, p. 2215-2232, 2018. http://dx.doi.org/doi:10.5433/1679-0359.2018v39n5p2215

SANTANA, M. C. A.; MESSANA, J. D.; FIORENTINI, G.; LAGE, J. F.; DIAN, P. H. M.; CANESIN, R. C.; REIS, R. A.; BERCHIELLI, T. T. Characteristics of carcass and meat of heifers finished on pasture amended with different supplement frequency and soybean oil source. **Canadian Journal of Animal Science**, v. 98, n.0, p. 32-43, 2017. http://dx.doi.org/doi:10.1139/cjas-2016-0185

SAS Institute - Inc. SAS/STAT User's guide. Version 9.1, Cary, NC: SAS Institute Inc. 2004.

SEGERS, J. R.; FELIX, T. L.; GREEN, A. R.; MAIA, G. N.; RAMIREZ, B. C.; SHIKE, D. W. Effect of dietary fat concentration from condensed corn distillers' solubles, during the growing phase, on beef cattle performance, carcass traits, digestibility, and ruminal metabolism. **Journal of Animal Science**, v.**93, n. 8**, p. 3990–4001, 2015. http://dx.doi.org/doi:10.2527/jas.2015-8917

VAN SOEST, P. J. Nutritional ecology of the ruminant. Ithaca, Cornell University Press, 1994. 476 p.

VAN SOEST, PJ; ROBERTSON, JB; LEWIS, BA Methods for dietary fiber, neutral detergent fiber, and nonstarch polyssacharides in relation to animal nutrition. **Jounal of Dairy Science**, v. 74, p. 3583–3597, 1991. http://dx.doi.org/doi::10.3168/jds.S0022-0302(91)78551-2