Animal Feed Science and Technology 221 (2016) 54–61

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

Effects of a *Bacillus*-based probiotic and dietary energy content on the performance and nutrient digestibility of wean to finish pigs

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ARTICLE INFO

Article history:
Received 4 January 2016
Received in revised form 29 July 2016
Accepted 5 August 2016

Keywords:
Bacillus subtilis
Bacillus amyloliquefaciens
Digestibility
Performance
Wean-to-finish pigs

ABSTRACT

The study was conducted to determine the effects of a *Bacillus*-based probiotic (mixture of spray-dried spore-forming *Bacillus licheniformis* (DSM 5749) and *Bacillus subtilis* (DSM 5750)) supplementation and different diet energy densities on growth performance and nutrient digestibility in wean-to-finish pigs. A total of 576 weaned piglets with initial body weight (BW) of 7.1 ± 1.1 kg were used. Pigs were randomly allotted to 1 of 4 treatments in a 2×2 factorial arrangement of treatments with 2 levels of energy (standard and reduced (~3% less in calculated NE)) and 0 or 400 mg/kg of the *Bacillus*-based probiotic according to their sex and BW (6 male and 6 female replicates per treatment, with 12 pigs each). During the prestarter period (28–42d), there were no treatment effects on growth performance. For the starter period (42–70d) pigs on the probiotic treatments grew significantly faster and tended to have a better feed:gain (F:G) than their control counterparts. During the same period pigs offered the standard energy diet exhibited significantly better F:G than those offered the lower energy diet. During the grower period (70–120d), the probiotic significantly improved growth rate by 11.2% and F:G by 8.6% with the proportional change in F:G being much higher for pigs offered the lower energy diet. During the finisher period (120–182d), the probiotic had a negative effect on F:G ($P = 0.047$). Over the whole period (28–182d), probiotic supplementation significantly improved growth and F:G. In addition, pigs receiving the standard energy diet exhibited improved F:G compared to pigs receiving the lower energy diet. Probiotic supplementation increased fat and phosphorus (P) apparent total tract digestibility (ATTD). Pigs fed the lower energy diets exhibited significantly higher ATTD of DM, CF and P, but lower ATTD of fat than pigs fed the standard energy diets. Probiotic increased CP ATTD under lower but not under the standard level of energy and was effective in improving Ca ATTD in the standard but reduced it on the lower energy diet. In conclusion, dietary supplementation of the *Bacillus*-based probiotic improved growth and F:G from weaning to slaughter, and exerted beneficial effects on ATTD of fat and P in the growing period. Major effects were observed in the starter and grower periods suggesting that strategy might be best targeted to pigs between 42–120d. Even though probiotic improved pig performance, the response varied with energy density of diets in the case of F:G in the grower period and ATTD of CP and Ca.

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http://dx.doi.org/10.1016/j.anifeedsci.2016.08.008

