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Original research article

Dose-response effects of in-feed antibiotics on growth performance and nutrient utilization in weaned pigs fed diets supplemented with yeast-based nucleotides

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ABSTRACT

Dietary nucleotides are bioactive compounds with the potential to mitigate weaning-associated challenges in piglets. An experiment was conducted to determine the interaction effect of antimicrobial growth promoters (AGP) and a nucleotide-rich yeast extract (NRYE) on growth performance and apparent total tract digestibility (ATTD) of dry matter (DM), crude protein (CP) and gross energy (GE), and to establish whether NRYE supplementation may completely or partially replace AGP in diets for weaned pigs. In phase 1 and 2, corn, wheat, canola meal and soybean meal based diets, which were formulated to contain 0.0 or 0.1% NRYE with 0, 25, 50, 75 or 100% of the recommended AGP dosage, were fed to 108 twenty-one day old piglets (initial body weight 7.11 ± 0.9 kg; mean ± SD) from d 1 to 14 and 15 to 28, respectively. Overall, increasing AGP level in NRYE supplemented diets linearly decreased average daily gain (ADG) ($P = 0.002$) and gain-to-feed ratio (G:F) ($P = 0.007$); and quadratically decreased ATTD of DM ($P = 0.001$), CP ($P = 0.003$) and G:F ($P = 0.017$) during phase 2. Compared with control and pigs fed NRYE with 100% of recommended AGP dosage, pigs fed 0.1% NRYE without AGP had greater ($P < 0.05$) ADG and G:F in phase 2 and overall. In conclusion, supplementing 0.1% NRYE improved growth performance of pigs but this beneficial effect was reduced by increasing dietary AGP dosage.

1. Introduction

Sub-therapeutic levels of antimicrobial growth promoters (AGP) have been supplemented in pig starter diets to mitigate proliferation of enteropathogenic bacteria associated with post-weaning diarrhea (Heo et al., 2013). However, public pressure to eliminate the use of in-feed AGP from livestock feed has intensified because of their potential association with the development of microbial antibiotic resistance in humans and livestock (Heuer et al., 2006), and environmental contamination (Carlson et al., 2004). Furthermore, pork products sourced from pigs raised under AGP-free regimen are on high demand in several major international markets. Therefore, there is an urgent need for viable alternatives to dietary antibiotics (Choct, 2001; Heo et al., 2013; Gong et al., 2014).

Dietary nucleotides have been suggested as a potential alternative therapy to in-feed AGP in mitigating post-weaning stress in piglets. Sauer et al. (2011) reviewed the role of dietary nucleotides in piglets and showed that they may have beneficial effects on intestinal morphology and function, intestinal microbiota, immune function, nutrient metabolism, and hepatic morphology and function. Zomborszky-Kovacs et al. (2000) and Weaver and Kim (2014) reported that dietary nucleotides supplementation improved the growth performance of weaned piglets. However, studies that simultaneously compare the effectiveness of dietary nucleotides and AGP are lacking thereby making it difficult to substantiate the role of nucleotides as alternatives to AGP.

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Nucleotides can be supplemented in pure forms or as part of a nucleotide-rich yeast extract (NRYE), the latter being more affordable than the former.

The aim of this study was to determine the effect of supplementing 0.1% NRYE to diets containing graded levels of AGP on piglet growth performance and apparent total tract digestibility (ATTD) of dry matter (DM), crude protein (CP) and gross energy (GE), and to establish whether NRYE supplementation may completely or partially replace AGP in piglet starter diets.

2. Materials and methods

All experimental procedures were reviewed and approved by the University of Manitoba Animal Care Committee, and pigs were handled in accordance with the guidelines described by the Canadian Council on Animal Care (2009).

2.1. Animals and housing

One-hundred and eight (Duroc × [Yorkshire × Landrace]) male and female piglets, weaned at 21 d and with an initial average body weight of 7.11 ± 0.9 kg were used in a 4-wk study. The pigs were housed in an environmentally controlled nursery building with pens equipped with a feeder, a nipple drinker, and plastic-covered expanded metal floors. The room temperature was maintained at 29 ± 1°C in wk 1, and then gradually decreased by 1°C every week thereafter.

