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Impacts of reduction of phosphorus in finishing diets for Holstein×Zebu steers

D. Zanetti[a,b,*], S.C. Valadares Filho[a], L.F. Prados[a], E. Detmann[a], M.V.C. Pacheco[a], L.A. Godoi[a], L.N. Rennó[a], T.E. Engle[b]

[a] Department of Animal Science, Universidade Federal de Viçosa, PH Rolfs St, 36570-900 Minas Gerais, Brazil
[b] Department of Animal Science, Colorado State University, 350 W Pitkin St, 80523 CO, United States

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ABSTRACT

In Brazil, commonly males of dairy herd are destined to beef production. However, little is known about the mineral requirements for dairy males. Therefore, the objective of this experiment was to evaluate the calcium (Ca) requirements of Holstein×Zebu steers by determining Ca body tissue concentrations, true absorption and retention coefficients, as well as the requirements for maintenance and weight gain of steers fed diets containing or not containing dicalcium phosphate. Twenty-eight Holstein×Zebu steers with an average initial body weight of 377.5 ± 49.4 kg were utilized. The experiment was conducted as a completely randomized design with a 2×2 factorial arrangement of treatments. Factors included 1) two concentrate levels (30% or 60%); and 2) two levels of dicalcium phosphate (DP), 0 or the amount necessary to attend the estimated dietary requirements. Absorption and retention coefficients, maintenance and gain requirements were estimated. The feedstuffs, refusals, feces, urine, blood and bone were sampled for Ca and phosphorus (P) analysis. Phosphorus intake was improved by the addition of concentrate and presence of DP. There were no variations in the daily fecal and urinary phosphorus excretion as a function of DP. The serum level of inorganic phosphorus was lower in non-supplemented animals, although it was within adequate concentrations for all treatments. Dry matter and organic matter intake, organic matter digestibility, performance, and efficiency were not affected by treatment. Absorption and retention coefficients, and the net requirements for maintenance are similar across treatments. Therefore, the lack of inorganic supplementary Ca and P in diets of feedlot finishing cattle does not change the concentrations of these minerals in bone. The dietary requirements of calcium and phosphorus obtained for cattle were lower than those described by the nutritional requirement systems from Brazil, USA, and UK.

1. Introduction

The demand for sustainable beef cattle production (i.e. the use of resources for feed production) have increased the number of crossbred cattle experiments with the goal of obtaining the minimum amount of inputs that are needed for animal production. Calcium and phosphorus are common minerals supplemented to beef cattle for growth, production, and reproduction. However, studies have shown that for beef cattle in feedlot systems (Erickson et al., 1999; Costa e Silva et al., 2015b; Prados et al., 2015) Ca and P supplementation is not necessary. The desire to obtain the correct nutritional requirements of minerals, mainly P, is based on the possibility of financial savings and reducing the environmental impact of excess P being excreted by the animal (Khorasani et al., 1997; Wu et al., 2000; Bogestrand et al., 2005; Schoumans et al., 2014; Murphy et al., 2015).

In regards to the search for more efficient systems that are financially and environmentally beneficial the nutritional aspect is the most important factor. Thus, the constant updating of nutrient databases that estimate the nutritional requirements of beef cattle is really important for the maintenance of the beef production systems. When comparing the systems of diet formulation (AFRC, 1991; Valadares Filho et al., 2010; NRC, 2016), Costa e Silva et al. (2015a) verified that the levels of recommended phosphorus for Nellore cattle are greater than the animal requirement, leading to an increase in production costs, excretion of phosphorus into the environment, and depletion of natural resources. In Brazil, the dairy herd is comprised of Holstein×Zebu (*Bos indicus*) due to their heat tolerance and disease resistance (Santana et al., 2014; Rotta et al., 2015). Commonly males of dairy herd are destined for beef production, in a system called “dairy cow, beef calf” (Menezes et al., 2015). However, little information is available describing the mineral requirements for these crossbred animals. Thus, our hypothesis is that not supplementing calcium and

* Corresponding author at: Department of Animal Science, Colorado State University, 350 W Pitkin St, 80523 CO, United States.
E-mail addresses: diego.zanetti@ufv.br, diego.zanetti@colostate.edu (D. Zanetti).

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phosphorus to Holstein×Zebu feedlot cattle does not affect the concentration of these minerals in several body tissues, and that predicted nutritional requirements of Ca and P are overestimated. Our objective was to evaluate the concentration of calcium and phosphorus in body tissues, true absorption and retention coefficients of Ca and P, and the requirements for maintenance and weight gain of Holstein×Zebu steers that are fed diet either supplemented or not supplemented dicalcium phosphate.

2. Materials and methods

This experiment was conducted in Universidade Federal de Viçosa, Viçosa, MG, Brazil in the Experimental Feedlot of Animal Sciences Department, following approval by the Ethics Committee for Animal Use (CEUA/DZO/UFV process number 77/2013).

2.1. Animals, treatments and experimental design

Twenty-eight Holstein×Zebu steers with an average initial body weight of 377.5 ± 49.4 kg were utilized. After a 21-d period of acclimation, the animals were randomly divided into two groups: maintenance (n=4) and performance (n=24).

The animals from the maintenance group were fed daily at 1.1% of body weight on a dry matter basis, while the animals from the performance group had *ad libitum* access to feed throughout the day. All steers were housed during 84-d in individual pens equipped with concrete feeders and waterer. Water was available *ad libitum*. The experiment was conducted as a completely randomized design with a 2×2 factorial arrangement of treatments with factors being 1) concentrate level (30% or 60% concentrate on a DM basis), and 2) with or without supplemental dicalcium phosphate. Once different nutrient intake levels are necessary to support linear and nonlinear regressions, and the regressions are the main tool for determination of nutritional requirements, maintenance group and two concentrate levels for performance group were adopted in our experiment.

