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Different sources of calcium for starter pig diets

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ABSTRACT

The study was conducted to determine the true Ca absorption coefficients and growth performance of piglets fed diets containing different sources of Ca. In the metabolism study, 30 piglets uncastrated, with initial weight averages of 20.52 ± 1.84 kg, were assigned to 5 treatments with 6 piglets per treatment in a randomized complete block design. A basal diet was formulated to meet the piglets nutritional requirements, except to Ca (0.09%), and was supplemented with different source of Ca (limestone, monodicalcium phosphate, calcined bone meal, and oyster meal) to provide 0.64% total Ca. A low-Ca diet (0.018%) and 6 additional piglets were used to estimate the endogenous Ca excretion in the feces. Total feces and urine were collected to determine the apparent and true absorption of Ca. After the adaptation period (7 d), the excreted feces were collected twice daily, weighed, stored in plastic bags in freezer (−18 °C) until the end of the collection period (5 d). The volume of the urine collected for 24 h was measured and a 20% aliquot was stored in glass containers in refrigerator (3 °C) until the end of the collection period (5 d). Experimental diets, feces and urine were analyzed for Ca. To determine the effect of different Ca sources on the growth performance, 160 piglets were assigned, to 2 sexes (males intact and females) and 4 sources of Ca (the same ones used in the metabolism study), in a 2 × 4 factorial arrangement and randomized complete block design with 4 pens per treatment and 5 intact males or 5 females per pen. At the end of the study (22 d), blood samples were collected of the all piglets and 5 piglets per treatment were selected randomly regardless of sex to collect samples of organs. All samples were stored at −18 °C. Response criteria were: weight gain, feed intake, feed efficiency, Ca deposition in organs, bone strength, weight and size of the third metatarsal bone, and serum in Ca. The sources of Ca and direct or indirect collection method did not affect the absorption coefficients. There was no interaction among the sources of Ca and sex of the piglets for the performance variables. The piglets growth performance was similar among treatments. Calcined bone meal and oyster meal resulted in a greater content of mineral matter in the kidney ($P = 0.013$). The bone meal resulted in a greater Ca concentration in the piglets hearts ($P < 0.001$). The sources are equally effective as a source of Ca for young piglets.

1. Introduction

The animal and plant tissues are made up of varying proportions and amounts of minerals, which are essential nutrients to maintain the physiological metabolism of organisms (Silva and Pascoal, 2014). Ca is a macromineral required for bone matrix formation and maintenance, stabilization of excitable membranes such as muscles and nerves, and participation in the blood coagulation process and the activity of enzymes.

Some studies have been conducted to determine the digestibility of Ca, update the P values in the sources used in the formulation of diets for piglets, and to evaluate the nutritional value of new sources (Rocha Junior et al., 2015; Salguero et al., 2014), which make the composition tables more complete and with more accurate values. However, studies report the associated use of some sources, such as limestone and phosphates.

The ingredients that make up the feed for piglets in large amount are from vegetable origin, such as corn and soybean, in which the Ca content is very low and the higher P percentage is in organic form; however, it is complexed with phytic acid which generally form salts with calcium, other minerals, and nutrients making them unavailable to pigs (Bünzen et al., 2008; Furlan and Pozza, 2014), thus, the need of supplementation.

The additional sources of Ca from animal and mineral origin are

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considered good bioavailability compared to Ca carbonate as the standard (Furlan and Pozza, 2014). In the formulations of feed for monogastric animals, sources from mineral origin are routinely used for supplementation of Ca through carbonates and phosphates from limestone rocks because they are more abundant and less expensive. However, according to Melo Moura (2009), the inorganic sources of Ca, non-renewable mineral resources, and their extraction promote environmental impact, making organic sources, such as oyster meal and bone meal, interesting alternatives since they have greater solubility in relation to sources from rocks. In this context, the study was conducted to determine the true **Ca** absorption coefficients and growth performance of piglets fed diets containing different sources of Ca.

2. Material and methods

Two experiments were conducted at the Swine Sector of the Experimental Farm in the Universidade Estadual do Oeste do Paraná – UNIOESTE (Marechal Cândido Rondon, Paraná, Brazil), the first to determine the Ca absorption coefficients, and the second to assess the animals' performances in the early stages, according to the regulations approved by the Ethics Committee on Animal Use from UNIOESTE (Protocol 80/14).

2.1. Metabolism study

2.1.1. Animals, experimental design, and accommodation

The study included 30 piglets intact males hybrid (BP 375; Biribas', Cascavel, Paraná, Brazil), with initial weight averages of 20.5 ± 1.8 kg, assigned to 5 treatments, with 6 piglets per treatment in a randomized complete block design, with the initial weight and the period used as a blocking factor. A piglets was the experimental unit. The piglets were housed individually in metabolism cages (Pekas, 1968), where they remained for 12 d, 7 d of adaptation to the cages, feed, and regulation of consumption and 5 d for feces and urine collection. The minimum (22 ± 3 °C) and maximum (25 ± 3 °C) temperatures of the internal atmosphere of the metabolism room were obtained through the maximum and minimum analog thermometer installed in the center of the room corresponding to the height of the **piglets**.

