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Effect of post-weaning growth rate on carcass traits and meat quality of Nellore cattle

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ABSTRACT

This study evaluated the effects of growth rate during post-weaning growing phase on carcass traits and beef quality. Thirty-four Nellore young bulls were randomly assigned to one of three treatments: **LOW**, **MEDIUM** or **HIGH** growth rate during post-weaning growing phase followed by high growth rate in the finishing phase. The growth rate affected ($P < 0.05$) all carcass traits evaluated at the end of post-weaning growing phase, except ultimate pH. Carcass dressing was greatest ($P < 0.05$) for the HIGH growth rate group in both phases. Beef from the HIGH group exhibited the greatest ($P < 0.05$) sarcomere length and a^* and b^* colour values at the end of post-weaning growing phase. However, post-weaning growth rate did not affected ($P > 0.05$) collagen content and solubility, myofibrillar fragmentation index and Warner-Bratzler shear force. Our data suggest that a low post-weaning growth rate produces lighter and leaner carcasses, but it does not affect meat quality traits in Nellore young bulls.

1. Introduction

A post-weaning growing phase is generally imposed for beef cattle prior to a finishing phase to allow body development before fatness ensues. Previous studies demonstrated that heavier carcasses without excess fat in yearling-fed production systems were obtained at the end of finishing phase compared to a calf-fed production system (Kuss et al., 2009; Lancaster, Krehbiel, & Horn, 2014; Sainz, Torre, & Oltjen, 1995).

The post-weaning growing phase in Brazil occurs in grazing systems. Therefore, the amount and availability of forage and additional feed supplement affect cattle performance during this phase, which results in a heterogeneity of the animals available for finishing in the feedlot. Animal performance and body composition at the post-weaning growing phase alters the quantity and quality of the meat that is produced at the finishing phase (Pordomingo, Grigioni, Carduza, & Volpi Lagreca, 2012).

Cattle performance during the post-weaning growing phase negatively correlates with finishing performance because the animal may experience a compensatory gain during the finishing phase (Hornick, Van Eenaeme, Clinquart, Diez, & Istasse, 1998). However, lower performance during the post-weaning growing phase produces a lighter and leaner carcass at the end of this phase. Therefore, characterizing the ability of the animal to compensate for these carcass traits is important.

Animal growth rate may modify protein turnover in vivo, and postmortem proteolysis may affect meat tenderness (Kristensen et al., 2002). Animals in compensatory growth during the finishing phase may also exhibit more postmortem myofibril proteolysis (Therkildsen, Stolzenbach, & Byrne, 2011; Therkildsen, 2005) and higher intramuscular collagen turnover (Purslow, Archile-Contreras, & Cha, 2012). Previous results on the effect of growth rate on carcass and meat quality are not consistent (Costa et al., 2015; Therkildsen et al., 2011; Sazili et al., 2003). Therefore, more experiments are required to confirm these effects.

We hypothesized that cattle exhibiting different growth rates throughout the post-weaning growing phase would affect carcass composition and meat quality at the beginning and end of the finishing phase. Therefore, the current study evaluated the effect of different post-weaning growth rates on carcass traits and meat quality at 24 h postmortem from Nellore young bulls in a feedlot.

2. Materials and methods

2.1. Animals and nutritional plans

The Animal Care and Use Committee of the Universidade Federal de Viçosa, Brazil, approved all animal handling procedures (protocol 090/

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2013) in accordance with ARRIVE guidelines (Kilkenny, Browne, Cuthill, Emerson, & Altman, 2010) and EU Directive 2010/63/EU (European Union, 2010).

A total of 34 Nellore young bulls, 8.4 ± 0.3 months of age and 230 ± 5.6 kg body weight, were used. Weaned animals were confined in collective pens using an electronic head gate system (Kloppen Soluções Tecnológicas, Pirassununga, SP, Brazil). Young bulls were dewormed at enrollment via a subcutaneous injection of ivermectin (Ivomec 1%, Merial, Paulínia, SP, Brazil).

Animals underwent 24 days of an initial adaptation period and were randomly assigned to one of three different nutritional plans to achieve LOW, MEDIUM or HIGH growth rates during the post-weaning growing phase followed by the same nutritional plan during the finishing phase. The LOW, MEDIUM and HIGH groups included 10, 12 and 12 animals, respectively. Half of the animals from each treatment were slaughtered at the end of the 90 days post-weaning growing phase. The remaining animals entered a transition phase (21 days for MEDIUM and HIGH groups and 31 days for the LOW group) followed by a 112 days finishing phase. All remaining animals were slaughtered at the end of the finishing phase.

The desired growth rates during the post-weaning growing phase were 0.0, 0.6 and 1.2 kg average daily gain (ADG) for the LOW, MEDIUM and HIGH groups, respectively. These three ADG during the post-weaning phase simulates a calf-fed production system (HIGH) which allow harvesting at 16–18 months old, a yearling-fed system (MEDIUM) which allow harvesting at 24 months old and an extensive beef system (LOW) with negligible gain and higher age at harvest. The desired ADG during the finishing phase was 1.5 kg/day.

Four diets were formulated to obtain the target ADG: the three diets for the growing phase and a common diet for the finishing phase (Table 1). All young bulls ate a diet with a forage-to-concentrate ratio of 50:50 and 155 g of crude protein per kg of dry matter (DM) throughout the 24 days initial adaptation period. Diets from the post-weaning growing phase were replaced by the finishing diet during the transition phase. The replacement diets for the MEDIUM and HIGH groups were 15% of DM each three days and 10% of DM each three days for the LOW group. The replacement diets for previously restricted cattle, such as LOW bulls, must be slower to enable the recovery of short-chain fatty acid absorption across the reticuloruminal epithelium, which is decreased by severe feed restriction (Albornoz, Aschenbach, Barreda, & Penner, 2013).

