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Effects of dibutyryl cAMP on growth performance and carcass traits in finishing pigs

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ABSTRACT

This study was designed to investigate the effects of dietary supplementation with N^6, 2′-O-dibutyryl adenosine 3′,5′-cyclic monophosphate (dbcAMP) on growth performance, carcass traits, histochemical characteristics and serum constituents in finishing pigs. Seventy-two Duroc × (Landrace × Large White) barrows (57.3 ± 0.6 kg) were randomly allotted to 3 treatments with 6 replicate pens/treatment (4 pigs/pen). The pigs were fed diets containing 0, 10 and 20 mg dbcAMP/kg, respectively, until the final slaughter weight of approximately 90 kg. There were no differences in growth performance among dietary treatments. Leaf fat proportion and first rib backfat thickness were reduced ($P<0.05$), whereas tenth rib backfat thickness tended to decrease ($P=0.10$), in pigs fed 10 mg dbcAMP/kg. Lean percentage was greater ($P<0.05$) and longissimus muscle area tended to increase ($P=0.10$) in pigs fed 10 mg dbcAMP/kg when compared to the control group, but hot carcass weight was not affected by dbcAMP. Growth rate of fat-free lean tissues tended to increase ($P=0.09$) in dbcAMP-supplemented pigs. Dietary dbcAMP decreased ($P<0.05$) adipocytes diameter in subcutaneous fat, whereas longissimus muscle fiber diameter tended to increase ($P=0.06$) with dbcAMP supplementation; however, no difference in longissimus muscle cell density was detected among treatments. Serum concentrations of total protein and 3′,5′-cyclic adenosine monophosphate increased ($P<0.05$) in response to dbcAMP, but concentrations of triglycerides, total cholesterol, glucose and urea in serum did not differ among dietary treatments. These results indicate that dbcAMP had a positive effect on carcass traits. Addition of 10 mg dbcAMP/kg to the diet was beneficial for growth performance and lean percentage, as well as improving protein and fat metabolism.

1. Introduction

Consumers demand nutritious and healthy meat products (Roper, 2000); therefore, it is important to find new methods for improving meat quantity and quality (Hollis and Curtis, 2001). Cyclic adenosine monophosphate (cAMP) and its synthetic analogue, dibutyryl cAMP (dbcAMP), play a crucial role in various biological activities, including regulating enzyme activities (Cohen, 1983), lipolysis (Jobgen et al., 2006), gene expression (Roesler et al., 1988), and cell growth (Gagelin et al., 1999; Sato et al., 1990). Additionally, dibutyryl cAMP has important therapeutic applications (Chio et al., 2004; Lomo et al., 1995; Schwede et al., 2000; Won et al., 2004). Interestingly, recent studies by Gao et al. (2004) have shown that dbcAMP can increase the amount of lean tissue and reduce the content of fat in pigs; thereby indicating that dbcAMP may be affective in promoting growth. At present, little is known about how dbcAMP redirects nutrients towards protein gain over fat accretion in various tissues. Therefore, the objective of this experiment was to investigate the effects of dietary supplementation with dbcAMP on growth performance, carcass traits, histochemical characteristics and serum constituents in finishing pigs.

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2. Materials and methods

2.1. Animals, managements, and diets

Crossbred barrows (n = 72), from the mating of Landrace × Large White females to Duroc boars (initial body weight of 57.3 ± 0.6 kg), were randomly allotted to one of three corn and soybean meal-based diet (Table 1) formulated with 0, 10, or 20 mg/kg of dbcAMP (Hangzhou Meiya Biotechnology Co., Ltd., Hangzhou, China), and dbcAMP was added to the basal diet at the expense of corn starch. There were six pens/treatment and four pigs/3.2 × 2.8-m pen. All the diets met the nutrient requirements of finishing pigs (NRC, 1998). During the experiment, pigs were housed in a slotted-concrete floor facility under standard conditions and were allowed *ad libitum* access to feed and water. Pigs were slaughtered at approximately 90 kg. Pigs were weighed individually at the beginning and at the end of the trial. Feed consumption was recorded daily on a pen basis during the experiment to calculate average daily gain (ADG), average daily feed intake (ADFI), and gain to feed ratio (G:F).

