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Feed efficiency indexes and their relationships with carcass, non-carcass and meat quality traits in Nellore steers

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ABSTRACT

Five hundred and seventy-five Nellore steers were evaluated for residual feed intake and residual feed intake and gain and their relationships between carcass, non-carcass and meat quality traits. RFI was measured by the difference between observed and predicted dry matter intake and RIG was obtained by the sum of −1*RFI and residual gain. Efficient and inefficient animals were classified adopting ±0.5 standard deviations from RFI and RIG mean. A mixed model was used including RFI or RIG and contemporary group as fixed effects, initial age as covariate and sire and experimental period as random effects, testing the significance of the regression slope for each evaluated trait. RIG was positively related to longissimus muscle area. Efficient-RFI animals had lower liver and internal fat proportions compared to inefficient-RFI animals. Efficient-RFI and efficient-RIG animals had 11.8% and 11.2% lower extracted intramuscular fat, compared to inefficient-RFI and inefficient-RIG animals, respectively. Efficient-RFI animals had tougher meat compared to inefficient-RFI animals.

1. Introduction

Brazil has the world's largest commercial cattle herd with a population of 211 million head, according to the Brazilian Institute of Geography and Statistics (IBGE, 2014). Approximately 80% of this herd is comprised by *Bos indicus*, 90% of which is composed of the Nellore breed (Brazilian Association of Meat Exporters — ABIEC, 2014). In 2013, circa 26.7 million animals were slaughtered, resulting in the production of 10.2 million tons of equivalent carcass (IBGE, 2014).

Feed efficiency is an important aspect for the reduction of feed and feeding costs and, thus, to increase profitability for the activity since feed costs may account for 55–75% of the total costs of beef production, excluding costs of animal acquisition (Arthur, Archer, Herd, & Melville, 2001).

In Brazil, feed efficiency is traditionally measured by feed conversion ratio (kg DMI (dry matter intake)/kg gain) or its inverse, gain:feed ratio. However, both are associated with growth rate (Herd & Bishop, 2000), thus genetic selection for those indexes may result in an increased adult size as well as higher nutrient demand from the selected animals.

Residual feed intake (RFI), calculated as the difference between observed and predicted DMI (Koch, Swigwr, Chambers, & Gregory, 1963), has been studied as an index of feed efficiency. Differently from the gain:feed ratio, selection based on RFI does not increase mature size of the herd because it is adjusted to growth rate, allowing the identification of animals with lower feed intake and methane production at the same body weight and gain (Jones, Philips, Naylor, & Mercer, 2011; Khiaosa-Ard & Zebeli, 2014). In addition, RFI-efficient animals seem to produce leaner carcasses with lower subcutaneous fat thickness and extracted intramuscular fat in longissimus muscle, important features to ensure meat quality (Gomes et al., 2012; Herd & Pitchford, 2011; Zorzi et al., 2013).

Residual intake and gain (RIG) recently proposed by Berry and Crowley (2012) is a new feed efficiency index that associates RFI and residual gain (RG), obtained by the difference between observed and predicted average daily gain (Koch et al., 1963). The most efficient animals based on RIG have both lower feed intake and greater BWG (body weight gain) at the same time, thus, it is more closely related to profitability than RFI.

Before including feed efficiency indexes in breeding programs, it is crucial to understand their phenotypic relationships with carcass and meat quality traits, avoiding the fact that future benefits achieved by reducing production costs are unfavorable changes in the final product.

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This study investigated the phenotypic relationships between RFI, RIG and performance traits with carcass, non-carcass and meat quality traits of Nellore steers finished in feedlot.

2. Materials and methods

2.1. Animals and diets

Animals were handled and managed according to the Institutional Animal Care and Use Committee Guidelines (Brazilian Agricultural Research Corporation — EMBRAPA, Brazil). Data from three years, where the animals had similar nutritional history (grazing systems), were used, totalling 575 steers from 34 sires, chosen to represent the main genealogies of the Nellore breed (Fig. 1).

The half-sib families were produced by artificial insemination in commercial and pure bred Nellore dams. Animals were born in three different ranches in spring of 2007, 2008 and 2009, where they stayed for about 21 mo. Feed efficiency tests were carried out for 3 yr, from November 2009 to December 2011, at two different feedlots of Brazilian Agricultural Research Corporation (Embrapa — Embrapa Southeast Livestock (São Carlos, SP, Brazil — Feedlot 1) and Embrapa Beef Cattle (Campo Grande, MS, Brazil — Feedlot 2) for at least 70 d.

The adaptation period was at least 28 d. After the adaptation period, according to the body weight and sire, the animals were allocated in individual or collective pens. The collective pens were equipped with Calan gate feeding system (American Calan Inc., Northwood, New Hampshire, USA), allowing to obtain individual intake of nine animals per pen (Table 1).

The animal were fed twice daily in excess to result in 5% of food refusals, with diet containing around 40% silage and 60% concentrate on a DM basis (Table 2).

