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Meat quality of young Nellore bulls with low and high residual feed intake

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ABSTRACT

Fifty-nine Nellore bulls from low and high residual feed intake (RFI) levels were studied with the objective of evaluating meat quality traits. Animals were slaughtered when ultrasound-measured backfat thickness reached 4 mm, and samples of *Longissimus* were collected. A mixed model including RFI as fixed effect and herd and diet as random effects was used, and least square means were compared by *t*-test. More efficient animals consumed 0.730 kg dry matter/day less than less efficient animals, with similar performance. No significant differences in carcass weight, prime meat cuts proportion, chemical composition, pH, sarcomere length, or color were observed between RFI groups. Shear force, myofibrillar fragmentation index and soluble collagen content were influenced by RFI, with a higher shear force and soluble collagen content and a lower fragmentation index in low RFI animals. Feedlot-finished low RFI young Nellore bulls more efficiently convert feed into meat, presenting carcasses within quality standards.

1. Introduction

The productivity and economic efficiency of beef cattle production systems are highly dependent on good practices of feeding management since feed is the most expensive component of raising beef cattle. In addition to a direct economic impact, efficient beef production has a positive effect on the environment, optimizing the use of natural resources and supplies and reducing the production of residues.

Wide genetic and phenotypic variation exists in the efficiency of nutrient use by animals for maintenance and growth, which also depends on the quantity and type of food consumed (Archer, Richardson, Herd, and Arthur, 1999). Thus, the identification of animals within the same management system that use feed more efficiently is important for the production system as a whole.

Residual feed intake (RFI), proposed by Koch, Swinger, Chambers, and Gregory (1963), is a measure of feed efficiency in cattle and is defined as the difference between an animal's actual feed intake and the predicted feed intake. Residual feed intake is calculated after a period of controlled feeding as the difference between the mean amount of feed consumed by the animal over the test period and the feed intake predicted by regression of intake on mean metabolic live weight and weight gain.

Studies have shown an association between RFI and maintenance requirements, composition of gain and, consequently, carcass composition and meat tenderness (Archer et al., 1999; Baker et al., 2006; Herd et al., 2003). However, the results are inconclusive and further investigations evaluating the associations between RFI and meat quality traits are urgently needed because of increased consumer market requirements. Therefore, the objective of the present study was to identify possible associations between RFI and carcass traits and the physicochemical properties of meat in feedlot-finished young Nellore bulls.

2. Materials and methods

Two experiments were conducted at Centro APTA Bovinos de Corte, Instituto de Zootecnia, Sertãozinho, State of São Paulo, Brazil. The experiments were carried out in accordance with guidelines of animal welfare and humane slaughter (State Law N. 11.977).

2.1. Selection procedures

In 1976, the Programa de Melhoramento Genético das Raças Zebuínas (Zebu Breeding Program) was started at the Instituto de Zootecnia with the goal of increasing the postweaning weight of animals based on individual performance in weight gain tests. At the beginning of the program, the Nellore herd was divided into three selection lines: Control Nellore (NeC), Selection Nellore (NeS), and Traditional Nellore (NeT).

Since then, the NeC herd has been selected based on selection differentials around zero for weight (measured at 378 days of age in males and at 550 days of age in females). In contrast, the NeS and NeT herds have been selected based on maximum selection differentials for the same traits. The main difference between these herds is

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the fact that animals originating from other herds are allowed to be introduced in the NeT line, whereas the NeS and NeC lines are closed herds, i.e., only sires and dams from these herds are used.

2.2. Evaluation of residual feed intake

For the evaluation of RFI, the animals were kept in individual pens for a minimum period of 70 days, following 28 days of adaptation, during the weight gain tests in 2008 and 2009. In each year, RFI was calculated as the difference between the individual dry matter intake (DMI) observed and that predicted by the regression model. The following equations were used: predicted $DMI = -0.95165 + 2.5576 \times ADG + 0.081 \times LW^{0.75}$ ($r^2 = 0.89$) for 2008, and predicted $DMI = 0.28616 + 1.70337 \times ADG + 0.07152 \times LW^{0.75}$ ($r^2 = 0.70$) for 2009, where $LW^{0.75}$ corresponds to the mean metabolic body weight of the animal (kg) and ADG to the average daily weight gain (kg/day) observed over the test period.

After calculation of RFI, the animals were classified into low (<0.5 standard deviation below the mean; more efficient), medium (±0.5 standard deviation from the mean), and high (>0.5 standard deviation above the mean; less efficient) RFI groups. The animals were kept on pasture during the rainy season (November to January) until the beginning of the feedlot period.

2.3. Finishing period

Animals of the high and low RFI groups were sampled for finishing in the two consecutive years (2009 and 2010). Fifty-nine animals with an initial mean live weight of 369 kg and an initial mean age of 567 days were chosen from the NeC ($n = 16$), NeS ($n = 18$), and NeT ($n = 25$) herds. In the first year (finishing and slaughter performed in 2009), 34 animals belonging to the 27th progeny of the NeC and NeS herds (low RFI: $n = 19$; high RFI: $n = 15$) were confined. In the second year (finishing and slaughter performed in 2010), 25 animals belonging to the 28th progeny of the NeT herd (low RFI: $n = 13$; high RFI: $n = 12$) were confined. Animals were randomly sampled based on their RFI classification (high and low), being chosen the ones that could not be used as sires for disqualifying problems on genealogical record.

