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The effect of grazing system intensification on the growth and meat quality of beef cattle in the Brazilian Atlantic Forest biome

P.P.A. Oliveira[a,*], R.R.S. Corte[b], S.L. Silva[b], P.H.M. Rodriguez[c], L.S. Sakamoto[b], A.F. Pedroso[a], R.R. Tullio[a], A. Berndt[a]

[a] Embrapa Pecuária Sudeste, São Carlos 13560-970, Brazil
[b] Animal Science Department, Faculdade de Zootecnia e Engenharia de Alimentos, USP, Pirassununga 13635-900, Brazil
[c] Animal Production Department, Faculdade de Medicina Veterinária e Zootecnia, USP, Pirassununga 13635-900, Brazil

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ABSTRACT

This study was carried out to evaluate the effects of four levels of intensification of grazing systems: 1) degraded pasture - DP; 2) irrigated pasture with high stocking rate - IHS; 3) dryland pasture with high stocking rate - DHS; 4) dryland pasture with moderate stocking rate - DMS; on growth, muscle development and meat quality of Nellore steers (271 ± 2.2 kg of live body weight - BW; 15 months old) during two consecutive periods (17 and 15 months). The final BW, the average daily BW gain, the hot carcass weight and the dress percentage were greater ($P < 0.0001$), and the ribeye area tended to be greater ($P = 0.085$), in the intensified systems compared to the degraded system. Animals in all systems presented similar back fat. Muscle development increased with the intensification of the grazing systems and meat quality was not affected.

1. Introduction

Brazil has the majority of its agricultural land covered with pastures (159 million ha), representing approximately 73% of its total agricultural land (IBGE, 2011). Brazilian beef cattle production is dispersed in the Amazonia (Amazon), Caatinga (semi-arid), Pantanal (wetlands), Pampa (prairies), Cerrado (savanna) and Atlantic Forest biomes (Lobato et al., 2014). The pasture area in the Atlantic Forest biome comprehends 29 mi ha (Observatório do Clima, 2017). Nonetheless, it is estimated that 80% of the cultivated pastures in Brazil are established on degraded soils (Barcellos, Vilela, & Zobi, 2001). In the Atlantic Forest biome, degrade soils are characterized by low organic matter and nutrient levels, high acidity, and normally are incapable of producing > 3 t dry matter - DM/ha per year, restricting average stocking rates to < 1 animal unit - AU/ha.

The present average stocking rate in Brazil, of < 1.0 animal per ha, represents a potential loss of more than US$ 10 billion in beef value, considering a potential stocking rate of 2.0 animals per ha, which could be easily obtained with improvements in pasture management (Oliveira, 2015). In order to reach these goals, the Brazilian Ministry of Agriculture, Livestock and Supply (MAPA) has proposed the Low Carbon Agriculture Program or “ABC Program” (MAPA, 2012), which aims at transferring new mitigation technologies, mainly the recovery of degraded pastures, to a large number of farmers. Therefore, the objective of this research was to assess animal growth, muscle development and meat quality of beef cattle raised in grazing systems with three levels of intensification (different levels of nitrogen fertilization; use of more productive grass species; irrigation) and in a degraded pasture system in the Atlantic Forest biome. The hypothesis is that intensification of grazing systems can improve animal growth and meat quality, simultaneously allowing higher stocking rates, contributing to environmental protection and, consequently, to the sustainability of the livestock sector in Brazil.

2. Material and methods

2.1. Animals and grazing systems

The experimental animals were handled and managed according to the Institutional Animal Care and Use Committee Guidelines (n° 05/2016) of the Brazilian Agricultural Research Corporation - EMBRAPA. The experiment was carried out at Embrapa Southeast Livestock, São Carlos - SP, (21° 57′ 33.32″ S; 47° 50′ 33.28″ W; 856 m), during two periods: March 2012 to August 2013 (Period 1) and September 2013 to December 2014 (Period 2).