Samples of diet and individual food refusals were collected weekly, dried in forced ventilation oven (55 °C ± 5 °C/72 h) and ground in a Willey-type mill (1 mm) to obtain composite samples at the end of the trial period. The samples were analyzed for the following fractions and methodologies: dry matter (DM) at 105 °C, ash and crude protein (CP) (AOAC, 2006), neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin (Van Soest, Robertson, & Lewis, 1991); N-NDF and N-ADF (Licitra, Hernandez, & Van Soest, 1996) and ether extract (AOCS Am 5-04, 2006).

2.2. Trial period and feed efficiency evaluation period

After the adaptation period the initial weight was determined following 16 h of feed and water fasting, designating the start of the trial. The total trial period corresponded to the difference between the first weighing and the harvesting, when animal reached 5 mm subcutaneous fat thickness (Fig. 1).

In each feedlot within a year, DMI and BWG were individually measured for at least the first 70 d of the trial, corresponding to the feed efficiency evaluation period. Animals that reached 5 mm before remained on the test until 70 d. According to the Australian protocol (Arthur et al., 2001) at least 70 d of intake and weight gain are required to determine RFI.

Table 1
Mean and standard error mean (SEM) and range of initial body weight and age of Nellore steers tested for residual feed intake (RFI) and residual feed intake and gain (RIG) in function of feedlot location and the pen type.

Feedlot location[a]	Year	Pen type	N	Initial age (d)	SEM	Initial BW (kg)	SEM
São Carlos	1	Collective[b]	85	712	2.00	390.8	3.93
		Individual	41	702	2.90	386.8	6.65
	2	Collective[b]	88	604	2.45	330.7	4.14
		Individual	66	606	3.06	326.2	4.33
	3	Individual	79	610	3.22	298.3	3.32
Campo Grande	1	Individual	66	665	2.48	367.5	3.45
	2	Individual	82	671	2.93	386.3	4.18
	3	Individual	71	630	4.13	401.9	5.80

[a] Embrapa Southeast Livestock (São Carlos, SP, Brazil — Feedlot 1) and Embrapa Beef Cattle (Campo Grande, MS, Brazil — Feedlot 2).
[b] Collective pens equipped with Calan gate feeding system (American Calan Inc., Northwood, New Hampshire, USA), allowing to obtain individual intake of nine animals per pen.

Body weight (BW) was obtained every two weeks before feeding to minimize differences in animal gut fill but with no food and water restriction. Initial body weight (IBW, kg) and final body weight (FBW, kg) of the feed efficiency evaluation period, as well as the weighing at pre-slaughter were also measured following 16 h of feed and water fasting. The mid-test metabolic body weight (MMBW) was calculated as the mean between IBW and FBW.

Average daily gain (ADG, kg/d) during the feed efficiency evaluation period and the total experimental period were estimated by regression between BW and days on feed using proc. REG (Sas Institute, 2012), where the slope represents growth rate.

Individual DMI (kg/d) was obtained by the difference between offer and refusal of DM. The DM content of the diet and food refusals were determined weekly. At the end of the trial period, DM was corrected to definitive DM (105 °C) using individual composite samples of refusals and diet.

2.3. Feed efficiency traits and calculations

Residual feed intake (RFI, kg/d) and residual gain (RG, kg/d) were computed by regression of DMI, $BW^{0.75}$ and ADG (Koch et al., 1963) using MIXED procedure (Sas Institute, 2012), resulting in these equations:

$$DMI = -2.711 + 0.106\ MMBW + 1.240\ ADG + \varepsilon 1 \quad (1)$$

$$ADG = 0.523 - 0.004\ MMBW + 0.131\ DMI + \varepsilon 2 \quad (2)$$

where ε1 represents residual feed intake (RFI) and ε2 residual gain (RG).

For both indexes the model included the random effect of the contemporary group, defined by year, feedlot site, place of birth, RFI

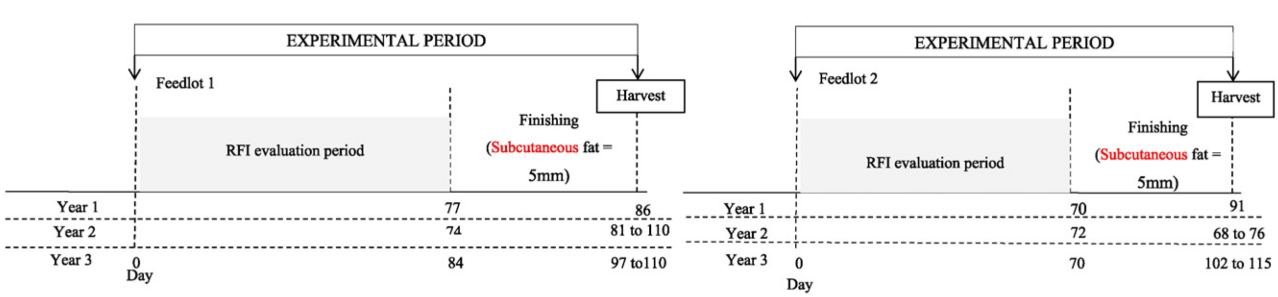

Fig. 1. Experimental design in both feedlots for 3 different years of evaluation.