The animals were fed a diet with a roughage:concentrate ratio of 19:81, 82% total digestible nutrients and 14% crude protein, which consisted of hay, corn, cottonseed, cottonseed meal, citrus pulp, and mineral mixture (Table 1). Voluntary food intake was calculated as the difference between feed offered and refused. For this purpose, refusals were weighed daily and sampled weekly at 10% of their weight. The diet was adjusted to refusals correspond to 5–10% of the total food supplied.

The animals were weighed at the beginning of the adaptation period and at the beginning and end of the experiment after 16 h of fasting from solids and were evaluated by ultrasound. The first post-adaptation weight recording corresponds to the initial live weight and the last recording to live weight at slaughter.

The animals remained in the feedlot until they reached a minimum subcutaneous fat thickness over the *Longissimus* muscle of 4 mm measured between the 12th and 13th ribs, the criterion established for slaughter. The ultrasound measurements were obtained at the beginning and at the end of the experiment and at intervals of 15 days during the experimental period. The animals were restrained and their skin was cleaned. The images were acquired with a veterinary Pie Medical Aquila ultrasound apparatus (Esaote Europe B.V.) equipped with an 18-cm probe and 3.5-MHz transducer using vegetable oil as standoff pad. The images were recorded and the measurements were obtained using the Echo Image Viewer 1.0 program (Pie Medical Equipment B.V.).

Table 1
Ingredients and chemical composition of experimental diets.

Item	Fist year	Second year
Ingredient composition (% DM)		
Hay	18.6	14.5
Sugar cane bagasse	–	5.00
Corn	39.4	46.0
Whole cottonseed	12.3	12.0
Cottonseed meal	7.7	6.00
Citrus pulp	18.2	14.0
Urea	1.20	1.00
Calcitic limestone	0.50	0.06
Mineral mixture[a]	2.00	1.42
Rumensin	–	0.02
Chemical composition (% DM)		
Dry matter	85.3	83.8
Organic matter	92.5	94.2
Crude protein	14.1	14.0
Ether extract	5.03	4.75
NDF[b]	30.0	35.0
ADF[b]	22.9	20.1
Total carbohydrates	76.7	78.3
Non-fiber carbohydrates	49.0	47.3
Lignin	3.69	4.15

[a] Mineral mixture composition/kg: 180 g Ca, 90 g P, 10 g Mg, 13 g S, 93 g Na, 145 g Cl, 17 mg Se, 1000 mg Cu, 826 mg Fe, 4000 mg Zn, 1500 mg Mn, 150 mg I, 80 mg Co, 900 mg F.
[b] NDF = Neutral detergent fiber; ADF = Acid detergent fiber.

2.4. Slaughter

The animals were slaughtered in an experimental slaughter house after fasting from water and solids for 16 h. The animals were stunned with a captive bolt pistol, suspended upside down, and bled through the jugular vein. All blood was collected for weight recording. The head was separated after removal of the skin and feet and all components were weighed. The liver, empty gastrointestinal tract (reticulum, rumen, omasum, abomasum, and intestines) and other organs (trachea, lungs, pancreas, esophagus, mesenterium, heart, spleen, liver, kidneys, tail, and penis) were also removed and weighed. Kidney, pelvic and heart fat were also separated from the carcass and weighed. Empty body weight was determined by the sum of weights of carcass, blood, head, skin, feet, tail, organs, and empty and clean viscera.

The half-carcasses were weighed (hot carcass weight) and transferred to the chilling room where they were kept at a temperature of 0 to 2 °C for 24 h. After chilling, pH was measured in the *Longissimus* and *Semitendinous* muscles of the left half-carcass with a digital pH meter (Sentron Model 1001, Sentron Europe B. V.). Next, the half-carcasses were removed from the chilling room and weighed (cold carcass weight). Dressing percentage (%) was calculated as the ratio between carcass weight and fasted live weight on the day of slaughter.

Measures of carcass length were taken in the left half-carcass as the distance between the anterior border of the pubic bone and the medial cranial border of the first rib. Similarly, measures of carcass depth were taken in the left half-carcass counting five ribs from top to bottom and measuring the distance from the sternum to the middle of the spine where passes the marrow. Rib eye area and backfat thickness were measured at the same anatomical sites used for the collection of the ultrasound images and rump fat thickness was measured over the intersection between the *Gluteus medius* and *Biceps femoris* muscles.

The right half-carcasses were divided into the forequarter (with five ribs), hindquarter, and spare ribs. The prime meat cuts obtained from the hindquarter were striploin, tenderloin, and complete rump.

2.5. Analysis of meat quality traits

Longissimus muscle samples were removed from the 11th rib of the left half-carcass for the analysis of meat quality traits. Shear