Livestock Science 134 (2010) 76–78

Contents lists available at ScienceDirect

Livestock Science

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

Effect of xylanase and β-glucanase on growth performance and nutrient digestibility in piglets fed wheat–barley-based diets ☆

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ARTICLE INFO

Keywords:
Carbohydrases
Xylanase
β-glucanase
Digestibility
Performance
Piglets

ABSTRACT

There is increasing interest in the use of exogenous enzymes to improve diet digestibility and performance of pigs fed mixed grain-based diets. The potential of combination of carbohydrase (xylanase and β-glucanase) to enhance nutrient digestibility and performance was examined in the present study using 160 crossbred pigs (Landrace × Large White) of initial mean BW of 7.4 kg. Pigs were randomly assigned to four dietary treatments with 4 pigs per pen and 10 pens per diet for a 42-d feeding period. The diets were: Control (T1, 92% of DE requirement of NRC, 1998, with no enzymes), and control plus carbohydrase combination. The enzyme was added at 50 (T2), 100 (T3) and 200 g/MT (T4). Celite was used as an indigestible marker and feed was available to pigs *ad libitum*. Pigs were weighed at 0, 3 and 6 weeks of the experiment and fecal samples were collected for 3 days at the end of week 5. On average, piglets grew 525 g/d, consumed 845 g/d, and exhibited mean FCR of 1.59. Weight gain and feed intake did not differ ($P>0.05$) among treatments, however, FCR for the overall period was better ($P<0.05$) for pigs fed diets supplemented with 200 g/MT enzyme compared with those fed the control diet. The FCR for the overall period were 1.66, 1.59, 1.60 and 1.57 (SE = 0.07) for T1, T2, T3 and T4, respectively. Faecal digestibility of energy and protein did not differ ($P>0.05$) among treatments, however improvement in performance was observed, suggesting improved nutrient absorption in the ileum. Digestibility of NSP and of some individual sugars (arabinose, xylose, mannose and glucose) numerically increased ($P>0.05$) with enzyme supplemented diets relative to the control. The digestibility of NSP improved by 2.7 to 5.6% in the carbohydrase-supplemented compared to the control diet. It can be concluded that adding a specific proportions of blend of exogenous xylanase and β-glucanase enzymes to mixed grain-based diets improved performance in weaned pigs.

1. Introduction

Considerable amount of energy yielding nutrients and minerals in plant-based feed ingredients are located in the aleurone layer, typically constitute of non-starch polysaccharides (NSP). Most of these nutrients are consequently protected from hydrolysis in the digestive tract since pigs do not secrete enzymes capable of degrading the NSP (Bach Knudsen, 1997). Supplementation of NSP-degrading enzymes in high-NSP containing diets should reduce their detrimental effects and improve the nutritional value of such diets for pigs (Li et al., 1996). However, responses of NSP-degrading enzymes have had inconsistent effects in swine. Partly because the specific proportions of the individual carbohydrases in the blend to elicit optimum response in pigs fed mixed grain-based diets have not been properly defined.

Therefore, we investigated the effect of different doses of pure carbohydrases blend (xylanase and β-glucanase) in

☆ This paper is part of the special issue entitled "11th International Symposium on Digestive Physiology of Pigs".

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doi:10.1016/j.livsci.2010.06.102

specific proportion on performance and apparent total tract nutrient digestibility (ATTD) in pigs fed mixed grains-based diets deficient in energy.

2. Materials and methods

The carbohydrase enzymes used were a blend of xylanase and β-glucanase (Danisco Animal Nutrition, Marlborough, Wiltshire, UK). The diets were (T1) control (NC, Table 1) formulated to meet NRC (1998) requirements for all nutrients except DE which was 92% of the requirement; (T2) NC + 50 g XB /MT of feed (on as-fed basis); (T3) NC + 100 g XB/MT; and (T4) NC + 200 g XB/MT. XB was added at 50, 100 and 200 g/MT to T2, T3 and T4, respectively The enzyme product was added as post-pellet liquid application and diets contained celite (acid insoluble ash) as an indigestible marker.

