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Effects of energy levels of diet and β-mannanase supplementation on growth performance, apparent total tract digestibility and blood metabolites in growing pigs

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ABSTRACT

The present study investigated the effects of energy levels of diet and β-mannanase supplementation on growth performance, apparent total tract digestibility (ATTD) of nutrients, blood metabolites and fecal volatile fatty acids (VFAs) and ammonia-N emission in growing pigs. A total of 192 grower pigs [average initial body weight (BW), 36.2 kg] were randomly allotted to 4 treatments on the basis of BW. There were 4 replicates in each treatment with 12 pigs per replicate. Pigs were fed diets containing 13.7 or 14.0 MJ/kg metabolizable energy (ME) and 0 or 400 units (U) of β-mannanase/kg in a 2 × 2 factorial arrangement. The experimental diets were fed in a meal form for 42 d. The final BW, average daily gain (ADG) and gain:feed (G:F) of pigs fed diets supplemented with β-mannanase were greater ($P < 0.05$) than in pigs fed diets without (0 U/kg) β-mannanase. In addition, final BW, ADG and G:F of pigs fed 14.0 MJ/kg ME diets were greater ($P < 0.05$) than in pigs fed 13.7 MJ/kg ME diets. The ATTD of dry matter (DM), gross energy (GE), mannose and galactose of pigs fed diets supplemented with β-mannanase was greater ($P < 0.05$) than in pigs fed diets without β-mannanase. The blood glucose concentration was increased ($P < 0.05$) in pigs fed diets containing β-mannanase or 14.0 MJ/kg ME diets. The energy level of diet and β-mannanase supplementation had no effect ($P > 0.05$) on fecal volatile fatty acids and ammonia-N concentrations. Moreover, final BW, ADG, G:F, ATTD of DM, GE, mannose and galactose and blood glucose concentration were not different ($P > 0.05$) among pigs fed 13.7 MJ/kg ME diet with β-mannanase and 14.0 MJ/kg ME diet without β-mannanase. These results indicate that dietary supplementation of 400 U of β-mannanase/kg had potential to improve the growth performance, ATTD of nutrients and may provide the equivalent of 0.36 MJ/kg of ME to growing pig diets.

Abbreviations: ADFI, average daily feed intake; ADG, average daily gain; ATTD, apparent total tract digestibility; BUN, blood urea nitrogen; BW, body weight; CP, crude protein; DM, dry matter; G:F, gain:feed; GE, gross energy; GLU, glucose; ME, metabolizable energy; NSP, non starch polysaccharides; TCHO, total cholesterol; TG, triacylglycerides; TP, total protein; VFA, volatile fatty acid; VH:CD, villus height:crypt depth ratio.

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1. Introduction

The main non starch polysaccharides (NSP) of pig diets are β-mannans, mainly glucomannan and galactomannan, which account for 150–370 g/kg of total NSP contents of the diet (CVB, 1998). The β-mannans are polysaccharides whose backbone comprises 90% or more β-1,4-mannopyranosyl residues with 10% or less of the mannose residues substituted by single units of α-1,6-linked galactose (Buckeridge et al., 2000). Pigs digestive tract lacks the enzymes targeting β-1,4-mannosyl and α-1,6-galactosyl bonds (Veum and Odle, 2001) which limits the nutrient and energy digestibility and growth performance of pigs. However, dietary supplementation with β-mannanase can directly target β-1,4-mannans in feed ingredients and improve the nutrient digestibility and growth performance of growing pigs (Pettey et al., 2002; Yoon et al., 2010).