The climate is classified as subtropical humid (Cwa (Köppen)), with two well-defined seasons: dry season, from April to September, and rainy season, from October to March. The average annual rainfall is

* Corresponding author.
E-mail address: patricia.anchao-oliveira@embrapa.br (P.P.A. Oliveira).

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1361.6 mm, with January being the rainiest (274.7 mm) and August the driest month (22.8 mm). The annual average temperature is 21.5 °C, with maximum and minimum averages of 27.1 and 15.8 °C, respectively. June is the coldest (18.4 °C) and February the hottest month (23.7 °C).

Soils under the pastures are in a *transition texture* area with two soil types: Red Latosol and Yellow Latosol, both Oxisol according to the FAO classification System (Hapludox, after US Soil taxonomy).

A total of 48 Nelore steers (24 steers per period; 271 ± 2.2 kg of live body weight - BW; 15 months old) were allotted to four grazing systems with two replicates each (blocks): irrigated pasture with high stocking rate (IHS); dryland pasture with high stocking rate (DHS); dryland pasture with moderate stocking rate (DMS) and degraded pasture (DP).

Pastures in IHS and DHS were established in 2002 with *Panicum maximum* and were managed as rotational grazing systems with three days of occupation and 33 days of rest cycles. Each replicate area had 1.75 ha, divided in 12 paddocks. Pastures in IHS and DHS received, respectively, 660 and 400 kg urea-N/ha per year. Pastures (meaning the two replicate areas) in IHS were irrigated based on the climatological water balance method (Rassini, 2002) and were overseeded with a mix of *Avena byzantina* cv. São Carlos (60 kg of seeds ha^{-1}) and *Loliun multifloram* Lan. cv. BRS Ponteio (30 kg of seeds ha^{-1}) in June 2012 and April 2013.

Pastures in DMS and DP were established in 1996 with *Brachiaria brizantha*, but were infested with *Brachiaria decumbens*. Pastures in the DMS system went through a recuperation process, beginning in 2011, by means of superficial lime application and general fertility correction. Each area in DMS had 3.3 ha divided in six paddocks, managed as a rotational system with six d of occupation and 30 d of rest cycles, and received 200 kg urea-N/ha $year^{-1}$. Pastures in DP were managed under continuous grazing and were never limed or fertilized after the establishment. The IHS, DHS and DMS pastures were limed and fertilized with superphosphate and potassium chloride to achieve, respectively, 20 mg $P{\cdot}dm^{-3}$ and 4% K in the CTC - cation exchange capacity of soil.

Three steers (testers) were used to evaluate performance in each system and additional animals were used to adjust the stocking rate, using the “put and take” technique and visual evaluation of forage availability. Pastures were managed aiming at maintaining a specific residue height for each grass species, according to recommendation by Costa and Queiroz (2013), with exception of the degraded pasture in which only the testers were maintained all year round, independently of the pasture's residue height. Animals were weighed at the beginning and at the end of the two experimental periods after overnight (16 h) water and feed fasting. A mineral supplement was available *ad libitum* to all animals.

2.2. Carcass and non-carcass traits

All animals were slaughtered, with a minimum of 430 kg of live BW, at the same day. The animals were fasted for 16 h on the day prior to transportation to the slaughterhouse and weighed to obtain the shrunk body weight (SBW). Groups of 18 animals were loaded into trucks and transported to the slaughterhouse (Figorífico Fribordogue, Bariri, S.P., Brazil) located 129 km from the experimental site. On arrival at the slaughterhouse, the animals were kept in resting pens during10 h, with free access to water, and slaughtered under Brazilian federal inspection, as follows: stunned by brain concussion and exsanguinated through the jugular vein. Carcasses were hung by the Achilles tendon with no electrical stimulation. Heads, feet, hides and visceral organs were removed.