Nutrient requirements were estimates based on BR-CORTE (Valadares Filho, Marcondes, Chizzotti, & Paulino, 2010). Fresh feed was provided twice daily, 60% at 7:00 h and 40% at 14:00 h. Animals from the MEDIUM and HIGH groups were fed ad libitum, and the LOW animals were restrictively fed at 1.2% of their body weight in dry matter.

Table 1
Experimental diet ingredients and chemical composition.

Items	Post-weaning growing phase			Finishing phase
	LOW[a]	MEDIUM[a]	HIGH[a]	
Ingredients (% DM)				
Sugarcane bagasse	–	–	–	16.13
Sugarcane silage[b]	80.68	60.23	36.94	–
Corn	8.42	22.58	44.63	57.73
Soybean meal	5.54	12.90	14.24	10.42
Whole cottonseed	–	–	–	11.68
Urea	2.06	1.10	1.07	1.00
Dicalcium phosphate	0.30	0.12	–	–
Commercial premix[c]	3.00	3.05	3.12	3.04
Chemical composition (g/kg of DM)[d]				
DM	387.49	512.15	654.82	864.30
OM	928.40	933.69	942.59	952.08
CP	130.14	146.97	164.83	167.82
EE	21.25	27.91	36.70	38.88
NDFap	507.19	407.64	291.21	266.84
NFC	314.45	378.63	476.91	504.09
DE (MJ/kg)	12.09	13.09	14.27	13.68

[a] Low, Medium or High average daily gain during post-weaning growing phase followed by high average daily gain during finishing phase.
[b] Sugarcane silage with 0.5% of calcium oxide.
[c] Contained per kg: 150 g of Ca, 17 g of P, 23 g of S, 45 g of K, 14 g of Mg, 57 g of Na, 360 mg of Cu, 21.6 mg of Co, 415 mg of Fe, 21 mg of I, 715 mg of Mn, 6 mg of Se, 397 g of CP (NPN) and 714 mg of Sodium Monensin.
[d] DM = dry matter, OM = organic matter, CP = crude protein, EE = ether extract, NDFap = neutral detergent fiber corrected for ash and protein, NFC = non-fiber carbohydrate, DE = digestible energy.

2.2. Slaughter procedure, carcass evaluation and meat sampling

Bulls were weighted after 16 h of fasting and slaughtered in an experimental packing plant. All procedures during the slaughters were performed in accordance with humane slaughter practices following the Sanitary and Industrial Inspection Regulation for Animal Origin Products (Brasil, 1997). Harvest at the end of the post-weaning growing phase was performed on three consecutive days with six bulls each day (2 bulls from each treatment). Harvest at the end of finishing phase was performed on two consecutive days for the HIGH and MEDIUM groups with six bulls each day (3 bulls from each treatment). The LOW bulls were slaughtered 10 days later to ensure that these animals had the same feeding period receiving the high grain diet throughout the finishing phase.

The carcasses were split, weighted and suspended by the aitch bone (tenderstretch method) and chilled at 4 °C. At 24 h postmortem, pH and temperature of the *Longissimus* muscle were recorded at the 13th rib from the left carcass using an electrode (model: Inlab® Solids Pro, Mettler-Toledo AG, Schwerzenbach, Switzerland) connected to a portable Mettler-Toledo pH meter.

The carcass weight at the beginning of the finishing phase was estimated by multiplying the fasting body weight of each remaining bull by the average carcass dressing percentage of their respective treatment. Therefore, carcass gain was calculated as the difference between the final and initial carcass weight divided by days between weightings (transition phase plus finishing).

The carcass length of the left cold carcass was measured (Boer, Dumont, Pomeroy, & Weniger, 1974) and it was ribbed between the 12th and 13th ribs to evaluate the rib eye area (REA) and back fat thickness (BFT). The 9th–11th rib section was removed according to Hankins and Howe (1946) for physical separation of bone, fat and lean tissues to estimate carcass physical composition (Marcondes, Tedeschi, Valadares Filho, & Chizzotti, 2012). *Longissimus* muscles were sampled between the 10th–12th ribs from the left side of each carcass. *Longissimus* samples were vacuum-packaged, frozen and stored at −20 °C until analysis.

2.3. Meat quality measurements

Three 2.54 cm thick steaks were obtained from each *Longissimus* muscle sample, one for the instrumental colour measurement, the second for estimations of thawing and cooking losses followed by Warner-Bratzler shear force determinations, and the third for analysis of collagen, myofibrillar fragmentation index and sarcomere length. All analyses were performed at the Meat Science Laboratory (*Laboratório de Ciência da Carne - LCC*) of the Department of Animal Science at Universidade Federal de Viçosa.

2.3.1. Instrumental colour measurements

Steaks were thawed overnight at 4 °C, removed from vacuum-packages and exposed to oxygen 30 min prior to measurements. Instrumental colour readings were obtained using a Hunter MiniScan EZ (4500L; Hunter Associates Laboratory, Inc., Reston, Virginia, USA), which was calibrated immediately prior to data collection. The mean L* (lightness), a* (redness), and b* (yellowness) values of each steak were determined