It has been reported that there is a direct, negative correlation among dietary fibers (NSP) and metabolizable energy value of feeds (Grieshop et al., 2001). The ability of the pigs to utilize the energy of a feedstuff decreases with an increase in NSP level of a feedstuff. A 1% increase in the crude fiber content of the diet depress gross energy digestibility by 1.3% and utilization of metabolizable energy (ME) by 0.9% (Fernandez and Jørgenson, 1986). High level of NSP in the diet may reduce the absorption of glucose and decrease the production of glucose dependent insulinotrophic polypeptide and insulin (Rainbird et al., 1984; Nunes and Malmlof, 1992). Therefore, it is necessary to improve the NSP degradation for the improvement of energy and nutrient utilization by pigs. Previous studies have been reported that dietary supplementation with β-mannanase to low energy diets can improve the performance of growing pigs (Pettey et al., 2002; Lv et al., 2013). However, the beneficial effects of exogenous enzymes vary according to enzyme products, cereal types and energy content of the diets (Pettey et al., 2002; O'Connell et al., 2005; Garry et al., 2007). Therefore, objectives of the present experiment were to investigate the effects of energy levels of the diet and β-mannanase supplementation on growth performance, apparent total tract digestibility of (ATTD) of energy and nutrients, blood metabolites and emission of fecal volatile fatty acids (VFA) and ammonia-N in growing pigs.

2. Materials and methods

The protocol for the present experiment was approved by the Institutional Animal Care and Use Committee of Kangwon National University, Chuncheon, Republic of Korea. The commercial exogenous enzyme, β-mannanase (patent 100477456-0000, CTC Bio, Inc.) was produced by using *Bacillus subtilis* (WL-7) grown on Luria broth and contained 800,000 U of β-mannanase/kg. One unit of β-mannanase is the amount of enzyme, which liberates 1 μmol of total reducing sugar (glucose equivalence) per minute at pH 4.0 and 30 °C.

2.1. Animals, diets and management

A total of 192 grower pigs (average initial body weight (BW), 36.2 kg) were randomly allotted to 4 treatments on the basis of BW. There were 4 replicates in each treatment with 12 pigs per replicate. Pigs were fed diets containing 13.7 or 14.0 MJ/kg ME and 0 or 400 units (U) of β-mannanase/kg in 2 × 2 factorial design. The experimental diets were fed in a meal form for 42 d. All the diets met or exceeded current nutrient requirements for grower pigs (NRC, 1998). The analyzed chemical composition and NSP levels of diets fed during experiment is presented in Table 1.

The experiment was conducted at the facility of Kangwon National University farm, and growing barrows (Landrace × Yorkshire × Duroc) were housed in partially slatted and concrete floor pens with a pen size of 2.8 × 5.0 m (1.17 m^2/pig). All pens were equipped with a self-feeder and a nipple drinker to allow ad libitum access to feed and water.

2.2. Sample preparation and measurements

Pigs were weighed individually, and feed consumption was measured at the end of experiment and the average daily gain (ADG), average daily feed intake (ADFI) and gain to feed ratio (G:F) were calculated. To evaluate the effects of dietary treatments on the ATTD of energy, nutrients and NSP, 2.5 g/kg chromic oxide was included to each diet as an inert, indigestible indicator. The pigs were fed diet containing chromium during last 7 d of experiment, and fecal samples were collected from the floor of each pen during the last 4 d. The fecal samples were pooled within pen and dried in a forced air drying oven at 60 °C for 72 h, and ground in Wiley mill (Thomas Model 4 Wiley Mill, Thomas Scientific, Swedesboro, NJ) using a 1-mm screen and used for chemical analysis. On the last day of each experiment, a 10-mL blood sample was collected by jugular vein puncture from 2 randomly selected pigs in each pen using a disposable vacutainer tube containing sodium heparin as an anticoagulant (Becton Dickinson, Franklin, NJ). After centrifugation (3000 × *g* for 15 min at 4 °C), plasma samples were stored at −20 °C and later analyzed for concentrations of total cholesterol (TCHO), triacylglycerides (TG), glucose (GLU), total protein (TP), and blood urea nitrogen (BUN). To measure the concentrations of VFA and ammonia-N, fecal samples were collected directly from anus of 1 randomly selected pig in each pen to minimize the air contact. These samples were immediately sealed in vinyl bags and placed on ice.