One hundred and sixty Landrace Large White piglets (mean BW 7.5 ± 1.4 kg) were used after one week adaptation to solid feed, housed in groups of 4 in 20 pens of two rooms for 42 days. The experiment was set up as a randomized complete block design with 4 dietary treatments, 10 replicates per treatment and 10 blocks of liveweight. During the experimental period, there were 2 dietary compositions (pre-starter and starter) formulated to meet the nutrient requirements of piglets (NRC, 1998). Piglets were fed *ad libitum* throughout the experiment, and were weighed before start, and at 3 and 6 weeks afterwards. Feed intake was also measured and feed conversion ratio determined. Grab faecal samples were collected on pen basis for 3 days and pooled. Total tract digestibility coefficients of energy, CP, NSP were calculated using the marker method.

Samples of diets and digesta were analyzed for DM and CP according to AOAC (2000). Gross energy was determined using an adiabatic oxygen bomb calorimeter (IKA C-4000, IKA®—Werke GmbH, Staufen, Germany). Non-starch polysaccharides were determined by gas chromatography (Agilent Technologies 6890N), and the NSP content correspond to sum of individual sugars (arabinose, xylose, mannose, galactose and glucose). The coefficients of digestibility were calculated using standard procedures (Nyachoti et al., 2002). The data were analysed using the mixed model procedures of SAS (SAS software release 9.1; SAS Institute, Cary, NC, USA) (Table 2).

Table 1
Composition of basal diets.

	Pre-starter	Starter
Ingredient composition (g/kg)		
Barley	250.0	250.0
Wheat	335.0	350.0
Sweet whey	100.0	30.0
Wheat middlings	30.0	55.0
Soybean meal 48%	196.5	183.7
Peas	30.0	36.6
Canola meal	–	38.2
Soyabean oil	20.0	15.0
Dicalcium phosphate	16.6	15.6
Calcium carbonate	9.2	10.1
L-lysine-HCl	3.2	2.0
DL-methionine	0.6	1.2
L-threonine	1.7	0.4
Salt	2.5	2.5
Choline chloride	0.7	0.7
Vitamin and mineral complex [a]	4.0	4.0
Celite (marker)	–	5.0
Calculated chemical composition (g/kg)		
Net energy (kcal/kg)	2354.3	2263.2
Crude protein	182.5	185.5
Digestible lysine	10.31	9.20
Digestible methionine	2.92	2.78
Digestible threonine	7.13	6.62
Calcium	9.72	9.50
Total phosphorus	7.22	7.18
Digestible phosphorus	39.7	35.9

[a] Vitamin–mineral premix per kg of piglet feed: Vitamin A: 10,000 IU; Vitamin D_3: 2000 IU; Vitamin E: 15 mg; Vitamin B_1: 1,3 mg; Vitamin B_2: 3,5 mg; Vitamin B_{12}: 0.025 mg; Vitamin B_6: 1,5 mg; Calcium Pantothenate: 10 mg; Nicotinic acid: 15 mg; Biotin: 0,1 mg; Folic acid: 0,6 mg; Vitamin K_3: 2 mg; Fe: 80 mg; Cu: 6 mg; Co: 0,75 mg; Zn: 150 mg; Mn: 60 mg; I: 0,75 mg; Se: 0,10 mg; Ethoxiquin: 150 mg.

3. Results

On average, piglets grew 525 g/d, ingested 845 g/d and exhibited a feed:gain ratio of 1.59. No statistical differences were observed for weight gain and feed intake during both phases of measurements and overall the experiment ($P>0.05$). However, overall feed:gain ratio improved (Table 3; $P<0.05$); pigs fed diets containing 200 g/MT of the enzyme converted better and were more efficient than those fed control diet. No statistical differences (Table 4; $P>0.05$) were observed for digestibility of DM, CP, energy or NSP between treatments. However, digestibility of NSP and individual NSP sugars (arabinose, xylose, mannose and glucose), numerically increased (Table 4; $P>0.05$) with carbohydrase inclusion.