Diets were formulated according to the BR-Corte (Valadares Filho et al., 2010) for a gain of 1.0 kg per day and were isonitrogenous (12% CP). Fresh sugarcane was utilized as roughage source and a mixture of urea/ammonium sulfate in the proportion of 9:1 was used to adjust the N content of all diets. The concentrate proportion of the diet consisted of ground corn, soybean hulls, soybean meal, salt, and mineral mix. The proportions of the ingredients of the concentrates and diets as well as their chemical composition are shown in Table 1.

Table 1
Ingredient and chemical composition (% DM) of diets containing either 30% or 60% concentrates and supplemented with and without dicalcium phosphate (DP).

Item	With DP		Without DP	
	30% Conc.	60% Conc.	30% Conc.	60% Conc.
Proportion				
Sugarcane	68.60	39.80	68.50	39.80
Soybean hulls	13.67	27.67	13.67	27.67
Grounded corn	13.30	27.10	13.30	27.10
Soybean meal	1.10	2.60	1.10	2.60
Urea	2.25	1.35	2.25	1.35
Ammonium sulfate	0.15	0.15	0.15	0.15
Salt	0.20	0.40	0.20	0.40
Sodium bicarbonate	0.30	0.50	0.30	0.50
Magnesium oxide	0.10	0.30	0.10	0.30
Mineral mix	0.03	0.03	0.03	0.03
Dicalcium phosphate	0.30	0.10	–	–
Sand	–	–	0.30	0.10
Chemical composition				
Dry matter (% as fed)	46.37	63.91	46.37	63.91
Organic matter	95.59	95.41	95.59	95.41
Crude protein	11.82	11.76	11.82	11.76
Neutral detergent fiber	46.48	42.08	46.48	42.08
Indigestible NDF	18.68	11.74	18.68	11.74
Non-fiber carbohydrates	39.63	42.18	39.63	42.18
Calcium	0.46	0.40	0.38	0.37
Phosphorus	0.15	0.16	0.10	0.14

2.2. Intake, excretion, and serum levels of the minerals

Animals were fed twice a day at 0800 and 1600 h. Feed delivery was adjusted daily to maintain approximately 5% refusals. The appropriate amount for each animal was based in refusal collection and weight every morning, before feed delivery. According to amount of refusals, TMR offered was reduced or increased to reach *ad libitum* intake with 5% refusals (as fed basis). Refusals and feedstuffs were sampled daily. All feed and refusal samples were proportionally grouped each week, dried in a forced-air drying oven at 55 °C for 72 h, ground through a 1 mm sieve using a knife mill and were packed in plastic containers for further laboratory analyses.

For the determination of mineral excretion, fecal and urine collection was conducted during weeks 4 and 9 of the experiment. Twenty-four hour fecal and urine output was determined for all steers over three days. Feces were collected immediately after spontaneous defecation, with the aid of a shovel, and stored in a bucket over a 24 h period. Daily, feces were weighed, thoroughly mixed, and sampled daily. Feces were packed in trays and were dried in a forced-air drying oven (55 °C) and were ground through a 1 mm sieve using a knife mill. For each animal, a composite sample was grouped for each collection period based on the dry weight of each day of collection for further laboratory analyses. The difference between intake and excretion via feces and urine was considered the apparent retained.

Two hundred mL of 50% sulfuric acid was added to the urine collection containers. Urine collection was performed through of an adapted funnel, made by a flexible material. In the start moment of collection, the funnel was fixed in the animal with elastic ropes. The funnel had a tube to drive the urine to an individual container. Urine collected each day (over a 24 h period) was measured in a graduated cylinder, mixed and sampled. Two hundred mL samples of urine be mixed, sealed in plastic bottles, thoroughly, and stored frozen (−20 °C). The urine was grouped as a composite sample based on the daily urinary volume and was immediately frozen for further analyses.

Urine samples were analyzed for uric acid and allantoin. The analyses of uric acid were performed in an automatic biochemical analyzer (brand Mindray, model BS200E, Shenzhen, China), while the analysis of allantoin were performed as described by Chen and Gomes (1995).

The total excretion of purine derivatives (PD) was calculated by the sum of the amounts of allantoin and uric acid excreted in the urine, expressed in mmol/d and obtained from the product of their concentration in the urine and the estimated urinary volume. The absorbed purines (AP, mmol/d) were calculated from the PD excretion (PD, mmol/d) by using the following equation:

$$AP = \frac{PD - 0.3 \times BW^{0.75}}{0.80}$$

where 0.80 is the recovery of absorbed purines as PD and 0.30 $BW^{0.75}$ is the endogenous purine excretion (Barbosa et al., 2011).

The ruminal synthesis of nitrogen compounds (SNC, gN/d) was calculated as a function of AP (mmol/d) by using the following equation (Barbosa et al., 2011):

$$SNC = \frac{70 \times AP}{0.93 \times 0.137 \times 1000}$$

where 70 is the N content from purines (mgN/mmol), 0.137 is the purine N: total N ratio in bacteria, and 0.93 is the true digestibility of microbial purines.

Microbial protein synthesis (MPS) was obtained by multiplying the ruminal synthesis of nitrogen by 6.25.