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Does a reduction in dietary crude protein content affect performance, nutrient requirements, nitrogen losses, and methane emissions in finishing Nellore bulls?

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ABSTRACT

An experiment was conducted to evaluate whether a reduction in dietary crude protein (CP) content affects animal performance, energy and protein requirements, N losses, and enteric methane emission in finishing Nellore bulls. Twenty-six animals, with an average age of 20 ± 1.0 months and initial body weight (BW) of 296 ± 8.1 kg were used in this experiment. Four animals were used as baseline reference animals and were slaughtered at the beginning of the experiment. Four animals were fed at maintenance level (MAIN), whereas 18 bulls were divided into 3 groups ($n = 6$ in each group) and were randomly assigned to the treatments consisting of three levels of CP in the diets: 10, 12, and 14% of CP. At the end of the experiment, all animals were slaughtered to evaluate their chemical body composition, energy and protein requirements, and carcass characteristics. A linear effect was observed for dietary CP level on CP intake and digestibility, while greater values were obtained for animals that were fed 14% CP. Nitrogen metabolism was affected by CP levels, where animals that were fed 12 and 14% CP had greater urinary N losses than those that were fed 10% CP. There was no effect of CP level on retained N, animal performance, and carcass characteristics among diets, and there was no effect of CP level on microbial efficiency and CH_4 emissions. Thus, this study showed that for finishing bulls, the level of dietary CP did not interfere with muscle deposition and greenhouse gas emissions. The reduction of CP content in diets does not affect DM intake, animal performance, and carcass characteristics, thereby suggesting that the use of 10% of CP in diets for finishing bulls reduces their environmental impact due to a lower urinary N excretion than 12 and 14% CP-based diets. Animals that were fed 10, 12, and 14% CP diets had emissions equivalent to 3893; 3755; and 4255 g d^{-1} of CO_2, respectively, and no difference was observed among diets. Furthermore, methane emission is not affected by CP levels ranging between 10 to 14% which, on average, is 16.3 g kg^{-1} of DM intake. Our study found that a decreased CP level did not influence animal performance, but it did decrease N losses in manure without affecting methane emissions. However, it is important to highlight that more studies are necessary to confirm these results.

1. Introduction

The environmental impact of feeding animals in a feedlot is a growing concern (Cole et al., 2006; Staerfl et al., 2012; Patra and Lalhriatpuii, 2016). The majority of nutrients that are absorbed from feedstuffs on feedlots are excreted as feces and urine, and cattle commonly retain only 10–20% of their nutrient intake (McBride et al., 2003). In addition, between thirty to fifty percent of N from feedstuffs may be lost via volatilization, mainly in the form of ammonia (Bierman et al., 1999; Todd et al., 2005), and this amount of ammonia can be affected by dietary crude protein (CP) level (Burgos et al., 2010). Furthermore, protein is considered to be the most expensive nutrient in a ruminant's ration. Thus, unbalanced diets contribute to negative environmental impacts and represent significant economic losses.

According to the NRC (1996), CP requirements decrease during the finishing phase; however, commercial feedlots use high CP levels to encourage greater intake and in order to slaughter animals

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earlier. In addition, methane (CH_4) emissions by livestock may be affected by diet, genetic, or individual differences among animals in a herd, which corresponds to 15–20% of human activities (Martin et al., 2008). Recent studies have demonstrated greater protein levels are related to increased dry matter (DM) intake (Berends et al., 2014) and increased feed intake leads to an increase in CH_4 production (Shibata and Terada, 2010; Chaokaur et al., 2015), which could also impact the reduction of CH_4 emissions by society and affect market pressure.

Therefore, we hypothesized that reducing CP levels in diets will reduce N losses and CH_4 emissions without affecting animal performance. Thus, an experiment was conducted to evaluate whether the reduction in dietary CP contents affects animal performance, nutrient requirements, N losses, and CH_4 emissions in finishing Nellore bulls.

2. Materials and methods

2.1. Animals, experimental design, and treatments

The experiment was conducted at the Experimental Feedlot of the Animal Science Department at the Universidade Federal de Viçosa (UFV), Viçosa, Minas Gerais, Brazil. Animal care and handling followed guidelines set by the UFV (process 96/2014). Twenty-six Nellore bulls, at 20 ± 1.0 months of age and with an average initial body weight (BW) of 296 ± 8.1 kg, were divided into the following groups: four animals were randomly selected as the baseline group to be slaughtered at the beginning of the experiment in order to evaluate initial body composition, four animals were fed at maintenance level (12 g kg^{-1} BW) while receiving a 12% CP-based diet, and eighteen bulls were fed *ad libitum* and were randomly selected to receive one of three diets with different levels of CP, either 10, 12, or 14% CP ($n = 6$ in each treatment).