4. Discussion

Unlimited ranges of polysaccharides are present in plants and plant by-products used in the feed industry. These NSP encapsulate other nutrients and act as a physical barrier to hinder effective nutrient hydrolysis and absorption. Thereby reducing digestibility of DM, energy and AA in diets containing high levels of NSP. The major NSP of plant cell walls

Table 2
Analyzed chemical composition of experimental diets (as fed).

	Control (NC)	BGL/Y5
Pre-starter feed		
Crude energy (Mcal/kg)	4.07	4.05
Net energy (Mcal/kg)	2.36	2.34
Dry matter, g/kg	891.6	895.5
Crude protein, g/kg	183.1	183.8
Starter feed		
Crude energy (Mcal/kg)	4.04	4.06
Net energy (Mcal/kg)	2.34	2.36
Dry matter, g/kg	893.3	896.9
Crude protein, g/kg	179.1	174.1
Acid insoluble ash	7.25	8.42
Non-starch polysaccharides	79.8	77.6
Arabinose	15.8	14.8
Xylose	25.0	25.7
Mannose	2.0	2.1
Galactose	10.7	8.0
Glucose	26.2	26.8

Table 3
Carbohydrase supplementation on weaned pigs performance.

	Carbohydrase, g/kg feed					
	Control	NC + 50	NC + 100	NC + 200	P value	RSD
Replicates	10	10	10	10		
Initial BW, kg	7.4	7.4	7.4	7.5	0.40	0.15
Final BW, kg	29.5	29.7	29.8	30.0	0.86	1.42
ADFI, g/d	861	835	843	834	0.74	59.6
ADG, g/d	519	524	527	530	0.90	32.8
Feed/Gain	1.66[a]	1.59[ab]	1.60[ab]	1.57[b]	0.05	0.072

[a,b] Means within the same row with different superscript differ ($P<0.05$).

comprise of cellulose (linear β-glucan chains), non-cellulosic polysaccharides (arabinoxylans, mixed-linked β-glucans, mannans, galactans, and xyloglucan) and pectic polysaccharides (Bach Knudsen, 1997). Thus, adding a combination of xylanase and β-glucanase enzymes to mixed grain-based diets should disrupt the physical barrier improving NSP hydrolysis, and subsequently improve pig performance. However, studies with supplemental carbohydrase have not shown consistent patterns of improved performance variables. For instance, similar to the present study, carbohydrase supplementation did not improve ADG and nutrient digestibility in pigs fed rye-based or barley-based diets (Zijlstra et al., 2004; Thacker et al., 1992; Baas and Thacker, 1996). In contrast, other studies showed carbohydrase supplementation improved ADG in pigs fed barley, hull-less barley or wheat-based diets (Bedford et al., 1992; Van Lunen and Schulze, 1996; Baidoo et al., 1998). Zijlstra et al. (2004) observed increased energy and DM digestibility, ADFI and ADG, but not feed efficiency with carbohydrase supplementation. In the study herein reported, adding a combination of β-glucanase and xylanase numerically increased digestibility coefficients of NSP sugars (arabinose, xylose, mannose and glucose) and improved efficiency of feed utilization, but not DM, CP or energy digestibility.

The basic principle of enzyme technology application in animal nutrition is to improve the nutritive value of feedstuffs by 1) breakdown of anti-nutritional factors that are present in many plant based feed ingredients, 2) increased availability of starch, protein and minerals that are either encapsulated within fibre-rich cell walls and/or bound up in a chemical form that the animal is unable to digest, 3) breakdown of specific chemical bonds in raw materials that are not usually broken down by the animal's own enzymes, thus releasing more nutrients, and 4) supplement the enzymes produced by young animals. In the present study, adding the carbohydrase blend at the higher dose improved efficiency of feed utilization in weaned pigs, suggesting that the added enzyme might have worked by one or all of the mechanisms listed above. It must however be mentioned that the lack of significant response in total tract digestibility in the present and other studies in the literature may be due to interference of microbial degradation in the hindgut (Li et al., 1996), and that total tract digestibility measurement may not be a good indicator to determine actual value of supplemental exogenous enzyme. Thus, where possible, the value of exogenous enzyme should be determined using both performance, and ileal and faecal digestibility measurements.