2.2. Serum constituents

Blood samples (5 ml/pig) were collected from anterior vena cava of two pigs per pen before slaughter and subsequently centrifuged at 1600 × *g* for 15 min at 4 °C, and the resulting serum was stored at −20 °C until analysis. Serum concentrations of total protein, urea nitrogen, triglyceride, total cholesterol and glucose were determined using a Beckman Spectrophotometer (Model CX5; Beckman-Coulter Inc., Fullerton, CA, USA) and assay kits from Beckman-Coulter Inc. (Fullerton, CA, USA). Serum concentration of urea nitrogen was analyzed by an enzymatic method involving urease and glutamate dehydrogenase, as previously described (Wu, 1995). Serum cholesterol and triglyceride concentrations were also determined by enzymatic-colorimetric methods. Total protein of serum was analyzed by biuret method. And serum glucose was measured using glucose dehydrogenase (Wu, 1995). The content of cAMP in serum was measured using an enzyme-linked immunosorbent assay kit (QRCT-301330123222EIA; ADL Inc., Garland, Texas, USA) and a microplate reader (Model 550, Bio-Rad, Hercules, CA, USA). The assays were performed according to manufacturer's instructions. All samples were analyzed in triplicate.

Table 1
Ingredient and composition of the basal diet for finishing pigs[a].

Item	%
Corn (CP, 7.8%)	66.44
Soybean (CP, 44.2%)	23.00
Wheat bran (CP, 14.3%)	8.00
Salt	0.30
Dicalcium phosphate	0.70
Limestone	1.20
Vitamin premix[b]	0.04
Mineral premix[c]	0.10
Chloride choline (50%)	0.10
Antimildew agent (calcium propionate)	0.10
Ethoxyquin	0.02
Chemical composition	
Dry matter	86.62
Crude ash	4.82
Crude fiber	3.10
Ether extract	5.83
Digestible energy (MJ/kg)	13.30
Crude protein	16.09
Calcium	0.73
Available phosphorus	0.26
Lysine	0.79
Methionine + cysteine	0.50

[a] As-fed basis.
[b] Supplied 700 IU vitamin D_3; 5000 IU vitamin A (*trans*-retinyl acetate); 25 IU vitamin E (DL-α-tocophery acetate); 2.5 mg vitamin K_3; 1.5 mg vitamin B_1; 5 mg riboflavin; 7.5 mg pantothenic acid; 20 mg niacin; and 0.02 mg cobalamin per kilogram of diet.
[c] Supplied 8 mg Cu ($CuSO_4 \cdot 5H_2O$); 60 mg Fe($FeSO_4 \cdot 7H_2O$); 0.30 mg Se($NaSeO_3$); 60 mg Zn($ZnSO_4 \cdot H_2O$); 35 mg Mn (MnO) per kilogram of diet.

2.3. Carcass data collection

One pig per pen with a final body weight close to the group average (±10%) was selected, rinsed with cool water, electrically stunned, and humanely slaughtered as described by Ma et al. (2010). Left and right carcass sides were placed in a 4 °C cooler within 30 min, and individual hot carcass weight was recorded to calculate dressing percentage. Backfat thickness at the first, tenth, and last rib, as well as the last lumbar vertebra, was measured on left side using the vernier caliper (RH OMBI 5-32294, Guangzhou, China). Longissimus muscle (LM) area was determined at the tenth-eleventh rib interface with the vitriol paper (Guangzhou Tool Factory, Guangzhou, Guangdong, China) and was measured using compensating planimeter (Model Q811; Xinanjiang Science Instrument Factory, Zhejiang, China). Growth rate of fat-free lean tissues was calculated using the hot carcass weight, backfat thickness and longissimus muscle area values according to the equation recommended by NPPC (2000). Then, right sides were dissected into skin, bone, muscle and fat to determine actual lean and fat percentages. Leaf fat was removed from the abdomen to calculate leaf fat percentage.

2.4. Measurement of muscle fiber diameter and density

Longissimus muscle samples were obtained between the ninth and the tenth rib from left carcass sides immediately following slaughter, and the samples (three/carcass) were cut parallel to the muscle fibers into 1 cm^3 pieces, and immersed into 10% formalin to fix about 24 h. Then, fixed LM samples were trimmed, rinsed, dehydrated (with n-butanol-alcohol), mounted (with paraffin wax), and sliced on a precise rotary microtome (Model STAT820, Reichert Histo, Bensheim, Germany) as described by Lefaucheur et al. (2002). Samples were stained with hematoxylin and eosin according to the procedures described by Cerri and Sasso-Cerri (2003). Five viewing sections/stained section (up, down, left, right and center) were photographed under a light microscope (Model BH-2; Olympus, Tokyo, Japan) and analyzed using the image analysis software (Model 3.1; Motic, Xiamen, Fujian, China). After the area of photograph was fixed, the number of fibers within each section was counted, and the fiber number and photograph area were used to calculate fiber density (Swatland, 1984). At each sample location, the long and short axes of each fiber were measured, and the mean diameter of each fiber was