Carcasses were split into two sides, weighed and chilled for 24 h at 2 °C. After chilling, the cold carcass weight (CCW) was recorded. Hot dressing percentage (%) was calculated as the ratio between the hot carcass weight (HCW) and the SBW. The left carcass side was used to measure the backfat thickness (BFAT) between the 12 and 13th ribs and the ribeye area (REA) in the cold *Longissimus* muscle, using a plastic grid (resolution = 1 cm^2). Half-carcasses were divided into forequarters (with five ribs), hindquarters and spare ribs. Cold carcass cuts corresponded to the carcass edible portion (CEP) and are expressed as kilograms and as a percentage of CCW (CEP%). The CEP was calculated as the sum of edible portions of the Brazilian primal cuts (Yokoo, Araujo, Sainz, & Rocha, 2003): hindquarter, forequarter, and spare ribs. The hindquarter and forequarter edible portions (HEP, FEP) and the spare ribs were also expressed in kilograms and as a percentage of CCW. The HEP and FEP were calculated as the sum of the edible portions of retail cuts: HEP - sirloin, tenderloin, rump, knuckle, topside, flat, eye of round, cap and tail, and shank; FEP - shoulder clod, hump, chuck and brisket. Hindquarter fat trimmings (HFT) and forequarter fat trimmings (HFT), with the standardization of about 3 mm of fat on the retail beefs, are expressed in kilograms (and as a percentage of CCW - HFT% and HFT%, respectively). These traits were considered representative of carcass fat content. Bones are non-edible components and were also expressed in kilograms and as a percentage of CCW.

2.3. Meat quality traits

At 24 h postmortem, 2.5-cm steaks were removed from the *Longissimus thoracis* muscle at the 12 rib of the left carcasses sides. The steaks were vacuum-packaged and frozen at − 18 °C until further analysis (pH, water holding capacity, cooking loss, objective colour and shear force) at Embrapa's Meat Analysis Laboratory. At the time of analysis, the frozen steaks were thawed overnight at 5 °C before evaluation of meat quality. Thawed steaks were removed from the vacuum packagings and allowed to bloom for 30 min. The CIE L* (lightness), a* (redness), and b* (yellowness) values of meat and subcutaneous fat were measured on the surface of the steaks, at three random locations, using a Mini Scan XE Plus 45/0 (HunterLab).The pH of the thawed steaks was measured in three different portions of the sample using a probe-type portable pH meter (Testo AG, Lenzkirch, Germany). Water holding capacity (%) was determined using the filter-paper press method using about 2 g of the *longissimus* sample and calculation according to (Grau & Hamm, 1953). Steaks were cooked in an electric oven (Tedesco, TC06/ELT model) at a temperature of approximately 170 °C. Cooking losses were obtained from the weight difference of the steaks before and after cooking. The shear force was measured according to AMSA (1995). After determining the cooking loss, the cooked steaks were stored for 12 h at 4 °C. Six cylindrical cores (1.27 cm in diameter) were taken from the samples, in the direction of the muscle fiber. These cores were sheared using Warner–Bratzler probe attached to a TA-TX2i texture analyzer (Stable Micro System, Surrey, United Kingdom) set at a speed of 20 cm/min.

2.4. Statistical analyses

Data were analyzed by the MIXED procedure of SAS software (SAS Inst. Inc., Cary, NC) with repeated measures (Littell, Henry, & Ammerman, 1998), after verifying the residue normality by the Shapiro-Wilk test (PROC UNIVARIATE). The model included the effects of treatment (four types of pasture) for average daily gain, carcass traits, carcass and no-carcass components and meat quality. For body weight and stocking rate, the effect of season (spring, summer, autumn and winter) was included as a fixed effect and the interaction between treatments and season as a fixed factor. The effects of block (area repetition) and period (year) were considered as random factors. The initial BW was used as a covariate for final BW and average daily gain (ADG) analysis. The matrix that fitted best to the data was the autoregressive covariance structure. Effects were considered significant at $P \le 0.05$. All means are presented as least squares means and effects were separated by the PDIFF option of SAS.