Table 4
Carbohydrase supplementation on total tract nutrient digestibility (%) in pigs.

	Carbohydrase, g/kg feed					
	Control	NC + 50	NC + 100	NC + 200	P value	RSD
Replicates	10	10	10	10		
Dry matter	84.4	84.7	84.5	85.0	0.82	1.39
Crude protein	80.1	81.4	81.2	81.1	0.54	2.08
Energy	85.4	85.5	85.7	85.9	0.88	1.50
NSP*	65.9	69.6	67.7	69.7	0.27	4.85
Arabinose	56.2	59.4	56.2	59.2	0.53	6.49
Xylose	46.2	51.4	50.5	52.6	0.39	8.58
Mannose	87.7	92.3	88.0	90.3	0.33	7.21
Galactose	85.5	86.7	85.8	86.3	0.71	2.32
Glucose	81.9	84.1	82.3	84.1	0.42	3.60

*NSP; non-starch polysaccharides.

5. Conclusion

Adding higher dose of xylanase and β-glucanase blend (200 g/MT) to the mixed grain-based diets improved efficiency of feed utilization in weaned pigs, suggesting rupturing of NSP-containing cell walls and making otherwise locked-up nutrients present in the fibrous fractions of mixed grain diets available for digestion in the weaned pigs.

Conflict of interest

A. Owusu-Asiedu and P.H. Simmins are employees of Danisco Animal Nutrition.

References

Association of Official Analytical Chemists, 2000. Official Methods of Analysis. Association of Official Analytical Chemists, Washington, DC.
Baas, T.C., Thacker, P.A., 1996. Impact of gastric pH on dietary enzyme activity and survivability in swine fed β-glucanase supplemented diets. Can. J. Anim. Sci. 76, 245–252.
Bach Knudsen, K.E., 1997. Digestion of carbohydrates in the small and large intestine of pigs fed wheat or oat based rolls. Proc. 7th Int. Symp. on Dig. Physiol in Pigs, No.88, pp. 562–566.
Baidoo, S.K., Liu, Y.G., Yungblut, D., 1998. Effect of microbial enzyme supplementation on energy, amino acid digestibility and performance of pigs fed hulless barley based diets. Can. J. Anim. Sci. 78, 625–631.
Bedford, M.R., Patience, J.F., Classen, H.L., Inborr, J., 1992. The effect of dietary enzyme supplementation of rye- and barley-based diets on digestion and subsequent performance in weanling pigs. Can. J. Anim. Sci. 72, 97–105.
Li, S., Sauer, W.C., Huang, S.X., Gabert, V.M., 1996. Effect of β-glucanase supplementation to hulless barley- or wheat–soybean meal diets on the digestibilities of energy, protein, β-glucan, and amino acids in young pigs. J. Anim. Sci. 74, 1649–1656.
National Research Council, 1998. Nutrient Requirements of Swine, 10th ed. Natl. Acad. Press, Washington, DC.
Nyachoti, C.M., McNeilage-Van de Wiele, E.M., de Lange, C.F.M., Gabert, V.M., 2002. Evaluation of the homoarginine technique for measuring true ileal amino acid digestibilities in pigs fed a barley–canola meal based diet. J. Anim. Sci. 80, 440–448.
Thacker, P.A., Campbell, G.L., GrootWassink, J., 1992. The effect of organic acids and enzyme supplementation on the performance of pigs fed barley-based diets. Can. J. Anim. Sci. 72, 395–402.
Van Lunen, T.A., Schulze, H., 1996. Influence of *Trichoderma longibrachiatum* xylanase supplementation of wheat and corn based diets on growth performance of pigs. Can. J. Anim. Sci. 76, 271–273.
Zijlstra, R.T., Li, S., Owusu-Asiedu, A., Simmins, P.H., Patience, J.F., 2004. Effect of carbohydrase supplementation of wheat- and canola-meal-based diets on growth performance and nutrient digestibility in group-housed weaned pigs. Can. J. Anim. Sci. 84, 689–695.