2.2. Experimental design

On d 1, pigs were randomly assigned to the dietary treatments based on the initial body weight with 3 pigs per pen and 6 replications per treatment. Piglets were fed a standard phase 1 and 2 diet (Table 1) without or with 0.1% NRYE from d 1 to 14, and d 15 to 28, respectively. Diets with 0.1% NRYE were supplemented with 0, 25, 50, 75 and 100% of the recommended AGP dosage in each phase. The NRYE supplement, Maxi-Gen Plus, was supplied by Canadian Bio-systems Inc. (Calgary, AB, Canada) and contained cell wall polysaccharides (21.6%), CP (32.7%), carbohydrates (14.3%) and a mixture of 5 nucleotides (1.1%; adenosine monophosphate, cytosine monophosphate, inosine monophosphate, uridine monophosphate and guanosine monophosphate), with 1 g of the NRYE additive supplying approximately 0.1% of mixed nucleotides. The AGP supplements, Aueromycin and Tiamulin, were supplied by Bio Agri Mix LP (Mitchell, ON, Canada) and were included following the Canadian Food Inspection Agency recommended dosage of 55 mg of Aueromycin (chlortetracycline) and 31.2 mg of Tiamulin per kg of diet. All diets were fed as mash and contained 0.3% titanium dioxide as an indigestible marker. Feed disappearance and body weight were recorded weekly. Representative freshly voided fecal samples were collected over the last 3 d of wk 2 and 4, and stored at −20 °C until required for analysis.

2.3. Sample preparation and chemical analyses

Fecal samples were dried in an oven at 60 °C for 4 d and pooled for each pen and week of collection and along with diet samples, they were finely ground to pass through a 1 mm screen using a Cyclotec 1093 Sample Mill (FOSS North America, Eden Prairie, MN, USA), and Thomas-Wiley mill (Thomas Scientific Swedesboro, NJ, USA), respectively, and thoroughly mixed before being analyzed for DM, GE, CP, and titanium dioxide.

Dry matter was determined according to AOAC (1990) method 925.09 and GE was determined using an adiabatic oxygen bomb calorimeter (Parr Instrument Co., Moline, IL, USA) which had been calibrated using benzoic acid as a standard. Crude protein (N × 6.25) was determined according to method 990.03 of AOAC (1990) using a combustion analyzer (model CNS-2000; Leco Corp., St. Joseph, MI, USA). Samples for TiO_2 were ashed and digested as described by (Lomer et al., 2000) and were measured by inductively coupled plasma mass spectrometer (Varian Inc., Palo Alto, CA, USA).

Table 1
Ingredient and chemical composition of the basal diets (as-fed basis).

Item	Phase 1[1]	Phase 2[2]
Ingredient, %		
Corn	25.90	38.35
Wheat	13.75	21.90
Canola meal	10.00	10.00
Soybean meal	20.00	23.85
Fish meal	5.00	0.00
Dried whey	20.00	0.00
Vegetable oil	2.50	2.35
Limestone	0.60	0.80
Monocalcium phosphate	0.60	1.00
Iodized salt	0.25	0.25
Vitamin-trace mineral premix[3]	1.00	1.00
L-Lys · HCl	0.10	0.20
Titanium dioxide	0.30	0.30
Calculated nutrient content		
DE, kcal/kg	3,472	3,450
CP, %	22.7	20.9
Ca, %	0.80	0.70
Total P, %	0.70	0.69
Available P, %	0.50	0.33
SID[4] AA, %		
Lys	1.40	1.24
Met	0.40	0.34
Thr	0.90	0.78
Analyzed composition, %		
CP	22.1	20.8
Ca	0.90	0.79
Total P	0.75	0.70

[1] Phase 1 diet was fed to pigs from d 1 to 14.
[2] Phase 2 diet was fed to pigs from d 15 to 28.
[3] Premix provided per kilogram of complete diet: 9,000 IU of vitamin A; 1,500 IU of vitamin D_3; 18 mg of vitamin E; 1.5 mg of vitamin K; 250 mg of choline; 30 mg of niacin; 27.5 mg of calcium pantothenate; 9.4 mg of riboflavin; 2 mg of pyridoxine; 25 μg of cyanocobalamin; 80 μg of biotin; 0.5 mg of folic acid; 18 mg of Cu from copper sulfate, 110 mg of Zn from zinc oxide, 0.2 mg of I from calcium iodide, 110 mg of Fe from ferrous sulfate, 50 mg of Mn from manganese dioxide, and 0.3 mg of Se from sodium selenite.
[4] SID = standardized ileal digestible.

2.4. Calculations and statistical analysis

The digestibility of nutrients were calculated using the following equation: apparent nutrient digestibility (%) $= \{1-[(T_d/T_f)\times(N_f/N_d)]\}\times 100$, where T_d and T_f are the titanium dioxide concentration in the diet and feces, respectively, and N_f and N_d are the nutrient concentration in the feces and diet, respectively. Data were analyzed using the mixed procedure of SAS (SAS Inst., Inc., Cary, NC). Initial body weight was used as a covariate for analyses of ADG data. Pre-planned contrasts were used to compare pigs receiving 0.1% NRYE with control and those offered 100% recommended AGP dosage. Linear and quadratic effects were determined using orthogonal polynomial contrasts and differences were considered significant at $P < 0.05$.

3. Results and discussion

The 0.1% inclusion level of NRYE was selected based on the study of Martinez-Puig et al. (2007) and preliminary studies in our laboratory (Waititu et al., 2013) showing that supplementing NRYE