The animals were housed in 30-m^2 individual pens with a concrete floor, which were equipped with feeders and concrete drinkers. The animals were submitted to a 21-d acclimation period to the experimental conditions, at which time animals with endo and ectoparasites were identified and treated. During this period, the animals were acclimated to Greenfeed equipment while aiming to evaluate CH_4 emissions in Nellore bulls. At the end of this period, the animals were weighed after a 16-hour solid fasting period, and the treatments were randomly assigned to the animals. The experiment lasted for 112 days with four 28-d experimental periods. During the 1st period, we conducted CH_4 emission evaluations, during the 2nd period we conducted nutrient digestibility trials, and during the 3rd and 4th periods we monitored animal performance. The bulls were weighed at the beginning and end of the experiment to evaluate their average daily gain (ADG).

Diets were formulated according to the Brazilian Tables of Nutrient Requirements of Zebu beef cattle—BR CORTE system (Valadares Filho et al., 2010) to achieve an ADG of 1.0 kg. These diets consisted of corn silage and a concentrate that was formulated with ground corn, wheat bran, soybean meal, urea, ammonium sulfate, sodium bicarbonate, common salt, and mineral mix (Table 1) while using a roughage:concentrate ratio of 50:50. Fresh feed was weighed daily and provided after removing the orts from the previous day. The feed was offered twice a day for the animals; at 0700 h, the roughage was supplied in full with half of the amount of concentrate, and at 1500 h, the remaining concentrate was provided according to procedures described by Pazdiora et al. (2011).

The feeding was adjusted on a daily basis to maintain orts at approximately 5–10% of the total feed and was supplied *ad libitum* to cattle. The difference between the amount of offered feed and the amount of orts was recorded as the amount of daily feed intake. Drinking water was continuously available to the animals. The amount of feedstuffs was recorded daily; additionally, the ingredients in the concentrate were sampled each time the concentrate was manufactured.

Table 1
Proportions of ingredients in each concentrate and composition of each concentrate and corn silage.

Item	Concentrate			Corn silage
	10% CP[a]	12% CP	14% CP	
Proportion of ingredients (% DM)				
Ground corn	79.0	79.0	80.0	–
Soybean meal	3.6	8.6	13.7	–
Wheat meal	12.0	6.0	0.0	–
Urea	0.59	1.4	2.2	–
Ammonium sulfate	0.07	0.16	0.25	–
Common salt	0.90	0.90	0.91	–
Mineral mix[b]	0.90	0.90	0.91	–
Sodium bicarbonate	1.5	1.5	1.5	–
Magnesium oxide	0.50	0.50	0.50	–
Chemical composition (% DM)				
Dry matter (%)	86.4	86.5	87.5	31.1
Organic matter	89.3	89.4	90.4	94.4
Ether extract	2.92	2.86	2.83	2.5
Crude protein	12.7	16.3	20.0	7.3
Neutral detergent fiber	13.9	11.5	9.3	50.2
Indigestible neutral detergent fiber	3.0	2.4	1.9	12.6
Non-fiber carbohydrates	59.8	58.7	58.3	34.4

[a] CP, crude protein.
[b] 266 g kg^{-1} calcium (calcium carbonate source); 147 g kg^{-1} phosphorus (dicalcium phosphate source); 7 g kg^{-1} magnesium; 3 g kg^{-1} potassium; 2 g kg^{-1} sodium (sodium chloride source); 7 g kg^{-1} sulfur (cobalt sulfate and zinc sulfate source); 1191 mg kg^{-1} copper (copper chelate source); 5070 mg kg^{-1} iron (iron sulfate source); 1728 mg kg^{-1} manganese (manganese chelate source); 4198 mg kg^{-1} zinc (zinc sulfate source); 136 mg kg^{-1} cobalt (cobalt sulfate source); 118 mg kg^{-1} chromium.

Samples of corn silage and orts were collected every day, and then stored in a freezer at −20 °C. Weekly, a composite sample of corn silage and orts from each animal were submitted to be dried in a forced ventilation oven at 55 °C and were ground in a Wiley mill using 1-mm mesh sieves. Then, composite samples of corn silage and orts were obtained per experimental period.

2.2. Apparent nutrient digestibility

To evaluate nutrient digestibility, spot samples of feces were obtained from each animal at the following hours: 0600 h, 1200 h, and 1800 h on the 53rd, 54th, and 55th days respectively. Fecal samples were dried in a forced ventilation oven at 55 °C and were ground using a knife mill with a 2-mm mesh sieve. Subsequently, a composite sample per animal was performed. Indigestible neutral detergent fiber (iNDF) was used as an internal marker to estimate the total amount of feces produced on a DM basis.

2.3. Methane and urine collections

During the first experimental period, each group of animals ($n = 6$) was confined for a 7-d period to a pen provided with Greenfeed equipment (C-Lock Inc, South Dakota, USA) that was used to measure enteric CH_4 production in grams per day. Methane production was estimated through continuous analysis point samples of excreted air via respiration and eructation of animals during feedings throughout the day. The Greenfeed equipment contained small feed portions of pelleted concentrate; this was