1. Introduction

Probiotics are live microorganisms which have been found to confer health benefits on the host when administered in adequate amounts (FAO/WHO, 2002; Reid et al., 2003; Weichselbaum, 2009). A number of microorganism strains are being used as probiotics with different efficacies; some of them may provide certain benefits for the host whereas others do not (Weichselbaum, 2009). Many strains of bacteria have been used as probiotics, the most commonly used species being lactic acid bacteria such as *Lactobacillus*, *Streptococcus* and *Bifidobacteria* (Dunne et al., 2001). Species other than lactic acid bacteria which are currently being used in probiotic preparations for livestock include *Bacillus* species (*B. cereus*, *coagulans*, *licheniformis*, *subtilis*) and yeasts (Ohashi and Ushida, 2009). Although various *Bacillus* spp. are used as probiotics for humans and animals (Hong et al., 2005), their mechanism of action is not yet fully understood. Supplementation of *Bacillus* species has resulted in improved growth rate and feed efficiency in piglets (Kyriakis et al., 1999) and in growing-finishing pigs (Meng et al., 2010), improved only feed efficiency in weaned piglets (Wang et al., 2011) and in growing-finishing pigs (Davis et al., 2008), improved growth and feed intake during the prestarter period (Gracia et al., 2004) and in growing pigs (Wang et al., 2009; Kim et al., 2014.), and increased only growth in growing (Chen et al., 2005) and finishing pigs (Chen et al., 2006). Munoz et al. (2007) suggested that addition of *Bacillus*-based probiotics to the diet of finishing pigs improved feed intake but had no effect on growth or feed efficiency. Stavric and Kornegay (1995) suggested that probiotics might be more effective in animals during microflora development or when microflora stability is impaired, however, other studies did not find improvement in piglet performance with the supplementation of the diets of nursery pigs with *Bacillus*-based probiotics (Barker et al., 2003; Kritas and Morrison, 2004; Min et al., 2004; Kunavue and Lien, 2012). As observed, the effect of *Bacillus*-based probiotics on performance in practice is highly inconsistent, probably because of different diet compositions, differences in strains, dose levels, age of the animals, and interactions with environmental factors (Loh et al., 2008; Khan et al., 2011). Therefore, the effects of *Bacillus*-based probiotics should be evaluated for a longer period of time. Yan et al. (2009) indicated that energy is highly associated with feed intake, which may indicate that the intake of probiotics may be affected by the energy density of the diet. Meng et al. (2010) also suggested that nutrient density could influence the effect of probiotics in growing pigs. However, to the best of our knowledge, most of the studies conducted to evaluate the effects of probiotics have used the same dietary nutrient concentration for all treatments.

The objective of this study was to investigate the effects of a *Bacillus*-based probiotic complex on the growth performance and apparent total tract digestibility (ATTD) of wean-to finish pigs fed diets varying in energy density.

2. Materials and methods

The probiotic preparation used in the current experiment is manufactured by Chr. Hansen A/S (Hørsholm, Denmark) under the name of BioPlus YC®. The product comprises a mixture of spray-dried spore-forming *Bacillus licheniformis* (DSM 5749) and *Bacillus subtilis* (DSM 5750) at a minimum concentration of 3.2×10^9 viable spores/g of product.

2.1. Animals, diets and experimental location

A total of 576 weaned piglets [(Landrace × Large White) × Pietrain, 28 d of age, average initial body weight (BW) 7.1 ± 1.1 kg] were randomly allotted to 4 treatments, so that each treatment started with the same initial BW. There were 6 male and 6 female replicates per treatment with 12 piglets per replicate. Experimental diets were fed in 4 phases, prestarter (28–42 d of age; Table 1), starter (42–70 d of age; Table 1), grower (70–120 d of age; Table 2) and finisher (120–182 d of age; Table 2). Piglets were fed diets containing standard level of energy or a reduced level of energy (∼3% less in calculated NE) and 0 or 400 mg/kg of the *Bacillus*-based probiotic in a 2 × 2 factorial design. The experimental diets were fed in a pellet form from weaning at 28 d of age to slaughter at 182 d of age. All the diets met or exceeded current nutrient requirements for weaned, grower and finishing pigs (NRC, 2012). The analysed chemical composition of diets fed during the experiment is presented in Tables 1 and 2. Weaned piglets were housed in two identical environmentally controlled rooms with slatted plastic floor and equipped with 24 pens (2.16 × 2.80 m). At the end of the starter period pigs were moved into the fattening unit with partially slatted concrete floor pens (3.0 × 3.2 m). 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

The pigs were weighed individually and feed consumption in each pen was measured at the end of each feeding phase. Growth performance in terms of average daily gain (ADG), average daily feed intake (ADFI) and feed:gain ratio (F:G) were calculated accordingly during the feeding trial. To evaluate the effect of dietary treatments on the apparent total tract digestibility (ATTD) of energy and nutrients, 5 g/kg HCl-insoluble ash (Celatom Clarcel DIC/M, Manuel Riesgo, Madrid, Spain) was added to the grower diets as an inert, indigestible indicator. The pigs were fed the diet containing HCl-insoluble ash during the entire grower period, and fresh faecal grab samples were collected randomly from four pigs from each pen during the last four days of the grower period. The faecal samples were pooled within pen and dried in a forced air drying oven at