2.1.2. Experimental feed, treatments composition, and feeding management

A basal diet was formulated to meet the nutritional requirements of piglets (Rostagno et al., 2011) except for Ca (0.09%), and the evaluated source replaced the basal diet to provide 0.64% total Ca. The percentage of the substitution of basal diet for food was: LC = limestone (1.166%), MP = monodicalcium phosphate (2.166%), BMC = calcined bone meal (1.301%), and OM = oyster meal (1.208%). To determine endogenous Ca in the feces, a diet with a low-Ca level (0.018%) was supplied simultaneously to a group of piglets (n = 6; Table 1).

Two methods of feces collection were simultaneously evaluated: total collection and fecal indicator. One percent acid insoluble ash (AIA; Celite Corp., Lompoc, CA - US) was added in feed to be used as an indicator. The restricted amount of feed provided in the collection period was determined based on voluntary consumption in the adaptation phase (7 d), adjusted for the metabolic weight of the piglets ($LW^{0.75}$; Sakomura and Rostagno, 2007), and provided in two meals a day (08:00 and 16:00 h), with water ad libitum.

2.1.3. Variables analyzed and chemical-bromatological analysis

The variables analyzed were the dry matter intake, total Ca intake, Ca consumption of the test source, Ca content in the feed, feces, and urine, and serum Ca excretion and indigestible factor. Data were applied to the formulas to determine the apparent absorption coefficients (AAC) and true absorption coefficients (TAC) of Ca from the sources evaluated (Sakomura and Rostagno, 2007).

The collections of feces and urine followed the procedures described by Sakomura and Rostagno (2007). The structure of the metabolism cage allows the total collection of feces produced daily through the collecting drawer fitted to the back of the cage and, likewise, the funnel at the bottom of the cage allows the collection of urine in a collection bucket.

Excreted feces were collected twice daily, in the morning and afternoon, weighed, stored in plastic bags in a freezer (−18 °C) until the end of the collection period (5 d), when were thawed at room temperature, homogenized and 2 samples were taken, weighed and dried in a forced ventilation stove at 55 °C for a period of 72 h. Subsequently, the samples were ground and stored in plastic pots for analysis. The volume of the urine collected for 24 h was measured and a 20% aliquot was stored in glass containers in a refrigerator (3 °C) until the end of the collection period (5 d), when they were homogenized and a 20% aliquot was removed and kept in the refrigerator until analysis. In the buckets for collection of urine was added 20 mL of a 1:1 hydrochloric acid (HCl) solution to prevent bacterial proliferation.

At the end of the collection period, the piglets were subjected to fasting for 8 h and blood was collected via the cranial vena cava with a syringe, transferred into collection tubes, and centrifuged (Centrifuge I - Model 206; FANEM, São Paulo - Brazil) at 1,240 × *g* for 15 min at 4 °C to obtain the serum which was transferred to polyethylene eppendorf microtubes and frozen for total Ca analysis. The Ca concentration was measured using the automated chemistry analyzer using a commercial

Table 1
Composition of the basal and low-Ca diets.

	Experimental diets	
	Basal diet	Low calcium diet
Item (%)		
Corn	58.72	–
Pre-cooked corn[a]	–	77.46
Soybean meal (45% **CP**[b])	32.42	1.25
Starch	5.25	3.74
Acid insoluble ash[c]	1.000	1.000
Cooking sugar (sucrose)	0.695	11.250
Lysine sulfate (50.7% lys)[d]	0.557	2.012
Soybean oil	0.500	–
Salt	0.458	0.464
DL-Met	0.133	0.437
L-Thr	0.115	0.587
Trace mineral[e]	0.100	0.100
Trace vitamin[f]	0.050	0.050
L- Trp	–	0.184
L-Val	–	0.625
L-Ile	–	0.625
L-Arg	–	0.219
Antibiotic[g]	–	0.005
Total	100	100
Calculated composition		
Total Ca (%)	0.090	0.018
Available P (%)	0.106	0.026
Metabolizable energy (Mcal/kg)	3.239	3.294
Digestible lys (%)	1.206	1.207
CP (%)	19.483	9.562
Analized composition		
Total Ca (% DM[h])	0.095	0.019
Total P (% DM)	0.328	0.154
CP (% DM)	19,225	9652

[a] These are the corn meal previously treated with steam, with low calcium content (0.02%) (Rostagno et al., 2011).
[b] CP = Crude protein.
[c] Acid insoluble ash (AIA; Celite Corp., Lompoc, CA - US).
[d] Evonik Degussa, Guarulhos, SP, Brazil.
[e] Supplied per kilogram of diet: 55.0 mg iron; 11.0 mg copper; 77.0 mg manganese; 71.5 mg zinc; 1.10 mg iodine.
[f] Supplied per kilogram of diet: 6000,000 IU vitamin A; 1500,000 IU vitamin D3; 15,000 IU vitamin E; 1.35 g vitamin B1; 4 g vitamin B_2; 2 g vitamin B_6; 9.35 g pantothenic acid; 1.5 g vitamin K_3; 20.0 g nicotinic acid; 20.0 g vitamin B_{12}; 0.6 g folic acid; biotin 0.08 g.
[g] Tialin 80 Evance (Tiamulin 80%), Rio Verde, GO, Brazil.
[h] DM = Dry matter.